Probing Models of Cosmic Acceleration

Author: Jochen Weller

Ludwig-Maximilians University Munich

Co-Authors:

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *11:45 Thursday 29th 11:45-13:15*

Summary:

We will review how different cosmological probes can constrain models of accelerated expansion of the Universe. We will look at the current constraint and give an outlook how future surveys can tackle this problem.

21st century Near IR and Optical wide field surveys

Author: Richard McMahon

University of Cambridge

Co-Authors:

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *12:05 Thursday 29th 11:45-13:15*

Summary:

I will review the current state of wide field NIR and optical imaging surveys including UKIDSS and VISTA in the NIR and the VLT Survey Telescope ESO Public surveys and the Dark Energy Survey in the optical. I will cover the current status of these surveys and highlight recent scientific results and prospects for the next 3-5 years.

Supernovae from the Dark Energy Survey

Author: Bob Nichol

ICG Portsmouth

Co-Authors: C. D'Andrea; H. Campbell; (for the DES collaboration)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *12:25 Thursday 29th 11:45-13:15*

Summary:

The Dark Energy Survey (DES) starts taking data this year and a key part of this next generation imaging survey is a dedicated supernova cosmology survey, covering 30 sq. degrees in griz over the 5 years of DES. We predict we will find >4000 high-quality SNeIa out to z=1.2, which will provide a DETF FoM of 120, even when plausible systematic uncertainties are included. This is an order of magnitude better than present SN surveys. To achieve this performance, we must control our systematics, including photometric calibration, SN classifications and host galaxy correlations. In this talk, I will outline our plans to deal with these issues.

Cosmology with SDSS-II Photometrically-Classified Type Ia Supernovae

Author: Heather Campbell

ICG

Co-Authors: B. Nichol (ICG Portsmouth);C D'Andrea (ICG Portsmouth); plus all the SDSSII SN team

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *12:45 Thursday 29th 11:45-13:15*

Summary:

Future supernova surveys, such as the Dark Energy Survey (DES), will be unable to spectroscopically classify all the Type Ia Supernovae (SNe Ia) that they are predicted to detect (approximately 4000). The development of an efficient and robust photometric classification system is thus essential. Here I present the cosmological analysis of a photometrically-classified sample of SNe Ia from the full Sloan Digital Sky Survey (SDSS) II Supernova Survey, supplemented with host galaxy redshifts from the Baryon Oscillation Spectroscopic Survey (BOSS). In total, we photometrically-classify 751 SNe Ia out to $z < 0.5$ with cosmologically-useful light curves, which is ~3 times the size of the comparable spectroscopically confirmed sample from SDSS. Tests with simulations show that our method results in less than 3% contamination, which we show does not bias our cosmological results. Using only photometrically-classified SNe Ia, we produce cosmological constraints comparable to the Supernova Legacy Survey (SNLS) 3 year spectroscopically confirmed SNe Ia. This work demonstrates the potential of photometric classification, which will become the primary method of compiling SN Ia samples in high-redshift surveys in the near future.

1-Minute poster summaries

Author: Poster Summaries

Co-Authors:

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *13:00 Thursday 29th 11:45-13:15*

Summary:

1-minute presentations given by those who will be displaying posters related to Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Observing the Dark Universe with Weak Lensing

Author: Thomas Kitching

University of Edinburgh

Co-Authors:

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *10:00 Friday 30th 10:00-11:15*

Summary:

I will present current observations of dark matter and measurements of dark energy properties inferred using weak gravitational lensing, using data from the largest deep imaging survey to data CFHTLS. Looking towards the future I will present prospects for dark Universe science that the ESA Euclid mission will enable.

The CFHT Lensing Survey

Author: Catherine Heymans

Institute for Astronomy, Royal Observatory, Edinburgh

Co-Authors: The CFHTLenS Collaboration

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *10:20 Friday 30th 10:00-11:15*

Summary:

We present the Canada-France-Hawaii Telescope Lensing Survey (CFHTLenS). This survey spans 155 square degrees in five ugriz optical bands incorporating data from the Wide, Deep and Pre-Imaging components of the CFHT-Legacy Survey. Applying our new methodology for data processing, photometric redshifts and weak lensing measurement to bring systematic errors under control, we present robust measurements of weak gravitational lensing, cosmological constraints and dark matter maps on unprecedented scales.

Combining Lensing and RSD

Author: Lars Koens

University of Edinburgh Institute for Astronomy

Co-Authors:

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *10:40 Friday 30th 10:00-11:15*

Summary:

Weak Gravitational Lensing has proved successful in measuring the bias b and stochasticity parameter r. The measurements, including recent CFHTLenS results, seem to suggest stronger nonlinear, stochastic biasing than simulations predict. If we trust the lensing results and use a model that extents the observations out to larger scales, we can work out the error in the cosmic growth rate as measured by Redshift Space Distortions (RSD). In this talk I will explain the lensing measurements and, subsequently, show the importance of b and r for distinguishing theories of gravity with RSD.

Multiwavelength Surveys for Cluster Cosmology- the South Pole Telescope and the Dark Energy Survey

Author: Joseph Mohr

Ludwig-Maximilians University, Munich

Co-Authors: G.~Bazin, S.~Desai, J.~Liu, A.~Saro, R.~Suhada, A.~Zenteno (LMU), K.~A.~Aird, B.~A.~Benson, L.~E.~Bleem, J.~E.~Carlstrom, C.~L.~Chang, T.~M.~Crawford, A.~T.~Crites, M.~D.~Gladders, F.~W.~High, S.~Hoover, J.~D.~Hrubes, R.~Keisler, E.~M.~Leitch, D.~Luong-Van, A.~Mantz, D.~P.~Marrone, J.~Mehl, S.~S.~Meyer, L.~Mocanu, T.~Natoli, S.~Padin, T.~Plagge, C.~Pryke, K.~K.~Schaffer, K.~Story, J.~D.~Vieira,

R.~Williamson (U Chicago), M.~L.~N.~Ashby, M.~Bayliss, R.~J.~Foley, A.~Rest, J.~Ruel, B.~Stalder, A.~A.~Stark, C.~W.~Stubbs (Harvard, CfA), A.~H.~Gonzalez (U Florida), J.~J.~McMahon, J.~Song (U Michigan), M.~Brodwin (U Missouri), R.~Armstrong (NCSA), A.~Clocchiatti (U Catholica), C.~L.~Reichardt, H.~M. Cho, E.~M.~George, N.~Harrington, W.~L.~Holzapfel, A.~T.~Lee, M.~Lueker, E.~Shirokoff, H.~G.~Spieler, O.~Zahn (UC Berkeley),, T.~E.~Montroy, J.~E.~Ruhl, B.~R.~Saliwanchik, J.~T.~Sayre, Z.~Staniszewski (CWRU), L.~Knox (UC Davis), J.~P.~Dudley, T.~de~Haan, M.~A.~Dobbs, G.~P.~Holder, L.~Shaw, A.~van~Engelen, K.~Vanderlinde (McGill), N.~W.~Halverson (U Colorado), M.~Joy (MSFC)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *10:55 Friday 30th 10:00-11:15*

Summary:

The South Pole Telescope has completed a 2500 deg^2 multi-frequency mm-wave survey in the southern sky to select galaxy clusters using their Sunyaev-Zel'dovich effect. We use multiband optical and near infrared imaging to identify optical counterparts, measure photometric redshifts, and constrain the cluster masses using weak lensing. The Dark Energy Survey begins operations this fall, and it will image the entire SPT survey region deeply in grizY bands, and a coupled VISTA survey will provide complementary NIR photometry. This new multiband survey data will enable improved mass constraints on the SPT selected clusters and will therefore lead to tighter constraints on cosmological parameters such as the equation of state parameter of the dark energy, the sum of the neutrino masses and non-Gaussianity in the initial density perturbations.

Newborn spheroids at the peak epoch of star formation

Author: Sugata Kaviraj

Imperial College London and University of Oxford

Co-Authors: S. Cohen, R. Windhorst (Arizona State); R. S. Ellis (Caltech); Robert W. O'Connell (Virginia)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *14:15 Friday 30th 14:15-15:30*

Summary:

Dominating the stellar mass density in the local Universe, spheroidal galaxies (SGs) are central to our understanding of galaxy evolution. While we know that the bulk (80%+) of the stars in today's SGs are 'old', surprisingly little is known about how and exactly when these stars formed. Accurately probing these significant issues requires a survey-scale study of newborn spheroids in the early Universe. Exploiting new HST/WFC3 near-infrared (Y/J/H) imaging (from the WFC3 Early-Release Science programme) and existing HST/ACS optical (B/V/i/z) imaging in GOODS-South, we perform a large statistical study of newborn SGs at the epoch of peak cosmic star formation (1

Looking at the Universe

Author: Karen Masters

ICG, Portsmouth

Co-Authors:

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *14:30 Friday 30th 14:15-15:30*

Summary:

The cosmological measurements from wide field imaging surveys depend on our understanding of how galaxies trace the distribution of matter; and at the same time a by-product of these surveys is a large well defined samples of galaxies. This partnership is well illustrated by the original SDSS – a survey designed to study large–scale structure, but which has been a gold mine for the detailed statistical characterisation of galaxy properties. While many galaxy properties can be measured automatically in pipelines, visual inspection remains the most reliable way to learn about the detailed shapes and types of galaxies. I will talk about the benefits of visual inspection of the images in current and future wide field imaging surveys, drawing on my experience with the Galaxy Zoo project.

Galaxy Clustering with Pan-STARRS1

Author: Daniel Farrow

Durham University

Co-Authors: S. Cole, N. Metcalfe (Durham University) and the Pan-STARRS1 team

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *14:45 Friday 30th 14:15-15:30*

Summary:

Pan-STARRS1 is on track to deliver 5 band photometry of 3pi steradians of sky to SDSS depths or deeper, in addition to several narrow but deep regions. We present the first, preliminary galaxy clustering measurements from the Pan-STARRS1 Small Area Survey, a 64sq degree field of verification data. We discuss our methods for sample selection, mitigating systematic errors and estimating the depth variations. We show how our angular selection mask & detection efficiency corrections affect estimates of the two point angular correlation function. Our work gives tantalizing hints of what can be achieved by the finished survey.

The emergence of the red sequence at z~2, seen through galaxy clustering in the UKIDSS UDS

Author: Will Hartley

University of Nottingham

Co-Authors: O.Almaini (Nottingham) C.Conselice (Nottingham) S.Foucaud (NTNU, Taiwan) R.Gruzbauch (Nottingham) A.Mortlock (Nottingham) C.Simpson (LJMU)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *15:00 Friday 30th 14:15-15:30*

Summary:

One of the longest-standing problems in extra-Galactic astronomy is the emergence of the red sequence of galaxies. Made up of predominantly passively-evolving systems, the origin of the red sequence is a problem that has never been fully answered. We are now in the era of exquisite multi-wavelength surveys and able to tackle this problem in ways that were not previously possible. With its unique K-band depth and Spitzer coverage (plus very deep data at shorter wavelengths) the UKIDSS Ultra-Deep Survey (UDS) is the ideal survey for studying the z~2 universe, and in particular the few faint, passive objects that exist at this redshift. This epoch is crucial for study as it is when the first significant populations of passive galaxies are observed. Using measurements of the large-scale structure of such samples I will show where these galaxies are located in the Universe (i.e. their host dark matter halo mass) and what this can tell us about the process of transformation from star-forming to passive.

Measuring the Power Spectrum with Peculiar Velocities

Author: Edward Macaulay

University of Oxford

Co-Authors: H. A. Feldman (University of Kansas); P. G. Ferreira (University of Oxford); A. H. Jaffe (Imperial College, London); S. Agarwal (University of Kansas); M. J. Hudson (Univeristy of Waterloo); R. Watkins (Willamette University)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Talk *15:15 Friday 30th 14:15-15:30*

Summary:

The peculiar velocities of galaxies are a unique cosmological probe, providing an unbiased estimate of the distribution of matter on scales much larger than the depth of the survey. Much research interest has been motivated by the high dipole moment of our local peculiar velocity field, which suggests a large scale excess in the matter power spectrum, and can appear to be in some tension with the LCDM model. We use the COMPOSITE peculiar velocity catalogue to estimate the matter power spectrum. We find that the most likely amplitude of large scale density fluctuations is several times higher than the LCDM expectation, although with a large uncertainty which includes the LCDM model at the 1 standard deviation level, and suggests that the high peculiar velocity dipole is not particularly challenging to the LCDM model.

Galaxy-scale gravitational lenses in large surveys: finding them, and what to do with them

Author: Neal Jackson

University of Manchester

Co-Authors:

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Poster *Poster Session B*

Summary:

30 years after the discovery of the first gravitational lens system, we are at the beginning of the period in which new lens systems can be discovered on industrial scales by wide-field surveys at multiple wavelengths. I describe some surveys for lenses from existing surveys such as NVSS, GB6 and UKIDSS and some efforts to find lenses in other surveys. Large numbers of such lenses can be important for understanding the structure of galaxies at different redshifts. I describe the aims and early results of an e-Merlin Legacy Programme aimed at followup of lenses already discovered.

Measuring the Cosmic Star Formation Rate Using Deep, Wide-Area, Narrow-Band Imaging

Author: Alyssa Drake

Astrophysics Research Institute, LJMU

Co-Authors: C.Simpson, I.K.Baldry, C.A.Collins, P.A.James (Astrophysics Research Institute, Liverpool John Moores University)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Poster *Poster Session B*

Summary:

The advent of wide-field narrow-band surveys allows for the first time the analysis of large statistical samples of star-forming galaxies, reaching lower stellar masses and star formation rates (SFRs) than ever before. Using ultra deep data from the SXDF-UDS Field, we construct a sample of >7000

stellar masses and star formation rates (SFRs) down to very faint levels. Using wide and deep data from the SWIRE-XMM-LSS field, we construct a sample of ~7000 narrowband-selected emission-line galaxies, in 12 redshift slices ranging from z=0.14 out to z=1.46. We use broad-band photometry across 11 filters from CFHT u band through to Spitzer IRAC, to determine accurate photometric redshifts, and confirm their reliability using ~250 spectra from the Magellan Telescopes. We trace the evolution of the SFR as a function of stellar mass to <108 Msun (and SFRs <<1 Msun yr-1) across ~10 Gyr.

A General Search for Rare Objects in the UKIDSS LAS

Author: Nathalie Skrzypek

Imperial College London

Co-Authors: S.J.Warren (Imperial College London); D.Mortlock (Imperial College London)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Poster *Poster Session B*

Summary:

The YJHK near-infrared bands of the UKIDSS Large Area Survey (LAS) are ideal for finding rare classes of object including high-redshift quasars, cool brown dwarfs, and cool white dwarfs. Here we present the results of a more general search for rare objects, by identifying sources with unusual colours from throughout the YJHK colour space. Unusual stellar sources are identified through chi^2 comparison against a wide set of colour templates, including stars, brown dwarfs, white dwarfs and quasars. Objects that do not match any of the templates are flagged as interesting. A small number of unusual sources merit further investigation.

Ultra-strong UV FeII Emission in a Large Quasar Group

Author: Kathryn Harris

UCLan

Co-Authors: R.G.Clowes(University of Central Lancashire); L.Haberzettl (University of Louisville); S.Mitchell(University of Louisville); M.J.Graham (California Institute of Technology); L.E.Campusano (Observatorio Astronomico Cerro Calan, Chile); G.M.Williger(Lab. Fizeau, University de Nice);I.K.Sochting (University of Oxford)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Poster *Poster Session B*

Summary:

I would like to present a region containing an excess of strong and Ultra-strong UV FeII emitting quasars, twice the number of previously published similar objects. These 16 quasars are spread over a redshift range 1.1

Gravitational Lens Statistics with Herschel-ATLAS

Author: Jo Short

Cardiff University

Co-Authors:

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Poster *Poster Session B*

Summary:

Whilst lens identification has traditionally been a rather timely exercise, early data from the Herschel-ATLAS survey demonstrated how efficiently lenses can be identified at submillimeter wavelengths using a simple flux criteria. Five lens candidates were identified in the H-ATLAS Science Demonstration Phase (SDP), however the full data set is expected to yield many more numbering in the hundreds. This has led us to consider how to utilise the statistical properties of the lenses. In this work we take a preliminary look at the different assumptions in analytical models for the redshift and magnification distributions of strong gravitational lenses, which include the cosmological parameters, the mass function and the lens density profile (for which we consider singular isothermal sphere and Navarro-Frenk-White approximations). We demonstrate how the SDP data compares to these models and consider about what could be done with the larger data set.

The WIRCam Deep Survey

Author: Rich Bielby

Durham University

Co-Authors: O. Ilbert (LAM), P. Hudelot (IAP), H. J. McCracken (IAP), E. Daddi (CEA Saclay), J. P. Kneib (LAM), Y. Mellier (IAP), C. Willott (NRC-CNRC)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Poster *Poster Session B*

Summary:

We present a new near-infrared imaging survey in the four CFHTLS deep fields: the WIRCam Deep Survey (WIRDS). WIRDS comprises extremely deep, high quality J, H and Ks imaging covering a total effective area of 2.1 sq. deg. and reaching AB 50% completeness limits of ~ 24.5. We combine our images with the CFHTLS to create a unique set of eight-band ugrizJHK photometric catalogues in the four CFHTLS deep fields; these four separate fields allow us to make a robust estimate of the effect of cosmic variance for all our measurements. We use these catalogues in combination with 9,800 spectroscopic redshifts to estimate precise photometric redshifts, galaxy types, star-formation rates and stellar masses for a unique sample of 1.8 million galaxies. We present an overview of the latest results based on the WIRDS data in the CFHTLS fields, including the evolution of the galaxy stellar mass function and mass-selected galaxy clustering to z~2, the identification of high redshift (z>1) clusters and the luminosity function of z=6 LBGs.

Clustering analysis of high-redshift Luminous Red Galaxies in Stripe 82

Author: Nikolaos Nikoloudakis

University of Durham

Co-Authors: T. Shanks (University of Durham); U. Sawangwit (University of Durham)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Poster *Poster Session B*

Summary:

We have measured the clustering for ~130000 colour selected Luminous Red Galaxies via the angular correlation function in Stripe 82 exploiting SDSS DR7 iz and UKIDSS LAS K photometry. We use the cross-correlation technique of Newman (2008) to establish that the average redshift of the LRGs is z~1. We have established that a sample with ~700deg^-2 has a comparable space density to the z~0.68 SDSS AAOmega LRG sample of Sawangwit et al. (2011) Compared to the AAOmega LRG w(θ) scaled to the depth of the Stripe 82 LRGs, the Stripe 82 w(θ) is higher at all scales. Thus at intermediate scales, the z~1 LRGs are not only more clustered than predicted by the long-lived evolutionary model, they are also more clustered than the comoving model. w(θ) shows a very flat slope at large scales which means that the ΛCDM linear model has become a poorer fit than at lower redshift. We present arguments that this is not caused by systematics. HOD models are fitted with best fit parameters : M_ min =2.2x10^13 M_sun, M_1 = 22x10^13 M_sun, F_sat=3.2%, bias=3.1 The flat slope in w(θ) cannot be explained on the basis of the HOD model. If the w(θ) excess proves reliable, we have made a significant detection of non-Gaussianity in the z~1 LRG distribution with an estimated local non-Gaussianity parameter estimate of f_=90+-20 which is a 4σ detection at a level comparable to the present upper limit from WMAP CMB measurements of f_<60.

Large-Scale Structure Surveys and Violations of Statistical Isotropy

Author: Dr. Yashar Akrami

Institute of Theoretical Astrophysics, University of Oslo

Co-Authors: H. K. Eriksen (Institute of Theoretical Astrophysics, University of Oslo)

Session: COS1: Cosmology and Structure Evolution with Wide-Field Optical and NIR Imaging Surveys

Presentation type: Poster *Poster Session B*

Summary:

The principles of isotropy and homogeneity of the Universe on large scales are two cornerstones of the cosmological concordance model. Despite the fact that these assumptions have so far been in good agreement with most cosmological observations of both cosmic microwave background (CMB) anisotropies and the large scale structure (LSS) of the Universe, subtle hints of the contrary have been claimed by some studies of the CMB and LSS data. Any violation of these cosmological principles may have strong impacts on our current understanding of the Universe, and therefore, it is of crucial importance to verify whether such claims hold against the tide of various high-quality data or they are only the results of systematic errors or statistical flukes. Here, we give an update on a previous analysis of the photometric luminous red galaxies (LRG) provided by the Sloan Digital Sky Survey (SDSS) to constrain the parameters of a quadrupolar anisotropic model of the primordial power spectrum. Our analysis is based on the construction of a quadratic estimator of the anisotropy coefficients and we use the latest SDSS-III photometric data (Data Release 8). We also present a more sophisticated technique based on a Gibbs sampling algorithm that can give a more flexible, accurate and computationally efficient way of searching for signatures of violations of statistical isotropy in the LSS data. We show that this method can provide a significantly more powerful tool for the statistical analysis of cosmological data from existing and forthcoming ground-based and space galaxy surveys.

WEAVE - The WHT Enhanced Area Velocity Explorer

Author: Prof. Gavin Dalton

RALSpace/University of Oxford

Co-Authors: S.C. Trager (RUG, Groningen); D. Carter (LJMU); P. Bonifacio (GEPI, Paris); J.A.L. Aguerri (IAC); C.J. Evans (UKATC); M. MacIntosh (UKATC)

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *11:45 Friday 30th 11:45-13:00*

Summary:

We present a summary of the science case and outline design for WEAVE, a new wide field spectroscopy facility for the William Herschel Telescope. WEAVE will provide MOS spectroscopy of up to 1000 simultaneous targets over a 2 degree diameter field of view, up to 30 small deployable integral field units (IFUs) and a large singe field IFU, each of which can be sampled either at full spectral coverage of 370nm--1000nm at R~5000 or a pair of limited wavelength ranges at R~20000. The instrument is currently in the PDR phase, with expected deployment at the WHT in late 2016. Primary science

goals include a Northern Hemisphere GAIA follow-up survey and targeted cosmological surveys that will complement the LOFAR survey programmes.

The BigBOSS project

Author: Jeremy Allington-Smith

Co-Authors: J.R. Allington-Smith (Durham University); W. Percival (Portsmouth University)

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *12:00 Friday 30th 11:45-13:00*

Summary:

BigBOSS is a ground-based (stage-IV) Baryon Acoustic Oscillation experiment. It will use the 4m Mayall telescope at Kitt Peak to deploy 5000 fibres over a 3-degree field to map large-scale structure via a sample of 50 million galaxies to redshift 3.5. It has recently been enthusiastically endorsed by the US Department of Energy and is now proceeding to a Conceptual Design Review next year. It will be constructed by an international collaboration led by the Lawrence Berkeley Laboratory. UK groups are responsible for key subsystems including the wide-field corrector (UCL) and the fibre system (Durham). This talk will focus on the hardware.

DESpec: Spectroscopic upgrade of the Dark Energy Survey

Author: Ofer Lahav

University College London

Co-Authors: The international DESpec team

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *12:15 Friday 30th 11:45-13:00*

Summary:

We propose a new initiative, the Dark Energy Spectrometer (DESpec), a 4000-fibre instrument for the Blanco 4-meter telescope in Chile that would take advantage of the infrastructure recently built for the Dark Energy Camera to achieve excellent science at low cost and relatively low technical and schedule risk for a project of this size. The wavelength range would be approximately 600 to 1000 nm with a resolution of R~3300 at the red end. Starting in 2017, when the Dark Energy Survey is completed, DESpec would obtain spectroscopic redshifts for ~10 million galaxies from DES+VISTA Hemisphere Survey (VHS) and thereby improve the Dark Energy Task Force (DETF) Figure of Merit by a factor of several. DESpec will also constrain neutrino masses, enable new techniques such as redshift-space distortions to constrain Dark Energy vs. Modified Gravity models, and enable powerful studies of galaxy evolution. As with DES, the UK investment would be highly leveraged by partnership with the Fermilab and other US groups and with other foreign partners.

The 3D clustering of SDSS-III BOSS DR9 Galaxies

Author: Ashley Ross

University of Portsmouth

Co-Authors: On behalf of the SDSS-III BOSS Collaboration

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *12:30 Friday 30th 11:45-13:00*

Summary:

I will present the 3D clustering of galaxies drawn from the first SDSS-III Baryon Oscillation Spectroscopic Survey (BOSS) data release (the ninth SDSS data release, DR9, public July 2012). The sample contains over 270,000 spectroscopic galaxy redshifts between $0.43 < z < 0.7$ that occupy a footprint of over 3,000 square degrees. The BOSS DR9 data set allows the baryon acoustic oscillation peak to be localised to within 2%. I will discuss the cosmological implications of this measurement.

Cosmological constraints from the large-scale galaxy clustering in BOSS

Author: Ariel Sanchez

Max Planck Institute for Extrarrestrial Physics

Co-Authors: for the BOSS collaboration

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *12:40 Friday 30th 11:45-13:00*

Summary:

We present cosmological constraints derived from the large-scale galaxy clustering in the Baryon Oscillation Spectroscopic Survey (BOSS). We analyse a sample of ~325,000 galaxies over ~3800 sq.deg. in the redshift range $0.43 < z < 0.7$, corresponding to the first two years of the survey. We combine this information with recent CMB, SN and BAO experiments, testing the consistency between these data sets. We explore a variety of cosmological parameter spaces, with an emphasis on the constraints on the properties of dark energy

spaces, with an emphasis on the constraints on the properties of dark energy

Forecasts for Extended Dark Matter & Dark Energy Models with the Next Generation of Redshift Surveys

Author: Edward Macaulay

University of Oxford

Co-Authors:

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *12:50 Friday 30th 11:45-13:00*

Summary:

The next generation of galaxy redshift surveys have the potential to precisely measure the nature of dark matter and dark energy. I will present forecast results for upcoming ground and space-based surveys for the standard cosmological model, and also extended models, with modified gravity alternatives to dark energy and an ultra-light axion component of dark matter. I will present forecasts for both a space-based Euclid-style survey, and a ground based survey with a 4m telescope.

4MOST: 4-meter Multi-Object Spectroscopic Telescope

Author: Roelof de Jong

Leibniz-Institut für Astrophysik Potsdam (AIP)

Co-Authors:

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *14:15 Friday 30th 14:15-15:30*

Summary:

The 4MOST consortium of 12 astronomical institutes led by the AIP aims to provide the ESO community with a fibre-fed spectroscopic survey facility on a 4m-class telescope with a large enough field-of-view to survey a large fraction of the southern sky in a few years. It will also have a high multiplex and a high spectral resolution enabling the detection of chemical and kinematic substructure in the Milky Way, and enough wavelength coverage to secure velocities of extra-galactic objects over a large range in redshift. 4MOST will run permanently on either the NTT or VISTA telescope to perform a 5 year public survey yielding more than >10 million spectra at resolution R>5000 and more than 1 million spectra at R>20,000. Such an exceptional facility enables many science goals, but the design is especially intended to complement three key all-sky, space-based observatories of prime European interest: Gaia, eROSITA and Euclid.

The Hector survey: an integral field spectrograph survey of 100,000 galaxies

Author: Joss Bland-Hawthorn

University of Sydney

Co-Authors: Jon Lawrence (Australian Astronomical Observatory)

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *14:30 Friday 30th 14:15-15:30*

Summary:

Over the past three years, we have developed and demonstrated a new photonic technology -- the hexabundle -- a special imaging fibre bundle designed to replace individual fibres in multi-object spectrographs. This technology lies at the heart of the newly commissioned SAMI instrument at the AAT which offers 13 bundles over a one-degree field (Croom et al 2011). We are now moving beyond the SAMI prototype towards a much larger concept known as Hector. This will allow 100 hexabundles to be positioned over a two-degree, or possibly a three-degree, field at the AAT. I will outline the main science drivers for a 100,000 galaxy survey to be carried out in the period 2014-2018.

Gaia, Gaia-ESO, and MOS spectroscopy

Author: Gerry Gilmore

IoA Cambridge

Co-Authors:

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *14:45 Friday 30th 14:15-15:30*

Summary:

There is a pressing need for new multi-object spectrographs (MOS) on 4m-class telescopes capable of measuring many thousands of spectra simultaneously over a large field-of-view, thereby enabling spectroscopy of millions of objects over a large fraction of a hemisphere in a few years. For Gaia, follow-up with a ground-based MOS is crucial for fully exploiting the substantial investment in the mission. This talk will review the status of Gaia launch due in 2013, will present the follow-up surveys starting, or being prepared, for Gaia spectroscopic followup, and will illustrate with those the

- launch due in 2013 - will present the follow-up surveys starting, or being prepared, for Gaia spectroscopic followup, and will illustrate with those the need and opportunity for more ambitious efforts. The Gaia-ESO Survey will be presented.

Large scale structure and galaxy formation studies with GAMA

Author: Dr Ivan Baldry

Liverpool John Moores University Astrophysics Research Insti

Co-Authors: P.Norberg (University of Durahm) GAMA team

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *15:00 Friday 30th 14:15-15:30*

Summary:

The extensive multi-wavelength GAMA survey has completed its 1st phase (GAMA-I). With GAMA-I data, we have performed detailed large scale structure studies, using over 120k galaxies with spectroscopic redshifts, spread over 140 sq.deg. and probing structures out to z=0.5. The first galaxy group catalogue is presented in Robotham et al.(2011), from which local group analogues are now found and which properties are now statistically compared to those of our Local Group. Additionally, redshift space clustering, with samples split by stellar mass, rest-frame colour and redshift enables us to put stringent constraints on the growth rate of structure (f_g). Currently we are able to show that f_g can be measured to a precision of better than 10%, without concern for systematics associated with the nature of the galaxy tracer. In this talk we will overview these two very different large scale structure results from GAMA-I, and give indications of future work to come with current and future extensions of GAMA.

MOONS: a new conceptual design for a multi-object spectrograph for the VLT

Author: Michele Cirasuolo

University of Edinburgh

Co-Authors:

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *15:10 Friday 30th 14:15-15:30*

Summary:

I will present a science and technical overview of MOONS, a new conceptual design for a Multi-Object Optical and Near-infrared Spectrograph, selected by ESO for a competitive phase A study. The grasp of the 8.2m Very Large Telescope (VLT) combined with the high multiplex (500 targets), wide wavelength coverage (0.8 - 1.8 microns) and spectral resolution (R=5000 and R=20,000) of MOONS will provide the astronomical community with a powerful, world-leading instrument able to serve a wide range of Galactic, extragalactic and cosmological studies. I will highlight the main science cases, from chemical abundance measurements of stars in the Milky Way and follow-up of the Gaia mission, to the evolution of galaxies and structure over >12 billion years of the history of the Universe. Finally, I will present the technical solutions and developments envisaged for MOONS and its overall design.

Spectroscopic follow-up of the eROSITA all sky survey

Author: Andrea Merloni

MPE

Co-Authors:

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Talk *15:20 Friday 30th 14:15-15:30*

Summary:

eROSITA (extended ROentgen Survey with an Imaging Telescope Array) is the core instrument on the Russian Spektrum-Roentgen-Gamma (SRG) mission which is current scheduled for launch in November 2013. eROSITA will perform a deep survey of the entire X-ray sky. In the soft band (0.5-2 keV), it will be about 30 times more sensitive than ROSAT, while in the hard band (2-8 keV) it will provide the first ever true imaging survey of the sky. The design driving science is the detection of large samples of galaxy clusters to redshifts z > 1 in order to study the large scale structure in the Universe and test cosmological models including Dark Energy. In addition, eROSITA is expected to yield a sample of around 2 million AGN, including obscured objects, revolutionizing our view of the evolution of supermassive black holes. The survey will also provide new insights into a wide range of astrophysical phenomena, including X-ray binaries, active stars and diffuse emission within the Galaxy. In this talk I will present the main characteristics of the mission and focus on the plans for spectroscopic followup of the eROSITA sources.

Improving the Spectroscopic Atomic Line Database

Author: Dr Matthew Ruffoni

Imperial College London

Co-Authors: Dr J.C.Pickering (Imperial College London)

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Poster *Poster Session B*

Summary:

High-resolution, high-quality spectra from both ground- and space-based spectrographs are vital in many fields of astronomy. However, they also highlight the inadequacies of the existing atomic database. Such inadequacies will be further exposed by future spectrographs, such as those on Gaia and E-ELT. For Gaia, follow-up measurements with a ground-based MOS on a 4-m class telescope will be crucial in extracting the most from the satellite's spectra. Yet neither the substantial investment in Gaia, nor the resources expended on such a follow-up, will be fully exploited so long as spectral analyses are limited by the quality of the atomic database. An investment must, therefore, also be made in improving the accuracy and reliability of parameters associated with important atomic lines. In many cases, order of magnitude improvements are needed and are achievable using Fourier transform spectroscopy, where wavelengths are accurate to at least 1:10^7 (30 ms^–1, 0.15 mÅ at 1500 Å), and f-values to a few percent. We present an overview of current needs for accurate atomic data, particularly f-values for iron group element spectra in the IR, optical, UV, and VUV spectral regions. Examples of current work for SDSS-III/APOGEE will be shown, which could be extended to support Gaia.

Mass Calibration of the South Pole Telescope Galaxy Clusters

Author: Bazin

Ludwig Maximilian Universitaet Muenchen

Co-Authors: Bazin (Ludwig Maximilian Universitaet Muenchen)

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Poster *Poster Session B*

Summary:

The South Pole Telescope, a 10-m telescope observing the CMB in 3 mm-wave bands, is a great machine to detect galaxy clusters using the Sunyaev Zeldovich Effect. The SPT cluster survey is now finished and it covers 2,500 sqdeg of the south hemisphere sky. I will present the SPT galaxy cluster sample and followups in optical, NIR and X-ray. I will summarize the cosmological analyses, and mainly focus on the SZ mass-observable calibration efforts that the collaboration is pursuing. In particular, I will present our calibration method based on dynamical masses using spectroscopic follow-up, a comparison with X-ray mass calibration, and limitations.

WEAVE - a new wide-field multi-object spectrograph for the William Herschel Telescope

Author: Chris Benn

ING, La Palma

Co-Authors: M. Balcells (ING), D. Abrams (ING), G. Dalton (Oxford/RAL), S. Trager (Groningen), D. Carter (LJMU), C. Evans (ATC, Edinburgh)

Session: COS2: Future wide-field massive spectroscopic surveys with 4m-telescopes

Presentation type: Poster *Poster Session B*

Summary:

WEAVE is a new multi object spectrograph (1000 fibres 2-deg field) planned for the 4.2-m William Herschel Telescope on La Palma. First light is expected in 2017.

Hydrodynamical Simulations of Galaxy Formation

Author: Volker Springel

Heidelberg Institute for Theoretical Studies

Co-Authors:

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *10:00 Tuesday 27th 10:00-11:15*

Summary:

Recent years have seen impressive progress towards hydrodynamic cosmological simulations of galaxy formation that try to account for much of the relevant physics in a realistic fashion. At the same time, numerical uncertainties and scaling limitations in the available simulation codes have been recognized as important challenges. I will review the state of the field in this area, highlighting a number of recent results obtained with large SPH and mesh-based simulations.

Cluster Galaxy interaction with Voronoi particle hydrodynamics (VPH)

Author: Steffen Hess

Leibniz Institute for Astrophysics

Co-Authors:

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *10:25 Tuesday 27th 10:00-11:15*

Summary:

Lagrangian Voronoi particle hydrodynamics (VPH) is a new fluid particle method whose density estimate is carried out with the help of an auxiliary mesh constructed as the Voronoi tessellation. This approach is capable to represent sharp density gradients and therefore avoids spurious surface tension effects across contact discontinuities that arise in SPH simulations.This makes it ideal to study phenomena that involve steep density gradients. For instance for the interaction of galaxies with the intracluster medium we find that the more accurate treatment of hydrodynamic instabilities in VPH leads to a more turbulent wake in the cluster and a faster transfer of gas from the galaxy.

SubHaloes Going Notts: The SubHalo-Finder Comparison Project

Author: Julian Onions

Nottingham University

Co-Authors: Frazer Pearce(Nottingham), Stuart Muldrew(Nottingham), Hanni Lux(Nottingham), Alexander Knebe(Universidad de Madrid), Steffen Knollmann(Universidad de Madrid)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *10:37 Tuesday 27th 10:00-11:15*

Summary:

We present a detailed comparison of the substructure properties of a single Milky Way sized dark matter halo from the Aquarius suite at five different resolutions, as identified by a variety of different (sub-)halo finders for simulations of cosmic structure formation. These finders span a wide range of techniques and methodologies to extract and quantify substructures within a larger host halo. For properties that rely on particles near the outer edge of the subhalo the agreement is at around the 20 per cent level. We find that basic properties (mass, maximum circular velocity) of a subhalo can be reliably recovered if the subhalo contains more than 100 particles although its presence can be reliably inferred for a lower particle number limit of 20.

Satellite Galaxies in a Warm Dark Matter Cosmology

Author: Mark Lovell

Institute for Computational Cosmology, Durham University

Co-Authors:

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *10:49 Tuesday 27th 10:00-11:15*

Summary:

LCDM has been shown over the last two decades to describe the large scale Universe (>10Mpc) very well. Recent observations of dwarf galaxies have, however, been more challenging. The cold dark matter paradigm (CDM) predicts that these galaxies should reside in haloes with a higher dark matter density than observations suggest. We show that this problem may be alleviated by a cut-off in the matter power spectrum - corresponding to a warm dark cosmology (WDM) - and discuss the implications of this work along with the challenges specific to any cosmology based on WDM.

The Structure of Stellar Haloes

Author: Ben Lowing

ICC, Durham University

Co-Authors: C.S.Frenk (ICC, Durham University); S.Cole (ICC, Durham University)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *11:02 Tuesday 27th 10:00-11:15*

Summary:

I will present a new technique for studying stellar haloes by populating subhaloes in N-body simulations with stellar tracer particles based on the predictions of semi-analytical models. The diffuse stellar halo surrounding the Milky Way contains only a small fraction of the total stars in our Galaxy, but holds a vast amount of information about its history and formation. It is thought to include a significant accreted component made up of the debris from infalling satellites disrupted in the potential of the Milky Way. The composition of the stellar halo therefore offers us a unique record of the assembly history of our Galaxy. Recently, huge advances in understanding stellar haloes have been made by Cooper et. al. (2010), using a new technique of tagging particles in dark matter simulations based on the star formation computed by semi-analytical models. In this work we go one step further and insert massless stellar tracer particles into the satellites in N-body simulations. The method provides a way to model the structure and kinematics of the stellar haloes at high resolution, yet with substantially lower cost than running full hydrodynamical simulations.

Simulations of large scale structure

Author: Raul Angulo

MPA

Co-Authors:

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *11:45 Tuesday 27th 11:45-12:45*

Summary:

I will review recent efforts to simulate the mass distribution on gigaparsec scales. Then, I'll focus on the recently completed Millennium-XXL and describe how we can use it to understand structure formation on the largest scales and to optimally exploit future and current galaxy surveys.

Creating fast galaxy mock catalogs using a PTHalos based approach

Author: Dr Marc Manera

ICG Portsmouth

Co-Authors: Roman Scoccimarro (NYU), Will Percival (ICG), Lado Samushia (ICG), Ravi Sheth (ICTP) Ashley Ross(IGG) Cameron McBride (CfA) and Andreas Berlind (Vanderbilt U)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *12:08 Tuesday 27th 11:45-12:45*

Summary:

We present a method to produce galaxy mock catalogs and compute covariance matrices of large scale clustering. The method populates 2LPT matter fields with halos and galaxies and is inspired in the paper of Soccimarro and Sheth 2002 (but with significant differences).The method is calibrated using LasDamas NBody simulations (McBride 2012)such that the clustering of halos is recovered at 10% accuracy. If the paper is released before the meeting, I will show how its method is applied to BOSS DR9 data.

What is galaxy environment?

Author: Stuart Muldrew

University of Nottingham

Co-Authors: D.J. Croton (Swinburne University of Technology, Australia); R.A. Skibba (University of Arizona, USA); F.R. Pearce (University of Nottingham, UK); H.B. Ann (Pusan National University, South Korea); I.K. Baldry (Liverpool John Moores University, UK); S. Brough (Australian Astronomical Observatory, Australia); Y.-Y. Choi (Kyung Hee University, South Korea); C.J. Conselice (University of Nottingham, UK); N.B. Cowan (Northwestern University, USA); A. Gallazzi (University of Copenhagen, Denmark); M.E. Gray (University of Nottingham, UK); R. Gruetzbauch (University of Nottingham, UK); I.-H. Li (Swinburne University of Technology, Australia); C. Park (Korea Institute of Advanced Study, South Korea); S.V. Pilipenko (Russian Academy of Sciences, Russia); B.J. Podgorzec (University of Nottingham, UK); A.S.G. Robotham (University of St. Andrews, UK); D.J. Wilman (Max-Planck-Institut fuer Extraterrestrische Physik, Germany); X. Yang (Shanghai Astronomical Observatory, China); Y. Zhang (Shanghai Astronomical Observatory, China); S. Zibetti (University of Copenhagen, Denmark)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *12:20 Tuesday 27th 11:45-12:45*

Summary:

The influence of a galaxy's environment on its evolution has been studied and compared extensively in the literature, although differing techniques are often used to define environment. Most methods fall into two broad groups: those that use nearest neighbours to probe the underlying density field and those that use fixed apertures. The differences between the two inhibit a clean comparison between analyses and leave open the possibility that, even with the same data, different properties are actually being measured. In this work we apply twenty published environment definitions to a common mock galaxy catalogue constrained to look like the local Universe. When considering environment there are two regimes: the 'local environment' internal to a halo best measured with nearest neighbour and 'large-scale environment' external to a halo best measured with apertures. This leads to the conclusion that there is no universal environment measure and the most suitable method depends on the scale being probed.

Constraints on star formation and accretion histories from an improved abundance matching model

Author: Benjamin Moster

MPA Garching

Co-Authors:

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *12:32 Tuesday 27th 11:45-12:45*

Summary:

We use a statistical approach to determine the relationship between the stellar masses of galaxies and the masses of the dark matter haloes in which they reside over the entire cosmic history from $z \sim 4$ to the present. Unlike the common abundance matching technique our new method is self-consistent taking into account that subhaloes are accreted at different times. To this end we employ a redshift dependent parameterization of the stellar-to-halo mass relation, populate haloes and subhaloesloes in the Millennium simulations with galaxies and requiring that the observed stellar mass functions at different redshifts be reproduced simultaneously. We show that a consistent stellar mass evolution of massive galaxies can only be obtained if observational mass errors are taken into account. The resulting relation is then used in combination with merger trees extracted from the simulations in order to predict the mean assembly histories of the stellar mass components within dark matter haloes (in situ and ex situ formation). Our main results are: The maximal

mean assembly histories of the stellar mass components within dark matter haloes (in situ and ex situ formation). Our main results are: The maximal baryon conversion efficiency decreases with redshift while the corresponding halo mass decreases with redshift. The star formation history of central galaxies peaks at a halo mass dependent redshift; for massive haloes this peak is at early cosmic times while for low mass galaxies the peak has not been reached yet. In Milky-Way sized haloes more than half of the central stellar mass is assembled at $z = 0.5$, which corresponds to the peak in the star formation history. In low mass haloes, the accretion of satellite galaxies contributes little to the formation of their central galaxies, while in massive haloes more than half of the central stellar mass is formed ex situ with a significant accretion of satellites at $z < 2$. We present convenient fitting functions for stellar masses, star formation rates, and accretion rates as a function halo mass and redshift. Our results put tight constraints on star formation and other physical processes that have to be captured in numerical simulations of galaxies.

The Physics of Galaxy Formation

Author: Richard Bower

Durham University

Co-Authors: the EAGLE collaboration

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *14:00 Tuesday 27th 14:00-15:30*

Summary:

I will discuss the physics of galaxy formation, reviewing the roles of super-nova driven feedback the heating of haloes by AGN. I will discuss the different ways in which these feedback schemes may work and how they can work together to create the observed galaxy population. I will highlight the most important constraints from observational data and illustrate some of the most puzzling inconsistencies of data and models. I will illustrate our growing understanding of the process of galaxy formation with results from phenomenological calculations, and present recent simulations from the EAGLE project. The EAGLE project aims to combine the best aspects of a phenomenological approach with hydro-dynamic simulations that resolve the Jean instability in galaxy disks.

Giant Clumps in High-Redshift Disk Galaxies

Author: Manuel Behrendt

Max-Planck-Institute for Extraterrestrial Physics

Co-Authors: A.M. Burkert (University Observatory Munich); E. Ntormousi (University Observatory Munich)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *14:25 Tuesday 27th 14:00-15:30*

Summary:

By performing numerical simulations, we aim to get a better understanding of the formation and evolution of disk galaxies at high redshifts. We use the grid code RAMSES and setup preformed gas disks in hydrodynamic equilibrium and let them evolve to analyze the disk transformation and the developed structures. By gravitational instability alone, the disks become highly turbulent with velocity dispersions of 50 kms/s. Clumps build up, accumulate gas and get sizes of 1kpc in diameter, in good agreement with observations. A special feature is their fast self-rotation, which is generally only seen in simulations. In future we want to go to higher resolution and study these clumps in more details.

The End of the Dwarfs Excess in Galaxy Formation models at high Redshift

Author: Bruno Henriques

MPA - Garching

Co-Authors: S.White (MPA-Garching), P. Thomas (Sussex), G.Lemson (MPA-Garching)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *14:38 Tuesday 27th 14:00-15:30*

Summary:

All public semi-analytic models of galaxy formation over-predict the number of dwarf galaxies by approximately factors of 3 and 10 (respectively at z=1 and z=2). A problem pointed out has a major failure in the galaxy formation theory and even a change in cosmology (warm dark matter) has been suggested as a possible solution. This hints at a fundamental difficulty with semi-analytics: due to the large number of free parameters used and observational properties predicted, it is hard to find the best possible solution and learn if the model is in fact ruled out. This is particularly true when trying to maintain the good match obtained at z=0 while adjusting the parameters to fit high redshift data. We use robust statistical techniques to sample the parameter space and test the likelihood of different physical implementations in the models when compared to a wide range of observational properties at multiple redshifts. This allows us to identify how a simple change in the treatment of the SN feedback physics can solve the long-standing dwarfs excess problem. The new model successfully predicts the number density of galaxies in all mass ranges from z=2 to z=0.

CLUES - Cosmological Simulations the Local Universe

Author: Matthias Steinmetz

Leibniz Institute for Astrophysics Potsdam (AIP)

Co-Authors: and the CLUES collaboration

Co-Authors: and the CLUES collaboration

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *14:51 Tuesday 27th 14:00-15:30*

Summary:

CLUES (Constrained Local UniversE Simulations) is a numerical simulation project to follow the evolution of the local universe. For the CLUES simulations we construct initial conditions based on observational data of the galaxy distribution in the local universe. We describe the setup of initial conditions, the suite of simulations and some first results regarding the accretion history of MW look-alikes in CLUES as compared to galaxies of similar mass in unconstrainted cosmological simulations.

The Origin of Disks and Spheroids in Simulated Galaxies

Author: Laura V. Sales

MPA

Co-Authors:

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *15:04 Tuesday 27th 14:00-15:30*

Summary:

In the simplest scenario, disk galaxies form predominantly in halos with high angular momentum and quiet recent assembly history, whereas spheroids are the slowly-rotating remnants of repeated merging events. We explore these assumptions using one hundred systems with halo masses similar to that of the Milky Way, identified in a series of cosmological gasdynamical simulations GIMIC. At z=0, the simulated galaxies exhibit a wide variety of morphologies, from dispersion-dominated spheroids to pure disk galaxies. Surprisingly, these morphological features are very poorly correlated with their halo properties: disks form in halos with high and low net spin, and mergers play a negligible role in the formation of spheroid stars, most of which form in-situ. More important to morphology is the coherent alignment of the angular momentum of baryons that accrete over time to form a galaxy. Spheroids tend to form when the spin of newly-accreted gas is misaligned with that of the extant galaxy, leading to the episodic formation of stars with different kinematics that cancel out the net rotation of the system. Disks, on the other hand, form out of gas that flows in with similar angular momentum to that of earlier-accreted material. Gas accretion from a hot corona thus favours disk formation, whereas gas that flows "cold", often along separate, misaligned filaments, favours the formation of spheroids. In this scenario, most spheroids consist of superpositions of stellar components with distinct kinematics, age, and metallicity, an arrangement that might survive to the present day given the paucity of major mergers. Since angular momentum is acquired largely at turnaround, morphology is imprinted early by the interplay of the tidal field and the shape of the material destined to form the galaxy.

Structural Evolution of Massive Galaxies

Author: Ludwig Oser

Max-Planck-Institute for Astrophysics

Co-Authors: T.Naab (MPA); J.P.Ostriker (Princeton University); P.H.Jonhansson (University of Helsinki)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *15:17 Tuesday 27th 14:00-15:30*

Summary:

We use a large sample of cosmological re-simulations of individual massive galaxies to investigate the origin of the strong increase in sizes and weak decrease of the stellar velocity dispersions since z=2. At the end of an rapid early phase of star-formation, where stars are created from infalling cold gas, our simulated galaxies are all compact with projected half-mass radii of $\lesssim 1 kpc$ and central line-of-sight velocity dispersions of $\approx$ 262 kms$^$. At lower redshifts (z<2) those galaxies grow predominantly by the accretion of smaller stellar systems and evolve towards the observed local mass-size and mass-velocity dispersion relations. We find that the evolution of massive galaxies can be explained by frequent minor stellar mergers which is the dominant mode of accretion for our simulated galaxies.

SZ in the New Millennium

Author: Scott Kay

Manchester

Co-Authors: P.A.Thomas (Sussex); C.J.Short (Sussex)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *17:00 Tuesday 27th 17:00-18:15*

Summary:

Results will be presented from the new Millennium Gas simulation, a large (10 billion particle) cosmological N-body/hydrodynamical simulation of structure formation in the WMAP-7 cosmology. A novel feature of the simulation is that it uses one of the latest and most successful semi-analytic galaxy formation models to compute the feedback energy from supernovae and active galactic nuclei, which is then used to directly heat the intracluster medium. In this talk I will focus on comparing the predicted SZ properties of the clusters in the simulation, with the latest observational data.

The simulated SZ-richness relation

The simulated SZ-Richness relation

Author: Peter Thomas

University of Sussex

Co-Authors: Luca Porcelli (University of Sussex) Scott Kay (University of Manchester)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *17:12 Tuesday 27th 17:00-18:15*

Summary:

We explore the simulated Sunyaev-Zel'dovich versus cluster richness (Y500-N200) relation using results from the Millennium Gas simulation. The simulation uses the Guo (2011) semi-analytic model to follow the growth of galaxies and their associated central black holes. Feedback from supernovae and active galactic nuclei are then used to determine the entropy history of the intracluster medium. Thus, we are able to follow the joint evolution of both the galaxies and the thermal history of the ICM. We compare with recent results from Planck.

The hot circumgalactic medium of typical galaxies

Author: Dr Robert Crain

Leiden Observatory, Netherlands

Co-Authors: Ian G. McCarthy (University of Birmingham), Carlos S. Frenk (University of Durham), Joop Schaye (Leiden Observatory), Tom Theuns (University of Durham, University of Antwerp)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *17:25 Tuesday 27th 17:00-18:15*

Summary:

Semi-analytic models typically derive star formation rates from the net cooling rate of circumgalactic gas reservoirs established by accretion from the IGM. Today's L* disc galaxies are expected to be fuelled by a T=10^6K corona that cools by soft X-ray emission. We recently reconciled this orthodoxy with the puzzling observation that coronal luminosities account for just ~1% of the cooling radiation predicted by simple semi-analytic models: simulations that model the detailed hydrodynamic evolution of circumgalactic gas in fact form hot coronae that follow the observed scaling relations (with SFR, M* & v_rot) inferred from X-ray and optical data (see Crain et al. 2010). Exploiting the first homogeneous sample of edge-on disc galaxies observed with Chandra (Li & Wang 2012), we compare their coronal properties with those of ellipticals. At fixed M*, the two types exhibit similar luminosities, signifying a common coronal origin - most plausibly the model advocated by Crain et al. - and presenting a fine-tuning problem for models appealing to the evolution of (in each type, markedly different) stellar populations as the source of hot gas. Moreover, we address the argument that the observed solar metallicity of coronae associated with ellipticals precludes an intergalactic origin: simulations indicate that high-metallicities are inferred due to the intrinsic flux-weighting of spectroscopic measurements, which biases measurements towards the small fraction (by mass) of dense, metal-rich and highly luminous gas at the very centre of galactic coronae.

The angular momentum of baryons and dark halos revisited

Author: Julien Devriendt

University of Oxford

Co-Authors: A. Slyz (Oxford), T. Kimm (Oxford), Y. Dubois (IAP, Paris), C. Pichon (IAP, Paris), D. Pogosyan (Alberta), S. Kassin (NASA Goddard)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *17:37 Tuesday 27th 17:00-18:15*

Summary:

I will present new results from high resolution adaptive mesh refinement cosmological simulations which highlight the role played by cold gaseous streams in the acquisition of angular momentum by disk galaxies. More specifically, I will show that the baryonic specific angular momentum profile of the vast majority of halo hosting galaxies has very little in common with that of the dark matter. I will explain that this can be understood as a different spatial re-distribution of the similar amount of total specific angular momentum shared by the two components and discuss the potential implications for galaxy disk formation.

The cosmic web and the orientation of angular momenta

Author: Noam I Libeskind

Leibniz Institute for Astrophysics

Co-Authors: M Steinmetz (AIP), Y Hoffman (Hebrew University) A Knebe (UAM, Madrid), G Yepes (UAM Madrid)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *17:49 Tuesday 27th 17:00-18:15*

Summary:

We use a 64 Mpc dark matter (DM) only cosmological simulation to examine the large scale orientation of haloes and substructures with respect the

We use a 64 Mpc dark matter (DM) only cosmological simulation to examine the large scale orientation of haloes and substructures with respect the cosmic web. A web classification scheme based on the velocity shear tensor is used to assign to each halo in the simulation a web type: knot, filament, sheet or void. Using ~ 10^6 haloes that span ~3 orders of magnitude in mass the orientation of the halo's spin and the orbital angular momentum of subhaloes with respect to the eigenvectors of the shear tensor is examined. We find that the orbital angular momentum of subhaloes tends to align with the intermediate eigenvector of the velocity shear tensor for all haloes in knots, filaments and sheets. This result indicates that the kinematics of substructures located deep within the virialized regions of a halo is determined by its infall which in turn is determined by the large scale velocity shear, a surprising result given the virilaized nature of haloes. The non-random nature of subhalo accretion is thus imprinted on the angular momentum measured at z = 0. We also find that haloes' spin axis is aligned with the third eigenvector of the velocity shear tensor in filaments and sheets: the halo spin axis points along filaments and lies in the plane of cosmic sheets.

Realistic N-body/SPH simulations of late-type spiral galaxies

Author: Awat Rahimi

UCL - MSSL

Co-Authors: D. Kawata

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Talk *18:02 Tuesday 27th 17:00-18:15*

Summary:

We have carried out several isolated galaxy evolution simulations using the new version of our N-body/SPH code GCD+, which includes new star formation and feedback schemes. The new code allows us to more accurately model and follow the evolution of the gas and stellar components of the system including powerful supernovae feedback and its effects on the inter-stellar medium. We primarily investigate the effects of varying baryonic physics within our chosen dark matter halo in reproducing our desired late-type spiral galaxy. We note that strong-feedback from supernovae is required to reproduce several observational trends, including the Kennicutt-Schmidt law and high velocity dispersion of the gas component.

Halo Statistics and Substructure at High Redshift

Author: William Watson

University of Sussex

Co-Authors: I. T. Iliev (University of Sussex)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

Using a suite of large N-Body Dark Matter Simulations (with 28bn - 216bn particles) the halo mass function is probed at high redshifts (z > 6) and compared to existing analytic functions from the literature. Two spherical overdensity (SO) halo finders and one Friends-Of-Friends (FOF) halo finder were used in the analysis. In addition, a presentation of the substructure of the most massive halos from the simulations is given, found using the AMIGA Halo Finder (AHF) and SUBFIND.

EAGLE: Producing Realistic SPH Simulation Data

Author: Michelle Furlong

Institute for Computational Cosmology, Durham University

Co-Authors: R. G. Bower(Institue for Computational Cosmology), T. Theuns(Institute for Computational Cosmolgy), Y. Rosas-Guevara(Institue for Computational Cosmology), J. Schaye(Leiden University), R. A. Crain(Leiden University), C.M.Booth(Kavli Institute for Cosmological Physics), C. Dalla Vecchia (Max Planck Institut fur Extraterrestrische Physik)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

Understanding the combination of ingredients required in galaxy formation, to produce the observed galaxy population, remains one of the challenges of Cosmology. Although the background cosmology is well understood, the properties of galaxies depend sensitively on the star formation model, stellar feedback, the effects of metallicity and the formation of black holes and their associated feedback. Using sub-grid physics for these processes introduces further parameters to simulations, which then need to be constrained by observations. A key aspect of the Eagle project is to reproduce the observed stellar mass function, through tuning the sub-grid parameters, focusing on the Type II SN feedback and AGN feedback. The completed data will consist of a 100Mpc^3 N-body SPH simulation with gas particle resolution of ~10^6 solar masses, providing sufficient resolution to study Milky Way size galaxies, with 10^5 particles. This size of simulation at such a high resolution puts Eagle as one of the largest SPH simulations to be carried out, with an added challenge of reproducing observable data. While the full volume is still in the preparatory stages, results for smaller volumes and zoomed simulations, constraining parameters are currently available. These tests also outline how the parameter selection can be carried out.

The predicted UV colours of galaxies at z>3

Author: Violeta Gonzalez-Perez

Durham University

Co-Authors: C. Lacey (Durham), C. Baugh (Durham), S. Wilkins (Oxford), C. Frenk (Durham), T. Theuns (Durham)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

The rest frame ultra-violet (UV) colours of galaxies are a powerful tool to select galaxies at z>3, in fact, the new Hubble Space Telescope has recently revealed several candidates at z=10. The UV continuum slope is widely used to estimate the dust content of galaxies and it can give us information about the end of the reionisation epoch. In this talk I will present a theoretical study of the UV colours of galaxies at z>3. Using GALFORM, a semi-analytical model of galaxy evolution, I will present results on how UV colour change with changing quantities from the physical distribution of dust with respect to stars to the dust extinction curve adopted, and how these affect the knowledge that we can extract from analysing the UV continuum slope.

Are z~5 QSOs found in the most massive high redshift halos?

Author: Kate Husband

University of Bristol

Co-Authors: M. Bremer (University of Bristol, UK), L. Douglas (University of Bristol, UK), L. Davis (University of Bristol, UK), E. Stanway (University of Warwick, UK)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

Luminous high redshift quasars are thought to exist within the most massive dark matter halos (M > 10^13 Msun) in the young universe, where simulations suggest the strongest evolution is expected to have occurred in the relatively brief time since the Big Bang. Given the expected halo clustering behaviour, the quasars may trace volumes containing an overdensity of other high redshift galaxies (i.e. Lyman Break Galaxies, LBGs). To test this hypothesis we searched three ~3' (~1Mpc at z~5) z=5 quasar fields for strongly star forming LBGs at the quasar redshift. We compared the numbers of spectroscopically-confirmed LBGs in these fields to those found through an identical procedure in blank sky fields (ESO Remote Galaxy Survey, ERGS; Douglas et al.'09,'10). We find no evidence for significant overdensities in the quasar fields; they appear typical of those found in ERGS. The lack of LBG clustering around high redshift quasars suggests that either high redshift quasars do not trace the peaks in the mass density at high redshift, or if they do, that LBGs are poor tracers of galaxy evolution in such high-redshift environments. Either way, this indicates our understanding of early galaxy formation is incorrect.

Particle-by-Particle M2M Galaxy Simulations

Author: Jason Hunt

MSSL (UCL)

Co-Authors:

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

The next European Space Agency (ESA)'s cornerstone mission, Gaia, is expected to be launched in 2013. We are developing a made-to-measure (M2M) Galaxy model to reconstruct the mass distribution and stellar kinematics of each component of the Milky Way, such as the thin and thick discs, bar/bulge and halo, from the data from Gaia and related surveys. M2M was originally suggested by Syer & Tremaine (1996), which adapts an existing model to better fit 'observables' by altering the particle weights of an N-body model. As the Gaia data will be in the form of individual stars, we have newly developed a particle-to-particle M2M (ppM2M), where the target observables are compared with the model observables at the position of target particles, i.e. stars. We demonstrate that ppM2M is capable of reproducing the target N-body models, including Hernquist (1990) models and disc galaxies simulated with N-body code.

Non-Gaussianity in Large Scale Structure and Minkowski Functionals

Author: Geraint Pratten

Cardiff University

Co-Authors: D. Munshi (Cardiff University)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

Minkowski Functionals (MFs) are topological statistics that have become one of many standard tools used in investigating statistical properties of cosmological random fields.To lowest order, the MFs depend on three generalised skewness parameters that can be shown to probe the bispectrum with differing weights. Recent studies have advocated the use of a power spectrum associated with the bispectrum, called the skew-spectrum, that has more

power to distinguish between various contributions to the bispectrum than the conventional formalism adopted when using the Minkowski Functionals. In this talk we will review the motivations for studying non-Gaussianity and emphasise the importance of the momentum dependence of higher order correlators in investigating inflationary models before introducing the skew-spectra, applied to galaxy surveys, as a tool for investigating primordial and gravitationally induced non-Gaussianity.

The Influence of Gas Physics on SZ Pressure Profiles

Author: Simon Pike

Co-Authors: Scot Kay - University of Manchester

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

The Sunyaev-Zel'dovich or SZ effect is caused by CMB photons being scattered off free electrons via Compton scattering, creating a predictable distortion in the CMB. The intracluster medium or ICM is a heated plasma in approximately hydrostatic equilibrium at the centre of clusters that forms the major contribution to the SZ effect. The SZ effect can be used to investigate the scaling relation between the Y parameter, which is a volume integral over the pressure of the gas, and cluster mass. It is therefore important to investigate how gas physics within the cluster might affect the pressure profile, and therefore its Y parameter. In my poster I will show preliminary results of a new set of 30 hydrodynamical simulations, spanning a mass range of 1e14 to 1e15 M_sun/h. These simulations will be used to see how the gas physics, including cooling, star formation and feedback will effect the pressure profiles and the SZ Y parameter.

The role of the AGN in the evolution of Eagle galaxy groups.

Author: Yetli Rosas-Guevara

Durham University

Co-Authors: R.G. Bower(ICC Durham University), C. Booth(University of Chicago), J. Schaye (Leiden Observatory Leiden University), Adrian Jenkins(ICC Durham University), R.Crain (Leiden Observatory Leiden University), T.Theuns (ICC Durham University and University of Antwerp), C.S. Frenk(ICC Durham University) , M. Furlong (ICC Durham University)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

Previous studies have shown that the AGN plays a key role in the shaping of the high end of stellar mass function and in the evolution systems such as groups and clusters. Motivated by this,, we study the evolution of the galaxy groups focusing on the variations in AGNs physics implemented in Evolution and Assembly of Galaxies and their Environments (EAGLE) project. In order to efficiently study the formation of galaxies in high mass haloes, we perform a set of hydrodynamical resimulations of galaxy groups of 10^13-14 h^-1 Msun at a resolution of 10^6 h^-1 Msun per gas particle. We explore some parameters of the AGN prescription. We focus mainly on follow the evolution of the Central Brightest Galaxy (CBG) and its star formation history as well as the Black Hole (BH) Mass -Bulge Mass relation. We explore the impact of several parameters such as the threshold amount of energy released by the BH to its surrounding gas and halo mass at which we inject BH seeds.

Numerical simulations with GPUs

Author: Martin Zintl

USM

Co-Authors: A.M. Burkert (University Observatory Munich)

Session: COS3: Simulations of the formation of galaxies and larger structures

Presentation type: Poster *Poster Session A*

Summary:

Many astrophysical problems are limited by the computational power of the machines running those simulations. Therefore, additional hardware to assist the CPU of a computer have been used in the past (Grape boards, FPGAs), to speed up simulations. Graphics processing units (GPUs) provide a novel way to gain massive performance speedups in certain situations due to their highly parallel nature. We will talk about the opportunities, but also the challenges of running simulations on a GPU. Since the raw floating point performance of a GPU exceeds the performance of a CPU by far, there is the potential for significant speedups. Early tests show that our SPH simulation code on one consumer GPU is approximately 60 times faster than the standard cosmological code "Gadget-3" running on a Core i7 Quadcore processor. We will also present a few results of simulations run with this code: The collision of two cold gas clouds with high mach numbers in an isothermal three-dimensional simulation, and the problems of standard SPH regarding the growth rate of the Kelvin-Helmholtz-instability in two dimensions, with and without various SPH modifications.

Modeling dark energy -- from Quintessence to Modified Theories of Gravity

Author: Ed Copeland

University of Nottingham

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *10:00 Thursday 29th 10:00-11:15*

Summary:

I briefly review models of dark energy. These include models of a cosmological constant including those arising in string theory, and dynamical models where a scalar field may be responsible for the observed late time acceleration through to the possibility that we are not fully in control of the gravity sector and the acceleration may be some manifestation of modified gravity. All cases require some degree of fine tuning for the models to be compatible with observation.

Generalized perturbations in modified gravity and dark energy

Author: Jonathan Pearson

Jodrell Bank Centre for Astrophysics

Co-Authors: Richard Battye

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *10:30 Thursday 29th 10:00-11:15*

Summary:

When recent observational evidence and the GR+FRW+CDM model are combined we obtain the result that the Universe is accelerating, where the acceleration is due to some not-yet-understood "dark sector". There has been a considerable number of theoretical models constructed in an attempt to provide an "understanding" of the dark sector: dark energy and modified gravity theories. The proliferation of modified gravity and dark energy models has brought to light the need to construct a "generic" way to parameterize the dark sector. We will discuss our new way of approaching this problem. We write down an effective action for linearized perturbations to the gravitational field equations for a given field content; crucially, our formalism does not require a Lagrangian to be presented for calculations to be performed and observational predictions to be extracted. Our approach is inspired by that taken in particle physics, where the most general modifications to the standard model are written down for a given field content that is compatible with some assumed symmetry (which we take to be isotropy of the background spatial sections).

A Generic Parameterisation of Modified Gravity

Author: Baojiu Li

ICC, University of Durham

Co-Authors: Phil Brax (CEA, France) Anne-C. Davis (DAMTP, Cambridge, UK)

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *10:45 Thursday 29th 10:00-11:15*

Summary:

We consider the effect of a scalar field degree of freedom on the dynamics of gravity from small to large scales. We show that the effects of modified gravity can be completely captured by the time variations of the scalar field mass and its coupling to matter. This leads to a parameterisation of modified gravity where local constraints are easy to analyse and large scale scale structure effects apparent.

Model-Independent Approaches to Testing Gravity

Author: Tessa Baker

University of Oxford (Astrophysics)

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *11:00 Thursday 29th 10:00-11:15*

Summary:

A diverse array of modified theories of gravity exists in the current literature, and testing each theory individually is impractical. Though very different in origin, many theories share some common structures at the level of the Einstein field equations. I will introduce a systematic way of mapping these extended field equations onto a common template. This model-independent framework can be tested with forthcoming experiments, allowing us to constrain large regions of theory space simultaneously.

Testing the Laws of Gravity with CFHTLenS and WiggleZ

Author: Fergus Simpson

University of Edinburgh

Co-Authors: CFHTLenS Collaboration; WiggleZ Collaboration

Session: COS4: Modelling Dark Energy and Modified Gravity
Presentation type: Talk *15:00 Thursday 29th 15:00-17:00*

Summary:

The observed presence of dark energy may be the first sign of new physics in the Universe, either in the form of a matter-energy component or by revising Einstein gravity. Weak gravitational lensing and galaxy peculiar velocities provide complementary probes of modifications to General Relativity, and in combination allow us to test theories of gravity in a unique way. I will present results from combining measurements of the growth of structure from the WiggleZ Dark Energy Survey with cosmic shear tomography from CFHTLenS, producing the strongest existing constraints on the metric potentials that describe general theories of gravity.

Decisive tests of large-scale homogeneity

Author: Phil Bull

University of Oxford

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *15:15 Thursday 29th 15:00-17:00*

Summary:

When interpreted within the framework of a spatially homogeneous and isotropic FLRW model, observations of distant supernovae imply the existence of an exotic dark energy component of the cosmological fluid. While CMB observations suggest that the Universe is approximately isotropic about us, much more information is required to establish homogeneity on large scales. Indeed, radially-inhomogeneous "giant void" models can be constructed which precisely reproduce the observed supernova Hubble diagram without requiring dark energy, while still remaining isotropic around observers at the centre of symmetry. A powerful test of inhomogeneity comes from the kinematic Sunyaev-Zel'dovich (kSZ) effect, which effectively allows us to probe conditions inside our past light cone. We use observations of the kSZ effect, plus three other observables, to rule out the general class of spherically-symmetric, inhomogeneous, dust-only models as explanations of the apparent cosmological acceleration. We go on to generalise the kSZ effect to include all CMB blackbody spectral distortions, and use this to propose a general test of homogeneity. This has the capacity to decisively establish the validity of the FLRW metric as a description of the universe on large scales, and in a much more economical way than competing methods.

Non-linear Large Scale Structure in the Warm Dark Matter Scenario

Author: Katarina Markovic

University Observatory Munich

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *15:30 Thursday 29th 15:00-17:00*

Summary:

A possible range of particle masses of dark matter is of the order of keV. This talk will discuss the issues of incorporating such Warm Dark Matter into existing models of non-linear large scale structure, namely the halo model and the halofit method by Smith et al. It will suggest modifications to the halo model to describe the evolution of the suppression of structure due to WDM free-streaming. It will also present the results of simulations of large scale structure formation in the WDM scenario and compare those to the above models. This talk will discuss the limitations and advantages of weak lensing data for constraining such a WDM model and present forecasts of the lower limit on the WDM particle mass from combining the results from a future weak lensing survey with Planck data.

Testing quantised inertia with wide binaries

Author: Mike McCulloch

University of Plymouth

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *15:45 Thursday 29th 15:00-17:00*

Summary:

Wide binary stars are within the low-acceleration regime where galactic rotation curves become non-Newtonian, and it has recently been observed that their orbital speeds are similarly anomalous in a way that is hard to explain using dark matter or MoND. For separations from 0.1pa to 0.3pa the observed speed was 8.4±0.3 km/s, whereas Newtonian dynamics and MoND predict only 0.46 km/s and 0.82 km/s respectively. A new theory has been suggested that modifies inertia by assuming it is due to Unruh radiation that is subject to a Hubble-scale Casimir effect (called MiHsC or quantised inertia). In MiHsC, for low accelerations, the Unruh waves lengthen, a greater proportion are disallowed by the Hubble-scale Casimir effect and the inertial mass decreases in a new way. Without adjustable parameters, MiHsC predicts cosmic acceleration, the Pioneer and flyby anomalies (quite well) and the Tajmar effect (very well). It violates equivalence, but not in a way that could have been detected by torsion balance tests. MiHsC predicts an orbital speed for the wide binaries of 4.3±0.3 km/s: closer to the observations, but still an underestimate. More wide binary data is needed to determine whether the increase in speed with separation predicted by MiHsC is correct.

speed with separation predicted by MaxBCG is correct.

Constraining Modified Gravity and Dark Energy Models with Weak Lensing

Author: Emma Beynon

Institute of Cosmology and Gravitation

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *16:00 Thursday 29th 15:00-17:00*

Summary:

Large forthcoming surveys will allow weak lensing to constrain cosmology with great precision. Lensing measures structure growth as well as expansion, and can therefore be used to break parameter degeneracies which exist with measurements from other probes (e.g. SNe, CMB). Here I present constraint predictions for modified gravities, interacting dark energy models and unified dark matter models for weak lensing with DES and Euclid, demonstrating how tightly we will be able to constrain cosmological models with these forthcoming surveys. I will discuss the importance of correctly modelling the non-linear matter power spectrum, and how using an incorrect prescription can lead to overestimation of the discriminatory power of lensing at small scales. I will also discuss the importance of including the full covariance matrix of lensing observations for these future surveys, in order to obtain accurate predictions.

Testing Cosmology with Extreme Galaxy Clusters

Author: Ian Harrison

Cardiff University

Co-Authors: P. Coles (Cardiff University)

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *16:15 Thursday 29th 15:00-17:00*

Summary:

The modern concordance model of cosmology makes definite predictions for the number density of massive gravitationally bound objects (visible as galaxy clusters) in the Universe and how this distribution evolves with redshift. It has been suggested that some recently observed objects are too massive at too early a time to exist within a standard model universe, hinting that modifications may be necessary. It is possible to consider this problem within the framework of Extreme Value Statistics (EVS): are any of theses objects more extreme than the most unusual objects we expect to observe? The current answer appears to be `no' and so the standard model currently passes this particular test. However, it is plausible that future observations will observe objects too extreme for the current concordance model; it may then also be possible to perform model selection between different models of enhanced structure formation - primordial non-Gaussinaity, modified gravity, scalar field dark energy - using these extreme clusters. Note: I would also be willing to give a poster, if available.

Cosmology with MaxBCG Galaxy Clusters

Author: Annalisa Mana

Excellence Cluster Universe, Munich

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *16:30 Thursday 29th 15:00-17:00*

Summary:

There has been recently a significant theoretical and observational progress in efforts to use clusters of galaxies as probes of cosmology and physics of structure formation. We use the abundance and weak lensing mass measurements of the SDSS MaxBCG cluster catalog to constrain cosmological parameters and the richness-mass relation of clusters simultaneously, reproducing the results of Rozo et al.(2009). This talk will point out how the constraints are significantly improved if we include the redshift-space power spectrum of the MaxBCG sample, which has been calculated by Hütsi(2009). It will also give some hints for future developments in modified gravity scenarios.

Models for F(R) gravity

Author: Richard Battye

University of Manchester

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Talk *16:45 Thursday 29th 15:00-17:00*

Summary:

We will discuss the conditions under which F(R) gravity models can lead to a viable self-accelerating epoch. We will review the different models that have been proposed all of which typically have w close to -1. We will then introduce a new model which can yield a wide range of values of w. We will also construct explicit models that can exactly mimic the the LambdaCDM model.

String Quintessence and the Formulation of Advanced Quantum Gravity

Author: Andrew Worsley

KCL

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Poster *Poster Session B*

Summary:

Since the publication of the general theory of relativity (GTR), gravity has been described by classical field equations. However, mathematically GTR results in the formation of infinite density singularities in black holes, it challenges simultaneity and causality, and it is generally incompatible with quantum mechanics. A separate problem is the presence of “dark energy”, the energy inherent in space-time. GTR helps explain this energy by the addition of a separate cosmological constant. However, what is required are formulae which treat the energy in space-time as an integral part of quantum gravity. This space-time energy is treated as integral in the quintessence model, and may be resolvable by the use of a minimum energy scale. In this paper we use the standard minimal energy scale, Planck’s constant, and in turn define a new quintessence. Using this string quintessence, we obtain advanced quantum gravity (AQG), which technically agrees exactly with GTR, in the range where GTR has been widely tested. Additionally, the principle of relativity is also maintained, and advanced in order to restore simultaneity and causality. Moreover, using string quintessence, AQG resolves the difficulties related to singularities, and in turn explains the apparent presence of dark energy. The separate presence of “dark energy” can also be explained. Overall, in this paper gravitation is taken to the next level, black holes and in turn dark matter are explained and “dark energy” the presence of space-time energy, becomes integral to the equations of advanced quantum gravity (AQG).

Discrimination between cosmological constant, quintessence, and modified gravity

Author: Houri Ziaeepour

Max Planck Institute fur Extratresstrische Physik (MPE)

Co-Authors:

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Poster *Poster Session B*

Summary:

In what concerns dark energy, the ultimate goal of space and ground based surveys is discriminating between various candidate models and a cosmological constant. Here we report results of a work on finding the best set of parameters and measurables for this purpose. In particular we show that independent measurements of cosmological parameters of homogeneous component - the background cosmology - and anisotropies are necessary, notably for distinguishing between interacting quintessence models and modified gravity. This put in evidence for the advantage of surveys able to observe Large Scale Structures as well as a large number of supernovae. The role of CMB measurements for improving discrimination will be mentioned too. We also propose quantities that determine the discrimination power of a survey independent of observed proxy. (based on arXive:1112.6025, submitted)

Testing modified gravity in the Solar System using LISA-pathfinder

Author: Pasquale Galianni

School of Physics & Astronomy, the University of St Andrews

Co-Authors: A.Martin Feix (Department of Physics, Technion - Israel Institute of Technology); B.Hongsheng Zhao;B.Keith Horne (SUPA, School of Physics and Astronomy, the University of St Andrews)

Session: COS4: Modelling Dark Energy and Modified Gravity

Presentation type: Poster *Poster Session B*

Summary:

There are many points in the Solar System where the total gravitational pull exerted by the Sun the planets and the galaxy cancels out exactly. These points, which do not coincide with the Lagrangian points, are embedded into low acceleration regions where paradigms a` la MOND predict significant deviations from Newtonian mechanics. Two of these bubbles are close enough to Earth to be visited by spacecrafts, providing a unique occasion to test the laws of gravity into extremely low gravitational acceleration regimes. I will discuss the possibility of testing MOND and QMOND using the instruments on-board the LISA-pathfinder spacecraft, which has been scheduled for launch in 2013.

Comparison between AMR and SPH

Author: S. Falle

University of Leeds

Co-Authors: D. Hubber, S. Goodwin (University of Sheffield), A. Boley (University of Florida)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *11:45 Wednesday 28th 11:45-13:00*

Summary:

The most widely used computational methods for astrophysical fluid dynamics are SPH (Smoothed Particle Hydrodynamics) and grid codes using AMR (Adaptive Mesh Refinement). The relative merits of these methods have been hotly disputed for a number of years, but in the end the only way to settle this is to compare them for a range of problems for which one has a good idea of the correct solution. I will discuss comparisons between the SPH code, SEREN, and the Godunov-type AMR code, MG, for a number of test problems, such as Kelvin-Helmholtz, radiative shocks, moving polytropes and a simple model of the Santa Barbara cluster formation problem.

Modelling AGN Feedback in Galaxy Simulations

Author: Rick Newton

The University of Manchester

Co-Authors: S.T.Kay (The University of Manchester)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *12:10 Wednesday 28th 11:45-13:00*

Summary:

AGN feedback plays a crucial role in the formation of galaxies and clusters. Through feedback, AGN influence properties including star formation rates, dynamics and the dark matter halo profile, particularly affecting massive elliptical galaxies by quenching cooling and supressing star formation. As such, AGN feedback has become a key ingredient in modern galaxy and cosmological scale simulations. Numerically, AGN pose many challenges due to the large disparity in length and time-scales between accretion and feedback processes. This is combined with the need for a robust, efficient and resolution independent model in high resolution massively parallel simulations. In this talk, I will present new results from simulations to highlight the practical issues, challenges and problems faced when implementing AGN feedback in a Smoothed Particle Hydrodynamics simulation, as discovered in the course of our work to produce a comparison of methods.

On the convergence of SPH simulations of self-gravitating accretion discs

Author: Ken Rice

Institute for Astronomy, University of Edinburgh

Co-Authors: D.H. Forgan (Institute for Astronomy, University of Edinburgh) P.J. Armitage (University of Colorado, Boulder)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *12:20 Wednesday 28th 11:45-13:00*

Summary:

Recent simulations of self-gravitating accretion discs, carried out using a three-dimensional smoothed particle hydrodynamics (SPH) have been interpreted as implying that three-dimensional global discs fragment much more easily than would be expected from a two-dimensional local model. Subsequently, global and local two-dimensional models have been shown to display similar fragmentation properties, leaving it unclear whether the three-dimensional results reflect a physical effect or a numerical problem associated with the treatment of cooling or artificial viscosity in SPH. Here, we study how fragmentation of self-gravitating disc flows in SPH depends upon the implementation of cooling. We run disc simulations that compare a simple cooling scheme, with a method in which the cooling is derived from a smoothed internal energy density field. For the simple cooling scheme, we find a significant increase in the minimum cooling time-scale for fragmentation with increasing resolution, matching previous results. Switching to smoothed cooling, however, results in lower critical cooling time-scales, and tentative evidence for convergence at the highest spatial resolution tested. We conclude that precision studies of fragmentation using SPH require careful consideration of how cooling is implemented, and that the apparent non-convergence of the fragmentation boundary seen in prior simulations is likely a numerical effect.

SPMHD Simulations using GCMHD+

Author: David Barnes

MSSL

Co-Authors:

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *12:30 Wednesday 28th 11:45-13:00*

Summary:

Observations have shown that galaxy clusters are permeated by μG magnetic fields, with some evidence that larger structures have coherent magnetic fields. Many mechanisms have been proposed to generate large scale cosmological magnetic fields, but their origin is uncertain. The new generation of radio telescopes will provide greater detail on these fields and, combined with a detailed understanding of the generation process, may allow the origin of these fields to be understood. To fully understand the generation mechanisms and their resulting fields, numerical simulations of the formation of large scale structure with a magnetic field are required. We present GCMHD+, an MHD addition to the Lagrangian SPH code GCD+. We demonstrate the

scale structure with a magnetic field are required. We present GCMHD+, an MHD addition to the Lagrangian SPH code GCD+. We demonstrate the performance of the code in various multidimensional tests relative to the ATHENA mesh code. The code is then used to simulate the formation of a galaxy cluster in the presence of a coherent, homogeneous primordial magnetic field. The cluster forms with a cosmological field which is amplified and radially dependant.

CSP-h: A simplification of smoothed particle (SP) algortihms built with variable spatial resolution

Author: Thomas Matthew Carpenter Knight

Institute of Mathematics and Physics, Aberystwyth University

Co-Authors: B. Pintér (IMAPS, Aberystwyth University)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *12:40 Wednesday 28th 11:45-13:00*

Summary:

Smoothed particle (SP) algorithms built with variable spatial resolution are more versatile and accurate than the standard implementation, particularly in simulations that suffer high deformation. These implementations, however, are more complex and highly variable, as they are formulated as a function of particular interpretations of the SP approximation method. These drawbacks lead us to present, herein, the Corrected Smoothed Particle with Variable Smoothing Length (CSP-h) Method. The SP method is a numerical procedure by which partial differential equations (PDEs) that govern the dynamics of a system are approximated. The resulting algorithms form computable, finite element, fully Lagrangian sets of equations. Quantities are calculated over some relative space, defined by dividing any position by a fixed smoothing length, h, which is proportional to the spatial resolution of the system. If the simulated medium diverges sufficiently, a fixed h allows the possibility of non-physical behaviour within the model. Thus, h must be allowed to vary in time and space. In this way, at a cost of significant modification of the SP algorithms, the spatial resolution can vary dynamically. Our CSP-h method results from manipulating an SP corrective matrix derivation, allowing for the elimination of additional terms and multiplying factors that arise from the variability of h. The method can be applied regardless of implementation perspectives and even allows for the redefinition of h as a function of numerical factors, rather than physical factors, while maintaining constant accuracy. It can, therefore, model Mm-scale phenomena within the solar corona with greater efficiently than widely used SP Hydrodynamic models.

The entropy condition of GodunovSPH

Author: Seung-Hoon Cha

Univ. of Leicester

Co-Authors:

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *12:50 Wednesday 28th 11:45-13:00*

Summary:

A new version of GodunovSPH (hereafter GSPH) has been developed and tested. Contrary to the old version, the new GSPH can satisfy the entropy condition, which is an essential property of the convergence of numerical schemes. The thermal compatibility has been identified as an important point for the entropy condition. The continuity equation and the density estimation has been modified to implement the thermal compatibility in the new GSPH. Both the entropy and energy can be conserved in the new GSPH. The derivation of the new GSPH is very similar to the finite volume method (FVM), and it can be reduced to the standard SPH and the previous version of GSPH with some assumption.

Accessing the STFC DiRAC HPC Facility

Author: Dr Jeremy Yates

STFC DiRAC Facility

Co-Authors:

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *17:00 Wednesday 28th 17:00-18:15*

Summary:

As part of the recently announced National E-Infrastructure Award of £158M, BIS awarded £15M to the UK STFC DiRAC Facility, which currently provides HPC services for both the Theoretical Astrophysics and Theoretical Particle Physics UK research communities. The DiRAC Facility will now take its place alongside other Open Time STFC Facilities and will be announcing a call for proposals from the Astrophysics and Particle Physics UK research communities in the areas of numerical simulation and data modelling. This presentation will outline what services DiRAC will offer and give a broad overview of the application process.

Fast MHD Code for Gravitationally Stratified Plasma Using Graphical Processing Units

Author: Dr Michael Griffiths

The University of Sheffield

Co-Authors: R.Erdelyi (The University of Sheffield); V.Fedun (The University of Sheffield)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *17:10 Wednesday 28th 17:00-18:15*

Summary:

Parallel MHD algorithms are important for numerical modelling of solar and astrophysical plasmas. Parallelisation techniques have been exploited most successfully by the gaming/graphics industry with the adoption of graphical processing units (GPUs) possessing hundreds of computational units. This success has been recognised by the computational science and engineering communities who have harnessed the computing power of GPUs. We describe the implementation of fully non linear magnetohydrodynamic 1-3D (MHD) codes called SMAUG (Sheffield MHD algorithm using GPUs). SMAUG may even be applied to gravitationally stratified media often applicable to astrophysical plasmas. The objective of this contribution is to describe the numerical methods used and the techniques for porting the code to this novel and highly parallel compute architecture. The methods employed are justified by the presentation of validation results and performance benchmarks. We describe the implementation of 1-3D (MHD) codes for gravitationally stratified media on graphical processing units and highly parallel compute architectures. We reveal the validity of our code by demonstrating agreement with the results for a stratified solar flux tube model for the quiet sun.

NIRVANA, a state-of-the-art MHD code : new features and recent development

Author: Fournier Yori

Leibniz-Institute for Astrophysics Potsdam

Co-Authors: Udo, Ziegler (Leibniz-Institute for Astrophysics Potsdam)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *17:25 Wednesday 28th 17:00-18:15*

Summary:

This talk has two main purposes. The first one consists in giving an overview of the state-of-the-art code NIRVANA (http://nirvana-code.aip.de) developed by Udo Ziegler at the AIP. The second one will be to introduce our preliminary work on the design of an accurate strategy for the constrained transport (CT) method making use of the well-known HLLD Riemann solver. NIRVANA is a non-ideal compressible MHD code based on a finite volume (FV) approach with a Godunov-type scheme (GS), and implements different approximate Riemann solvers including HLLD. Moreover, one of its major strengths is to ensure the solenoidality of the magnetic field thanks to a CT method. We will also give a non-exhaustive list of recent features, such as the adaptive mesh refinement (AMR) for spherical geometry, and present some associated test cases and realistic applications. In the second part, we will give a quick description of the strategy we are currently working on, and discuss the first results and analysis.

Accuracy and Efficiency of Raytracing Photoionisation Algorithms

Author: Jonathan Mackey

Argelander-Insitute for Astronomy, University of Bonn

Co-Authors:

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *17:35 Wednesday 28th 17:00-18:15*

Summary:

Obtaining an efficient and accurate solution for non-equilibrium photoionisation coupled to hydrodynamics is a challenging problem in astrophysics. It is shown here that most existing raytracing+photoionisation explicit algorithms are first order accurate in time as regards photon conservation, hence the requirement of very short timesteps to accurately track R-type ionisation fronts. It is quite simple to construct an explicit second order accurate algorithm which, although it requires two raytracings per step, is ultimately more efficient because it allows much longer timesteps for a given error tolerance. Implicit methods allow ionisation fronts to cross many grid cells per timestep while maintaining photon conservation accuracy, but for the algorithm used here the errors become large for multi-frequency radiation when an ionisation front crosses many optical depths in a single step. The accuracy and convergence rates of the different algorithms are quantified to identify an appropriate timestep criterion for each algorithm. Using these criteria the second order explicit algorithm is the most efficient of the three, and its parallel scaling is significantly better than that of the implicit algorithm, running with >50 per cent efficiency on hundreds of cores (compared to a calculation on 8 cores).

3D General Relativistic Transport of Photons and Particles with Mass

Author: Ziri Younsi

MSSL, University College London

Co-Authors: K. Wu (MSSL, University College London, Holmbury St Mary, Surrey, RH5 6NT)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *17:45 Wednesday 28th 17:00-18:15*

Summary:

We present a numerical code for radiative transfer calculations based on a general covariant formulation that we have derived for the transport of relativistic particles with mass (e.g. neutrinos) or without mass (e.g. photons). Our formulation is self-consistent and Lorentz invariant. It takes account of various general relativistic effects: gravitational red-shift, time dilation, lensing and Doppler boosting. Absorption and emission processes are treated

explicitly. The formulation is applicable to high-energy astrophysical environments ranging from photonic emission from accreting black holes in AGN to neutrino emission from remnant neutron tori.

Astrophysical simulations with interactive computer graphics

Author: Wolfgang Steffen

Instituto de Astronomia, UNAM, and ICG, TU Braunschweig

Co-Authors: N.Koning (University of Calgary); S. Wenger (TU Braunschweig); M. Magnor (TU Braunschweig)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *17:55 Wednesday 28th 17:00-18:15*

Summary:

A multi-purpose interactive astrophysical modeling system is presented. The system called “Shape” includes an interactive 3D environment to construct morpho-kinematic model structures on which radiation transfer and hydrodynamic evolution can be computed. The built-in prototypical hydrodynamics module distinguishes itself from conventional systems through its 3D interface and interactivity during simulation that requires no programming intervention by the user. The hydrodynamics is parallelized and can run on CPUs or GPUs using OpenCL. Visualization and analysis can be done directly within Shape. Hydrodynamics and 3D-mesh based graphics objects and texturing can be mixed to allow for the modeling, analysis and realistic visualization of highly complex objects.

Simulation of dusty plasma environment

Author: Abul Khair Anuar

Lancaster UNiversity

Co-Authors: F. Honary (Lancaster University); M. Hapgood(CLRC Rutherford Appleton Laboratory); J-F. Roussel (Onera)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Talk *18:05 Wednesday 28th 17:00-18:15*

Summary:

A dust charging simulation of dusty plasma is presented in this paper. Dusty plasma is a mixture of charged dust or macro-particles, electrons, ions and neutral and can be found in abundance in the solar system such as on the lunar surface, planetary environment, asteroids and comets. The presence of massive particle (dust) that can carry thousands of elementary charge increases the plasma complexity which can affect space sytems by reducing material lifetime due to adhesion and abrasion, reducing optical equipment visibility, and presents a health hazard to astronaut. SPIS software which originally intended to study spacecraft-plasma interaction is extended to include dust with varying charge and mass, and Monte Carlo collision algorithm is introduced to simulate the dust-plasma interaction using particle in cell method. The Monte-Carlo method employed allows multiple collision per time step to accomodate the different charging rate between larger and smaller dust particle. The SPIS software capabilities including dusty plasma environment is first validated against well known OML theory and results show good agreement between simulation and analytic solution.

Simulations of Cosmological Magnetic Fields using GCMHD+

Author: David Barnes

MSSL

Co-Authors:

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Poster *Poster Session A*

Summary:

Observations show that a range of galaxy clusters are permeated by cosmological magnetic fields of micro gauss strength. The origin of these fields is uncertain and several processes have been suggested to generate them. Numerical simulations are required to show how the strength and profile of a cosmological magnetic field from a generation mechanism changes in a range of systems. We simulate the formation of ten different galaxy clusters with a range of final virial masses using GCMHD+, where the gas particles are embedded with a homogeneous primordial magnetic field. The merging of protoclusters and infall of material lead to an amplification of the magnetic field in the cluster and the emergence of a radial profile for the magnetic field. We show how the magnetic field and the amplification of the field changes with the mass of the system. The effect of the resolution of the simulation on the strength and profile of the cosmological field is also shown for one system.

Updated GCD+: A new Galactic Chemo-Dynamical evolution code

Author: Awat Rahimi

UCL - MSSL

Co-Authors: D.Kawata (UCL-MSSL)

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Poster *Poster Session A*

Summary:

We have made several important enhancements to our original Chemo-Dynamical galaxy evolution code: GCD+. GCD+ is a N-body/SPH code which takes into account self-gravity, hydrodynamics, radiative cooling, star formation, SNe feedback and chemical enrichment. The new code incorporates new schemes for gravitational N-body dynamics and SPH. We implement a novel star formation and feedback recipe. We describe these new schemes and outline their effects on numerical simulations of galaxy evolution. The new schemes lead to a significant improvement in the ability of TreeSPH codes, such as GCD+, to capture strong shocks and model Kelvin-Helmholtz instabilities.

An SPMHD Mean Field Dynamo

Author: Federico Stasyszyn

Universitäts-Sternwarte München (USM)

Co-Authors: D. Elstner (AIP);

Session: CP1: Current Developments in Numerical astrophysics

Presentation type: Poster *Poster Session A*

Summary:

Following the developments in SPMHD we implemented the turbulent transport terms in the induction equation for the evolution of the magnetic field in , with the aim to perform realistic modelling of dynamo action in global galaxy simulations. Besides the spatial dependent turbulent diffusion η also the α-tensor is included. For a disk setup we could verify our numerical results with a known analytical model of Meinel 1990. Further comparisons with grid based numerical simulations for disks with a galactic rotation law and an anisotropic α-effect are shown. This allow us to perform global galaxy simulations with a subgrid model for dynamo action, which can be linked to upcoming and present day radio observations

Gas, Dust and Star Formation in M51 and Nearby Galaxies

Author: Eva Schinnerer

MPIA

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:00 Tuesday 27th 10:00-11:15*

Summary:

Understanding the gas and dust properties of nearby galaxies is vital to develop a physical model for the star formation process in galaxies. Detailed observations of molecular gas in a galactic disk such as obtained by the PdBI Arcsecond Whirlpool Survey (PAWS, PI Schinnerer) as well as better knowledge of the dust and its cooling channels provided by the KINGFISH project (Key Insights into Galaxies: a Far-Infrared Survey with Herschel, PI Kennicutt) are key to the success of this endeavor. I will present recent results on the physical properties of the molecular gas as a function of galactic environment including implications for its star formation probability from the PAWS project. In addition, I will highlight results on the dust properties in a large diverse set of nearby galaxies from KINGFISH that are relevant for studies of galaxies in a cosmological context.

Dust and Gas in Andromeda with HELGA

Author: Matthew Smith

Cardiff University

Co-Authors: S. Eales (Cardiff University); H. Gomez (Cardiff University); The SPIRE SAG2 Consortium; The Ghent University PACS Consortium

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:20 Tuesday 27th 10:00-11:15*

Summary:

Andromeda and the Milky Way (MW) are the two large spirals in the local group. Studies of Andromeda are important as unlike the MW we can obtain a complete census of all star-formation, gas and dust in the galaxy. The high-angular resolution of Herschel and the close proximity of Andromeda allow us to analyse the properties of the ISM with ~4000 quasi-independent pixels. By fitting a modified-blackbody model to each pixel, we find the first evidence for variations of dust properties within a galaxy. In the 10kpc ring the dust-emissivity index (beta) is ~1.8 and increases to a peak value of ~2.5 at 3.3kpc with a small decrease in Temperature. We attribute the high beta values to either efficient grain coagulation or mantle growth in molecular clouds. From 3.3kpc to the centre a different T-beta relation is found with beta values lowering with a strong increase in temperature. In the inner 3.3kpc we find the heating of the dust is dominated by the emission from old stars in the bulge, while at radii >3.3kpc there is a weak correlation between star-formation and temperature. We find that the gas-to-dust profile is described by an exponential model which agrees with that predicted from the metallicity gradient. We also present results on our search for ‘dark gas’ and compare them results for the MW found by the Planck Collaboration.

CO and H2O as diagnostics in (U)LIRGs

Author: Paul van der Werf

Leiden Observatory

Co-Authors:

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:30 Tuesday 27th 10:00-11:15*

Summary:

I will present results from the Herschel Comprehensive (U)LIRG Emission Survey (HerCULES), an Open Time Key project carried out with the the Herschel Space Observatory. HerCULES consists of deep SPIRE and PACS spectroscopy of a complete sample of about 30 local (U)LIRGs. High quality CO, [CI] and H2O excitation conditions are derived for all target objects. I will discuss the use of the CO ladder for separating star formation and AGN-driven excitation, and the use of H2O for deriving extreme local conditions in the most IR-luminous objects.

CO line SEDs in local (U)LIRGs with the APEX

Author: Yiping Ao

MPIfR

Co-Authors: A. Weiss; K. M. Menten; C. Henkel

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:40 Tuesday 27th 10:00-11:15*

Summary:

Using the APEX during 2006 to 2009, we obtained small maps in multiple CO transitions (CO line SEDs) towards a small sample of (U)LIRGs. With the help of radiative transfer modelling of the CO line SEDs, we investigated gas excitation of galaxies. Including the 13CO 1-0 and 2-1 data from the literatures, it will help us to break the degeneracies of LVG solutions. The gas excitation of the sample will be discussed and compared to other types of counterparts.

The Spitzer Interacting Galaxies Survey

Author: Nicola Brassington

University of Hertfordshire

Co-Authors: A. Zezas (University of Crete; Harvard-Smithsonian Center for Astrophysics) H. Smith (Harvard-Smithsonian Center for Astrophysics) M. Ashby (Harvard-Smithsonian Center for Astrophysics) C. Mundell (Liverpool John Moores University) E. Brinks (University of Hertfordshire) L. Lanz (Harvard-Smithsonian Center for Astrophysics)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:50 Tuesday 27th 10:00-11:15*

Summary:

It is widely believed that very few galaxies exist today that have not been formed or shaped in some way by an interaction with another galaxy. These interactions play a major role in the evolution of galaxies by triggering star formation and nuclear activity. However the parameters that influence this enhanced activity are poorly understood. The Spitzer Interacting Galaxies Survey (SIGS) is addressing this question by using IR data obtained with the Spitzer Space Telescope to study a large sample of 105 galaxies in different stages of interaction. In this presentation I will provide an overview of the sample and present the results from the IRAC and MIPS photometric analysis. Following this, I will compare interaction parameters with the specific star formation rate derived for each system and discuss the point at which star formation is triggered in these interactions.

Ionized vs molecular gas feedback in local ULIRGs

Author: Mark Westmoquette

ESO

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *11:00 Tuesday 27th 10:00-11:15*

Summary:

Feedback and winds are an essential and unavoidable component of galaxy evolution. However, over what spatial and temporal scales they act, or which gas components or phases are affected most, are largely unknown. Recent multi-wavelength studies show that some systems have, for example, detectable outflows in the molecular phase but none in the ionized phase, or faster neutral vs. ionized gas outflows. In this talk I will present the results of an optical IFU study of a sample of nearby ULIRGs ($z<0.09$) we carried out with VLT/VIMOS. In a significant proportion of these systems we find evidence for spatially resolved fast ionized gas outflows. A number of targets in our sample have also been (or are being) observed with Herschel as part of the HERUS project. I will therefore conclude with a preliminary comparison between the winds detected (or not) in the ionized and molecular phases by these two surveys and discussion what consequences that has on our understanding of galaxy-scale feedback.

The physical properties of sub-mm galaxies

Author: James Dunlop

Author: James Dunlop

University of Edinburgh

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *11:45 Tuesday 27th 11:45-13:00*

Summary:

I will discuss our current knowledge of the physical properties of sub-mm galaxies as derived from multi-frequency follow-up of sub-mm/mm surveys undertaken at the JCMT with SCUBA, AzTEC and, most recently, SCUBA2. I will focus on determinations of the redshifts, stellar masses, specific star-formation rates and morphologies of sub-mm galaxies, and attempt to place these results in the context of studies of the general galaxy population at z = 1 - 3. In particular I aim to highlight the impact of the new high-resolution WFC3 near-infrared imaging being delivered by the CANDELS HST Treasury program, and the power of the first deep 450/850 micron imaging being delivered by SCUBA2 as part of the SCUBA2 Cosmology Legacy Survey.

AGN and SMGs in the WISE zoo

Author: Andrew Blain

University of Leicester

Co-Authors: WISE science team

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:05 Tuesday 27th 11:45-13:00*

Summary:

The WISE 4-band IR all-sky survey final data release is imminent. There are over 530,000,000 sources listed in the catalogue. The survey bands match the Spitzer-IRAC 3 and 4 micron channels, a broad 12-micron channel that has not been probed since IRAS flew a quarter of a century ago, and a 22-micron channel that covers the whole sky at a depth broadly equivalent to the Spitzer-SWIRE survey. Using a 40-cm primary mirror, 1k-sized detectors, and with an open-shutter duty cycle of about 70% WISE is likely to will be the baseline infrared sky atlas for the foreseeable future. I will describe the survey, and some of the interesting distant galaxies discovered using it, along with the WISE properties of known samples - SMGs, different classes of AGN, including the sample at z>6, about 65% of which are detected by WISE, and the merging of the WISE sample with the much-shallower, but wider spectral coverage of the Akari all-sky catalogue.

The Herschel view of the dust-obscured Universe

Author: Myrto Symeonidis

MSSL-UCL

Co-Authors: the Herschel HerMES and PEP consortia + COSMOS collaboration

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:20 Tuesday 27th 11:45-13:00*

Summary:

As part of the Herschel HerMES and PEP consortia and including involvement from the COSMOS collaboration, we have performed a study on the properties (SED shapes, SED peak wavelength, dust temperatures, infrared colours etc.) of infrared (IR) galaxies from the nearby to the high redshift (z~3) Universe. This is the largest study to date which uses the deepest available Herschel PACS and SPIRE data to unveil the properties of the dust-obscured galaxy population and examine their evolution through cosmic time. Moreover, this is the first time that survey selection biases are brought to a minimum, enabling an unbiased view of the dust-obscured population in the early Universe. In this talk, I will give an overview of our results, placing them in the context of what we know about the local IR galaxies as well as the sub-mm (>800um)-detected population.

Luminous Red Quasars at z~2: Signposts for Massive Dusty Starbursts?

Author: Manda Banerji

Institute of Astronomy, Cambridge

Co-Authors: R.G. McMahon (IoA, Cambridge), P.C. Hewett (IoA, Cambridge)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:30 Tuesday 27th 11:45-13:00*

Summary:

We present results from a search for extremely red and reddened quasars at z~2 using large area infra-red surveys like the UKIDSS Large Area Survey, VISTA Hemisphere Survey and WISE. We discuss the photometric selection of these red quasars and results from our spectroscopic follow-up campaign which confirms that the colour selection is extremely effective in isolating highly reddened Type 1 AGN with dust extinction values of Av=3-6. We compare the luminosities and black-hole masses of these reddened quasars to more typical quasars at similar redshifts that have been selected using optical surveys and demonstrate that the optical selection misses many bolometrically luminous dust-obscured AGN at the main epoch of galaxy formation

surveys and demonstrate that the optical selection misses many bolometrically luminous dust obscured AGN at the main epoch of galaxy formation. Finally, we end by discussing our ongoing program for submillimeter and millimetre follow-up of these reddened quasars as well as what current

generation long-wavelength surveys with Herschel, SCUBA-2 and the South Pole Telescope will tell us about these rare but nevertheless astrophysically interesting objects.

Herschel-ATLAS: VISTA VIKING near-IR counterparts in the Phase 1 GAMA 9h data

Author: Simone Fleuren

Queen Mary University London

Co-Authors: W. Sutherland (Queen Mary, University of London), L. Dunne (University of Canterbury NZ), D.J.B. Smith (University of Hertfordshire), S.J. Maddox(University of Canterbury NZ), J. González-Nuevo (SISSA, Italy), J. Findlay (Queen Mary, University of London), R. Auld (Cardiff University), M. Baes (Universiteit Gent), N.A. Bond (NASA Goddard Space Flight Center), D.G. Bonfield (University of Hertfordshire), N. Bourne (Nottingham University), A. Cooray (University of California, Irvine), S. Buttiglione (INAF, Italy), A. Cava (Universidad Complutense de Madrid), A. Dariush (Imperial College London), G. De Zotti (INAF and SISSA, Italy), S.P. Driver (University of St Andrews and ICRAR, Australia), S. Dye (Nottingham University), S. Eales (, Cardiff University), J. Fritz (Universiteit Gent), M. L. P. Gunawardhana (Macquarie University, Sydney and Univeristy of Sydney and Australian Astronomical Observatory), R. Hopwood (Open University and , Imperial College London), E. Ibar (Royal Observatory, Edinburgh),R.J. Ivison (Royal Observatory, Edinburgh), M.J. Jarvis (University of Hertfordshire), L. Kelvin (, University of St Andrews), A. Lapi (Universita Tor Vergata and SISS, Italy), J. Liske (ESO, Germany), M.J. Michalowski (Royal Observatory, Edinburgh), M. Negrello (Open University), E. Pascale (Cardiff University), M. Pohlen (Cardiff University), M. Prescott (Liverpool John Moores University), E.E. Rigby (Nottingham University), A. Robotham (University of St Andrews), D. Scott (University of British Columbia, Vancouver), P. Temi(NASA Ames Research Center), M.A. Thompson (University of Hertfordshire), E. Valiante (Cardiff University), P. van der Werf (Leiden University)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:40 Tuesday 27th 11:45-13:00*

Summary:

We identify near-infrared Ks band counterparts to Herschel-ATLAS sub-mm sources, using a preliminary object catalogue from the VISTA VIKING survey. The sub-mm sources are selected from the H-ATLAS Phase 1 catalogue of the GAMA 9h field, which includes all objects detected at 250, 350 or 500 um with the SPIRE instrument. We apply and discuss a likelihood ratio (LR) method for VIKING candidates within a search radius of 10" of the 22,000 SPIRE sources with a 5 sigma detection at 250 um. We find that 11,294 (51%) of the SPIRE sources have a best VIKING counterpart with a reliability $R\ge 0.8$, and the false identification rate of these is estimated to be 4.2%. We expect to miss ~5% of true VIKING counterparts. There is evidence from Z-J and J-Ks colours that the reliable counterparts to SPIRE galaxies are marginally redder than the field population. We obtain photometric redshifts for ~68% of all (non-stellar) VIKING candidates with a median redshift of 0.405. Comparing to the results of the optical identifications supplied with the Phase I catalogue, we find that the use of medium-deep near-infrared data improves the identification rate of reliable counterparts from 36% to 51%.

IFU observations of Submm Galaxies

Author: Susannah Alaghband-Zadeh

Institute of Astronomy, Cambridge

Co-Authors: S.C. Chapman (Institute of Astronomy, Cambridge) A.M. Swinbank (Institute for Computational Cosmology, Durham University) I. Smail (Institute for Computational Cosmology, Durham University) C.M. Casey (Institute for Astronomy, University of Hawaii) R. Dave (Astronomy Department, University of Arizona) D. Narayanan (Steward Observatory, University of Arizona) C. Harrison (Department of Physics, Durham University) D. Alexander (Department of Physics, Durham University)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:50 Tuesday 27th 11:45-13:00*

Summary:

Submm Galaxies (SMGs) have some of the highest star formation rates in the Universe. Determining the trigger of the ultraluminous bursts in these galaxies is key to understanding their extreme properties. It has been suggested that most SMGs are formed in major mergers however simulation outputs have shown that this may not always be the case and that SMGs may also be large disk-like systems. I will present the results of integral field spectroscopy observations of a sample of SMGs which allows for the mapping of the gas morphologies and dynamics within the sources. The SMGs show strong evidence for distinct multiple components with no disk-like features in the velocity fields. Furthermore, the results of a kinemetry analysis classifies the systems as mergers. By comparing the SMGs' Halpha intensity and velocity fields to a sample of normal star forming galaxies (the SINS survey) in a similar redshift range, we find that the SMGs are morphologically and kinematically distinct. The measure of how rotation dominated a system is, V/sigma, and the SFRs are higher in the SMGs than in SINS galaxies providing evidence that SMGs form a very different population to other star forming galaxies.

Studies of Galaxy Evolution with Herschel/PEP

Author: Dieter Lutz

MPE

Co-Authors: PEP consortium

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *14:15 Tuesday 27th 14:15-15:30*

Summary:

The PEP survey has used the PACS instrument on board Herschel to obtain deep far-infrared photometric surveys of some of the most popular multiwavelength deep fields, resolving the cosmic infrared background into its constituents. This talk will summarize recent studies of galaxy evolution that are based on this resource.

The Redshift Distribution of H-ATLAS Sources

Author: Elizabeth Pearson

Cardiff University

Co-Authors: Stephen Eales

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *14:35 Tuesday 27th 14:15-15:30*

Summary:

Upon its completion H-ATLAS will be the largest blind sub-mm survey to date, and has currently completed its first phase. A third of Phase 1 detected sources have optically measured SDSS redshifts and a campaign of CO follow up observations have yeilded a handful of sub-mm redshifts. Using this data, we create a new method for estimating redshifts from the SPIRE fluxes alone. We adjust a subset of sources with known redshifts to their rest frame to callibrate a two temperature template, using a jackknife technique to gauge the accuracy of the method, and present our estimation of the redshift distribution for the field.

SEDs of dusty galaxies at low and high redshift

Author: Kate Rowlands

University of Nottingham

Co-Authors: S. Dye (University of Nottingham); A. Aragon-Salamanca (University of Nottingham); L. Dunne (University of Nottingham, University of Canterbury); S. Maddox (University of Nottingham, University of Canterbury) and the Herschel ATLAS consortium

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *14:45 Tuesday 27th 14:15-15:30*

Summary:

Our understanding of dust evolution over cosmic time is paramount in order to further our knowledge of galaxy evolution. Studies of cold dust in galaxies have until recently been hampered by small sample sizes due to the difficulty in observing at submillimetre wavelengths. We present a comparison of the properties of a large sample of ~250μm rest-frame selected galaxies at low ($z<0.35$) and high ($z\sim2.2$) redshift. Physical parameters are derived in a self-consistent way from multiwavelength SED fitting using an energy balance method. We find that the high redshift galaxies have dust masses comparable to some of the dustiest galaxies at low redshift, but have star-formation rates which are higher by 1-2 orders of magnitude. We will discuss the physical interpretation of this and also explore possible evolutionary links between the high and low redshift dusty galaxy populations.

Hot and cold: star formation and dust at high-redshifts

Author: Pratika Dayal

Institute for Astronomy, University of Edinburgh

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *14:55 Tuesday 27th 14:15-15:30*

Summary:

Lyman Alpha Emitters (LAEs) are arguably the best astrophysical probes of cosmic reionization and high redshift galaxy evolution. However, interpreting Lyman Alpha data is complicated by the fact that these galaxies are dust enriched. Using theoretical calculations that are firmly based in state of the art numerical simulations, I will present results on the FIR dust emission expected from LAEs at $z\sim4$-7, and their detectability with ALMA. Such detections are imperative for constraining reionization, as well as understanding dichotomous high redshift galaxy populations, namely Lyman Alpha Emitters and Lyman break Galaxies. I will also present theoretical estimates of the molecular content of LAEs, and how they could be detectable in the very near future with ALMA and the PdBI, yielding the best available constraints on high redshift star formation.

LABOCA Survey of the COSMOS Field

Author: Felipe Pedro Navarrete Avendaño

Max Planck Institut für Radioastronomie

Co-Authors: F.Bertoldi (AIfA); V.Smolcic (AIfA); Sameera Salim (AIfA)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *15:05 Tuesday 27th 14:15-15:30*

Presentation type: Talk *15:05 Tuesday 27th 14:15-15:30*

Summary:

The Cosmological Evolution Survey (COSMOS) field covers 2 sq.deg., and it has been observed in a wavelength range that spans from the X-rays to the radio. It has been specially designed to probe the relation between the evolution of galaxies with the Large Scale Structure (LSS) over a redshift range from z~0.5 to z~6. In this talk, I will present the analysis of the first submillimeter survey of the COSMOS field at 870 microns carried out with the LABOCA bolometer on the APEX telescope, which covers the inner ~0.7 sq.deg., and reaches a depth of 1.5 mJy/beam at the center. This data set is complementary to previous millimeter surveys of the same field , i.e., MAMBO (1.2 mm), BOLOCAM (1.1mm), and AzTEC (1.1mm). I will present the specifics of the LABOCA-COSMOS map and source catalog, as well as the statistical (P-statistics) multi-wavelength counterpart assignment to the LABOCA sources, and their redshift distribution. I will end the talk with an outline discussing new methods for SMG counterpart association, and multi-wavelength and high-resolution follow-up.

Detecting dusty protoclusters with Planck and Herschel

Author: Filiberto Braglia

Imperial College London

Co-Authors: D. Clements (Imperial College London)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *15:15 Tuesday 27th 14:15-15:30*

Summary:

We are conducting a study of Planck sources detected in selected fields from the Herschel Multi-Tiered Extragalactic Survey (HerMES), with the aim of detecting dusty protoclusters by means of their integrated far-IR flux. Starting from the Planck Early Release Compact Source Catalogue (ERCSC), we selected compact sources ("clumps") not identified with known, nearby, sources. Herschel fluxes and multi-wavelength ancillary data is then used to examine these clumps further, looking for three-dimensional overdensities of galaxies, and analysing optical and nIR colours and SEDs of individual galaxies. So far, we were able to confirm four clumps as groups of galaxies ranging from z~0.7 to z>2 and at various evolutionary stages, from fully-fledged clusters to protoclusters in the very process of assembly. This preliminary study shows the feasibility of using combined Planck and Herschel data to efficiently detect protoclusters of galaxies at virtually any redshift and without bias with respect to their formation history. It is the first step toward building a larger sample of high-redshift protoclusters that will allow us to probe the cosmic star-formation and mass assembly history of galaxy clusters, eventually providing strong constraints on models of structure formation and evolution.

GOODS-Herschel; The deepst view of the far-IR skies

Author: Georgios Magdis

University of Oxford

Co-Authors: GOODS-H team

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *17:00 Tuesday 27th 17:00-18:15*

Summary:

The GOODS-Herschel survey provides the deepest view of the far-IR skies (100 - 500 μm) "daring" to detect typical (L*_IR), galaxies up to z~2. These unique data have lead to exciting discoveries, opening a new window into our understanding of galaxy evolution. In my talk I will present an overview of these results, focusing on : - the infrared main sequence of star forming galaxies - the population of silicate absorbed galaxies, missed by the deepest 24um surveys - the links between star formation in galaxies and accretion on to their central black holes - the star formation mode and morphology of distant ULIRGS.

H-ATLAS Lens Survey: looking for lensed galaxies in the submm with the Herschel Space Observatory

Author: Mattia Negrello

INAF - Osservatorio Astronomico di Padova, Italy

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Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *17:20 Tuesday 27th 17:00-18:15*

Summary:

The Herschel Astrophysical Terahertz Large Area Survey (H-ATLAS) is the widest extragalactic survey currently undertaken with the Herschel Space Observatory, that will map about 550 square degrees of the sky at far-infrared to sub-mm wavelengths. Thanks to its large area coverage, it has recently allow us to prove a new efficient method to select gravitationally lensed galaxies, by exploiting sub-mm imaging data alone. I will present this method and discuss its application to the first H-ATLAS data. I will show some examples of lensed galaxies discovered so far with Herschel and present

discuss its application to the first H-ATLAS data. I will show some examples of lensed galaxies discovered so far with Herschel and present multiwavelength follow-up observations for those objects. I will then review the current status of the search for lenses in H-ATLAS and briefly mention the kind of astrophysical constraints that may be obtained from the statistics of the lensed galaxy sample that will be delivered by the full H-ATLAS.

Strongly lensed SMGs from the SPT survey

Author: Carlos De Breuck

ESO

Co-Authors: J. Vieira (Caltech), Axel Weiss (MPIfR), Dan Marrone (Univisity of Arizona), James Aguirre (University of Pennsylvania), Thomas Greve (DARK, Copenhagen) & the SPT SMG collaboration.

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *17:30 Tuesday 27th 17:00-18:15*

Summary:

The South Pole Telescope has uncovered over 100 extremely bright (S_1.4mm>15 mJy) submm galaxies (SMGs) in the 2500 square degree sky area covered. APEX/LABOCA+SABOCA 870/350μm imaging not only confirms their high brightness, but also suggests a median redshift of 3.1 from SED fitting. Initial results from our spectroscopic follow-up using Z-spec/APEX and ALMA confirm this higher median redshift due to the longer selection wavelength than Herschel or 850μm-selected samples. We argue that the high brightness is due to strong gravitational lensing by foreground galaxies or clusters. We have embarked on a comprehensive multi-wavelength campaign to characterize this population using HST, Herschel, VLT, Spitzer and ALMA.

Resolved star-forming clumps in lensed galaxies at z = 1-2

Author: Rachael Livermore

Durham University

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *17:40 Tuesday 27th 17:00-18:15*

Summary:

Strong lensing by massive galaxy clusters allows us to study 'typical' high-redshift galaxies in a level of detail that would otherwise have to wait until JWST or E-ELT. The spatial magnification enables us to reach source-plane resolution of ~100pc, which approaches the size of individual giant HII regions. I will present the results of a HST narrow-band program which maps the star formation within high-z galaxies on scales of 100-1000pc. I will show that it is possible to identify individual star-forming HII regions on these scales, and measure their scaling relations. I will show that the star formation within HII regions has comparable intensity to that seen in local starbursts. However, I will also show that there is strong evolution in the mass function of clumps with redshift, and will show that this is a natural consequence of the rapidly evolving gas mass fraction for turbulent disks with redshift. By comparing these results for clumpy disks with simulations, I will show that there is no requirement for a different ‘mode’ of star formation in high-redshift turbulent disks.

Molecular gas in the ISM of z~2 star-forming galaxy

Author: Alice Danielson

Durham University

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *17:50 Tuesday 27th 17:00-18:15*

Summary:

I will present our most recent observations of molecular gas in the interstellar medium of the 'Eyelash', a z~2 star-forming galaxy, magnified ~32x by a foreground cluster, providing an excellent opportunity for detailed study of the interstellar medium in a high redshift, rapidly star-forming galaxy. There has been detailed follow-up of this source across the spectrum, however, I will focus on our most recent observations, probing multiple transitions of 13CO and C18O to try and understand the properties of the molecular gas and the conditions required for star formation in the most active era in the Universe. There has been an increasing amount of work using 12CO (as a tracer of molecular hydrogen) to probe the conditions within giant molecular clouds where stars are forming. However, 12CO has the disadvantage that it can be optically thick, whereas 13CO and C18O tend to be optically thin (due to low 13C/12C abundances). Measuring these species thus allows us to probe more deeply into star-forming regions than is possible with 12CO observations, and can provide better constraints on molecular mass, gas density and temperature in order to better understand the initial conditions for star-formation and furthermore to understand the dominant heating processes in high redshift ULIRGs and how this differs from local star-forming galaxies.

Connecting stellar mass, star formation rate and halo mass across 80 per cent of cosmic time

Author: Lingyu Wang

University of Sussex

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *18:05 Tuesday 27th 17:00-18:15*

Summary:

We present an empirical relation between galaxy stellar mass, star-formation rate (SFR) and dark matter halo mass across 80 of cosmic time. We achieve this using the framework of the extended halo model (EHM): first we build the conditional stellar mass function (CSMF), which describes the distribution of galaxies in stellar mass as a function of halo mass; then we extend the CSMF to the joint distribution in stellar mass and SFR as a function of halo mass. The key datasets used to constrain the EHM include the Sloan Digital Sky Survey (SDSS), the Cosmic Evolution Survey (COSMOS), the Multiwavelength Survey by Yale-Chile (MUSYC) and the Herschel Multi-tiered Extragalactic Survey (HerMES), which are crucial for deriving accurate SFRs for dusty star-forming galaxies at high redshift.

Gas Contents and Dynamics of High-z Star Forming Galaxies

Author: Javier Graciá Carpio

Max Planck Institute for Extraterrestrial Physics

Co-Authors: L.J. Tacconi (MPE); R. Genzel (MPE); F. Combes (Observatoire de Paris); R. Neri (IRAM); P. Cox (IRAM); M.C. Cooper (Steward Observatory); K. Shapiro (University of California); A. Bolatto (University of Maryland); N. Bouché (University of California); F. Bournaud (CEA/Saclay); A. Burkert (Universitätssternwarte der Ludwig-Maximiliansuniversität); J. Comerford (University of California); M. Davis (University of California); N.M. Förster-Schreiber (MPE); S. Garcia-Burillo (OAN); D. Lutz (MPE); T. Naab (Universitätssternwarte der Ludwig-Maximiliansuniversität); A. Omont (Institut d'Astrophysique de Paris); A. Shapley (University of California); A. Sternberg (Tel Aviv University); B. Weiner (Steward Observatory)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:00 Wednesday 28th 10:00-11:15*

Summary:

I'll review the main results from our studies of the molecular gas properties of luminous and massive, but otherwise typical (i.e. non-merging, not extreme starbursting), star forming galaxies (SFGs) in the early Universe. We have been using the IRAM Plateau de Bure Interferometer to detect, and in several cases map and resolve, the molecular gas emission in a sample of ~50 galaxies at z~1.2 and z~2.2. We found large molecular gas masses in these objects, implying relatively low star formation efficiencies, with gas depletion time-scales between 0.5–1.5 Gyrs. The average fraction of cold gas relative to total baryonic mass is ~ 34% and ~44% at z~1.2 and 2.2, respectively, much higher than in z=0 massive galaxies. I'll discuss the implications of these results to our understanding of galaxy evolution and star formation, and relate them with similar results obtained by our group in the IR using the Herschel Space Observatory.

The molecular gas content of z~2 Submillimetre Galaxies

Author: Alasdair Thomson

Institute for Astronomy, University of Edinburgh

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:20 Wednesday 28th 10:00-11:15*

Summary:

Observations of the interstellar medium in high-z galaxies provide insight into the processes of star formation in these systems. Though most of the molecular gas -- the fuel from which stars form -- is in the form of H_2, properties of the molecule prevent H_2 from radiating strongly under normal ISM conditions. We therefore probe the molecular ISM in these systems using the cooling transitions of tracer molecules, the most ubiquitous of which is CO, which are themselves stimulated by collisions with H_2. Much effort over the years has been put into studying the molecular gas in star-forming galaxies across cosmic time, as this offers a snapshot of their evolutionary state and narrows down the possibilities of their likely descendents. Until recently however, available technology has limited the study of CO at high-z to the bright, high-J lines which are biased towards dense, warm molecular gas and blind to the cool, extended component wherein much of the molecular gas is routinely found. We present a summary of recent developments in the field, including early results from programs undertaken with the upgraded EVLA to probe the cold molecular gas reservoir of a sample of bright z~2 SMGs, determining their masses, extent and physical properties in an unbiased manner.

Intermediate resolution mm-mapping of SMGs in the COSMOS field: Redshift distribution & z>4 fraction

Author: Vernesa Smolcic

ESO, AIfA

Co-Authors: M. Aravena (ESO), F. Navarrete (MPIfR), F. Bertoldi (AIfA), E. Schinnerer (MPIA), D.A. Riechers (Caltech), M. Albrecht (AIfA) and (VLA-)COSMOS collaboration

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:35 Wednesday 28th 10:00-11:15*

Summary:

Submillimeter galaxies (SMGs) are ultra-luminous, dusty starbursting systems with extreme star formation rates in the range of ~100-1000 Msol/yr. With such star formation rates they trace a phase of the most intense stellar mass build-up in cosmic history. Studies of large samples of SMGs have placed them predominantly at redshifts 2-3, and only recently have the first z>4 SMGs been detected. However, given two fundamental difficulties, namely i) associating multi-wavelength counterparts to SMGs detected at low (~10-35") angular resolution, and ii) determining their redshift, the role of SMGs in galaxy evolution, as well as the relation between high- and low-redshift SMGs remain largely unclear. I will present results based on intermediate resolution (<2") mm-mapping (with PdBI/SMA/CARMA interferometers) of ~40 (LABOCA/AzTEC/MAMBO selected) SMGs in the COSMOS field, forming to-date the largest sample of this kind. I will discuss the efficiency of statistical counterpart association methods, and photometric redshift derivation for these SMGs, and present their redshift distribution. This will be compared to results from other surveys, and the fraction of z>4 SMGs in the context of galaxy formation and evolution will be discussed.

Evidence for a clumpy, rotating disk in an SMG at z=4

Author: Jacqueline Hodge

MPIA

Co-Authors: C. C. Carilli (NRAO), F. Walter (MPIA), W. J. G. de Blok (Univ. of Cape Town), D. Riechers (Caltech), E. Daddi (CEA)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:45 Wednesday 28th 10:00-11:15*

Summary:

We present a study of the formation of clustered, massive galaxies at large look-back times, via high resolution spectroscopic imaging of CO(2-1) in the unique GN20 proto-cluster at z = 4.05. Existing observations show that this is a dense concentration of gas rich, actively star forming galaxies, including two of the brightest SMGs known at z > 4. We present an analysis of >120 hours of high-resolution EVLA data on this molecular proto-cluster, allowing us to image the molecular gas with a resolution of only ~1 kpc just 1.6 Gyr after the Big Bang. In the SMG GN20, the data reveal evidence for an extended gas reservoir, 14 kpc in diameter, that is resolved into multiple kpc-sized clumps. A dynamical analysis shows that the data are consistent with a large, rotating disk. We use our dynamical mass estimate to put constraints on the CO-to-H_2 mass conversion factor. These state-of-the-art data give new insight into the detailed physical processes involved in early massive galaxy formation, and they provide a first glimpse of the morphological studies that will become feasible on a regular basis with ALMA.

Strong [CII] 158 micron emission from a z=7.1 quasar host

Author: Bram Venemans

MPIA Heidelberg

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *10:55 Wednesday 28th 10:00-11:15*

Summary:

Recently a bright quasar, J1120+0641, was discovered at a redshift of z=7.1, which is significantly more distant than the previous highest redshift quasar at z~6.4. In this talk I will present mm observations of the host galaxy of J1120+0641. We not only detect strong [CII] emission, but also the underlying, rest-frame far-infrared continuum. The [CII] line luminosity is only a factor ~4 lower than observed in the bright SDSS quasar J1148+5251 at z=6.4, while the line width is among the smallest observed when compared to the molecular line widths detected in z~6 quasar hosts. I will discuss the implications of these observations and the constraints they put on the physical properties of a quasar host at z=7.1.

Constraining Dust Properties and Energy Sources of Lyman Alpha Blobs at z~3

Author: Yujin Yang

Max-Planck-Institut fuer Astronomie

Co-Authors: R. Decarli (MPIA); H. Dannerbauer (Wien); F. Walter (MPIA); A. Weiss (MPIfR); C. Leipski (MPIA); A. Dey (NOAO); S. C. Chapman (IoA, Cambridge); E. Le Floc'h (CEA, Saclay); M. Prescott (UCSB); R. Neri (IRAM); C. Borys (Caltech); Y. Matsuda (Durham); T. Yamada (Tohoku); T. Hayashino (Tohoku); C. Tapken (AIP); K. M. Menten (MPIfR)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *11:05 Wednesday 28th 10:00-11:15*

Summary:

In order to constrain the bolometric luminosities, dust properties of giant Ly-alpha nebulae, the so-called Ly-alpha "blobs", we study the dust continuum in two Ly-alpha blobs (LAB) at z~3: an LAB discovered by its strong Spitzer MIPS 24um detection (LABd05) and the Steidel blob 1 (SSA22-LAB01). The SSA22-LAB01 has been known to contain a very bright submm galaxy, thus also providing enough energy source for Ly-alpha. However, our new LABOCA 870um and ultra-deep Plateau de Bure Interferometer (PdBI) observations (~2" resolution) rule out the previously reported submm detection of the SSA22-LAB01. Therefore, in contrast to the previous claims, what powers this best-studied blob remains uncertain. No CO line is detected in either blobs, indicating a modest molecular gas reservoir: M(H2) < (1-3)x10^10 Msun. The increased sensitivity afforded by the ALMA will be critical in studying molecular gas and dust in these interesting systems.

HerMES: Tracing the cosmic evolution of star formation

Author: Isaac Roseboom

Institute for Astronomy, University of Edinburgh

Co-Authors: the HerMES team

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *11:45 Wednesday 28th 11:45-13:00*

Summary:

The Herschel space observatory allows us for the first time to accurately probe the dust emission for large numbers of distant galaxies at the peak of its intensity (i.e. rest frame ~ 100 microns). The Herschel Multi-Tiered Extragalactic Survey (HerMES) is a key Herschel legacy project, having performed deep imaging on nearly 400 sq. deg. at the wavelengths of 100 and 160 micron from the PACS instrument, and 250, 350 and 500 micron from the SPIRE instrument. The Herschel data alone has been invaluable in understanding the gross properties of IR luminous galaxies (e.g. number densities, and relation to dark matter halos). However, because HerMES has observed the best-studied extragalactic survey fields, the combined multi-wavelength dataset, including Spitzer mid-IR, HST and ground based optical/near-IR imaging and spectroscopy, Chandra/XMM X-ray, VLA radio, and of course our Herschel far-IR/submm data, represents an unprecedented panchromatic view of distant galaxies. In this talk I will review the key results of the HerMES project so far, focusing on a variety of topics such as; multi-wavelength star formation tracers and the star formation history of the Universe, the interplay between AGN and star formation, and the relationship between star forming galaxies and their dark matter halos. This talk will coincide with a major public release of HerMES data.

A new approach to understanding the relation between star formation and molecular gas

Author: Claudia Lagos

Durham University

Co-Authors: E.Bayet (Oxford); C.Baugh (Durham); C.Lacey (Durham); S. Viti (UCL); T.Bell (CALTECH); J.Geach (McGuill); N.Fanidakis (MPAI)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:05 Wednesday 28th 11:45-13:00*

Summary:

We present a new theoretical framework to study the connection between star formation, and CO emission and molecular gas in an ab-initio galaxy formation model in the cold dark matter cosmology. This technique consists of coupling the state-of-the-art galaxy formation model of Lagos et al. (2011a,b), which self-consistently estimates the molecular abundance and star formation rates for millions of galaxies at all cosmic epochs, with the Photon Dominated Region Code of Bayet et al. (2011), which outputs the chemistry of the cold interstellar medium. This combined model is able to explain the CO emission from multiple transitions and its relation to other galaxy properties, as observed in local and high-redshift galaxies. We elucidate the physical mechanisms behind these relations and illustrate the predictive power of this hybrid model by studying the potential to characterise the evolution of the cold gas mass in galaxies through observations of colour selected samples of high-redshift star-forming galaxies using the Atacama Large Millimeter Array.

Theoretical modelling of galaxy evolution in the far-IR and sub-mm

Author: Cedric Lacey

Institute for Computational Cosmology, Durham University

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:15 Wednesday 28th 11:45-13:00*

Summary:

I will present latest results from our work on multi-wavelength modelling of the evolution of galaxies. The work combines a theoretical model of galaxy formation based on Lambda-CDM with a detailed radiative transfer calculation of the reprocessing of stellar emission by dust in galaxies. Our previous work implied the need for a top-heavy IMF in starbursts in order to explain the number counts and redshifts of sub-mm galaxies in this framework, once the observational constraints from the present-day galaxy luminosity function at optical and near-IR wavelengths were included. We have revisited this using an improved galaxy formation model, which includes a more realistic treatment of star formation, as well as feedback from AGN. We also impose the additional constraint that the model reproduces the observed evolution of the galaxy luminosity function at near-IR wavelengths. I will present results from our new model, and discuss the implications for the properties of sub-mm galaxies, for understanding galaxy evolution in the far-IR as revealed by Herschel, and for future surveys with instruments such as SCUBA-2 and ALMA.

A predicted ALMA view of the Hubble Ultra Deep Field

Author: Elisabete da Cunha

Max Planck Institute for Astronomy

Co-Authors: F. Walter (MPIA Heidelberg); Roberto Decarli (MPIA Heidelberg); Frank Bertoldi (Argelander Institut für Astronomie - Bonn); Chris Carilli (NRAO); Emanuele Daddi (CEA Saclay); Mark Dickinson (NOAO); David Elbaz (CEA Saclay); Rob Ivison (Royal Observatory Edinburgh); Roberto Maiolino (INAF - Rome); Dominik Riechers (Caltech); Hans-Walter Rix (MPIA Heidelberg); Mark Sargent (CEA Saclay); Ian Smail (Durham Univ.);

Axel Weiss (MPIfR Bonn)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:25 Wednesday 28th 11:45-13:00*

Summary:

The unprecedented sensitivity and spatial resolution of ALMA will offer exciting opportunities to investigate the dust and gas content of high-redshift galaxies. In this study, we simulate and explore the feasibility of a blank deep survey with ALMA in the Hubble Ultra Deep Field (UDF). We use publicly available deep optical data for this field, including optical (ACS) and near-infrared (NICMOS) photometry of galaxies in the UDF up to redshift 5. We use spectral energy distribution models to interpret the optical emission of the galaxies in terms of their star formation activity and dust attenuation properties. We then use a Bayesian method to obtain predictions of the infrared and sub-millimetre continuum emission of these galaxies which are consistent with their observed optical colours from an energy balance perspective. This enables us to provide predictions for the continuum and line emission of these galaxies in several ALMA bands and to produce simulated ALMA images of the UDF. We discuss the implications of our results to the planning and execution of deep extragalactic surveys with ALMA.

What do we know about the stellar masses of submillimetre galaxies?

Author: Michal Michalowski

Institute for Astronomy, University of Edinburgh

Co-Authors: J.S.Dunlop (IfA, Edinburgh); M.Cirasuolo (IfA, Edinburgh); J.Hjorth (DARK, Copenhagen); C.C.Hayward (CfA, Harvard); D.Watson (DARK, Copenhagen)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:35 Wednesday 28th 11:45-13:00*

Summary:

Establishing the stellar masses, and hence specific star-formation rates of submillimetre galaxies (SMGs) is crucial for determining the role of such objects in the cosmic history of galaxy/star formation. Before we will be able to interpret the wealth of data delivered by ALMA, SCUBA2 and Herschel we need to understand the methods we use to derive stellar masses of SMGs. I will discuss the impact of the assumptions in the spectral energy modelling of SMG and will review current observational evidence for and against these alternatives. I will show that the choice of the star formation history (SFH) has a great impact on the derived stellar masses of SMGs, but this is the case only to a lesser degree for general population of star-forming galaxies. Using a realistic assumption of SFH I will show that SMGs are the most massive extension of the star-forming galaxies on the stellar mass - star formation rate diagram and therefore majority of them are not outliers with respect to the so-called main-sequence of star-forming galaxies.

Contribution from the main sequence and starburst galaxies to the infrared/sub-mm observables

Author: Matthieu Béthermin

CEA Saclay

Co-Authors: Mark Sargent, Emanuele Daddi, David Elbaz

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *12:45 Wednesday 28th 11:45-13:00*

Summary:

Some recent works indicate that the majority of the star-forming galaxies follow a main sequence in the SFR-stellar mass plane with a surprisingly low scatter of ~0.2 dex. Nevertheless, Herschel identifies a population of starbursting galaxies, probably triggered by mergers, presenting large excess of specific star formation rate (sSFR=SFR/Mstar) compared to the main sequence. We will present a set of modeling works about the contribution of this population to the IR/sub-mm luminosity function, but also to the source counts selected at various wavelengths. Our modeling is based on the stellar mass function of star-forming galaxies, the distribution of sSFR measured at z=2 and its double-Gaussian decomposition, and the observed evolution of the main sequence in the sSFR-Mass plane as a function of redshift. We found that the non-Schechter bright-end of the LF is due to the starbursting galaxies, which represent only ~4% in number density and ~15% in luminosity density. This fraction of starburst is remarkably constant with the redshift, contrary to naive expectation from hierarchical merging. We will discuss the contribution of starbursts to the number counts and the selection effects towards starburst sources for various flux-limited IR/sub-mm samples. We also present some prediction of the possibility to detect main-sequence and starburst galaxies with CO surveys, considering their different αCO (CO luminosity to molecular gas mass conversion factor).

Flux density variations of radio sources in M82

Author: Melanie Gendre

JBCA

Co-Authors: D. Fenech (UCL); R. Beswick (JBCA); T. Muxlow (JBCA)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

M82 is one of the closest (d = 3.2 Mpc) starburst galaxies known, producing a large population of massive, rapidly evolving stars, and an equally large

number of supernovae. In the past 30 years, M82 has been subject to frequent radio monitoring at centimetre wavelengths with the VLA and MERLIN. With detection of over 50 discrete objects, including over 30 SNRs, these regular observation programmes have the advantage of tracking the evolution of supernova remnants as their shells expand, which provide a way to investigate properties of the Inter-Stellar Medium. Regular observation programmes also allow for the monitoring of flux variability in sources such as 41.95+57.5, which has shown a continued decrease in flux density since its first observation in 1965. We present the results of the 2009-2010 monitoring sessions of the starburst galaxy M82, obtained with MERLIN)at 5-GHz and e-MERLIN at 6-GHz. Combining the 5-GHz MERLIN epochs to form a map with 11.8 uJy/beam noise level, 52 discrete sources, mostly supernova remnants and HII regions, are identified. These include 3 objects which were not detected in the 2002 5-GHz MERLIN monitoring session: supernova 2008iz, the transient source 43.78+59.3, and a new supernova remnant shell. Flux density variations, both in the long (1981 to 2010), medium (2002 to 2010) and short (2009 to 2010) term, are investigated. We find that flux densities of SNR in M82 stay relatively constant in most of the sample (~90-95%). In addition, aside from SN2008iz and the well-known variable source 41.95+57.5, 4 sources display long term variations over the period 1981-2010, three of which have measured sizes among the most compact in M82. These variations could be explained by changes in the mediums in which the shocks travel.

The star formation history of the Galactic Bulge

Author: Albert Zijlstra

University of Manchester

Co-Authors: K. Gesicki (University of Torun, Poland), B. Rees (University of Machester, UK)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

The star formation history of the Galactic Bulge is an important constraint on its origin - either as a separate entity of the Galaxy or as a pseudo-bulge. We derive the star formation history using HST and VLT observations of compact planetary nebulae. Stellar ages are derived from the mass distribution of the central stars. There is evidence for a range of ages, estimated at 10-8 Gyr, with a significant peak for the youngest ages. We derive an approximate star formation rate of 4 solar masses per yr over these 2 Gyr (for a Bulge mass of 10^10 solar masses), with a peak of 8 solar masses per yr during the last 0.5 Gyr. A possible explanation is that the Bulge formed 8 Gyr ago, from an event which scattered stars and gas into the central regions. The structures of the planetary nebulae indicate that the star formation in the Bulge took place under a strong and well-ordered magnetic field.

Star Formation and AGN Activity in Interacting Galaxies: A Near-UV Perspective

Author: Caroline Scott

Imperial College

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

Galaxy interactions produce intense star formation episodes, driving the build-up of stellar mass and black holes and alter the morphological mix of the universe. While they are routinely included in galaxy formation models, the evolution of star formation and AGN activity is only now being investigated from a purely observational perspective. SDSS and GALEX data is employed to analyse our close pairs catalogue. UV and optical colours are used to approximate recent star formation in close pair systems as a function of separation, galaxy properties (eg. morphology and luminosity) and local environment, and NUV-derived luminosities provide specific star formation rates. Our large homogeneous dataset allows us to study the interplay between star formation and AGN activity. Using SDSS spectra, we probe the AGN fraction and its evolution as mergers advance. The results provide constraints on our current theoretical infrastructure and provide a picture of how merging affects galaxy evolution from an observational perspective using state-of-the-art spectro-photometric data from current large-scale observational surveys.

Galaxy-wide outflows in z~1.5-3.5 infrared-luminous galaxies

Author: Christoper Harrison

Durham University

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

Leading models of galaxy evolution predict an active period, peaking around z~2, of supermassive black hole (BH) and stellar growth. These processes are thought to be self-regulating through powerful active galactic nuclei (AGN) driven outflows; however, direct observational evidence of this at high redshift remains very limited. I present integral field spectroscopy observations, covering the [OIII] emission line, of eight submillimetre-luminous galaxies (SMGs) that host radio-quiet AGN activity. These SMGs display extremely broad (FWHM~1000-2000 km/s) [OIII] emission across 4-15 kpc, a signature of vigorous outflows over galaxy-wide scales. These outflows are dumping considerable amounts of energy into their host galaxies which is likely to disrupt star formation. For example, we identify a spectacular, two-sided, high velocity (v~830 km/s) AGN-driven outflow in a galaxy that is also undergoing a merger and intense star formation activity. We speculate that we are observing galaxies in a transition phase from obscured star formation and AGN activity to an unobscured quasar, potentially a key evolutionary stage in the formation of local massive galaxies.

H-ATLAS: The FIR Properties of BAL Quasars

Author: Jose Manuel Cao Orjales

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Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

We have used data from the Herschel-ATLAS at 250, 350 and 500 microns to determine the far-infrared (FIR) properties of Broad Absorption Line Quasars (BAL QSOs). Our sample contains 49 high-ionization BAL QSOs (HiBALs) and 1 low-ionization BAL QSO (LoBAL) which are compared against a matched sample of 329 non-BAL QSOs. We calculate star-formation rates (SFR) for our individually detected HiBAL QSOs and solitary LoBAL QSO as well as average SFRs for the BAL and non-BAL QSO samples based on stacking the Herschel data. We find no difference between the HiBAL and non-BAL QSO samples in the FIR, even when separated based on differing BAL QSO classifications. Despite tentative claims in the literature, we are unable to show a decisive dependence of CIV equivalent width on FIR emission, suggesting that the strength of any outflow in these objects is not linked to their FIR output. These results suggest strongly that BAL QSOs (more specifically HiBALs) can be accommodated within a simple AGN unified scheme in which our line-of-sight to the nucleus intersects outflowing material. Our results do not support evolutionary models.

Spectral Aging In The Lobes of FR-II Radio Galaxies

Author: J Harwood

University of Hertfordshire

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

It has become increasingly apparent in recent times that radio-loud active galaxies play an important role in the evolution of galactic populations. Understanding their dynamics and energetics is therefore vital if we are to build a true picture of galaxies came to be the way they are today. Determining the spectral shape of a population can often give key insights in to the underlying physics of a radio source, specifically, the ability to derive information about age of emission and the rate and which energy is being transferred to the local environment. In principle, since higher-energy electrons lose energy faster by synchrotron radiation, we expect to see steeper, more strongly curved spectra in older regions of plasma. Models describing this curvature ('spectral ageing'), fitted to narrow-band observations of a radio source at several frequencies have been a standard tool in this field for many years. The poor sampling in frequency space has traditionally meant that determining which of these models (if any) are correct has been hard to achieve; however, the capability of the upgraded EVLA to observe at widely spaced frequencies and broad-bandwidths allows this problem to be overcome. Here I present the latest results in using these capabilities to provide high resolution spectral maps to answer the long standing question of possible spectral ageing in the lobes of FRII radio galaxies.

Sweeping up the Dust in the Low Redshift Universe by Stacking in the Herschel ATLAS

Author: Nathan Bourne

University of Nottingham

Co-Authors: S.J.Maddox (Canterbury, NZ); L.Dunne (Canterbury, NZ); and the H-ATLAS and GAMA teams.

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

The Herschel-ATLAS survey provides the largest ever map of the sub-millimetre sky. We have used over 100 square degrees of this revolutionary data set, with multi-wavelength photometry and redshifts from GAMA, to conduct an unbiased census of the dust mass in optically selected galaxies up to z=0.35, using stacking techniques to recover emission from sources well below the noise and confusion limits of H-ATLAS. I will summarise the results and discuss the relationship between the typical dust and stellar content of galaxies, and how this depends on optical colour, stellar mass and redshift.

The host galaxies and black-hole:galaxy mass ratios of luminous quasars at z~4

Author: Thomas Targett

IfA, Edinburgh

Co-Authors: J.S. Dunlop (IfA, Edinburgh) R.J. McLure (IfA, Edinburgh)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

We present and analyse the deepest, high-quality Ks-band images ever obtained of luminous quasars at z~4, in an attempt to determine the basic properties of their host galaxies less than 1 Gyr after the first recorded appearance of black holes with Mbh > 10^9 Msol. Via carefully-controlled separation of host-galaxy and nuclear light, we estimate the luminosities and stellar masses of the host galaxies, and set constraints on their half-light radii. The quasar host galaxies have K-band luminosities similar to radio galaxies at comparable redshifts, suggesting that these quasar hosts are also among the most massive galaxies in existence at this epoch. However, the quasar hosts are a factor ~5 smaller than the host galaxies of luminous low-redshift quasars. We estimate the stellar masses of the z~4 host galaxies to lie in the range 2-10x10^11 Msol, and use the CIV emission line to estimate the masses of their black holes. The results imply a black-hole:host-galaxy mass ratio Mbh:Mgal~0.01-0.05. This is an order of magnitude higher than typically seen in the low-redshift Universe, and is consistent with existing evidence for a systematic growth in this mass ratio with increasing redshift, at least for objects selected as powerful AGN.

The LITTLE THINGS Survey

Author: Elias Brinks

University of Hertfordshire

Co-Authors: and the LITTLE THINGS Team

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

We present the LITTLE THINGS project, a multi-wavelength dataset consisting of 41 relatively normal, nearby (<10 Mpc) gas-rich dwarf irregular galaxies. LITTLE stands for Local Irregulars That Trace Luminosity Extremes, and is the low-mass, low-metallicity extension of THINGS, The HI Nearby Galaxy Survey. Our data include GALEX UV images, ground-based UBV and Halpha images, some ground-based JHK images, Spitzer archival mid-IR images, and HI-line maps. The HI maps, obtained with the VLA, go deep (12/6/2 hrs in B/C/D arrays) and are characterised by high spectral resolution (<2.6 km/s) and high angular resolution (typically 6", which is 110 pc at the average distance of our sample). Our datasets trace the stellar populations, gas content and structure, dynamics, and star formation indicators in the galaxies, and are being used to answer questions about star formation in dwarf galaxies. All data have now been made publicly available. We give here an overview of the data and the project's aims.

A Multi-Wavelength View of the ISM in Nearby Galaxies

Author: Ioannis Bagetakos

University of Hertfordshire

Co-Authors: E.Brinks (University of Hertfordshire)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

We are developing an objective, automated method to compare multi-wavelength images based on 2–D pixel-by-pixel cross-correlations. We introduced a measure for the degree of correlation, Ccoef, which takes values from 1 (perfect correlation) to −1 (perfect anti-correlation). This we subsequently applied to NGC 2403, in a pilot project. We produce spatially resolved cross-correlation maps, on scales of 250 pc to 1000 pc and radial profiles of the cross-correlation coefficients. We find that 1.) all dust tracers, 8μm–70μm, are well correlated (Ccoef > 0.7) at all scales; 2.) all the star formation tracers are well correlated at scales larger than 500 pc (Ccoef > 0.6); 3.) at 250 pc scale, FUV correlates poorly (Ccoef ~ 0.3) with any the dust tracer, a direct consequence of the absorption of FUV photons by dust; and 4.) neutral atomic hydrogen is tightly correlated with the 8μm emission (Ccoef ~ 0.6), illustrating the fact that HI is mixed with PAH's.

Deep Radio Continuum Imaging Of The Dwarf Irregular Galaxy IC 10: Tracing Star Formation And Magneti

Author: Volker Heesen

U Hertfordshire

Co-Authors: U. Rau (NRAO); M. Rupen (NRAO); E. Brinks (U Hertfordshire); D. Hunter (Lowell)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

We exploit the vastly increased sensitivity of the Expanded Very Large Array (EVLA) to study the radio continuum and polarisation properties of the post-starburst, dwarf irregular galaxy IC10 at 6 cm, at a linear resolution of ~50 pc. We find close agreement between radio continuum and Halpha emission, from the brightest HII regions to the weaker emission in the disk. A quantitative analysis shows a strictly linear correlation, where the thermal component contributes 50% to the total radio emission, the remainder being due to a non-thermal component with a surprisingly steep radio spectral index

of between -0.7 and -1.0 suggesting substantial radiation losses of the cosmic-ray electrons. We confirm and clearly resolve polarised emission at the 10-20% level associated with a non-thermal superbubble, where the ordered magnetic field is possibly enhanced due to the compression of the expanding bubble. A fraction of the cosmic-ray electrons has likely escaped because the measured radio emission is a factor of 3 lower than what is suggested by the Halpha-inferred SFR.

Spectroscopic Followup of Radio-loud AGN Sources in the South Pole Telescope Survey

Author: Kate Husband

University of Bristol

Co-Authors: S. Chapman (Institute of Astronomy, UK), J. Vieira (California Institute of Technology, USA)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

A study of radio loud AGN sources in ~1500 square degrees of the South Pole Telescope point-source survey has revealed three classes of sources: radio-loud quasars whose radio to sub-mm SED is a flat power law, radio-loud quasars whose spectrum turns over due to self-absorption and sources with an upturning spectrum in the far-infrared (FIR). The upturning spectrum has an excess 'upturn' flux of 5-84 mJy at 1.4mm thought to be due to thermal emission from dust. If the upturn is thermal emission from dust the implied far-infrared luminosities are huge and the sources are ultraluminous infrared galaxies (ULIRG: L>10^12). Despite this none of the upturning sources are detected by Plank or IRAS. Follow-up spectroscopy of a sub-sample of upturns with VLT-ISAAC indicates that these ATCA-identified radio sources are typically broad line radio-QSOs at z=1.0-2.3. Possible scenarios are discussed to explain these observations.

Herschel

Author: Chris Fuller

Cardiff University

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

Using the superb resolution and sensitivity of Herschel we have measured the FIR (100, 160, 250, 350, 500u) fluxes of an optically selected sample of Coma cluster galaxies. Using these data we fit spectral energy distributions to derive dust temperature and masses. We cover both the cluster core which is dominated by early type galaxies and also the extended outer regions of the cluster. We make comparisons of the FIR properties of these galaxies with those of a similar sample detected and measured in the Virgo cluster.

The Distribution of Star Formation in a Representative Sample of 69 Barred Galaxies.

Author: Richard Taylor

Co-Authors: W.X. Maciejewski (Liverpool John Moores University)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

We study the distribution of H-alpha emission in barred spiral galaxies from the H-alpha Galaxy Survey, a survey that is representative of a wide range of galaxy luminosities. Of the 69 galaxies in our sample, about half exhibit emission from the main body of the bar, whilst only 13% show emission from the leading edge of the bar. Emission from the nucleus is present in 75% of galaxies, with extended nuclei preferred by strongly barred galaxies, while in weak bars, extended and compact nuclei are both equally common. Nuclear rings are extremely rare in H-alpha emission (6% of the sample). Our findings challenge the generic picture of gas flow in barred galaxies and of the evolution of barred galaxies.

The X-ray/infrared connection in star-forming galaxies

Author: Myrto Symeonidis

MSSL-UCL

Co-Authors: the HerMES consortium

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

I will present results from our recent study of the X-ray/infrared correlation, carried out as part of the Herschel Multi-tiered Extragalactic Survey (HerMES) guaranteed-time key programme, with data from the field of GOODS-North. Combining X-ray data from the 2Ms Chandra survey and infrared

data from Herschel's sub-millimeter bolometer array, SPIRE, we are able to investigate the X-ray/infrared correlation in the high star formation rate (SFR), starburst-mode regime for galaxies at cosmologically significant redshifts. Once obvious AGN are excluded, the X-ray/infrared properties of our sample of luminous and ultraluminous infrared galaxies (LIRGs and ULIRGs) at ~1, are compared to those of local (z<0.1) and intermediate redshift (z~0.6) samples of equivalently infrared-luminous sources. We conclude that there is no evidence for evolution in the X-ray/IR correlation with redshift, however, we note that in contrast to normal star-forming galaxies, LIRGs and ULIRGs are X-ray deficient relative to their infrared output. This suggests fundamental differences in the origin of X-ray emission in systems undergoing starburst episodes and has implications on the use of the X-ray/infrared correlation, both as a star-formation tracer and as a means of separating AGN from star-forming galaxies in extragalactic surveys.

X-Ray properties of star-forming BzK galaxies

Author: Cyprian Rangel

Imperial College London

Co-Authors: K. Nandra (Max Planck Institut fur Extraterrestrische Physik); E. S. Laird (Imperial College London); S. J. Warren (Imperial College London)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

X-Ray background models predict a large population of heavily obscured (Compton thick) AGN at z>1 that to date remains undiscovered. These heavily obscured AGN are too faint to be directly detected in even the deepest x-ray surveys, hence we search for this population using multi-wavelength techniques. We present x-ray stacking of a sample of BzK galaxies binned according to the ratio of their Infrared and dereddened UV star formation rates (SFRs) in Chandra Deep Field South (CDFS) 4Ms and Chandra Deep Field North (CDFN) 2Ms. Galaxies with IR SFR greater than their dereddened UV SFR (IR Excess) are deemed to be strong Compton thick AGN candidates, based upon previous stacking analyses using CDFS 1Ms data, while the remaining BzK galaxies (IR Non-Excess) are thought to be purely star forming. A greater proportion of the BzKs have now been directly x-ray detected in the CDFS 4Ms data, ranging from heavily obscured AGN to faint and unobscured AGN. From stacking we conclude the IR Excess galaxies are a mixture of obscured and unobscured AGN and star forming galaxies. The IR Non-Excess galaxies have an almost identical x-ray emission profile but are less x-ray bright.

Spying on the neighbour - Mapping the ISM and star formation in Andromeda

Author: George Ford

Cardiff University

Co-Authors: Walter Gear (Cardiff University); Steve Eales (Cardiff University); Matt Smith (Cardiff University)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

Here we explore how the star formation rate relates to density of gas in M31, and hence test the Schmidt law on smaller scales than was previously possible. We use two methods of calculating the star formation. FUV + 24μm emission probes the embedded and unobscured star formation separately. We use a modified version of the prescription found in Leroy et al (2008) combining Galex and MIPs data, corrected for the old stellar population. Total infrared luminosity probes dust heating only and is calculated using recently acquired data from the Herschel Space Observatory. We compare the two methods, and discuss the limitations of both. We further look at possible means to calibrate one or both maps to reach an agreement. Gas mass is traced by summing the total HI and H2 (from CO). We calculate gas-to-dust ratios at every pixel (dust mass found from Herschel data) and find a variation with radius. This is used to create a second gas map, using dust as the tracer. The Schmidt law is tested in several elliptical annuli. It appears the dust tracer gives the most consistent results throughout the galaxy, but gives an index much lower than values previously found.

The search for cool baryons at z~5

Author: Luke Davies

University of Bristol

Co-Authors: M.N.Bremer (University of Bristol); E.R.Stanway (University of Warwick); M.Birkinshaw (University of Bristol); M.N.Lehnert (Observatoire de Paris, Meudon); A.Omont (Institut dAstrophysique de Paris); E. J.Mannering (University of Bristol)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

Lyman Break Galaxies (LBGs) form a substantial fraction of the known high-z (z~5) galaxy population. While these systems have been extensively studied at rest-frame UV/optical wavelengths (probing the bulk of their stellar mass), little work has been undertaken to explore their cool dust and interstellar gas content. In order to fully understand star-formation activity at high-z and the subsequent evolution of early star-forming galaxies, we must observe their complete baryonic budget. Until recently studies of the dust and molecular gas content of the highest-z galaxies has been limited to massive/rare systems which maybe atypical of the general star-forming population at z~5. To this end we have carried out a pilot study, targeting molecular gas and dust emission from regions which are over-dense in LBGs at z~5. We place constrains on the UV-dark baryonic content of high-z galaxies, indicating that these systems are likely to be small, independent galaxies and not super-starburst regions embedded in a much larger obscured system (for reasonable assumptions of T_dust and `X-factor'). Though this study we have pushed the limits of current instrumentation but discuss how the

system (for reasonable assumptions of T_dust and T factor). Though this study we have pushed the limits of current instrumentation but discuss how the detection cool material at high-z will become routine with the fully operational ALMA.

The influence of star formation and nuclear activity on the molecular gas in nearby active galaxies

Author: Stefanie Muehle

Argelander-Institut fuer Astronomie

Co-Authors: C. Henkel (Max-Planck-Institut fuer Radioastronomie) M. Rodriguez (Instituto de Astrofisica de Andalucia) T. de Maio (University of Colorado) S. Aalto (Onsala Space Observatory) E.R. Seaquist (University of Toronto)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

Star formation processes and nuclear activity play a crucial role in the evolution of galaxies, locally as well as at high redshifts. The question whether or not the initial mass function (IMF) is universal is subject to intense debate. A number of recent observations have been interpreted as evidence for a non-standard IMF in a variety of environments. Hydrodynamical simulations suggest that the kinetic temperature of the collapsing molecular gas is a key factor for the shape of the resulting IMF. In active environments like the cores of starburst galaxies or near AGN, the dense molecular gas may be much warmer than the dense cores in the Milky Way disk, but unfortunately, the kinetic temperature of the molecular gas in external galaxies is rarely well constrained. We demonstrate the diagnostic power of a selected set of paraformaldehyde lines, in particular in the ALMA era, as tracers of the kinetic temperature as well as of the gas density in external galaxies using our non-LTE radiative transfer model. The first results of our survey of nearby starburst galaxies and AGN using this new tool support the notion of a significant warm molecular gas phase in at least some of these environments.

Concurrant star formation and black hole growth in the most massive galaxies

Author: Jason Rawlings

MSSL-UCL

Co-Authors: N.Seymour (CSIRO Astronomy & Space Science) M.J.Page (MSSL-UCL) M.Symeonidis (MSSL-UCL)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

High redshift radio galaxies (HzRGs) are extremely powerful, rare, radio-loud AGN whose hosts are known to be among the most massive galaxies in the Universe. While it is expected that the AGN has a strong contribution to the bolometric output, about a third of HzRGs have sub-mm detections which implies considerable star formation in the host galaxy. While observations at these wavelengths inform us of the cold dust associated with the galactic star forming regions, they reveal little about the AGN buried deep within. At mid-infrared (MIR) wavelengths however, both components can play an important role in terms of the energy output of such objects. In order to disentangle the contributions from AGN activity and star formation, we obtained MIR spectra of a sample of HzRGs ($1 < z < 3.2$) using the Infrared Spectrograph on-board the Spitzer Space Telescope. About a third of the MIR spectra in our sample show polycyclic aromatic hydrocarbon features indicative of considerable star formation and most show relatively weak silicate absorption, implying a more clumpy and extended dust structure surrounds the central engine. With the aid of a library of AGN and starburst models, we examine the properties of HzRGs such as star formation rates, AGN unobscured luminosities and extinction. Our aim is to gain a better understanding of the connection between star formation and the radio-loud phase of powerful obscured AGN.

Submillimetre and X-ray observations of star-forming AGN in the epoch of galaxy formation.

Author: Mat Page

MSSL-UCL

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

The present day black hole / bulge mass correlation tells us that star formation and the growth of black holes by accretion must be intimately linked. In the years prior to Herschel, ground based submillimetre observations combined with X-ray surveys identified a subset of luminous QSOs, those with significant X-ray absorption as embedded in powerful star-forming submillimetre galaxies. I will present evidence that the X-ray absorbers in these objects are highly-ionised winds, and discuss the evolutionary-sequence suggested by these observations. I will move on to describe the results obtained from the Herschel Multi-tiered Extragalactic Survey (HerMES) observations of the Chandra Deep Fields, which pairs the deepest submillimetre images ever obtained with the deepest X-ray surveys. The Herschel data provide the first sensitive glimpse into the far-infrared and star formation properties of a large part of the AGN population at cosmological distances. With Herschel SPIRE we identify star formation in a much greater fraction of AGN than in pre-Herschel observations. The association of X-ray absorption with star-forming QSO host galaxies is found to extend well below the break in the luminosity function of AGN. We discuss the implications of these findings with respect to the co-evolution of galaxies and the black holes that reside in their centres.

The AGN-Starburst Connection in $1 < z < 4$ Quasars

Author: Ashley K Hyde

Imperial College London

Co-Authors: D.L.Clements (Imperial College London), H.Patel (Imperial College London), HerMES Collaboration

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

We model the optical-to-IR SEDs of 38 SWIRE quasars with optical spectroscopic redshifts. Our key results are: 1) All these quasars are experiencing starbursts. 2) 21 of our quasars are detected by the Herschel SPIRE instrument. By fitting and integrating an M82 starburst SED, we find that all 21 host galaxies are HLIRGs with log(L,8-1000um/L,sun)=13-14, and they are experiencing very high star formation rates of ~10,000Msun/yr where they harbour non X-ray detected quasars, but ~7,000Msun/yr if their AGN is X-ray bright (L[2-8keV]>10^37W). This suggests that in the latter group the AGN may be suppressing star formation in the host galaxy, as predicted by the quenching paradigm. 3) We estimate black hole masses from the CIV or MgII broad line and we find a range of 8.06

Radio to infrared spectra of late-type galaxies with Planck and WMAP data

Author: Michael Peel

Jodrell Bank Centre for Astrophysics, University of Manchest

Co-Authors: M. W. Peel [1], C. Dickinson [1], R. D. Davies [1], D. L. Clements [2], R. J. Beswick [1] [1] Jodrell Bank Centre for Astrophysics, University of Manchester [2] Astrophysics group, Imperial College London

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Talk *00:00 Poster Session A*

Summary:

Using the Planck ERCSC, WMAP and other archival measurements, we construct continuum spectra of the nearby late-type galaxies Messier 82, NGC 253 and NGC 4945. We find that their spectra are consistent with steep spectrum synchrotron emission, a substantial amount of free-free emission, and cold thermal dust. The higher levels of free-free emission than previously found bring the star formation rate calculated from it into better agreement with that from non-thermal emission. We place limits on the amount of anomalous microwave emission from the galaxies, finding that it is lower than expectations from our own Galaxy. (MNRAS Letters, 416, 99, arXiv:1105.6336)

Dust heating in nearby galaxies from the Herschel Reference Survey

Author: Lingjie Kong

University of Manchester

Co-Authors: George J. Bendo (University of Manchester), Herschel Reference Survey, Herschel Virgo Cluster Survey

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

Recent research with Herschel Space Observatory data has shown that dust emission at >250 microns appears to be heated by the total stellar population rather than just star forming regions. This has implications for using dust to measure star formation and for modelling dust emission. However, these results have been based on observations of a relatively small number of galaxies. We expand this analysis using data for a subset of galaxies observed by the Herschel Reference Survey. We will compare variations in the surface brightness ratios to tracer of total stellar emission and star formation to identify the dust heating sources, and then we will compare our results with prior observational results for other galaxies and prior modelling results.

Probing the star formation and AGN connection using NMF analysis of IRS spectra

Author: Peter Hurley

University of Sussex

Co-Authors:

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

Understanding the star formation and AGN connection in infrared galaxies still poses an interesting problem for astronomers. The infrared spectra obtained from the Spitzer IRS spectrograph, has provided a unique probe, but difficulties remain in utilising the spectra due to the limited modelling tools available for the mid-infrared. Blind source separation techniques such as principal component analysis (PCA), provide an alternative tool to modelling. PCA has already successfully decomposed the IRS spectra of local ULIRGs into 5 unique components. However, due to the nature of PCA, the components do not have an obvious physical interpretation. Non negative matrix factorisation (NMF) is similar to PCA, but constrains both weights and derived templates to be non-negative. This more closely resembles the physics of emission in the mid-infrared and as a result the derived components are more physically intuitive. We have applied the NMF technique to the IRS spectra of galaxies from the CASSIS database (Lebouteiller et al. 2011). Our derived NMF components/templates can be used to quantify the contributions from different physical environments and are therefore an ideal

classification tool for constraining properties such as the star formation and AGN contribution for galaxies with IRS data.

H-ATLAS/GAMA: The star formation history of H-ATLAS galaxies and its correlation to the environmen

Author: Ali Dariush

Imperial College London

Co-Authors: S. Eales (Cardiff University); S. Dib (Imperial College London)

Session: GAL1: 12 billion years of star formation and nuclear activity in galaxies - the submillimetre view

Presentation type: Poster *Poster Session A*

Summary:

The aim of this work is to see how star-formation-histories (SFH) correlate with the environmental density and/or dust properties of low-redshift galaxies detected by H-ATLAS. We use multi-band photometric data (e.g. UV, optical, and NIR) in order to measure the SFH of galaxies from their spectral energy distributions (SEDs). To do so, we will consider all galaxies with submillimetre detections and measure their SFHs against a control sample. We analyse differences between the SFHs as well as dust mass/temperature of low-mass and high-mass systems and investigate the effect of environment (density) on such properties.

Galaxy haloes moving into focus

Author: Daniel Thomas

Institute of Cosmology and Gravitation, University of Portsm

Co-Authors:

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *17:00 Wednesday 28th 17:00-18:30*

Summary:

After decades of studying central galaxy properties, the attention is increasingly shifting towards galaxy outskirts. This is partly technology driven, as observations of galaxies at large radii are challenging owing to the very low stellar surface brightnesses. But galaxy haloes have also gained attention through recent galaxy formation modelling and observations that provide evidence for the build-up of galaxy haloes by satellite accretion processes. Haloes of galaxies show invaluable imprints of galaxy formation processes that yet wait to be deciphered. With this talk I will provide a brief review of the major milestones and recent advances in the field.

Dissecting Centaurus A

Author: Denija Crnojevic

Institute for Astronomy, Royal Observatory Edinburgh

Co-Authors: A.M.N. Ferguson (Institute for Astronomy, Royal Observatory Edinburgh) M.J. Irwin (Institute of Astronomy, Cambridge) E.J. Bernard (Institute for Astronomy, Royal Observatory Edinburgh) N. Arimoto (National Astronomical Observatory of Japan, Tokyo) C. Kobayashi (University of Hertfordshire)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *17:15 Wednesday 28th 17:00-18:30*

Summary:

We present the first deep survey of the resolved stellar populations in the remote outer halo of our nearest giant elliptical, Centaurus A (D=3.8 Mpc). We use the VLT/VIMOS optical camera to target four fields along the major and minor axes of the galaxy for a total area of ~0.25 deg^2, at projected elliptical radii of ~35 to 85 kpc. Analyzing the resulting deep color-magnitude diagrams (~2 magnitudes below the red giant branch tip), we are able to trace the halo structure (radial profile, extent and content) out to a remarkable 14 R_eff. We discuss evidence for a stellar overdensity along the major axis at R<50 kpc, most probably tidal debris from the recent gas-rich accretion event. The colours of red giant branch stars indicate that the halo remains metal-rich out to the furthest extent traced, with no evidence for a significant gradient. We discuss these findings in the context of galaxy formation models.

Debris from disrupted galaxies in the Hydra~I cluster and the formation of intracluster light

Author: Magda Arnaboldi

ESO

Co-Authors: Giulia Ventimiglia (MPE) Enrica Iodice (INAF, OAC) Ortwin Gerhard (MPE) Lodovico Coccato (ESO)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *17:30 Wednesday 28th 17:00-18:30*

Summary:

The formation of intracluster light and of extended halos around brightest cluster galaxies is closely related to morphological transformation, tidal

The formation of intracluster light and of extended halos around brightest cluster galaxies is closely related to morphological transformation, tidal stripping and disruption of galaxies in the densest region of clusters. Using NIR and V band deep and wide field imaging, we discovered an off-centered extended halo around the galaxy NGC 3311, and the presence of extended tidal tails around a dwarf and an S0 galaxy in the Hydra cluster core. The

kinematics of the stars in the envelope and tails document how the strong gravitational interactions in the densest part of the cluster are efficient in stripping stars from infalling galaxies and substructures in deep radial plunging orbits. These on-going strong interactions change the morphologies of the satellite galaxies and add stars to the intracluster component at redshift 0.

Stellar population properties of outer halos of massive ellipticals

Author: Lodovico Coccato

European Southern Observatory

Co-Authors: O. Gerhard (MPE); M. Arnaboldi (ESO); G. Ventimiglia (MPE)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *17:45 Wednesday 28th 17:00-18:30*

Summary:

I will present the kinematics and stellar population properties of the stellar halos of two Brightest Cluster Galaxies (NGC 3311 and NGC 4889) from deep long-slit spectroscopic data out to several effective radii. These data support the idea that the build up of the halos of these galaxies took place on a separate phase, through accretion of smaller satellites (dwarf galaxies, minor mergers) onto a preexisting object. I will also discuss how these data : i) support the predictions of some cosmological simulations; ii) can be interpreted as the stellar population signature of the size evolution of galaxies through redshift; and iii) probe the transition region between galaxy stellar halo and intra-cluster light.

Color Gradients in Galaxies out to z~3: Dependence on Galaxy Properties

Author: Niraj Welikala

Institut d

Co-Authors: J.P.Kneib (Laboratoire d'Astrophysique de Marseille)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *18:00 Wednesday 28th 17:00-18:30*

Summary:

Using HST/ACS observations, we measure the colour gradients of 3248 galaxies in the GOODS-South field out to z~3 and i_<25.5 and characterize their dependence on galaxy properties (luminosity, apparent magnitude, galaxy size, redshift and morphological type). The colour gradient is measured by the difference of v-i colour outside (R_ < r < 2R_) and inside the half light radius. The gradient shows little evolution with redshift up to z~1 but increases from z~1 to z~2 before flattening out. It also increases with apparent magnitude, with a median value of 0.24 magnitudes at i_~25.5. It has a strong colour dependence, with the bluest galaxies (in terms of observed colour) having cores that are bluer relative to their outskirts. We probe the redshift evolution by stacking galaxies and measuring the radial variation of v-i colour within them. At low redshifts (z<0.5), the centres of galaxies (r < R_) are slightly redder than their outskirts (1.5R_ < r < 2R_). Galaxies at z~1 and -22.0 < M_I < -21.0 are bluer in their cores by 0.1 magnitudes, on average, compared to their outskirts. For z>1, galaxies show increasingly bluer cores while the colour of the outskirts does not change as rapidly. At z~2.5 and -22.0 < M_I < -21.0, we observe a difference, on average, of 0.4 magnitudes between the centre and the outskirts. The observed colour gradients may indicate that strong star formation in galaxies at z>=2 is concentrated in their central regions. These colour gradients and their dependence on galaxy properties could also have a significant impact on shear measurements in upcoming weak lensing cosmological surveys.

Probing the dark matter haloes of lensing galaxies.

Author: Ignacio FERRERAS

UCL

Co-Authors: D.Leier (Heidelberg); P.Saha (Zurich)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *18:15 Wednesday 28th 17:00-18:30*

Summary:

Strong gravitational lenses allow us to probe in detail their projected surface mass distribution. In combination with photometric data from HST and population synthesis modelling, we measure the baryon and the dark matter mass maps of a sample of lensing galaxies. In this talk, I will present recent work in collaboration with Dominik Leier (ARI-Heidelberg) and Prasenjit Saha (Zurich) on a sample of lenses at moderate redshift. The analysis extends to the concentration of the DM haloes and the effect of adiabatic contraction.

Determination of stellar population parameters from high-resolution spectral fitting

Author: David Wilkinson

ICG, University of Portsmouth

Co-Authors: C. Maraston, D. Thomas (ICG, Portsmouth)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *10:00 Thursday 29th 10:00-11:15*

Summary:

Up-to-date stellar population models for the interpretation of elliptical galaxies contain several assumptions, including the stellar libraries used to obtain the integrated spectral energy distribution. In particular, modern empirical libraries such as MILES, ELODIE, STELIB, are widely used and have been shown to affect the stellar population model. In this paper we assess the robustness of age, metallicity, etc. determinations for massive galaxy spectra against the use of these different libraries. We perform full spectral fitting of a range of galaxy spectra from the SDSS. The faintest among these galaxies well mimic the low signal-to-noise of halos of massive galaxies. We quantify the possible bias in population parameters carried by individual libraries and we suggest the wavelength range for performing the optimal analysis.

Reconciling observations and simulations of the most massive elliptical galaxies since z~1

Author: Claire Burke

LJMU

Co-Authors: C.A.Collins (LJMU) J.P.Stott (Durham)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *10:15 Thursday 29th 10:00-11:15*

Summary:

The intracluster light (ICL) is a diffuse, low surface brightness stellar component between galaxies in clusters, which may contain a large fraction of the baryonic mass of clusters. The ICL is observed in nearby clusters but it is not known how and when it formed and evolved, its evolution thought to be linked to the evolution of brightest cluster galaxies (BCGs) and their cD halos. We present the first observations of the diffuse halos of BCGs and the ICL in X-ray clusters at z~1. We use deep data from HAWK-I on the VLT to measure this low surface brightness component down to J=22 mag/arcsec^2. We find that the fraction of the total cluster light contained in the ICL is between ~1-4% at low surface brightness levels, suggesting an evolution of 2-3 times between z~1 and the present day. We also find that 20-50% of the total BCG light is contained in the surrounding halo and ICL at z~1. Recent observations of BCGs show that they are almost fully assembled in terms of their mass and scale sizes at z~1, this is contrary to cosmological simulations which predict that these objects should assemble at least half of their masses over this time. Our results show that a substantial amount of starlight stripped from galaxy-galaxy interactions is not bound to the BCG and therefore such material may not be tagged in semi-analytic models of the growth of these systems. We suggest that the inclusion of this component in simulations may allow reconciliation with the observed BCG masses and scale sizes.

Modelling the dual nature of stellar haloes

Author: Andreea Font

University of Birmingham

Co-Authors:

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *10:30 Thursday 29th 10:00-11:15*

Summary:

Recent observations indicate that the stellar haloes of nearby L_* disc galaxies have a 'dual nature', with both dissipation and accretion playing an important role. I will present results from a suite of cosmological hydro-dynamical simulations that include a representative sample of haloes of Milky Way-mass galaxies. These simulations show that in situ star formation is the dominant factor in the build-up of the inner $<20-30$~kpc of these haloes, whilst tidal disruption of satellite galaxies contributes primarily to the outer regions. The in situ stars are found to originate in an earlier disc, at redshifts $\sim 1-1.5$, and subsequently to be ejected from the disc by dynamical heating associated with later mergers. The in situ component of the halo is found to be more flattened, with a net prograde rotation and with more metal-rich populations, all in quantitative agreement with Milky Way and M31 observations. We conclude that the dual nature of the stellar haloes is entirely compatible with the Λ-CDM model.

Inside-out formation of elliptical galaxies

Author: Ludwig Oser

Max-Planck-Institute for Astrophysics

Co-Authors: T.Naab (Max-Planck-Institute for Astrophysics), J.P.Ostriker (Princeton University), P.H.Johansson (University of Helsinki)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Talk *10:45 Thursday 29th 10:00-11:15*

Summary:

We use a large sample of cosmological re-simulations of individual massive galaxies to investigate the galaxy assembly and origin of the strong increase in sizes at z=2. At the end of a rapid early phase of star-formation (6 < z < 2), where stars are created from infalling cold gas, our simulated galaxies are all compact with projected half-mass radii of ~ 1 kpc. At lower redshifts (z<2) those galaxies grow predominantly by the accretion of smaller stellar systems which deposit stars at large galactocentric radii. Driven by this process the galaxies evolve towards the observed local mass-size and mass-

systems which deposit stars at large galactocentric radii. Driven by this process the galaxies evolve towards the observed local mass-size and mass-velocity dispersion relations. We discuss the effects of this accretion mechanism on the evolution of the distribution and dynamics of dark and luminous matter at the centers and the outer halos of galaxies. In addition, we propose simulation based tests of the inside-out accretion driven growth scenario with observed photometry and dynamics at large radii.

Testing Theoretical Element Response Functions with an Empirical Stellar Spectral Library.

Author: Dr. Anne E. Sansom

University of Central Lancashire

Co-Authors:

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Poster *Poster Session A&B*

Summary:

Element abundance ratios hold important clues to understanding the evolution of stellar populations, through the varying timescales of different nucleosynthetic contributors(including SNII, SNIa, stellar winds and mass loss). Newly measured and compiled [Mg/Fe] ratios in the MILES stellar library are used to confront models of different star spectra. Such models have been used in recent years to provide estimates of differential changes in spectral line strengths of stellar populations, due to enhancements in [alpha/Fe]. This talk presents tests of the most widely used sets of theoretical element response functions. Using magnesium as a proxy for all alpha elements the reliability of these theoretical response functions are tested against empirical observations. This study probes the reliability of current methods of measuring element abundance ratios in stellar populations.

On the optical+NIR color gradients in the external regions of early-type galaxies

Author: Francesco La Barbera

INAF-OAC

Co-Authors: I. Ferreras (UCL-MSSL); R.R. de Carvalho (INPE-DAS); A. Pasquali (ARI-ZAH); E. Merlin (INAF-OAP)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Poster *Poster Session A&B*

Summary:

We stack the optical+NIR colour profiles, out to a large galactocentric distance of eight Re's, for a sample of ~1000 nearby (z~0.05), massive (M*~10^10-10^11Msun), early-type galaxies (ETGs), with grizYJHK photometry available from SDSS and UKIDSS-LAS. ETGs are split according to the environment where they reside, into field and group galaxies. Combining g-r through g-K colours allows us to constrain stellar population properties (i.e. age and metallicity) from the central regions to the outskirts of ETGs. I will present how age and metallicity profiles depend on stellar mass, environment, and galactocentric distance, providing new constraints to the formation and evolution scenario of massive galaxies.

Diagnostics of Dusty vs Non-Dusty Early-Type Galaxies

Author: Nicola Agius

University of Central Lancashire

Co-Authors: A.E.Sansom (UCLan)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Poster *Poster Session A&B*

Summary:

Early-type galaxies are known for being generally smooth, passive, red objects with no spiral arms. With the aid of recent results from Herschel-ATLAS and GAMA, a sample of 508 morphologically selected ETGs detected in the sub-mm has been created. By comparing and contrasting this sample with an optically selected sample of ETGs undetected in the sub-mm, we explore their relative properties. We examine the environmental densities of these two samples and find no significant difference in their environments. The dusty ETG data are fit with a modified Planck function, giving us specific dust masses which increase with decreasing stellar mass. Statistical testing shows that other host galaxy properties are also shown to have different distributions for the two samples.

Building the galactic halo through the evolution and dissolution of star clusters.

Author: Poul Alexander

Institute of Astronomy

Co-Authors:

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Poster *Poster Session A&B*

Summary:

An unknown portion of galactic halo stars originate in globular clusters. The evolution of such clusters therefore represents an ideal means through which we can explore their contribution to the formation and evolution of the halo, and allows us to link the halo's cosmological origins to it's current stellar kinematics and population. We have developed a computationally fast yet physically motivated code to efficiently explore the long term evolution of star clusters. We find that this code is able to reproduce N-body simulations to ~10% accuracy, over a wide range of initial conditions. Using this code, we are able to rapidly explore an extremely large parameter space expressing the distribution and nature of star cluster formation, and hence place constraints on the nature and origin of the stars that comprise the galactic halo.

Quantifying the stellar assembly in early-type galaxies using spatially-resolved spectro-photometry

Author: Sugata Kaviraj

Imperial College London and the University of Oxford

Co-Authors: R. W. O'Connell (Virginia); B. C. Whitmore (Space Telescope Science Institute); J. Silk (IAP and Johns Hopkins); M. Cappellari (Oxford); R. M. Crockett (Oxford)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Poster *Poster Session A&B*

Summary:

Traditionally considered to be old and passively-evolving, I show how recent rest-frame UV studies have demonstrated (and quantified) widespread recent star formation in early-type galaxies (ETGs). Together with the past literature these studies show that, while the bulk of the stellar mass in ETGs is old, ~20% forms after z~1, via minor mergers between ETGs and gas-rich dwarfs. While our traditional understanding of galaxy evolution is largely based on integrated spectro-photometry, I demonstrate how spatially-resolved studies, using high-resolution UV/optical imaging and integral-field spectroscopy (IFS), is a uniquely powerful tool to quantify the formation of individual ETGs. Combining new HST/WFC3 UV-optical imaging and IFS from the SAURON project, I present a case study of the ETG NGC 4150, showing (empirically) that this galaxy experienced a minor merger with mass ratio ~1:20 around ~0.9 Gyr ago, which formed 3% of its stellar mass and a young kinematically-decoupled core. A UV/optical analysis of its globular cluster system then shows that the bulk of the stars in this galaxy formed ~6-8 Gyrs in the past. I introduce a new HST/WFC3 programme (PI: Kaviraj), that will extend this spatially-resolved analysis to a representative sample of ETGs and serve as a prototype for work using the extremely large telescopes, that will routinely provide high-resolution imaging at the end of this decade.

Structure and Dynamics of Hot Stellar Systems

Author: Mark Norris

University of North Carolina at Chapel Hill

Co-Authors: Sheila J Kannappan (UNC - Chapel Hill)

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Poster *Poster Session A&B*

Summary:

I will present results from two studies: (1) Determining the dynamical mass of galaxies like S0s, where cold gas emission is weak or absent, and where neither stellar dispersion or stellar rotational support dominates has traditionally been extremely difficult. In order to produce a more reliable mass estimator for S0s we have therefore examined the relations between central stellar velocity dispersion, and the maximum rotation velocity of both stars and cold gas for more than 60 S0 galaxies drawn from the RESOLVE survey (http://resolve.astro.unc.edu/). In doing so we are determining a dynamical mass estimator for S0s which improves on standard practice. (2) The second project is an HST archival survey designed to investigate the nature and origins of massive globular clusters, ultra compact dwarfs, and compact elliptical galaxies. We are finding many of these previously understudied objects in a range of environments from the field to galaxies clusters. We find that some massive GCs/UCDs are created in periods of intense in-situ star formation, while others are created during later accretion events. We will discuss how the objects discovered to date put constraints on the two-phase build up of galaxy halos.

Automated Measurement of Interacting Galaxies in the Sloan Digital Sky Survey

Author: Alex Lockey

University of Bristol

Co-Authors:

Session: GAL2: Diving into the outer halos of elliptical galaxies: clues to galaxy formation and evolution

Presentation type: Poster *Poster Session A&B*

Summary:

We investigated an approach to quantifying the morphological effects of galactic mergers. A main sample of visually- and spectroscopically-identified merging galaxies was selected from SDSS DR4, and a control sample of galaxies corresponding to the main sample was selected by matching morphological classification, mass, luminosity and environmental density. The merging and control sample galaxies were modelled using single-Sèrsic model fits to SDSS r-band images, and the model error used to calculate a disruption value. The disruption value is found to be substantially dependent on morphological type, but to also vary between merging galaxies and control galaxies. The disruption value is shown to vary with the projected separation of interacting galaxies.

Dwarf Galaxies: Nature and Nurture

Author: Till Sawala

University of Durham

Co-Authors:

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *10:00 Friday 30th 10:00-11:15*

Summary:

Local Group dwarf galaxies present an opportunity for testing the predictions of cosmological models on small scales. At the same time, they are ideal laboratories for studying different astrophysical processes and their interplay. In a high resolution, hydrodynamical cosmological simulation of a Milky Way sized halo and its environment, we follow the formation of a large population of satellites and isolated dwarf galaxies, allowing a systematic study of the internal and environmental processes that determine their evolution. We find that 95 per cent of satellite galaxies are gas free at z= 0, and identify three mechanisms for gas loss: supernova feedback, tidal stripping and photoevaporation due to re-ionization. Gas-rich satellite galaxies are only found with total masses above ~5 × 10^9 M⊙. In contrast, for isolated dwarf galaxies, a total mass of ~10^9 M⊙ constitutes a sharp transition; less massive galaxies are predominantly gas free at z=0, more massive, isolated dwarf galaxies are often able to retain their gas. In general, we find that the total mass of a dwarf galaxy is the main factor which determines its stellar content, but that stripping may explain the observed difference in gas content between field dwarf galaxies and satellites with total masses close to 10^9 M⊙.

Survival of Satellites of a Highly Resolved Milky Way-class Halo

Author: Sam Geen

Observatoire de Lyon

Co-Authors: A.Slyz (University of Oxford) J.Devriendt (University of Oxford)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *10:20 Friday 30th 10:00-11:15*

Summary:

We use the NUT suite of simulations to explore the effect of supernova feedback, UV photoionisation and gas physics on the properties and survival of satellite galaxies of a Milky Way-sized halo with sub-parsec resolution, cosmological hydrodynamic AMR simulations using RAMSES. We find that supernova feedback up to the epoch of reionisation reduces the stellar mass of low-mass satellites but increases it in high-mass satellites. Photoionisation has limited impact on star formation above a certain halo mass at the epoch of reionisation. The inclusion of gas cooling is the most important factor in destroying satellite galaxies, enhancing dynamic stripping in the centre of the halo and dramatically reducing the survival of satellite galaxies to z=0.

Dissipative phenomena in dwarf galaxies of the Local Group and their synthetic CMD

Author: Stefano Pasetto

UCL/MSSL in London (UK) and ARI/ZAH in Heidelberg (Germany)

Co-Authors: E.K. Grebel (Astronomisches Rechen-Institut, Zentrum fur Astronomie der Universitat Heidelberg, Heidelberg, Germany); D. Kawata (University College London, Department of Space & Climate Physics, Mullard Space Science Laboratory, Holmbury St. Mary, Dorking Surrey RH5 6NT, United Kingdom); C. Chiosi (Astronomy Department, Padova University, Padova, Italy); Y. Fujita (Department of Earth and Space Science, Graduate School of Science, Osaka University, Toyonaka, Osaka, Japan); G. Bertelli (INAF - Padova Astronomical Observatory, Padova, Italy)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *10:35 Friday 30th 10:00-11:15*

Summary:

We present an analytical and numerical study of dissipative phenomena occurring during the orbital evolution of a dwarf satellite galaxy orbiting around a host galaxy. These dynamical phenomena leave signatures in the star formation activity and signatures in the colour magnitude diagram of the galaxy stellar content. We obtained a simple and qualitative description of the complicated connections existing between gas consumption processes (e.g., ram pressure, Kelvin-Helmholtz instability, Rayleigh-Taylor, tidal forces) and star formation processes in the context of the two extended-body interaction with special attention to the dwarf galaxies dynamical regime. The work is developed at UCL/MSSL in UK and at the University of Heidelberg. Simulation are performed on HLRBII & SuperMUC at Leibniz-Rechenzentrum in Germany.

Full 3D Evolution Models of Tidal Dwarf Galaxies

Author: Sylvia Ploeckinger

Institute for Astronomy, University of Vienna

Co-Authors: G. Hensler (Institute for Astronomy, University of Vienna); S. Recchi (Institute for Astronomy, University of Vienna); P. Kroupa (Argelander Institute for Astronomy, University of Bonn)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *10:50 Friday 30th 10:00-11:15*

Summary:

Summary:

Self-gravitating objects in the same mass ranges as classical dwarf galaxies are found in large tidal streams of interacting galaxies. We investigate both the dynamical and chemical evolution of "tidal dwarf galaxies" (TDGs). We place them on eccentric orbits around their interacting host galaxies to explore whether TDGs can survive longer than the tidal arm they were born in and turn into an object which can be mistaken as a regular dwarf galaxy. Given their origins, these objects should not have a substantial dark matter content to stabilize the galaxy against loss from stellar feedback and tidal disruption. We use the adaptive-mesh hydrodynamic code FLASH V3.2 to perform full 3D simulations of active star forming objects which formed out of pre-enriched disk material. Internal processes such as radiative cooling, star formation, stellar feedback (wind + SNII) and metal enrichment are as well included as an external tidal field in addition to the self-gravitating galaxy. Furthermore we discuss possible differences between survived TDGs and classical dwarf galaxies which diverge in their dark matter content and their chemical enrichment history.

Tidal dwarf galaxies in the nearby Universe: a statistical perspective

Author: Sugata Kaviraj

Imperial College London and University of Oxford

Co-Authors: J. Silk (IAP and Johns Hopkins); D. Darg (Oxford); C. Lintott (Oxford)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *11:05 Friday 30th 10:00-11:15*

Summary:

Born in the gaseous tidal debris of mergers, tidal dwarf galaxies (TDGs) offer valuable insights into the galaxy formation process and a route to testing fundamental physics. We present the largest statistical study of nearby TDGs to date, using a large, homogeneous catalogue of mergers from the SDSS. 95% of TDG-producing mergers involve two blue spirals with a mass ratio greater than 1:7. TDG stellar masses are less than 10% of the parent stellar masses. TDG colours are bluer than their parents (median [g-r] offset ~ 0.3 mag), and appear unaffected by AGN activity in the parent galaxies. An analysis of their star formation histories indicates that TDGs contain both young stars (median age ~ 30 Myr) and old stars from the parent disks, each component contributing equally to the stellar mass. Thus, TDGs are not formed purely through gas condensation in tidal tails but host a significant component of old stars from the parent disks. Finally, an analysis of the TDG contribution to the dwarf-to-massive galaxy ratio shows that only 6% of dwarfs in nearby clusters may have a tidal origin, making it unlikely that the entire dwarf population today was born in mergers over cosmic time. (Based on Kaviraj et al. 2012, MNRAS, 419, 70. URL: http://adsabs.harvard.edu/abs/2012MNRAS.419...70K)

The Sagittarius Streams in the Southern Galactic Hemisphere

Author: Sergey Koposov

Institute of Astronomy, University of Cambridge

Co-Authors: V.Belokurov (IoA, Cambridge), N.W. Evans(IoA, Cambridge)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *11:45 Friday 30th 11:45-12:45*

Summary:

The structure of the Sagittarius stream in the Southern Galactic hemisphere is analysed with the Sloan Digital Sky Survey Data Release 8. Parallel to the Sagittarius tidal track, but ~ 10deg away, there is another fainter and more metal-poor stream. We provide evidence that the two streams follow similar distance gradients but have distinct morphological properties and stellar populations. The brighter stream is broader, contains more metal-rich stars and has a richer colour-magnitude diagram with multiple turn-offs and a prominent red clump as compared to the fainter stream. Based on the structural properties and the stellar population mix, the stream configuration is similar to the Northern "bifurcation". In the region of the South Galactic Cap, there is overlapping tidal debris from the Cetus Stream, which crosses the Sagittarius stream. Using both photometric and spectroscopic data, we show that the blue straggler population belongs mainly to Sagittarius and the blue horizontal branch stars belong mainly to the Cetus stream in this confused location in the halo.

Constraining the Milky Way halo shape with cold streams

Author: Hanni Lux

University of Nottingham

Co-Authors: J.I.Read(ETH Zurich, University of Leicester); G. Lake (University of Zurich); K.V. Johnston (Columbia University)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *12:05 Friday 30th 11:45-12:45*

Summary:

Tidal streams are a powerful probe of the Milky Way halo shape. A classic example is the Sagittarius stream. Its advantages are its length and its good data quality from over a decade of observations. Its disadvantages are its thickness and complexity. Thinner tidal streams avoid these obstacles and hold a promise of simpler analysis techniques. We determine the applicability of the simple test particle orbit technique to cold streams and analyse which of the currently known streams are particularly interesting for constraining the Milky Way halo shape. In particular, we show the special constraining power of the globular cluster stream NGC 5466.

Extended star clusters: nature or nurture

Author: Mark Gieles

Institute of Astronomy

Co-Authors: J. Penarrubia (Granada) F. Renaud (Saclay)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *12:20 Friday 30th 11:45-12:45*

Summary:

A large fraction of the globular clusters in the outer halo of the Milky Way and M31 are thought to have been accreted from satellite galaxies. Recent observations of the outer parts of M31 revealed a population of low-surface brightness clusters, referred to as `extended clusters'. Their sizes and luminosities are comparable to the `faint fuzzy' clusters found in S0 galaxies, and also to some of the Galactic Palomar clusters. This contribution considers to what extent these clusters are unique and what their properties tell us about their former galactic host.

Barred Spirals on the Red Sequence: An Important Evolutionary Stepping Stone?

Author: Karen Masters

ICG, Portsmouth

Co-Authors: R.C.Nichol (ICG, Portsmouth), R. Skibba (Arizona), B. Hoyle (Barcelona), C. Lintott (Oxford), S.P. Bamford (Nottingham), E. M. Edmondson (ICG, Portsmouth), K. Schawinski (Yale), B. Simmons (Yale) and the Galaxy Zoo Team

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *12:35 Friday 30th 11:45-12:45*

Summary:

The first results from Galaxy Zoo 2 (Masters et al. 2011) show that the fraction of bars visually identified in SDSS disk galaxies is a strong function of the galaxy colour. We showed clear evidence for a colour bi-modality within disk galaxies, with a "red sequence" that is both bulge and bar dominated, and a "blue cloud" which has little, or no, evidence for a (classical) bulge or bar. The extreme of this population are the Galaxy Zoo red spirals (Masters et al. 2010) which are as red and passive as most ellipticals - and almost all have bars. These objects are more likely than other spirals to be satellites in massive halos (Skibba et al. 2009). The bar forming instability in disk galaxies is well understood, but it remains unclear why some disks have bars and others do not. Bars have a clear impact on the evolution of a disk galaxy through their ability to move gas, stars and dark matter radially. We question if the bars can be helping the cessation of star formation which creates red spirals, or if bars are simply important side effects to environmental processes which turn preferentially satellite spirals red.

Clues to Galaxy-Satellite Interactions from the M31 Subgroup

Author: Annette Ferguson

Institute for Astronomy, Edinburgh

Co-Authors:

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *14:00 Friday 30th 14:00-15:30*

Summary:

Our nearest giant neighbour, M31, hosts a substantial satellite population consisting of a myriad of globular clusters, dwarf galaxies and most probably the disc galaxy M33. M31's proximity allows an exquisite view of its satellite population and provides a unique laboratory for studying host-satellite interactions in detail. The CFHT PAndAS survey has mapped almost 400 square degrees around M31 enabling faint satellites to be traced out to distances of several hundred kpc. I will review highlights from this survey as well as complementary/follow-up space-based and spectroscopy studies, focusing on the role of the satellites in shaping the evolution of M31.

Andromeda

Author: Michelle Collins

Max Planck Institute for Astronomy

Co-Authors: R. M. Rich (UCLA), S. C. Chapman (Cambridge) and the PAndAS collaboration

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *14:20 Friday 30th 14:00-15:30*

Summary:

The rich system of dwarf spheroidal galaxies surrounding Andromeda presents an excellent opportunity for us to study these faintest and most dark matter dominated of galaxies in exquisite detail. As part of the PAndAS survey, we have studied the photometric and kinematic properties of individual stars within these objects to gain an improved understanding of them. I will present a homogenous analysis of Keck II DEIMOS spectroscopic information for 20 of the 28 Andromedean dSphs, detailing their velocity dispersions, masses and dark matter contents. I will compare these findings to those determined for the Milky Way dSph system, with particular focus on a number of Andromedean objects where the central densities of their dark matter halos are

for the Milky Way dSph system, with particular focus on a number of Andromedean objects where the central densities of their dark matter halos are surprisingly low, and I will discuss what this means in terms of the universal mass profile for dSph galaxies.

Dissolving satellites dwarf galaxies

Author: Dominik J. Bomans

Astronomical Institute of the Ruhr-University Bochum

Co-Authors: A. Miskolczi (Astronomical Institute of the Ruhr-University Bochum) B. Biskup (Astronomical Institute of the Ruhr-University Bochum) R.-J. Dettmar (Astronomical Institute of the Ruhr-University Bochum)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *14:35 Friday 30th 14:00-15:30*

Summary:

Using the imaging data of the Sloan Digital Sky Survey DR7, we searched for the remnants of recent mergers/accretions of satellite dwarf galaxies, the faint stellar halo streams. We up to now searched two input samples: a sample of 474 of edge-on galaxies and the diameter selected sample of the CALIFA IFU survey consisting of 937 galaxies. Applying the methods described in Miskolczi et al. (2011) we show that specially processed SDSS data can be used for detecting for low surface brightness structures down to 28 mag/sqarcsec in the halos of galaxies. About 30% of the surveyed galaxies show faint perturbations and stream-like features in their halos. This immediately implies that accretion of satellite dwarf galaxies are a common and ongoing process in the local universe. For streams around several galaxies we will present the mass estimates and rough star formation histories as well as the time scales of the interaction based on imaging and IFU spectroscopy.

Satellite abundances around bright isolated galaxies

Author: Wenting Wang

Max-Planck Institute for Astrophysics

Co-Authors: S. White (Max Planck Institute for Astrophysics)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *14:50 Friday 30th 14:00-15:30*

Summary:

We count SDSS/DR8 photometric galaxies around primaries selected from the SDSS/DR7 spectroscopic catalog in order to study the luminosity/stellar mass functions, the colour and size distributions, and the number density profiles of satellite galaxies. We apply the same isolation and selection criteria to galaxies in a mock survey of Guo et al. (2011), allowing a first detailed comparison of LCDM predictions to the systematic properties of the observed satellite/primary populations. In both SDSS and model, red primaries have more satellites than blue ones of the same stellar mass. This is because red primaries are hosted by more massive dark matter halos. In the model, luminosity/stellar mass functions of satellite galaxies have similar faint end slopes to the field, but in the SDSS they are steeper around faint primaries, particularly the stellar mass function. To a good approximation, the number of satellites increases in direct proportion to halo mass. Both in the SDSS and in the model, more massive primaries have redder satellites, and at given mass red primaries have redder satellites. This is because satellites of red primaries are accreted earlier and orbit through a denser hot gas atmosphere and thus are preferentially reddened. The satellite radial number density profile parallels that of the dark matter, both in the SDSS and in the model. At given primary luminosity, the satellite density profile depends neither on satellite luminosity nor on stellar mass, but it does depend on satellite colour, with red satellites more abundant in the central regions.

Satellite Galaxy Number Density Profiles in the Sloan Digital Sky Survey

Author: Quan Guo

Durham University

Co-Authors: Vincent Eke(Durham University), Shaun Cole(Durham University),Carlos Frenk(Durham University)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *15:05 Friday 30th 14:00-15:30*

Summary:

We study the spatial distribution of satellite galaxies around isolated primaries using the Sloan Digital Sky Survey (SDSS) spectroscopic and photometric galaxy catalogues. We select isolated primaries from the spectroscopic sample and search for potential satellites in the much deeper photometric sample. For specific luminosity primaries we obtain robust statistical results by stacking as many as ~ 50, 000 galaxy systems. We derive accurate projected number density profiles of satellites down to 4 magnitudes fainter than their primaries. We find the normalized satellite profiles generally have a universal form and can be well fitted by projected NFW profiles. The NFW concentration parameter increases with decreasing satellite luminosity while being independent of the luminosity of the primary except for very bright primaries. The profiles of the faintest satellites show deviations from the NFW form with an excess at small galactocentric projected distances. In addition, we quantify how the radial distribution of satellites depends on the colour of the satellites and the colour and concentration of their primaries.

The carbon star phase in the Sagittarius Dwarf Spheroidal

Author: Iain McDonald

University of Manchester

Co-Authors: J.R.White (University of Manchester) A.A.Zijlstra (University of Manchester) J.Th.van Loon (Keele University) G.C.Sloan (Cornell University) E.Lagadec (ESO)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *00:00 Poster Session B*

Summary:

Carbon stars are an important source in the enrichment of heavy elements in galaxies. They help control the balance of carbon and oxygen in the interstellar medium and subsequent generations of stars, as well as changing the observed properties (colours, spectrum) of their host galaxies. Whether a star becomes carbon rich depends on its mass and metallicity, thus a galaxy's C/O ratio changes with time. We have recently carried out a spectral survey of over 1000 stars in the Sgr dSph, whose population is close to the limit of carbon star production. I will discuss the carbon star population and its impact on the galaxy, and present the Sgr dSph in context with other local dwarf galaxies.

The Structure of the Sagittarius Stellar Stream as Traced by Blue Horizontal Branch Stars

Author: Christine Ruhland

University of Hertfordshire

Co-Authors: E. F. Bell (University of Michigan); H.-W. Rix (Max Planck Institute for Astronomy); X.-X. Xue (Max Planck Institute for Astronomy)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Poster *Poster Session B*

Summary:

We use a sample of blue horizontal branch (BHB) stars from the Sloan Digital Sky Survey Data Release 7 to explore the structure of the tidal tails from the Sagittarius Dwarf Galaxy. We use a method yielding BHB star candidates with up to ~70% purity from photometry alone. The resulting sample has a distance precision of roughly 5% and can probe distances in excess of 100 kpc. Using this sample, we identify a possible extension to the trailing arm at distances of 60-80 kpc from the Sun with an estimated significance of at least 3.8σ. Current models predict that a distant "returning" segment of the debris stream should exist, but place it substantially closer to the Sun where no debris is observed in our data. Exploiting the distance precision of our tracers, we estimate the mean line-of-sight thickness of the leading arm to be ~3 kpc, and show that the two "bifurcated" branches of the debris stream differ by only 1-2 kpc in distance. With a spectroscopic very pure BHB star subsample, we estimate the velocity dispersion in the leading arm, 37 km s-1, which is in reasonable agreement with models of Sgr disruption.

On the star formation history of IKN dSph

Author: Tudorica Alexandru

Argelander Institute for Astronomy

Co-Authors: Iskren Georgiev (Argelander Institute for Astronomy); Ana Chies Santos (Nottingham University)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Poster *Poster Session B*

Summary:

I will present an optical-NIR photometric investigation of the age and metallicity of globular clusters in the ultra-faint IKN dwarf spheroidal galaxy in the M81 group. Age and metallicity distributions of GCs in a galaxy can provide valuable information about the physical conditions of major starburst episodes during which these GCs were formed. With the highly sensitive to age and metallicity VIKs color indices we find a large spread in age (1-15Gyr) and metallicity (-1.6

Kinematic analysis of the M31 halo globular clusters

Author: Jovan Veljanoski

Institute for Astronomy, University of Edinburgh

Co-Authors: A.M.N. Ferguson (Institute for Astronomy, University of Edinburgh); D.A.Mackey (Research School of Astronomy & Astrophysics, Australian National Observatory, Mt. Stromlo Observatory); M.J.Irwin (Institute of Astronomy, University of Cambridge); A.P.Huxor (Astronomisches Rechen-Institut, Zentrum fur Astronomie der Universit¨at Heidelberg);

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Poster *Poster Session B*

Summary:

The halo of M31 hosts nearly 90 globular clusters. Using low resolution spectra, we present kinematic and chemical analysis for a significant sample of these objects. Many of the M31 outer halo globular clusters lie along stellar streams, suggesting that they have been accreted along with their host dwarf galaxies. We discuss evidence for this via velocity and metallicity correlations of globular clusters which lie along particular debris features.

The nature of stars in the nucleus of M32

Author: Olivia Jones

JBCA, University of Manchester

Co-Authors: C. Kemper (ASIAA, Taiwan) M. Rich (UCLA)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Poster *Poster Session B*

Summary:

We investigate the infrared properties of cool, evolved stars in the local group dwarf elliptical galaxy M32 (NGC 221), using IRAC observations from the Spitzer Space Telescope. Our images resolve the dust-producing asymptotic giant branch population of M32 at 8 microns. These objects are highly enshrouded and have no apparent counterparts in the 1 micron WFPC2 HST images. Using IRAC colour information we can determine the nature of these dusty sources and through the comparisons of the 8 micron luminosity function with globular clusters the number of oxygen rich and carbon rich sources can be estimated giving clues to the global dust injection rate and the life cycle of matter on a galaxy wide scale. Here, we describe the program and present some first results.

Structure of the Intermediate and High Velocity Clouds towards the LMC and SMC

Author: Jonathan Smoker

European Southern Observatory, Chile

Co-Authors: A.J. Fox STSci F.P. Keenan Queen's University Belfast

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Poster *Poster Session B*

Summary:

We present interstellar absorption-line spectroscopy of early-type stars in CaK and NaD towards the Large and Small Magellanic Clouds to investigate the large- and small-scale structure in foreground Intermediate and High Velocity Clouds (IHVCs). The data include FLAMES-GIRAFFE observations of 403 stars in four open clusters plus FEROS spectra of 52 in the LMC and 8 in the SMC. From the FLAMES data we find that, within a 0.5 degree field-of-view, the CaII K equivalent width in the IHVC components varies by factors exceeding 10. A number of lines-of-sight toward NGC 1761 and NGC 2004 in the LMC show velocity structure in the IHVC gas, indicating multiple clouds are present along each sightline, possible fragmentation of the clouds, or a two-phase medium. There are detections of molecular gas in LMC absorption towards a handful of sightlines, although no molecular detections are made in either IHVC or Galactic gas. From the FEROS data we find CaII K IHVC absorption in around 60 per cent of sightlines. No NaI D is found at non-Magellanic HVC velocities aside from a tentative detection towards the star LHA 120-S 93. The lower limits on the CaII/NaI ratio in IHVCs are large, with a maximum value exceeding +1.5 dex, illustrating the Routly-Spitzer effect. In four sightlines with previous OI measurements,we find CaII/OI ratios in the LMC gas ranging from 0.23 to 1.3 dex below the solar value, indicating either dust or ionisation effects. Both CaII and HI data are available for three sightlines, with HVCs showing (a) similar CaII/HI ratios to the general IHVC population,and (b) identical CaII and HI velocities (within the errors), implying that at least in these sightlines the two elements form part of the same structure.

Towards a complete stellar mass function of the Hyades with PanSTARRS1

Author: Bertrand Goldman

MPIA

Co-Authors: S.Roeser(ARI); E. Schilbach (ARI); E.A. Magnier (IfA); C. Olczak (ARI,MPIA,NAOC/CAS); T. Henning (MPIA); M. Juric (CfA); and the PanSTARRS1 Science Consortium

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *00:00 Poster Session B*

Summary:

The Hyades cluster is an ideal target to study the dynamical evolution of a star cluster over the entire mass range due to its intermediate age and proximity to the Sun. We want to extend the Hyades mass function towards lower masses down to 0.1M_sol and to use the full three-dimensional spatial information to characterize the dynamical evolution of the cluster. We perform a kinematic and photometric selection using the PPMXL and Pan-STARRS1 sky surveys, to search for cluster members up to 30 pc from the cluster centre. We determine our detection efficiency and field star contamination rate to derive the cluster luminosity and mass functions down to masses of 0.1 M_sol. A minimum spanning tree algorithm was used to quantify the mass segregation. We discover more than 50 new Hyades member candidates with mass estimates between 0.48 and 0.085 M_sol, and double the number of low-mass member candidates. The cluster is significantly mass segregated. The extension of the mass function towards lower masses provided an even clearer signature than estimated before.

Scaling relation of dwarf galaxies in the core of Coma cluster

Author: Habib Khosroshahi

IPM

Co-Authors: E. Kourkchi (IPM); Habib Khosroshahi (IPM); D Carter (ARI); B. Mobasher (UCR)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Poster *Poster Session B*

Summary:

Rich environment of Coma galaxy cluster offers a unique environment to study many galaxy properties including dwarf galaxy scaling relations, such as the Fundamental Plane (FP) and Photometric Plane. We present a study of scaling relations for a large sample of dwarf galaxies in the core of Coma cluster down to -15 mag, for the first time, taking advantage of high resolution DEIMOS spectrograph on Keck II for measuring the internal velocity dispersion of galaxies and high resolution imaging of HST/ACS, which allows an accurate surface brightness modeling. We find that the faint end galaxies in the sample show significantly higher velocity dispersion, for their optical luminosity, than expected from their more luminous counterparts thus resulting in a higher M/L. We also find that, the scatter about the FP depends on the faint-end luminosity cutoff, such that the scatter increases for fainter galaxies. The residual from the FP correlates with the galaxy colour, with bluer galaxies showing larger residuals from FP. We find that less massive dwarf ellipticals are bluer than their brighter counterparts, possibly indicating ongoing star formation activity. Although tidal encounters and harassment can play a part in removing stars and dark matter from the galaxy, we believe that the dominant effect will be the stellar wind associated with the star formation, which will remove material from the galaxy resulting in larger M/L ratios. We attribute the deviation of a number of faint blue dwarfs from the FP of brighter ellipticals to this effect. We explore the scatter around the Photometric Plane of the sample galaxies and show that, compared to the FP, the scatter about the photometric plane is smaller at the faint end.

The mass function of dwarf galaxies: Going beyond the Local Group with gravitational lensing

Author: John McKean

ASTRON

Co-Authors: S. Vegetti (MIT); D. J. Lagattuta (Uni. Melbourne); M. W. Auger (Uni. Cambridge); C. D. Fassnacht (Uni. California, Davis); L. V. E. Koopmans (Uni. Groningen)

Session: GAL3: The nature of satellite and dwarf galaxies

Presentation type: Talk *00:00 Poster Session B*

Summary:

Gravitational lensing provides an opportunity to measure the mass-fraction and the mass-function of low-mass substructure in massive galaxies well beyond the Local Group. I will review the gravitational lensing method of detecting substructures, which is independent of whether the substructure is luminous or not, from lensed quasar flux-ratio and astrometric anomalies. I will present new results from the ongoing SHARP project, which aims to image lensed quasar systems to search for luminous and dark substructures by searching for surface brightness anomalies in extended lensed images. The first major result from this survey is the detection of a low mass (2 x 10^8 M_sol) dark dwarf galaxy that is a companion of a massive early-type galaxy at redshift 0.881. I will also present the first constraints on the substructure mass-function for massive elliptical galaxies beyond the Local Group by combining this result with a previous detection.

1-minute poster presentations: Pitkin, Santiago-Prieto, Macarthur and Sorazu

Author: GW1 Poster Summaries:

Co-Authors:

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:00 Wednesday 28th 10:00-11:15*

Summary:

1-Minute poster presentations: Pitkin, Santiago-Prieto, Macarthur and Sorazu

GW detection across frequencies: Current status, challenges, and future opportunities

Author: Dr. Harald Lück

Albert Einstein Institute Hannover

Co-Authors:

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:04 Wednesday 28th 10:00-11:15*

Summary:

A large diversity of known astronomical sources generates gravitational waves in a wide frequency band reaching from nano-Hertz to about 10 kHz. A similar diversity in methods is required for their detection and has been pursued over the last decades. The first generation of interferometric ground based GW detectors have been operating in extended, word-wide, joint data taking runs and are now being upgraded to the second, 'advanced' generation and new 'advanced' detectors are being built. Their design sensitivity will allow detecting tens of events per years at the predicted strength and estimated population of astrophysical sources. Routine precision GW astronomy will require yet another step in sensitivity and frequency range, which the next generation of GW observatories, the ground based third generation and space based instruments will be able to accomplish. Pulsar timing methods covering the low frequency end have been pushed to unprecedented sensitivites and promise reaching 'detection sensitivities' soon. This presentation will give an overview of past achievements, challenges that lie ahead and prospects of future instruments paving the road to GW astronomy.

An update on the installation of monolithic fused silica suspension elements in Advanced LIGO

Author: Angus S Bell

University of Glasgow

Co-Authors: M A Barton (LIGO Hanford), N Beveridge (Glasgow University), B Bland(LIGO Hanford), D Cook (LIGO Hanford), A Cumming (Glasgow University), L Cunningham (Glasgow University), M Evans (MIT), G D Hammond (Glasgow University), G Harry , K Haughian (Glasgow University), A Heptonstall (Caltech), J Hough (Glasgow University), R Jones (Glasgow University), J Kissel (MIT), R Kumar (Glasgow University), R Mittleman (MIT), G Moreno (LIGO Hanford), J Oberling (LIGO Hanford), N Robertson (Caltech), J Romie (LIGO Livingston), S Rowan (Glasgow University), T Sadecki (LIGO Hanford), D Sellers (LIGO Livingston), B Shapiro (MIT), K A Strain (Glasgow University), K Tokmakov (Strathclyde University), C Torrie (Caltech), G Traylor (LIGO Livingston), A A van Veggel (Glasgow University), S Waldman (MIT)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:28 Wednesday 28th 10:00-11:15*

Summary:

Interferometric gravitational wave detectors have been operational for over 10 years, placing interesting upper bounds on the gravitational emission of many sources. Work is currently underway on upgrading both the US LIGO, and French-Italian,Virgo instruments. This should increase detector sensitivity by approximately a factor of 10 and also increase the detection bandwidth. It is expected that these upgrades will increase detection rates to the point where the most likely rate of detections is predicted to be around a few per 10's per month. In this talk we shall describe the monolithic fused silica suspensions that will support the test mirrors in the Advanced LIGO instruments, and give an update on the progress of their installation in Advanced LIGO. This forms one of a number of key improvements that are required to reduce the instrumental noise by a factor of ten over the current instrument.

Reducing coating thermal noise in gravitational wave detectors

Author: Dr Iain Martin

University of Glasgow

Co-Authors: I. W. Martin, M. Abernathy, K. Evans, J. Hough, I. MacLaren, P. Murray, S. Reid, S. Rowan (University of Glasgow); R. Nawrodt, C. Schwarz (University of Jena); R. Bassiri, M. M. Fejer, R. Route (Stanford University); A. Gretarsson (Embry-Riddle Aeronautical University); G. M. Harry (American University); S. Penn (Hobart and William Smith College)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:40 Wednesday 28th 10:00-11:15*

Summary:

Thermal noise associated with the mechanical dissipation of the ion-beam sputtered mirror coatings is expected to limit the sensitivity of the next generations of gravitational wave detectors at their most sensitive frequencies. Here we present an overview of our research aimed at the reduction of coating thermal noise in both room-temperature and cryogenically-cooled detectors. Understanding the dissipation mechanisms in tantala and thus identifying methods of further reducing the level of dissipation is a key area of research, and we have recently identified the first correlations between the dissipation and the atomic structure of tantala coatings. Tantala may not be the most suitable coating material for at cryogenic temperatures due to the presence of several low-temperature peaks in the dissipation. Our initial studies of hafnia and amorphous silicon suggest that these materials may be promising alternatives to tantala. Amorphous silicon coatings are of particular interest for use in possible future detectors utilising silicon optics and operating at a wavelength of 1550 nm, and may also be of interest for use at room temperature. One proposed scheme to provide suitable reflectivity without optical coatings involves the use of nano-structured waveguide mirrors. Initial measurements of the mechanical dissipation of nano-structured surfaces will be presented.

Interferometry with higher order spatial modes for future gravitational wave detectors

Author: Bryan Barr

University of Glasgow

Co-Authors: B. Sorazu (University of Glasgow), P. Fulda (University of Birmingham), A. Bell (University of Glasgow), J. Macarthur (University of Glasgow), C. Bond (University of Birmingham), L. Carbone (University of Birmingham), A. Freise (University of Birmingham), S. Hild (University of Glasgow), S. Huttner (University of Glasgow), K. Strain (University of Glasgow)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:52 Wednesday 28th 10:00-11:15*

Summary:

Higher-order Laguerre-Gauss mode beams are currently being considered for implementation on future gravitational wave interferometers. These beams are expected to reduce the impact of mirror thermal noise (both mirror coating and substrate Brownian noise) on detector sensitivity compared to the fundamental transverse electromagnetic mode beams used in current instruments. This method of reducing thermal noise has the advantage of improving performance with minimal changes to the infrastructure of existing detectors. With these goals in mind a series of experiments was carried out at the Glasgow 10m prototype interferometer facility, in collaboration with colleagues from Birmingham, to investigate the practical use of LG beams in a fully suspended prototype environment. We present the results of these investigations including the effects of mode-degeneracy, comparison with theoretical simulations and the implications for this technology with regard to use in future gravitational wave detector systems.

A Synthetic Gravitational Wave Aperture at 30GHz

Author: lucio piccirillo

university of manchester

Co-Authors: G. Pisano (University of Manchester), M. Cruise (University of Birmingham)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *11:04 Wednesday 28th 10:00-11:15*

Summary:

Gravitational Wave emission from Black Hole encounters in higher dimensional gravity theories can be at very high frequencies (above 1MHz) and detectors are being designed to operate at GHz and Optical frequencies using the well documented process of graviton to photon conversion in a static magnetic field. A collaboration between Birmingham University and Jodrell Bank Centre for Astrophysics is planning a synthetic aperture detector at 30GHz to search for emission from the Galactic Centre and perform an all sky search for other sources. This contribution describes the design concept, preliminary architecture and predicted sensitivity of this instrument.

1-Minute poster presentations: Adams, Vousden, Erickson, Puerrer, Wallis

Author: GW1 Poster Summaries

Co-Authors:

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *11:45 Wednesday 28th 11:45-13:15*

Summary:

1-Minute presentations by Adams, Vousden, Erickson, Puerrer, Wallis

Transient Gravitational-Wave Astronomy in 2015-2020: Challenges and Opportunities

Author: Patrick Sutton

Cardiff University

Co-Authors: for the LIGO Scientific Collaboration and the Virgo Collaboration

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *11:50 Wednesday 28th 11:45-13:15*

Summary:

A new generation of "advanced" gravitational-wave detectors is under construction and expected to begin scientific operations c.2015. These instruments will be sensitive to the inspiral and merger of neutron-star and black-hole binaries to redshifts of 0.1-0.4, with expected detection rates of at least several per year. They will also search for emissions from other cataclysmic events such as gamma-ray bursts, core-collapse supernovae, and soft-gamma repeater giant flares. I will discuss the challenges and opportunities presented by the onset of the advanced interferometric detector era, with emphasis on opportunities for joint observations with traditional astronomical instruments.

Electromagnetic Follow Up Observations of Gravitational Wave Candidates

Author: Darren White

University of Sheffield

Co-Authors: On behalf of the LIGO Scientific Collaboration and the Virgo Collaboration

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *12:14 Wednesday 28th 11:45-13:15*

Summary:

During the most recent joint science run of the LIGO, Virgo and GEO detectors, the LIGO and Virgo collaborations joined with several partners to carry out a follow up observing program. A low-latency search for gravitational wave transients selected interesting event candidates and estimated apparent source positions in the sky. Alerts were sent promptly to several telescopes observing in optical, X-ray and radio wavelengths to attempt to detect accompanying EM transients. This talk describes the methods used to select, observe and analyse the GW and EM data taken during this run, and the implications for the Advanced LIGO/Advanced Virgo era.

Inferring Core-Collapse Supernova Physics with Gravitational Waves

Author: Joshua Logue

University of Glasgow

Co-Authors: C.D.Ott (LIGO Laboratory, California Institute of Technology);I.S.Heng (University of Glasgow);P. Kalmus (LIGO Laboratory, California Institute of Technology); J.H.C.Scargill (LIGO Laboratory, California Institute of Technology)

Session: GW1: Dawn of Gravitational Astronomy

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *12:26 Wednesday 28th 11:45-13:15*

Summary:

Stellar collapse and the subsequent development of a core-collapse supernova explosion emit bursts of gravitational waves (GWs) that will be potentially observable by the advanced generation of laser interferometer gravitational-wave observatories. GW bursts from core-collapse supernovae encode information on the intricate multi-dimensional dynamics at work at the core of a dying massive star and may provide direct evidence for the yet uncertain mechanism driving supernovae in massive stars. Motivated by this, we describe a promising method for determining the most likely explosion mechanism underlying a hypothetical GW signal, based on Principal Component Analysis and Bayesian model selection.

Neutron star oscillations from starquakes

Author: Lucy Keer

University of Southampton

Co-Authors:

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *12:38 Wednesday 28th 11:45-13:15*

Summary:

Glitches - sudden increases in spin rate - are observed in many pulsars. One mechanism that has been proposed to account for these is the starquake model, in which glitches are triggered by a loss of strain in the solid crust of the star. Starquakes can be expected to excite some of the oscillation modes of the neutron star, which means that they are of interest as a source of gravitational waves. We describe a model that we are developing to calculate the change in the properties of the star during a starquake, in order to work out how the star oscillates after the glitch.

Modelling of precessing waveforms

Author: Patricia Schmidt

Cardiff University

Co-Authors: Mark Hannam

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *12:50 Wednesday 28th 11:45-13:15*

Summary:

We have developed a simple method to track the precession of a generic binary black hole system, using only information from the gravitational-wave signal. We have now applied this method to further configurations as well as to post-Newtonian waveforms. Long hybrid waveforms between post-Newtonian and Numerical Relativity waveforms in this particular frame allow us to calculate mismatches between these "quadrupole-aligned" waveforms and non-precessing waveforms. We use the results of these mismatch calculations to propose a procedure to construct phenomenological models of generic processing-binary waveform.

Sky localisation of coalescing binaries from gravitational-wave data using Bayesian methods

Author: Ben Aylott

University of Birmingham

Co-Authors: T.Sidery (Birmingham), B. E. Aylott (Birmingham), B.Farr (Northwestern), W.Farr (Northwestern), F.Feroz (Cambridge), J.Gair (Cambridge), P.Graff (Cambridge), V.Kalogera (Northwestern), N.Christensen (Carlton) , I.Mandel (Birmingham), M.Pitkin (Glasgow), L.Price (Caltech), V.Raymond (Northwestern), C.Roever (AEI Hannover), M.Sluys (Nijmegen), A.Vecchio (Birmingham), J.Veitch (NIKHEF)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *13:02 Wednesday 28th 11:45-13:15*

Summary:

When the next generation of gravitational-wave interferometers come online we expect to follow up detections of coalescing compact binaries with electromagnetic observations. Accurate sky locations will be needed to help point these follow up searches. We have developed a number of codes based on Bayesian analysis that search for the parameters of a source, including its sky position.Here we present the first systematic comparison of the performance of the different algorithms. In particular we investigate the trade off between a potentially greater positional accuracy in these fully coherent codes and the faster algorithms that rely on timing triangulation alone.

1-Minute poster presentations: Ohme and Downing

Author: GW1 Poster Summaries

Co-Authors:

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *17:00 Wednesday 28th 17:00-18:15*

Summary:

1-Minute presentations by Ohme and Downing

Gravitational wave detection using pulsar timing arrays

Author: David Champion

Max-Planck-Institut für Radioastronomie

Co-Authors: EPTA collaboration

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *17:02 Wednesday 28th 17:00-18:15*

Summary:

The technique of pulsar timing uses extremely accurate measurements of pulse arrival times to construct timing models that account for every rotation over years to decades. Any effect that could cause a delay or advance in these arrival times, can therefore be uncovered. In recent years this technique has been further developed with a view to detecting ultra-low frequency (10E-9 to 10E-8 Hz) gravitational waves. Particularly, the quadrupolar correlation between the timing of various pulsars, as induced by the gravitational waves, is predicted to be detectable in the near future. Coordinated international efforts, in particular in Europe with the European Pulsar Timing Array (EPTA) and Large European Array for Pulsars (LEAP) are on the way. In this talk, we will clarify this detection technique; the current status of the projects worldwide; and future prospects for detection and gravitational wave science.

Measuring the evolution of super-massive black hole binaries with pulsar timing arrays

Author: Chiara Mingarelli

University of Birmingham

Co-Authors: K. Grover, T. Sidery, R.J.E. Smith, A. Vecchio (University of Birmingham)(all)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *17:26 Wednesday 28th 17:00-18:15*

Summary:

The observation of ultra-stable radio pulsars in a Pulsar Timing Array (PTA) is a prime astronomical tool to observe gravitational waves from super-massive black hole binary systems. We discuss the sensitivity of present and future PTA observations to post-Newtonian contributions (including spin-orbit effects) to the orbital evolution of individually resolvable sources.

The new Gravitational Wave Space Mission NGO

Author: Bernard Schutz

Albert Einstein Institute

Co-Authors:

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *17:38 Wednesday 28th 17:00-18:15*

Summary:

In the last year, since NASA withdrew its cooperation on the next large mission, a team of european scientists has developed a new proposal for a gravitational wave mission that can fit within European resources. Using for the first time a contribution from member states, and making the most efficient re-use of components of the LISA Pathfinder mission (due for launch 2014), the design of the New Gravitational Observatory is capable of returning very exciting science. The mission would expect to detect several mergers of massive black holes out to redshift 3, dozens of mergers of smaller black holes during the structure-building phase out to z=15, dozens of captures of small black holes by massive ones in nearby galaxies, and thousands of binary white dwarf systems in our Galaxy. These observations will lead to ultra-precise measurements of the parameters of black holes, rigourous tests of strong-field general relativity, and new insight into the evolution of binary systems and central star clusters.

Secular evolution of supermassive binary black holes: between dynamical friction and GWs

Author: Constanze Roedig

Albert Einstein Institute for gravitational physics, Potsdam

Co-Authors: A. Sesana (Albert Einstein Institute, Potsdam); M. Dotti (Universita Milano Bicocca); J. Cuadra (Pontificia Universidad Catolica de Chile, Santiago); M. Colpi (Universita Milano Bicocca)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *17:50 Wednesday 28th 17:00-18:15*

Summary:

Summary:

I will outline the eccentricity and semi-major axis evolution of sub-parsec massive black hole binaries (MBHBs) forming in galaxy mergers. In both stellar and gaseous environments, MBHBs are expected to grow large orbital eccentricities before they enter the gravitational wave (GW) observational domain. I re--visit the predicted eccentricities detectable by space based laser interferometers (as the proposed ELISA/NGO) for both environments. Close to coalescence, many MBHBs will still maintain detectable eccentricities, spanning a broad range from <10^ up to <~ 0.5. Stellar and gas driven dynamics lead to distinct distributions, with the latter favoring larger eccentricities. At larger binary separations, when emitted GWs will be observed by pulsar timing arrays (PTAs), the expected eccentricities are usually quite large, in the range 0.01-0.7, which poses an important issue for signal modelling and detection algorithms. In this window, large eccentricities also have implications on proposed electromagnetic counterparts to the GW signal, which I will briefly review.

Automation of the ROTSE Image Pipeline for Rapid Identification of EM counterparts to GW triggers

Author: Laura Nuttall

Cardiff University

Co-Authors: This talk will be: Laura Nuttall for the LIGO Scientific Collaboration and Virgo Collaboration and the ROTSE Collaboration

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *18:02 Wednesday 28th 17:00-18:15*

Summary:

During the last science run by LIGO and Virgo, the ROTSE-III telescope system participated in a program whereby a number of optical telescopes responded to gravitational wave (GW) triggers. Consisting of four optical telescopes, ROTSE-III took over 700 follow-up images as a result of 5 GW triggers. The image processing pipeline used by the ROTSE collaboration has been automated to allow large scale processing. These alterations are essential to quantify the false alarm rate which in turn will be vital in adding confidence to a GW detection. We describe the alterations made to the pipeline as well as the results of some ‘background’ images taken from the ROTSE archives to estimate the rate of optical transients in ROTSE images.

Astrophysics with gravitational waves: reconstructing the massive black hole assembly with eLISA/NGO

Author: Alberto Sesana

AEI Potsdam, Germany

Co-Authors: J. gair (Cambridge); M. Volonteri (IAP, Paris); E. Berti (University of Mississippi)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *18:14 Wednesday 28th 17:00-18:15*

Summary:

NGO will be a milestone of our understanding of the formation and evolution along the cosmic history of massive black holes residing in the center of galaxies. NGO will explore almost all the mass-redshift parameter space relevant for reconstructing their cosmic build-up. The gravitational wave signal from coalescing black holes reveals their spin and redshifted mass, and the collective distributions of masses and spins of detected binaries will provide invaluable hints for discriminating among several possible formation and accretion scenarios. I will describe in details NGO observations of massive black hole binaries highlighting prospects for constraining their cosmic history through gravitational wave astronomy.

The status of galactic neutron star searches using gravitational waves

Author: Matthew Pitkin

University of Glasgow

Co-Authors: The LIGO Scientific Collaboration; The Virgo Collaboration

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:00 Poster Session A*

Summary:

Rotating neutron stars are expected to be weak emitters of quasi-monochromatic gravitational waves. Data from the initial generation of interferometric gravitational wave detectors, LIGO and Virgo, have been used to search for such sources. We present a status report on these, including searches for specific targets, such as known pulsars and supernova remnants, and blind all-sky searches for unknown sources. We will also examine the prospects for future searches using the Advanced LIGO and Virgo detectors.

Optical rigidity concepts at the Glasgow 10m prototype interferometer

Author: John Macarthur

University of Glasgow

Co-Authors: J. Macarthur (University of Glasgow), B.W. Barr (University of Glasgow), M.P. Edgar (University of Glasgow), S. Hild (University of Glasgow), S. Huttner (University of Glasgow), B. Sorazu (University of Glasgow) and K. A. Strain (University of Glasgow)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:01 Poster Session A*

Summary:

Ground based gravitational wave detectors are currently undergoing a major upgrade expected to improve sensitivity in their detection band by a factor of 10. As a result quantum noise, made of shot noise and radiation pressure noise, will become the dominant noise source across most of the frequency band. The obvious improvement consists of increasing laser power to reduce shot noise at high frequency, which in turn inescapably gives rise to a larger radiation pressure effect at low frequency. However, using innovative interferometer topologies, this effect can be used to our advantage by creating coupling of the cavity mirrors via the pendulum restoring force to the radiation pressure force, also known as the Optical Spring effect. This and other optical rigidity schemes can significantly surpass the Standard quantum limit and are going to become vital for future gravitational wave detectors. We will give an overview on the experimental testing of optical rigidity concepts at the Glasgow 10m prototype interferometer.

Status of the ground based interferometric gravitational wave detector GEO 600

Author: Borja Sorazu

University of Glasgow

Co-Authors: GEO team.

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:02 Poster Session A*

Summary:

GEO 600 is the German-British contribution to the first world network of ground based, large scale, interferometric gravitational wave detectors in operation during the last decade. In 2009 this detector initiated an upgrade program, called GEO-HF, which targeted an improvement of around one order of magnitude in its measurement sensitivity at the high frequencies where the limiting factor is photon shot-noise. We present a review of the current status of this upgrade, focusing on the main techniques being implemented; homodyne readout and output mode cleaner (OMC) installation, transition to tuned signal recycling, laser power increase and injection of squeeze vacuum states. We also report on our efforts on detector commissioning and characterisation.

Transient gravitational waves at r-mode frequencies associated with pulsar glitches

Author: Ignacio Santiago-Prieto

University of Glasgow

Co-Authors: Ik Siong Heng (University of Glasgow); D.I. Jones (University of Southampton); James Clark (University of Massachusetts, Amherst)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *10:03 Poster Session A*

Summary:

Pulsar glitches can cause oscillations in the fluid interior of the pulsar which lead to gravitational wave emissions at the r-modes frequencies of the neutron star. The emitted gravitational waves can have long damping time scales, ranging from minutes to days. We estimate the strength of the emitted gravitational waves from potential sources and demonstrate their detectability for future detectors through simulated data, using parameters derived from radio and X-ray observations.

Searching for Gravitational waves associated with Gamma-ray bursts

Author: Thomas Adams

Cardiff University

Co-Authors: Thomas Adams for the LIGO collaboration and VIRGO collaboration

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *11:45 Poster Session A*

Summary:

Gravitational waves (GWs) are oscillations in the gravitational field which propagate at the speed of light and are emitted by accelerated masses. Gamma-ray bursts (GRBs) are intense flashes of gamma rays which can be grouped into two classes by their duration and spectral hardness. The progenitors for short-hard GRBs (duration < 2s) are thought to be neutron star binaries or neutron star black hole binaries, while long-soft GRBs (duration > 2s) are associated with core-collapse supernovae. These objects are compact, asymmetric, relativistic and emit large amounts of energy in a short period of time which makes them likely sources for GWs. Using data from the LIGO, VIRGO and GEO detectors an unmodelled "burst" search for GWs associated with GRBs observed by the SWIFT, FERMI and IPN satellites was performed. We give the status of this search and look at prospective searches for the advanced detector era.

Optimal use of astrophysical priors for electromagnetic follow-ups of gravitational wave candidates

Author: Will Vousden

University of Birmingham

University of Birmingham

Co-Authors: I. Mandel (University of Birmingham)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *11:46 Poster Session A*

Summary:

Current methods for locating EM counterparts to GW events generated by neutron star binary mergers rely on several optimistic assumptions regarding their distribution and genesis. However, due to the rarity of detectable GW events that will yield observable counterparts, it is important that the preciseness of sky location priors is commensurate with our confidence in their correctness. I will present an analysis of the effects on EM follow-up success rates of the choice of astrophysical priors, tested against simulated distributions of candidate events under a range of corresponding astrophysical models. It is expected that successful follow-ups will deliver rich insight into the underlying astrophysics of compact binary mergers.

A conservation law formulation of nonlinear elasticity in relativity for NS crust shattering

Author: Stephanie J. Erickson

University of Southampton

Co-Authors: C. Gundlach (University of Southampton); I. Hawke (University of Southampton)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *11:47 Poster Session A*

Summary:

Tidal shattering of neutron star crusts is expected to play a role in the dynamics of binary neutron star mergers, giving rise phenomena such as energetic gamma-ray bursts. For this reason, we have developed a general relativistic conservation-law formalism for nonlinear elasticity; this allows us to use high-resolution shock-capturing methods to resolve strong shocks. We hope to use this formalism to simulate the evolution of discontinuities in the crust of a neutron star caused by shattering and refreezing of the crust, thus illuminating the role this process may play in the evolution of a binary neutron star system.

A New Method to Reduce Eccentricity in Numerical-Relativity Simulations of Black-hole-Binary Inspira

Author: Michael Puerrer

School of Physics & Astronomy, Cardiff University

Co-Authors: S.Husa (Departament de Fisica, Universitat de les Illes Balears, Palma, Spain) M.Hannam (School of Physics & Astronomy, Cardiff University, UK)

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *11:48 Poster Session A*

Summary:

We present a new iteration method for producing low-eccentricity of black-hole-binary simulations. Given reasonably low eccentricity starting momenta for puncture initial data we evolve these data numerically for 3-4 orbits and construct improved initial parameters by comparing numerical relativity with post-Newtonian quantities. We can reach eccentricities below ~0.001 in one or two iteration steps. We also comment on the difference between the eccentricities calculated from the orbital motion and the GW signal.

What we (don't) know about gravitational waveforms from black-hole binaries

Author: Frank Ohme

Albert Einstein Institute

Co-Authors:

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *11:49 Poster Session A*

Summary:

Accurately predicting the complete gravitational-wave signal of coalescing black-hole binaries is of fundamental importance in the efforts to detect and correctly interpret these signatures in the data of current and future detectors. The best waveform models today combine information from both analytical and numerical calculations into complete inspiral-merger-ringdown waveforms, and I will review the current status of such models. I will particularly focus on the question of how reliable these models are and which statistical and systematic bias we have to expect when using these template waveforms to estimate the source parameters of the signal.

Genuine field theory needed to support Gravitational Waves

Author: Max K Wallis

BCAB, Buckingham University

Co-Authors: T.W.Marshall

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *13:04 Poster Session A*

Summary:

Our theme is that gravitational waves necessitate the gravitational field having material status, like the electromagnetic field of Faraday-Maxwell, which motivated the gravity mass/energy term in Einstein's field equation. To properly formulate gravitational theory as a field theory, we need a real (not pseudo-) tensor for gravitational energy-momentum, as recognised by Hilbert and accomplished by Weinberg. Implicit in Einstein's derivation of quadrupole radiation was that the gravitational field is carried by the Minkowski space of 'special' relativity. Babak & Grishchuk etc. have developed this field interpretation of gravity to explicitly include the Minkowski metric in the field equations. Field theorists commonly demand covariance, gauge invariance and the Principle of Equivalence - we argue for maintaining the first, abandoning the second, and accepting only the weakest form of the third (Eötvös Principle). Gravitational waves being real rather than a metric fluctuation followed from the orbit decay of the Hulse-Taylor double pulsar, at the rate predicted by Einstein's quadrupole formula. Yet few challenge the view of gravity as only geometry and the catch-phrase "Space tells matter how to move" coupled to "matter tells space how to curve" persists. The material nature of gravitational energy and gravitational waves shows instead that "fields tell matter how to move".

Black hole binaries galactic and intergalactic globular clusters

Author: Jonathan Michael Blake Downing

ARI, Zentrum für Astronomie der Universität Heidelberg

Co-Authors:

Session: GW1: Dawn of Gravitational Astronomy

Presentation type: Talk *17:00 Poster Session A*

Summary:

Mergers of black hole binaries are one of the most promising sources for the next generation of ground-based gravitational wave detectors. Black hole binaries are a rare outcome of stellar evolution but can be produced efficiently by dynamical interactions in globular clusters. I will present a summary of a large set of Monte Carlo globular cluster simulations that show that black hole binary detection rates will be dominated by binaries produced in star clusters. I will also present first results for the black hole binary population in intergalactic globular clusters, such as those recently found in Coma, that have not been taken into account in previous black hole binary population synthesis studies.

XMM-Newton observations of transients

Author: Norbert Schartel

ESA

Co-Authors:

Session: HE1: Extragalactic Transients

Presentation type: Talk *10:00 Wednesday 28th 10:00-11:15*

Summary:

During its first 12 years of operation XMM-Newton has performed approximately 400 targets of opportunity (ToO) observations. ToO observations are used to observe all kinds of transients, starting from supernovae to tidal disruption in the vicinity of supermassive black holes and active galactic nuclei variability. These observations have an enormous potential study the strongest gravitational and magnetic fields, most extreme tidal forces and explosive energy releases. They provide tight constraints on our understanding of accretion physics and jet formation. Author will briefly introduce the technical constraints for XMM-Newton TOO observations and the organizational procedures. The main focus of the talk will be the discussion of scientific results based on XMM-Newton ToO observations of transients. Finally, the author will try to identify requirements for future research on transients.

Searches for gravitational wave signals associated to gamma-ray bursts

Author: Stephen Fairhurst

Cardiff University

Co-Authors: the LIGO Scientific Collaboration and the Virgo Collaboration

Session: HE1: Extragalactic Transients

Presentation type: Talk *10:15 Wednesday 28th 10:00-11:15*

Summary:

We present the results of searches for gravitational-waves associated with gamma-ray bursts (GRBs) that were detected by satellite-based gamma-ray experiments during recent LIGO and Virgo science runs. These include two short GRBs, 051103 and 070201 whose location error boxes overlapped nearby galaxies. We perform two distinct searches; a modeled search for coalescences of either two neutron stars or a neutron star and a black hole; and a search for generic, unmodeled gravitational wave bursts. Finally, we discuss the prospects for future searches in the era of advanced gravitational wave

detectors.

Early Time GRB Optical Afterglow Evolution

Author: Richard Harrison

Astrophysics Research Institute

Co-Authors:

Session: HE1: Extragalactic Transients

Presentation type: Talk *10:30 Wednesday 28th 10:00-11:15*

Summary:

We expect to uncover further evidence to the origin of GRBs due to recent advances in early time follow up of these events. With fast response telescopes such as the LT and FTS/N, we can now obtain early time optical evolution during the rise time of the light curve and, with instruments such as RINGO2, high quality polarisation data in the optical regime. The early time detection of 10% polarisation (Steele et. al. 2009) in the optical has shown this can be achieved and with improved capabilities we will be able to get accurate temporal polarisation measurements along with accurate light curves. Here I will present numerical and analytical evolution in the optical regime for GRBs during the early phase of their evolution. We will investigate what the effect of internal shocks, in the prompt phase of GRB evolution, have on the optical evolution through the observed light curve. I will also show how polarisation observed in the early time evolution of GRBs, can be used to distinguish between different GRB models.

A new intrinsic correlation between Gamma-ray Burst optical/UV afterglow brightness and decay rate

Author: Samantha Oates

Mullard Space Science Laboratory, University College London

Co-Authors: P. Schady (MPE), M. De Pasquale (UNLV), M. J. Page (MSSL-UCL)

Session: HE1: Extragalactic Transients

Presentation type: Talk *10:40 Wednesday 28th 10:00-11:15*

Summary:

At this conference, I shall present the largest sample of UVOT optical/UV light curves of gamma-ray bursts to-date. The number of well sampled optical light curves has significantly increased since previous studies were performed and it is now an ideal time to extend the systematic analysis performed by Oates et al. 2009. It is important to study the optical afterglows because they are not usually contaminated by prompt emission and therefore may hold the key to answering questions on the physics and jet structure of the outflow. During this presentation, I will provide evidence for a new and interesting intrinsic correlation between the average decay rate and brightness of the optical afterglow, determined using a sample of 52 long GRB optical/UV light curves. This correlation has (at least) two possible origins: the energy is released more quickly for bright afterglows, or the energy is released at a similar rate in all afterglows, but we are observing the jets over a wide range of angles. In the latter scenario the fainter, slower-decaying afterglows will be viewed at larger angles than the brighter, faster-decaying afterglows. To conclude, I will discuss these possible causes and the consequences for GRB afterglow physics.

On the nature of the ``hostless

Author: Rachel Tunnicliffe

University of Warwick

Co-Authors: Andrew Levan, University of Warwick Nial Tanvir, University of Leicester

Session: HE1: Extragalactic Transients

Presentation type: Talk *10:50 Wednesday 28th 10:00-11:15*

Summary:

There is a growing population of well-localised short gamma ray bursts (SGRBs) with no detected host galaxy coincident with the burst location to deep limits, and no unique host galaxy candidate proximate on the sky. This shows a distinct difference from long GRBs which exclusively reside in regions of star formation. These SGRBs either represent a population at moderately high redshift, with so far undetected host galaxies, or a distribution of GRBs well offset from their hosts. These scenarios have important implications for the projenitors of these systems. High offsets may be evidence for one proposed model of coallescing compact object binaries, specifically NS-NS or NS-BH, where the systems receive a natal kick when the compact objects are born. We investigate this issue using our afterglow and host observations of two ``hostless" bursts (GRB 090305A and 091109B). We also expand to look at a full sample of optically localised SGRBs finding that nearby galaxies are closer than we would expect to observe for random positions along with some evidence for low absorption at the burst positions, strongly suggestive of high offsets. These results may be taken as evidence in favour of the ``hostless" bursts being kicked from nearby, presumably relatively low-mass galaxies.

What I did with that sparker

Author: E. F. Keane

Max Planck Institute for Radio Astronomy

Co-Authors:

Session: HE1: Extragalactic Transients

Presentation type: Talk *11:00 Wednesday 28th 10:00-11:15*

Summary:

In a followup to my talk at last year's NAM, I will discuss observations of a transient signal detected in a search of archival data from the Parkes Telescope. This signal, which lasted only a few milliseconds, is bright, highly dispersed, apparently extragalactic and has been declared a second example of the now famous `Lorimer Burst', discovered in 2007. I will present the results of the followup campaign aimed at determining the source of this burst. These have enabled such scenarios as dying pulsars, annihilating mini black holes, and many more in between, to be tested. The scenarios which remain feasable, in light of these new observations, will be discussed. Throughout I will highlight the caveats one must be aware of in searches for such signals, and consider the benefits in this regard of the next generation instruments like LOFAR and the SKA.

2 Minute Poster Summaries for HE1

Author: HE1 Poster Summaries

Co-Authors:

Session: HE1: Extragalactic Transients

Presentation type: Talk *11:10 Wednesday 28th 10:00-11:15*

Summary:

Two 2-minutes poster summaries will be give by: Joe Lyman: CLASP (Create Lightcurves with Alignment, Subtraction and Photometry) Mark Burke: A black hole transient, and other X-ray binaries in Cen A

The Flare Activity of Sagittarius A* at the Center of the Milky Way

Author: Andreas Eckart

University of Cologne

Co-Authors:

Session: HE1: Extragalactic Transients

Presentation type: Talk *11:45 Wednesday 28th 11:45-13:00*

Summary:

The super-massive 4 million solar mass black hole (SMBH) SgrA* shows flare emission from the millimeter to the X-ray domain. Near-infrared polarimetry shows signatures of strong gravity that are statistically significant against randomly polarized red noise. This allows us to derive spin and inclination information of the SMBH. A detailed analysis of the flares in the framework of a Synchrotron Self Compton (SSC) mechanism shows that a scenario in which the infrared flares are explained by synchrotron emission and the associated X-ray flares are produced via SSC emission can also explain the variability spectrum observed in the sub-millimeter radio domain. The light curves suggest in many cases that the mm flare emission follows the NIR emission with a delay of 1.5 - 2 hours indicating that adiabatic expansion of a plasma of relativistic electrons is at work. A detailed analysis of the infrared light curves allow us to address the accretion phenomenon in a statistical way. The analysis shows that the flare amplitudes are dominated by a single state power law. SgrA* also allows us to study the interaction of the SMBH with the immediate interstellar and gaseous environment of the central stellar cluster. It appears that through infrared imaging of the central few arcseconds one can study both inflow and outflow phenomena linked to the SgrA* black hole.

Relativistically beamed tidal disruption events

Author: Andrew Levan

University of Warwick

Co-Authors:

Session: HE1: Extragalactic Transients

Presentation type: Talk *12:00 Wednesday 28th 11:45-13:00*

Summary:

I will present the discovery of two high energy events, Swift 1644+57 and Swift 2058+0516, which appear to represent a new class of astrophysical transient. They are characterised by long-lived X-ray, optical and radio emission, which exceeds the Eddington luminosity of a 10^9 solar mass black hole, and appear to originate from the nuclei of distant galaxies. A prime model for their origin is in the tidal disruption of a main sequence star by the central massive black hole, which creates a powerful relativistic jet. However, other explanations, involving long-lived engines in massive star collapse have also been proposed. I will present up to date imaging, spectroscopic and polarimetric observations of both events, and compare these to the expectations of differing models for their origin.

Extragalactic Transients with MAGIC: A MWL view of AGNs, GRBs and TDFs

Author: Ulisses Barres de Almeida

Max-Planck-Institute for Physics

Co-Authors: the MAGIC Collaboration

Co-Authors: the MAGIC Collaboration

Session: HE1: Extragalactic Transients

Presentation type: Talk *12:15 Wednesday 28th 11:45-13:00*

Summary:

The Major Atmospheric Gamma-ray Imaging Cherenkov (MAGIC) experiment is an array of two 17-meter telescopes located in the Canary Island of La Palma that observes the very-high energy (VHE) gamma-ray sky in stereoscopic mode since 2009. MAGIC is distinguished by its low-energy threshold of approximately 50 GeV, which grants the system a unique potential in the study of extragalactic transients. In this talk we will present a quick review of recent MAGIC results on extragalactic transients. We will discuss flares of AGNs, concentrating on its synergy with multiwavelength observations (specially optical and polarimetric measurements). We will also review the status of MAGIC searches for GRBs in VHE, one of the driving and most challenging scientific goals of the experiment, and show our recent results on the MAGIC observations of the unique tidal flare (TDF) transient of March/2011, Sw 1644+57, for which MAGIC obtained the most stringent UL among the high-energy gamma-ray experiments.

Variability analysis of X-ray point sources in NGC 4472

Author: Tana Joseph

University of Southampton

Co-Authors: T.J. Maccarone (univeristy of Southampton); R.P. Kraft (Harvard-Smithsonian Center for Astrophysics)

Session: HE1: Extragalactic Transients

Presentation type: Talk *12:25 Wednesday 28th 11:45-13:00*

Summary:

I present some of the interesting results of the investigation of X-ray point sources in NGC 4472 using recent deep Chandra observations. A black hole (BH) globular source (GC) identified by Maccarone et al. (2007) was later found to be have decreased in luminosity by a factor of about 20 (Maccarone et al. 2010). Our analysis found that this source was still faint a year later, but showed flaring activity for short periods. The source did not appear to undergo spectral state transitions during these flaring episodes. The second BH GC source was still found to be as luminous as first reported by Maccarone et al. (2011). A new transient BH source was also discovered. This source was not detected in the 2000 or 2010 observations. More intriguingly, the source's luminosity increased by a factor of 8 between in period of about a week from 8.8x10^37 ergs\s to 6.8x10^38 ergs\s (0.5-5 keV).

Breaks and Curvature in the GeV Spectrum of Bright FSRQs

Author: Jonathan Harris

Durham University

Co-Authors: P.M. Chadwick (Durham University) M.K. Daniel (Durham University

Session: HE1: Extragalactic Transients

Presentation type: Talk *12:35 Wednesday 28th 11:45-13:00*

Summary:

Knowing the site of gamma-ray emission in AGN jets will do much for our understanding of the physics of the source. Absorption from broad line region photons is predicted to produce two specific spectral breaks in the gamma-ray spectrum of FSRQs. We test this hypothesis using 3 years of Fermi observations of several bright FSRQs. All of the sources are found to deviate significantly from a simple power law, but the break energies are inconsistent with those predicted by the double-absorber model. The implications of this will be discussed, including possible time variability in the break energies.

Modelling the temporal variability of the optical polarization of the blazar PKS 2155-304.

Author: Nikki Pekeur

North-West University, Durham University

Co-Authors: S.I. Loubser; S.B. Potter; M.K. Daniel; P.M. Chadwick

Session: HE1: Extragalactic Transients

Presentation type: Talk *12:45 Wednesday 28th 11:45-13:00*

Summary:

We observe the optical polarization of the archetypal blazar PKS 2155-304 with the HIgh Speed Photo-POlarimeter (HIPPO) of the South African Astronomical Observatory as part of an ongoing observation campaign. We then attempt to model the temporal variability of the polarization which may constrain the number of emission sites that are required to produce the observations. Complementary observations that were recorded by the Steward Observatory are also used.

2-Minute poster summaries for HE1

Author: HE1 Poster Summaries

Co-Authors:

Co-Authors:

Session: HE1: Extragalactic Transients

Presentation type: Talk *12:55 Wednesday 28th 11:45-13:00*

Summary:

Two 2-minute poster summaries will be given by: Roberto Soria: Long-term X-ray variability of Swift J1644+57 Kate Dutson: A Stacked Analysis of Cluster-centre AGN with Fermi-LAT Data

Long-term X-ray variability of Swift J1644+57

Author: Roberto Soria

ICRAR

Co-Authors: C.J. Saxton (MSSL), K. Wu (MSSL), N.P.M. Kuin (MSSL)

Session: HE1: Extragalactic Transients

Presentation type: Poster *Poster Session A*

Summary:

Exactly 1 year ago, the nuclear black hole in a galaxy at redshift 0.35 went into outburst, blazing a jet along our line of sight; this increased activity was interpreted as the result of a tidal disruption event. We studied the decline of the X-ray flux over the following months, and noticed a series of dips recurring on characteristic timescales (eg 4.5E5 s) and their harmonics. We show that the dips have a softer X-ray spectrum but no additional absorption; this rules out obscuration from orbiting clouds. We propose that the dips are caused by temporary, partial loss of alignment with the (wobbling) jet axis, so that sometimes we only see emission from a slower, less collimated part of the outflow. The existence of a pattern of characteristic timescales in the dipping behaviour may be due to a combination of jet precession and nutation.

A black hole transient, and other X-ray binaries in Cen A

Author: Mark Burke

University of Birmingham

Co-Authors: Somak Raychaudhury (University of Birminham), Ralph Kraft (Harvard-Smithsonian Center for Astrophysics), + Cen A VLP collaboration

Session: HE1: Extragalactic Transients

Presentation type: Poster *Poster Session A*

Summary:

We model the X-ray spectra of point sources in the nearby early-type galaxy NGC 5128 (Cen A), focussing on the discovery of a bright X-ray transient, CXOU J132527.6-430023. The source was first detected over the course of six 100 ks Chandra observations in 2007, reaching an unabsorbed outburst luminosity of 1-2*10^38 erg/s in the 0.5-7.0 keV band before returning to quiescence. Such luminosities are possible for both stellar-mass black hole and neutron star X-ray binary transients. The brightness of the source after a >100 fold increase in flux, coupled with the results from spectral fitting appear to lend weight to the view that this is a black hole transient observed in the thermally dominant state. We discuss this result in the context of our work modelling all of the bright X-ray binaries in Cen A that were observed in deep Chandra pointings. The proximity of the galaxy combined with the depth of the data will lead to this being the largest spectral investigation of X-ray binaries outside of the Local Group, while correlation with the large globular cluster population will provide new insights into binary formation and evolution.

CLASP (Create Lightcurves with Alignment, Subtraction and Photometry)

Author: Joe Lyman

Liverpool John Moores University

Co-Authors: D.F.Bersier (Liverpool John Moores University) P.A.James (Liverpool John Moores University)

Session: HE1: Extragalactic Transients

Presentation type: Poster *Poster Session A*

Summary:

CLASP (Create Lightcurves with Alignment, Subtraction and Photometry) comprises two pipelines developed to automate data reduction and lightcurve creation from SNe imaging through template subtraction. Images are cleaned, then accurate alignment is achieved between a science image containing the SNe and a template image. Subtraction of the template light from the science image, after seeing and flux matching, is performed utilising a version of the ISIS routine of Alard (2000). The subtracted image permits accurate photometry of faint SNe, whose significant host galaxy light would compromise photometry otherwise. Photometry is performed on the subtracted image and calibrated using the science and template images, allowing lightcurves to be created with minimal user interaction required. The pipelines have been extensively tested on Liverpool Telescope data for instruments with FOVs ranging from 5 arcminutes to 1 degree, performing well in the vast majority of cases; other telescope data are also accepted. With huge amounts of observational follow-up being performed for surveys such as PTF, as well as the intense monitoring of individual SNe that is feasible presently, the quick and automated nature of these pipelines make them equally invaluable to both large data sets and individual objects. A catalogue of multi-colour, pseudo-bolometric lightcurves of Liverpool Telescope observations of PTF CCSNe is being created using these pipelines. These lightcurves allow analytical extraction of the physical parameters (ejected mass, mass of nickel-56 and kinetic energy) of the explosions for a sample of CCSNe of unprecedented size.

This will allow investigation into trends of these parameters across CCSNe subtype and host properties, thereby probing the progenitor systems of CCSNe in combination with further constraints from environment measures.

A Stacked Analysis of Cluster-centre AGN with Fermi-LAT Data

Author: Kate Dutson

University of Leicester

Co-Authors: R. J. White (University of Leicester) A. C. Edge (University of Durham) J. A. Hinton (University of Leicester)

Session: HE1: Extragalactic Transients

Presentation type: Poster *Poster Session A*

Summary:

Radio-synchrotron and hard X-ray emission establish clusters of galaxies as hosts to significant populations of non-thermal particles, and it is believed that feedback from the central active galactic nucleus (AGN) plays a crucial, cluster-scale role in accelerating these particles, and counteracting the observed cooling flow; driving weak shocks through the intracluster medium and inflating bubbles of relativistic plasma tens of kiloparsecs in extent. Observational evidence for variable high-energy (HE) γ-ray emission associated with the central engine of a number of clusters supports this view. Motivated by Fermi-LAT detections of active galaxies such as NGC 1275 and M87 (the dominant members of the Perseus and Virgo clusters, respectively), we present a radio-selected sample of 63 such Brightest Cluster Galaxies (BCGs) within cooling-core clusters, treating each as a candidate source of ~GeV γ rays. The standard Fermi-LAT analysis procedure is augmented by a source-specific normalisation of the diffuse γ-ray background, and following a maximum likelihood fitting of the data, the distribution of Test Statistic values across the sample is studied. The counts and model maps for candidate sources below an appropriate critical statistical significance are stacked: imitating a deeper observation of the BCG class than is currently achievable in HE γ rays.

Pulsar observations with the Fermi LAT

Author: Lucas Guillemot

Max-Planck-Institut fuer Radioastronomie

Co-Authors: on behalf of the Fermi LAT Collaboration, the Fermi LAT Pulsar Timing Consortium, and the Fermi LAT Pulsar Search Consortium

Session: HE2: The Gamma-ray/radio connection

Presentation type: Talk *17:00 Wednesday 28th 17:00-18:15*

Summary:

The Large Area Telescope (LAT) on the Fermi satellite has opened a new era in the study of pulsars, by increasing the population of known gamma-ray pulsars from fewer than 10 to more than 100 objects, thereby establishing pulsars as the dominant class of GeV sources in the Galaxy. The improved sensitivity of the LAT has allowed studies of the light curves and spectra of gamma-ray pulsars with unprecedented details. Multi-wavelength observations in support of the Fermi mission have however been crucial for the success of pulsar studies with the LAT: for example, searches for radio pulsars in unidentified Fermi sources yielded the discovery of several tens of new millisecond pulsars. I will review Fermi LAT observations of pulsars after three years of mission, discuss some implications of these results, and present some of the results of multi-wavelength studies of Fermi unidentified sources.

The Radio/Gamma-ray connection of Millisecond Pulsars

Author: Cristobal M. Espinoza

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Co-Authors: B. W. Stappers (JBCA); P. Weltevrede (JBCA); L. Guillemot (MPIfR); D. Smith (CENBG); Fermi LAT Collaboration

Session: HE2: The Gamma-ray/radio connection

Presentation type: Talk *17:15 Wednesday 28th 17:00-18:15*

Summary:

The time difference between the arrival of radio and gamma-ray pulses offers information on the relative location in the magnetosphere of the emitting regions. While radio emission is usually thought to be produced above the magnetic poles and somewhat near the surface of the star, gamma-ray emission is believed to be produced higher up in the magnetosphere and at lower magnetic latitudes. Millisecond pulsars (MSPs) are radio pulsars with rotational periods of the order of a few milliseconds. They slowdown very slowly and steadily and are mostly found in binary systems. The recent detection of several MSPs exhibiting radio pulses in phase with gamma-ray pulses has challenged most emission models. We report on a study of the morphology and rotational-phase relation between radio and gamma-ray pulse profiles of a sample of 30 MSPs detected by the Fermi Large Area Telescope. It is found that gamma-ray MSPs can be grouped into two or three classes. In particular, one class contains those MSPs with aligned radio and gamma-ray pulsed emission. Besides this defining characteristic, we find that they exhibit various other properties which differ significantly from the rest of the gamma-ray MSP population. We discuss the implications of these results in light of some recently proposed models for aligned emission.

The precessing radio jet of the gamma-ray binary LS I+61°303

Author: Lisa Zimmermann

Max Planck Institute for Radio Astronomy, Bonn, Germany

Co-Authors: Maria Massi (Max Planck Institute for Radio Astronomy, Bonn, Germany); Eduardo Ros (University of Valencia, Spain)

Session: HE2: The Gamma-ray/radio connection

Presentation type: Talk *17:25 Wednesday 28th 17:00-18:15*

Summary:

LSI+61°303 is one of the few GeV and TeV emitting X-ray binaries and famous for the modulation of its radio/gamma-ray emission. The origin of the gamma-rays, in LSI+61°303 and in X-ray binaries in general, is strongly debated and explained as either leptonic or lepto-hadronic. To disentangle these processes, the true nature of this object needs to be understood. Two models exist for this source, the young pulsar and a microquasar model. Recently, radio spectral index analysis and high energy results, e.g. from Fermi-LAT, rekindled the microquasar model and re-analysis of archival VLBA data by Massi, Ros & Zimmermann (2012, A&A, u.r.) now confirm double-sided and fast switches to one-sided structures. This is not compatible with a pulsar, though well explainable in a microquasar scenario with a jet pointing close to our line of sight - a microblazar. The core position of the jet traces a clear ellipse with a period of ~28d. Our hypothesis is that this ellipse is the cross-section of the precession cone of the jet and its period a first estimate of the precession period. Massi & Zimmermann (2010) demonstrated that general relativistic effects, i.e. Lense-Thirring precession, could be responsible for such a short precession period.

Spectral decomposition of broad-band radio spectra of gamma-ray blazars

Author: Rebekka Schmidt

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Co-Authors: E.Angelakis (Max-Planck-Institut für Radioastronomie) L.Fuhrmann (Max-Planck-Institut für Radioastronomie) I.Nestoras (Max-Planck-Institut für Radioastronomie) T.P.Krichbaum (Max-Planck-Institut für Radioastronomie) J.A.Zensus (Max-Planck-Institut für Radioastronomie) H.Ungerechts (Institut de Radio Astronomie Millimétrique) A.Sievers (Institut de Radio Astronomie Millimétrique) D.Riquelme (Institut de Radio Astronomie Millimétrique)

Session: HE2: The Gamma-ray/radio connection

Presentation type: Talk *17:40 Wednesday 28th 17:00-18:15*

Summary:

The F-GAMMA program (Fermi-GST AGN Multi-frequency Monitoring Allicance) is a highly coordinated effort to probe the AGN physics via multi-frequency monitoring studies. It observes monthly a sample of approximately 65 Fermi detectable blazars at a total of 12 frequencies. The core program utilizes the 100-m Effelsberg telescope (2.6 – 43 GHz), the 30-m IRAM telescope (86, 145, 240 GHz) and occasionally the 12-m APEX telescope oberving at 345 GHz. The coherency of the combined spectra is kept within 10 days. One of the most prominent characteristics of blazars is the intense variability. In this talk, first we review the most discussed mechanisms proposed to explain it. Subsequently, we discuss a novel approach to the spectral decomposition of the observed broad-band radio spectra into individual spectral components. This method allows the model-independent study of the evolution of those components as well as that of the physical parameters associated with flaring events (i.e. magnetic fields and particle densities). Some typical cases will be presented and finally, we investigate the possible correlation of different behaviours with the gamma-ray properties of the studied sources.

Fermi detectability of prominent radio blazars. A study of the mm-radio variability characteristics.

Author: Ioannis Nestoras

Max Planck Institut for Radioastronomie

Co-Authors: L. Fuhrmann; E. Angelakis; R. Schmidt; J. A. Zensus (Max Planck Institut for Radioastronomie)

Session: HE2: The Gamma-ray/radio connection

Presentation type: Talk *18:00 Wednesday 28th 17:00-18:15*

Summary:

The Fermi-GST launched in 2008 has initiated a new era in AGN astrophysics and provides a distinct opportunity of understanding e.g. the higher energy component of blazars spectral energy distribution and the general γ-ray properties of blazars. However, a particular open question is: what makes a blazar γ-ray loud? Here we present the study of a sample of Fermi-detected and non-detected blazars monitored by the IRAM 30-m telescope at short-mm bands since mid 2006. We explore differences in the variability characteristics of the two samples possibly connected to their γ-ray detectability, such as variability amplitudes, typical time scales, brightness temperatures, Doppler factors, viewing angles, source sizes and radio spectral indices. First results of this study are presented indicating that mm-band variability plays an important role for γ-ray detected blazars. For instance, they show larger variability amplitudes compared to the Fermi non-detected sources.

FR dichotomy, accretion modes and environmental factors in the local Universe

Author: Melanie Gendre

JBCA

Co-Authors: P. N. Best (IfA Edinburgh); J. V. Wall (UBC)

Session: HE2: The Gamma-ray/radio connection

Presentation type: Poster *Poster Session A*

Summary:

Summary:

Active galactic nuclei (AGN) comprise the majority of currently observed radio galaxies, and the Fanaroff-Riley (FR) categorisation provides a classification of extended AGN. The FRI objects have the highest surface brightness along the jets near the core, while FRII sources show the highest surface brightness at the lobe extremities, as well as more collimated jets. This FR dichotomy is based purely on the appearance of the radio objects, and the mechanisms differentiating the two populations are still unknown. Two main streams of models exist to explain these differences in morphology. Extrinsic models are purely based on the source environment, where inter-galactic medium density is the differentiating factor: jets of sources in higher/lower density mediums experience a higher/lower degree of resistance, yielding sources with FRI/FRII structures respectively. Intrinsic models, on the other hand, suggest that the dichotomy arises from differences in the properties of the central black hole. In these scenarios, low-excitation galaxies (LEG) have jets produced by low accretion-flow rate which are generally weak and mostly display FRI-type structure, whereas high-excitation galaxies (HEG) have higher accretion flow rates giving rise to stronger, mainly FRII-type jets. If the FR dichotomy was fully dependent on the jet properties, FRI/II sources would be systematically associated with LEG/HEG respectively. However, in several cases, small subsets of FRIs were found in HEG samples, as well as some FRIIs being associated with LEGs. The presented work is based on the CoNFIG catalogue, a sample of radio sources at 1.4-GHz, including FRI/FRII/Compact morphology classifications, optical identifications and redshift estimates. High/low excitation classification and environmental richness factor of a subsample of local (z<0.3) CoNFIG extended galaxies were compiled to investigate the possible FR morphology-accretion mode-environment relations. The sub-sample contains 208 sources, including 75 FRIs and 108 FRIIs, 76% of which have available spectra, mostly from SDSS. We found that there is a broad overlap of properties, although FRIs generally reside in denser environments that FRIIs. More interestingly, a source found in a rich environment has a very high probability of being both LEG and FRI, fitting with scenarios in which cooling occurs from the X-ray halo. In addition, FRIs broadly show the same RLF shape in all 4 classes (poor/rich HEG/LEG), while FRIIs show more evidence for a switch between HEGs at high luminosities to LEGs at low luminosities.

Recent Galactic Results from the VERITAS Collaboration

Author: Gareth Hughes

DESY Zeuthen

Co-Authors: VERITAS Collaboration

Session: HE2: The Gamma-ray/radio connection

Presentation type: Poster *Poster Session A*

Summary:

The Very Energetic Radiation Imaging Telescope Array System (VERITAS) is a ground-based gamma-ray observatory, located in southern Arizona, sensitive to energies from 100GeV up to 30TeV. VERITAS has been fully operational since 2007 and the current sensitivity enables the detection of a 1% Crab Nebula flux at 5 sigma in under 30 hours. The scientific observations include a strong galactic program. Objects observed comprise of pulsars, PWNe, HMXB and sources with unknown counterparts in other wavelengths. This talk will review the status of the current galactic science results.

Radio observations of unidentified Fermi LAT sources

Author: Ewan Barr

MPIfR

Co-Authors: L. Guillemot, D. Champion, M. Kramer and R. Eatough (MPIfR)

Session: HE2: The Gamma-ray/radio connection

Presentation type: Poster *Poster Session A*

Summary:

In the 4 years since its launch, the Large Area Telescope (LAT) aboard Fermi has revolutionised gamma-ray astronomy. However, due to a low number of incident gamma-ray photons, it is not possible to identify many of the sources discovered by the LAT. This is especially true for binary pulsars, where orbital motion may obfuscate periodicities. Our solution is to perform sensitive pulsar searches at radio wavelengths at the position of the gamma-ray source, a technique which has, to date, found 36 new millisecond pulsars (MSP). Here we present an overview of the current efforts to further understand the population of radio selected LAT pulsars, with particular focus on a 1.4 GHz targeted search in LAT error boxes performed with the 100-m Effelsberg telescope. This search, the largest of its type, covered 289 unidentified sources with > 200 hours of telescope time. In addition to the discovery of the "Black Widow" MSP, PSR J1745+1017, this survey has provided strong luminosity and spectral index limits on several newly detected radio and gamma-ray pulsars. Furthermore, with the large number of sources covered in this work we have performed a statistical analysis of the population distribution of radio selected LAT pulsars.

Radio variability of Fermi gamma-ray loud AGNs and S_gamma - S_radio correlations

Author: Emmanouil Angelakis

Max-Planck-Institut für Radioastronomie

Co-Authors: L. Fuhrmann(1), V. Pavlidou(1), I. Nestoras(1), R. Schmidt(1), J. A. Zensus(1), T. P. Krichbaum(1), H. Ungerechts(2), A. Sievers(2), D. Riquelme(2), L. Foschini(3) 1: Max-Planck-Institut für Radioastronomie, Bonn, DE 2: Instituto de Radio Astronomía Milimétrica, Granada, Spain 3: INAF - Osservatorio Astronomico di Brera, Merate, Italy

Session: HE2: The Gamma-ray/radio connection

Presentation type: Talk *00:00 Poster Session A*

Summary:

It has always been thought that two types of Active Galactic Nuclei, namely Blazars and Radio Galaxies, are strong gamma-ray emitters. The recent discovery of gamma-ray emission from Narrow Line Seyfert 1 galaxies by Fermi/LAT, revolutionises , among others, the belief that jet emission is exclusively associated with old elliptical galaxies. The F-GAMMA program with its unprecedented radio frequency coverage, fast observing cadence, and long time baselines, allows us the detailed study of the variability characteristics and properties of their radio jet emission. Here we present the most recent

results of the F-GAMMA monitoring and compare their variability characteristics with the rest of the targeted Fermi blazars. Among the most debated topics, on the other hand, in AGN research is the correlation between the radio and the gamma-ray emission. Several claims have been made with respect to possible connections between radio to gamma-ray fluxes and luminosities, relations which are know to be subject to severe biases influences. Here, a statistically robust method for the evaluation of the significance of such a correlation between F-GAMMA radio and Fermi/LAT gamma-ray 1FGL flux is presented and it is argued that, in certain cases, such correlations hold; indicating that a possible intrinsic connection in the production of radio and gamma-ray photons, may be at play.

Multi-wavelength Observations of Compact Objects

Author: Phil Charles

University of Southampton/University of Cape Town

Co-Authors:

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *11:45 Friday 30th 11:45-13:15*

Summary:

The last 20 years has seen the development of systematic monitoring of the X-ray sky at wavelengths from hard X-ray/gamma-ray to optical/near-IR. This has led to the creation of public archives which is transforming our understanding of luminous X-ray binaries involving all forms of compact objects. I will illustrate the power of multi-wavelength studies with examples including high-mass X-ray binaries (BeX sources, supergiant fast X-ray transients), supersoft sources (super-Eddington accretion onto white dwarfs) and low-mass X-ray binaries (both neutron star and black hole systems).

The most constraining test of scalar-tensor gravity

Author: Paulo Freire

Max Planck Institute for Radio Astronomy

Co-Authors:

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *12:15 Friday 30th 11:45-13:15*

Summary:

In this talk, we highlight two recent studies of the binary millisecond pulsar - white dwarf system PSR J1738+0333. Optical studies of the white dwarf companion have established the component masses and orbital inclination of the system. This allowed a prediction of the orbital decay of the system caused by gravitational waves. Precise timing of the pulsar over the last ten years at Parkes and Arecibo allow a precise measurement of the orbital decay of the system that matches the predictions of general relativity. We highlight the consequences for alternative theories of gravity that rely on coupling with scalar and vector fields. For such theories the PSR J1738+0333 test represents the most severe constraint to date.

Deep Spacecraft Navigation With Pulsars

Author: Werner Becker

Max-Planck-Institut für extraterrestrische Physik

Co-Authors: M.G. Bernhardt(Max-Planck-Institut für extraterrestrische Physik, Giessenbachstrasse, 85741 Garching, Germany)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *12:30 Friday 30th 11:45-13:15*

Summary:

An external reference system suitable for deep space navigation can be defined by making use of the characteristic signals emitted from strongly magnetized and fast spinning neutron stars, called pulsars. Their periodic signals have timing stabilities comparable to atomic clocks and provide characteristic temporal signatures that can be used as natural navigation beacons, quite similar to the use of GPS satellites for navigation on Earth. By comparing pulse arrival times measured on-board the spacecraft with predicted pulse arrivals at a reference location, the spacecraft position can be determined with an accuracy of a few kilometers, autonomously and everywhere in the solar system and beyond. The unique properties of pulsars make clear already today that such a navigation system will have its application in future astronautics. We report on the current development status of this novel technology.

Stellar life and death in a grand-design spiral galaxy

Author: Roberto Soria

ICRAR

Co-Authors: K.D. Kuntz (JHU), K.S. Long (STScI), W.P. Blair (JHU), P.F. Winkler (Middlebury College), L.E.H. Godfrey (ICRAR), J.C.A. Miller-Jones (ICRAR), P.P. Plucinsky (CfA), P. Ghavamian (STScI), B.C. Whitmore (STScI), C.J. Stockdale (Marquette University)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *12:45 Friday 30th 11:45-13:15*

Summary:

We are conducting a multiwavelength study of star formation and death in the nearby spiral galaxy M83. We combine deep Chandra observations (750 ks), HST coverage in 7 filters (50 orbits), Magellan and Gemini images, and ATCA radio maps. We measure and model the relative distributions of HII regions, hot gas, young supernova remnants (SNRs), and various types of X-ray binaries. We detect almost 700 X-ray sources: at least 100 of them are young SNRs (age <~ 3000 yrs); the rest are mostly high mass X-ray binaries. This is more than the corresponding populations found in the Milky Way to date, and they are all at a similar, known distance. We discovered a transient ultraluminous X-ray source with a low-mass donor, still a largely unexplored class. We followed the radio decline of SN1957D and the appearance of a hard X-ray source at its position (a young Crab-like pulsar?) We are currently studying the intrinsic and environmental differences between X-ray, radio- and optically-bright SNR.

The discovery of Galactic Gamma-ray transients with Fermi

Author: Adam Hill

University of Southampton & SLAC National Accelerator Lab

Co-Authors:

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *13:00 Friday 30th 11:45-13:15*

Summary:

The Large Area Telescope on-board the Fermi Gamma-ray Space Telescope has been surveying the sky above 100 MeV since August 2008. The high energy source population is dominated by the variable, flaring AGN and the steady, persistent rotation-powered pulsars. Hidden amidst these sources, Fermi has discovered and identified new transient sources from within the Milky Way. Two examples of very different systems are presented: the detection of GeV flares from the microquasar Cygnus X-3; and the unexpected discovery of a gamma-ray nova from V407 Cygni. We present multi-wavelength observations of these natural particle accelerators and place them into context with the suspected gamma-ray production and emission mechanisms.

Near-infrared data of X-ray sources from the Galactic Bulge Survey

Author: Sandra Greiss

The University of Warwick

Co-Authors:

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *14:15 Friday 30th 14:15-15:30*

Summary:

Multi-wavelength studies of galactic X-ray sources have mainly been carried out towards the Galactic Centre region (Muno et al., 2003). However, this region suffers from very high extinction and crowding, making the optical and near-infrared matching very difficult. X-ray sources are predominantly coronally active stars and accreting compact objects in binaries. In either case, their detections and identifications are useful in the understanding and studies of the X-ray populations. Detecting X-ray accreting objects such as low-mass X-ray binaries, cataclysmic variables (CVs) and AM Canum Venaticorum stars (AM CVns) is very useful in order to calculate the masses of the compact objects (neutron star, black hole, white dwarf) and understand their formation and evolution (Jonker et al., 2011). The main objective of X-ray point source studies is to achieve their classification and characterisation. This requires multi-wavelength data, as well as spectroscopic follow-up in order to confirm their identities. The Galactic Bulge region suffers from significantly reduced extinction compared to the centre, yet still offers high source densities. It is therefore easier to study the Galactic Bulge than the Centre, yet still very challenging due to the crowdness in that area. The exploitation of near-infrared data is practical in this case, since sources lying behind the dust are much more likely to be detected. The Galactic Bulge Survey (GBS, Jonker et al., 2011) identified over 1600 unique X-ray sources in two 6 sq. deg. strips in the bulge of our galaxy. We present data from the VISTA Variables in the Via Lactea (VVV) survey (Minitti et al., 2009) to search for counterparts to the GBS X-ray sources. Our multi-wavelength follow-up program is particularly targeted at the exotic accreting compact objects. I will also briefly introduce other relevant galactic plane surveys that offer additional diagnostics in our search for compact objects.

Can we really measure black hole spin, and does it really power relativistic jets?

Author: Daniel Plant

University of Southampton

Co-Authors: R.P.Fender (University of Southampton); M.Coriat (University of Southampton); G.Ponti (University of Southampton)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *14:30 Friday 30th 14:15-15:30*

Summary:

Summary:

Modelling the profile of relativistic broadened iron 6.4keV emission lines has become a prominent tool in the estimation of black hole spin. However in some cases this method directly contradicts the results from the other major technique, fitting of the accretion disc continuum. This implies that the application of one or both of these models is unreliable. Additionally, the iron line method assumes that the accretion disc extends to the innermost stable circular orbit (ISCO), a conclusion which is still very much under debate for accretion at relatively low luminosities. It is regarded that in the very faint 'quiescent' state the disc has receded, but to what extent, and at which point this occurs in the evolution of the outburst, is yet to be established. We present a study of several black hole binary systems in the canonical 'hard' states, firstly to determine the accuracy in which reflection features can be used to determine black hole spin. Our results indicate that, in some cases without strong independent constraints, parameter degeneracies can significantly alter the inferred result. Finally we present a case study of the black hole GX339-4, which we show displays distinct evolution of the iron line as it reaches higher luminosities in the low/hard state. To this end we consider how the accretion disc transforms throughout an outburst, discussing the implications this has upon spin determination and the truncated disc model. We furthermore utilise quasi-simultaneous radio observations; understanding how the radio emission and iron line profile vary together will help us to reliably test if black hole spin really does power relativistic jets in black holes on all scales.

A new interpretation of the Crab Nebula high energy flare 2010

Author: Natalia Lewandowska

University of Würzburg

Co-Authors: D.Elsässer (University of Würzburg) K.Mannheim (University of Würzburg)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *14:45 Friday 30th 14:15-15:30*

Summary:

The Crab nebula experienced several flares in the last years. Repetitive observations by AGILE and Fermi LAT prove the variety of these outbursts in their energy and duration. Optical observations by the Hubble Space Telescope (HST) of the flare in September 2010 hint at a structural change of the anvil region in the Crab Nebula. With the results from a photometrical analysis of HST exposures the energetics of this flare are reconstructed and interpreted. Possible connections between the spindown of the Crab pulsar and the high energy flares are discussed.

Improving pulsar population statistics: The all-sky HTRU Pulsar Survey in radio-wavelength

Author: Cherry Ng

Max-Planck-Institut für Radioastronomie

Co-Authors:

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *15:00 Friday 30th 14:15-15:30*

Summary:

The extreme conditions found in and around pulsars make them fantastic natural laboratories, providing insights to a rich variety of aspects of fundamental physics and astronomy. To discovery more pulsars we have begun the High Time Resolution Universe Legacy (HTRU) survey; a blind survey of the northern sky with the 100-m Effelsberg radio telescope in Germany and a twin survey of the southern sky with the 64-m Parkes radio telescope in Australia. Blind pulsar surveys are the only way to significantly increase the known population of pulsars in an unbiased way. Surveys of this type allow us to remain sensitive to all varieties of pulsars, including slowly-rotating isolated magnetars, short-period transient pulsars, and exotic relativistic binary systems. Here I will provide an overview of the HTRU survey. I will discuss the standard pulsar searching pipeline, and the computational challenges arising from the processing of the resulting petabyte-sized survey data. With particular emphasis on the deepest search of the Galactic Plane region, I will discuss the innovative segmented search technique which aims to improve the population statistics of pulsars in highly accelerated orbits. The current progress and up-to-date discoveries in both the Northern and the Southern Survey will also be presented.

Poster Summaries

Author: Poster Summaries

Co-Authors:

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *15:15 Friday 30th 14:15-15:30*

Summary:

1-minute summaries to be given by those presenting posters

LOFT - Large Observatory for X-ray Timing

Author: Dr Silvia Zane

MSSL-UCL

Co-Authors: Jan-Willem den Herder, Marco Feroci, Enrico Bozzo, Luigi Stella, Michiel van der Klis on behalf of the LOFT Team Silvia Zane, Roberto Mignani, Dave Walton, Tom Kennedy, on behalf of the MSSL-LAD team

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Poster *Poster Session B*

Summary:

LOFT is one of the four M3 missions that have been selected by ESA for an Assessment Phase with launch in 2020-2022. LOFT is specifically designed to study the very rapid X-ray flux and spectral variability that directly probe the motion of matter down to distances very close to black holes and neutron stars. A 10 m2-class instrument in combination with good spectral resolution (<260 eV around 6 keV) is required to exploit the relevant diagnostics and holds the potential to revolutionise the study of collapsed objects in our galaxy and of the brightest supermassive black holes in active galactic nuclei. High-time-resolution X-ray observations of compact objects are unique in providing direct access to strong-field gravity, black hole masses and spins, and the equation of state of ultra-dense matter. LOFT will carry two main instruments: a Large Area Detector (LAD, to be built at MSSL with the collaboration of Leicester for the collimator) and a Wide Field Monitor (WFM). The ground-breaking characteristic of the LAD (that will work in the energy range 2-50keV) is a mass per unit surface in the range of ~10 kg/m2, enabling an effective area of ~10 m2 (@10 keV) at a reasonable weight and improving by a factor of ~20 over all predecessors. This will allow timing measurements of unprecedented sensitivity, allowing for instance the capability to measure the mass and radius of neutron stars with ~5% accuracy, or to reveal blobs orbiting close to the marginally stable orbit in active galactic nuclei. The LOFT scientific payload is completed by the coded-mask WFM, for monitoring a large fraction of the sky potentially accessible to LAD, to provide the history and context for the sources observed by LAD and trigger its observations on their most interesting and extreme states. In this poster, we will illustrate the scientific goals and the unique potential of the mission and the major role played by MSSL and UK scientists in the LOFT team.

Understanding X-ray Reflection in AGN

Author: Dan Wilkins

Institute of Astronomy, University of Cambridge

Co-Authors: A.C. Fabian (Institute of Astronomy, University of Cambridge)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *00:00 Poster Session B*

Summary:

High quality X-ray observations of AGN reveal a number of spectral features resulting from the reflection of X-ray continuum emission from a source in a corona surrounding the central black hole off the accretion disc. These features include the prominent iron K emission line at 6.4keV, broadened by relativistic effects close to the black hole and can probe right down to the event horizon. Detailed analysis of the emission line profile reveals the illumination pattern of the accretion flow by the X-ray source (the emissivity profile), which depends on a number of factors including the location and geometry of the primary X-ray source. Observed emissivity profiles are naturally explained by general relativistic effects on the rays and the accretion disc. Comparing observed emissivity profiles to systematic, high performance GPU-based ray tracing simulations relates the emissivity profile to the properties of the X-ray source. When combined with measurements of reverberation time lags, constraints can be placed on the location and geometry of the coronal X-ray sources in AGN from observed emissivity profiles. Such analysis has been completed for the narrow line Seyfert 1 galaxy 1H 0707-495 and other sources, revealing the location and extent of the primary X-ray source.

Magnetars are super hot and super cool

Author: Wynn C.G. Ho

University of Southampton

Co-Authors: K.Glampedakis (Universidad de Murcia); N.Andersson (University of Southampton)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *00:00 Poster Session B*

Summary:

We examine to what extent the inferred surface temperature of magnetars in quiescence can constrain the presence of a superfluid in the neutron star core and the role of magnetic field decay in the core. By performing detailed simulations of neutron star cooling, we show that extremely strong heating from field decay in the core cannot produce the high observed surface temperatures nor delay the onset of neutron superfluidity in the core. We find that it is not possible to conclude that magnetar cores are in a non-superfluid state purely from high surface temperatures, and we find that neutron superfluidity in the core occurs less than a few hundred years after neutron star formation for core fields < 10^16 G. Thus all known neutron stars, including magnetars, without a core containing exotic particles, should have a core of superfluid neutrons and superconducting protons.

Optical Monitoring of the Black Hole X-Ray Binaries, XTE J1118+480 and GX 339-4

Author: Fraser Lewis

Faulkes Telescope Project

Co-Authors: D.M. Russell (Amsterdam, IAC)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *00:00 Poster Session B*

Summary:

We present results from the long-term optical monitoring of these two black hole X-Ray Binaries using the Faulkes Telescopes North and South. These two 2-metre facilities (in Hawai'i and Australia) have allowed us to undertake regular monitoring of these sources in V, R and i' bands. The flexibility of our monitoring campaign allows us to alter the cadence of our observations in response to outbursts or state transitions within these systems. We show that the long-term (~ 5 years) variability of XTE J1118+480 can be accounted for by just the variability of its (orbital) ellipsoidal modulation. We also show that the system is bluer when brighter comensurate with emission from an accretion disc. We discuss results from short-term variability studies of GX

339-4 in outburst and during its fades towards quiescence and show that the rms variability in the optical is state dependent as seen at X-ray wavelengths.

What is feeding the intermediate-mass BH candidate HLX1?

Author: Roberto Soria

ICRAR

Co-Authors: P.J. Hakala (FINCA), G.K.T Hau (ESO), J.C. Gladstone (Alberta), A.K.H. Kong (NTHU), G Dubus (Grenoble)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Talk *00:00 Poster Session B*

Summary:

HLX1 is the strongest candidate proposed to date for an intermediate-mass black hole. It showed 3 FRED-like X-ray outbursts in the last 3 years, almost exactly one year apart. The peak X-ray luminosity of all 3 outbursts is about 1E42 erg/s, decreasing to about 3E40 erg/s between outbursts. We observed the optical counterpart with the VLT, during the decline from the 2010 and 2011 outbursts, and compared it with the HST observations of Dr Sean Farrell & collaborators, obtained closer to outburst peak. We argue that the optical luminosity declines along with the X-ray luminosity. Hence, we suggest that at least the blue/UV optical emission is mostly due to the accretion disk rather than a massive cluster of young stars around the BH. We propose that the BH is fed by a long-period pulsating star, as an alternative to the eccentric orbit scenario.

The Proper Motion of the Central Compact Object RX J0822-4300 in the Supernova Remnant Puppis-A

Author: Werner Becker

Max-Planck-Institut für extraterr. Physik

Co-Authors: T.Prinz (Max-Planck-Institut für extraterrestrische Physik, Giessenbachstrasse, 85741 Garching, Germany), P.Frank Winkler (Department of Physics, Middlebury College, Middlebury, VT 05753), R.D. Petre (NASA Goddard Space Flight Center, Greenbelt, MD 20771)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Poster *Poster Session B*

Summary:

Using the High Resolution Camera (HRC) aboard the Chandra X-ray satellite we have re-examined the proper motion of the central compact object RX J0822-4300 in the supernova remnant Puppis A. New data taken in summer 2010 along with three additional archival data sets, of which the oldest dates back to December 1999, provide a baseline of 3886 days (more than 10 1/2 years) to perform the measurement. Correlating the four positions of RX J0822-4300 as measured in each data set implies a projected proper motion of m_u ~69 mas/yr (preliminary). For a distance of 2 kpc this proper motion is equivalent to a recoil velocity of ~ 650 km/s. The position angle is found to be 242.5±7.0 degrees. Both the magnitude and direction of the proper motion are in agreement with the birth place of RX J0822-4300 being near to the optical expansion center of the supernova remnant. For a displacement of 371 ± 8 arcsec between its birth place and today's position we deduce an age of 5170 ± 650 yrs for RX J0822-4300 and hence for the supernova remnant Puppis A.

Short period variables in the Kepler field

Author: Adam Brooks

Armagh Observatory/UCL

Co-Authors: Gavin Ramsay (Armagh Observatory); Thomas Barclay (NASA-Ames Research centre); Pasi Hakala (FINCA, Tuorla Observatory, Finland)

Session: HE3: Multi-wavelength observations of compact objects

Presentation type: Poster *Poster Session B*

Summary:

In the summer of 2011 we commenced a deep, high cadence, photometric survey of the Kepler field using the Isaac Newton Telescope (INT) on La Palma. We take a series of 20 sec exposures in the g band lasting one hour. Light curves are obtained for all sources in the field and those which are variable, identified. We are sensitive to objects in the range 13.5

Chair's report on the work and future of the IAU's Johannes Kepler working group (JKWG)

Author: T. J. Mahoney

Co-Authors:

Session: HIS1: Kepler and his discoveries

Presentation type: Talk *17:00 Tuesday 27th 17:00-18:15*

Summary:

A short account of the formation of the JKWG in 2009; an outline of its aims; and a report on its current activities.

Kepler's Laws: A Celestial Detective Story
Author: AEL DAVIS

Imperial College, London and ANU, Canberra ,

Co-Authors:

Session: HIS1: Kepler and his discoveries

Presentation type: Talk *17:10 Tuesday 27th 17:00-18:15*

Summary:

Kepler (1571-1630) is celebrated, above all else, for discovering the laws of planetary motion. These three laws constitute the basis of our modern system of celestial dynamics. It will therefore come as a surprise to many people that Kepler himself formulated the laws in a kinematical context, in which the mathematical representation of all three is exactly true. In this paper, we shall demonstrate how the use of ancient Greek methods of construction enabled Kepler to derive the first two laws by applying the geometry of Euclid and Archimedes alone. Further notable features of Kepler's approach were a respect for observations, and a conviction that his results should express physical reality. Assorted erroneous opinions have been misattributed to him over the years, so we shall almost certainly present evidence that will overturn some long-cherished beliefs.

Kepler's Lunar Astronomy: putting his Somnium into historical context.

Author: Dr Stephen Pumfrey

Lancaster University

Co-Authors:

Session: HIS1: Kepler and his discoveries

Presentation type: Talk *17:45 Tuesday 27th 17:00-18:15*

Summary:

Kepler's _Somnium_, known in English as his _Dream, or Posthumous Work on Lunar Astronomy_, was published in 1634, although he began it in 1593. It is a pioneering work of science fiction which brilliantly imagines the world-view of lunar inhabitants and how they would understand the Earth, but the novelty of the lunar astronomy he described in it has not been fully realised. This paper intends to remedy that by situating it in a new account of the role of the moon in the history of astronomy. Before Kepler, the moon was treated as the closest, most observable and hence most informative of the seven planets in geocentric orbit. The paper will argue that, more than any other supporter of Copernicus, Kepler realised how the cause of heliocentrism could be advanced by reconceptualising the moon as the earth's satellite (his very own word) and thus as a body unique in the solar system. Kepler's new insight is explored by contrasting it with theories of the moon from Aristotle to Galileo.

ALMA: Progress and Development

Author: Robert Laing

ESO

Co-Authors:

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *10:00 Tuesday 27th 10:00-11:15*

Summary:

I will summarise recent progress towards the completion of ALMA construction in 2013, with an emphasis on the European contribution. I will also describe the initial phase of the ALMA Development Plan, which is just getting under way.

Progress Report on Commissioning and Science Verification of ALMA

Author: Richard Hills

Joint ALMA Observatory

Co-Authors:

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *10:15 Tuesday 27th 10:00-11:15*

Summary:

In the last two years ALMA has gone through the initial stages of commissioning to reach the point where it is able to perform straight-forward astronomical observations: "Early Science" is under way. Much remains to be done, however, before ALMA can reach its full potential in terms of

sensitivity, angular resolution and the range of observations that it can undertake. This talk will outline where we have got to so far and what the plans are for the coming years.

Massive star formation and global collapse: ALMA observations of a massive IRDC

Author: Gary Fuller
Jodrell Bank Centre for Astrophysics, Univ. of Manchester

Co-Authors: Nicolas Peretto (CEA, Saclay)

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *10:45 Tuesday 27th 10:00-11:15*

Summary:

The initial conditions for the formation of massive stars remain poorly constrained, their large distances and short lifetimes being a main obstacle to their observation. Large samples of massive star progenitors are therefore necessary to catch the evanescent early phases of massive star formation. Peretto & Fuller (2009) constructed the largest sample of Spitzer Infrared Dark Clouds (IRDCs) to date. These clouds are pristine dense molecular clouds seen in silhouette against the mid-IR emission of the galactic plane. I will present ALMA cycle 0 observations of a massive and filamentary IRDC in which two of the brightest massive protostellar objects of the Galaxy are forming in the centre. While single-dish observations of the cloud kinematics suggest that dense gas is collapsing along the filaments, feeding the massive YSOs, only the high sensitivity and resolution of ALMA observations can confirm such a scenario.

More-than-LESS: An ALMA continuum survey of Submm Galaxies from the LABOCA ECDFS Submm Survey (LESS)

Author: Mark Swinbank

University of Durham

Co-Authors: Ian Smal others to be added

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *11:00 Tuesday 27th 10:00-11:15*

Summary:

Submm galaxies are an important, if enigmatic, component of the high-redshift starburst population, which may dominate the total star formation rate density in the Universe at z>2. The difficulty in studying this population arises from their high redshifts and strong dust obscuration (both of which mean they are faint in wavebands other than the submm), coupled with the poor resolution of the submm maps used to initially detect them. ALMA is a transformational facility for the study of this population, allowing us for the first time to construct robustly identified samples. I discuss recently delivered data from a high-priority Cycle 0 ALMA 345-GHz imaging survey of the complete submm galaxy sample from the LESS consortium's LABOCA survey of the Extended Chandra Deep Field South (ECDFS). These maps have 1-sigma depths of <0.4 mJy and arcsecond resolution, allowing us to precisely locate the submm sources, without recourse to indirect tracers such as radio or mid-infrared emission, in the same band in which they were original selected, but at >10x better resolution. The 122 submm sources show a wide variety of structure at ALMA resolution, both single, double and multiple components on scales of >1-10 arcsec (10-100 kpc) and I discuss the multi-wavelength properties of this uniquely complete sample and the early insights it has provided into the nature of submm galaxies.

Preparing for ALMA Cycle 1

Author: Martin Zwaan

ESO

Co-Authors:

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *13:05 ALMA Lunch - Tuesday 27th 13:00-13:45*

Summary:

The call for ALMA "Cycle 1" observing is expected to be announced in the next few months. The Cycle 1 proposal deadline is scheduled to be in July this year and observations will commence early 2013. This talk will give an overview of the expected enhanced capabilities that will offered for this Cycle. I will discuss what types of observations will be possible in Cycle 1 and how can can prepare optimally for the upcoming proposal deadline, making use of the services provided by the European ALMA Regional Centre network.

The ALMA Observing Tool for Cycle1: What's new?

Author: Alan Bridger

UK ATC/STFC

Co-Authors:

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *13:20 ALMA Lunch - Tuesday 27th 13:00-13:45*

Summary:

I will present a brief update on the changes that will be delivered with the ALMA Observing Tool (OT) that will be released with the Cycle1 Call for Proposals. The OT is used to prepare and submit proposals to use ALMA, and has already been used by the community to submit proposals for Cycle0. This talk and short demonstration will highlight the changes to the tool that have been made to accommodate the expanded capabilities of the ALMA

Observatory that will be available in Cycle1.

Unwinding the secrets of thermal pulses and sculpted winds in AGB stars with ALMA

Author: Matthias Maercker

ESO / AIfA

Co-Authors: W. Vlemmings (OSO) S. Ramstedt (AIfA) S. Mohamed (AIfA)

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *10:00 Wednesday 28th 10:00-11:15*

Summary:

I will present ALMA Cycle 0 observations of the CO emission around the carbon AGB star R Sculptoris. The observations show the detached shell and circumstellar medium around this star in unprecedented detail. The detached shell is formed due to the change in mass-loss rate and expansion velocity during a thermal pulse. Amazingly, the data also reveal a clear, and previously unobserved, spiral structure within and connected to the detached shell, indicating the likely presence of a companion star or high-mass planet. Combined with 3-dimensional hydrodynamical models, we for the first time set direct observational constraints on the changes in mass-loss rate and expansion velocity during and after a thermal pulse. By modelling the stellar wind from a binary system, we show that the shape and density of the observed spiral depend on the changes in mass-loss rate and expansion velocity, as well as the duration of the pulse. The results imply a change in pulse to post-pulse mass-loss rate by a factor of 3, and a gradual decrease of the expansion velocity. We are thus able to uncover the fossil record of mass-loss on the AGB in unprecedented detail, ushering in a new paradigm in our understanding of this fundamental period of stellar evolution.

Early ALMA observations towards the Galactic Centre

Author: Anthony Rushton

ESO

Co-Authors: S. Muller; J. Black; and the European ARC

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *10:15 Wednesday 28th 10:00-11:15*

Summary:

ALMA observations of the Galactic Centre are discussed: Initial observations taken as part of the commissioning and science verification program are presented, including results taken at band 3 and band 6 of the hydrogen recombination line. Observations of the compact continuum source Sgr A* are also discussed, including methods to understand the origin of the emission; these include fast band switching, to model the optical depth of the plasma and direct imaging of the event horizon with a phased ALMA array.

Energy dissipation tracing the early stages of cluster formation in the Antennae galaxy merger

Author: Cinthya N. Herrera

Institut d

Co-Authors: F. Boulanger (IAS), N. Nesvadba (IAS), E. Falgarone (LERMA)

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *10:30 Wednesday 28th 10:00-11:15*

Summary:

We analyse ALMA CO and SINFONI near-IR H2 data, at sub-arcsecond resolution, in the interacting zone of the Antennae galaxy. In this merger, most of the stars form in super-star clusters (SSCs). These data is used to investigate how large-scale gas dynamics of the galaxy interaction triggers the formation of SSCs. The interaction is observed to make turbulence much higher than in normal galaxies. This turbulence must be dissipated for gravity to collect and bind the mass necessary to form a SSC. Thus, we expect the early stages of cluster formation to be associated with energy dissipation. By combining ALMA and SINFONI data of the Antennae, we observe for the first time the link between dissipation of the gas kinetic energy and the early stages of star formation. We use CO as tracer of the distribution of the molecular gas mass and we show that the near-IR H2 lines trace the dissipation of the gas kinetic energy on small spatial scales. These two tracers reveal an extraordinary massive (Mvir~5x10^7 Msun) and compact (diameter 50pc) H2 luminous source which we argue represents an early evolutionary step in the formation of SSCs, traced by the localized dissipation of the gas turbulent kinetic energy. This is the first scientific results based on ALMA observations, accepted for publication in a refereed journal.

Initial Results from SCUBA2

Author: David Nutter

Cardiff University

Cardiff University

Co-Authors: JCMT Gould Belt Legacy Survey Team / SCUBA2 Guaranteed Time Team

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *10:45 Wednesday 28th 10:00-11:15*

Summary:

We will show some of the initial SCUBA2 data obtained by the JCMT Gould Belt Survey in the SCUBA2 Guaranteed Time of star formation across a range of scales, from the relatively modest star formation in Taurus, through the more distant MonocerosR2, to the star forming powerhouse Orion. At the wavelengths of 450 and 850 microns, SCUBA2 is sensitive to the coldest dust, which it can map with sub-10 arcsec angular resolution. This cold material allows SCUBA2 to map the very earliest stages of star formation.

SCUBA2 observations of the DR21 region

Author: Toby Moore

Liverpool John Moores University

Co-Authors: L.K. Morgan (LJMU UK); M.A. Thompson (University of Herts, UK); D.J. Eden (LJMU UK); A.C. Chrysostomou (JAC)

Session: INS1: Evolution with ALMA - first science results on the cool universe

Presentation type: Talk *11:00 Wednesday 28th 10:00-11:15*

Summary:

The results of SCUBA2 mapping of the 1-degree wide field around the DR21 star-forming region will be presented. The data were taken during Science Verification observations, in preparation for the JCMT (Galactic) Plane Survey (JPS).

The European Extremely Large Telescope - Overview and Status update

Author: Markus Kissler-Patig

European Southern Observatory

Co-Authors:

Session: INS2: The European Extremely Large Telescope

Presentation type: Talk *11:45 Thursday 29th 11:45-13:00*

Summary:

The European Extremely Large Telescope (E-ELT) is an ESO-led project for a 40m-class telescope that will allow us to address many of the most pressing unsolved questions about our Universe. The E-ELT will be the largest optical/near-infrared telescope in the world. The project has completed the E-ELT's detailed design, which passed the Final Design Review successfully in September 2010. Between the end of 2010 and the summer of 2011 the E-ELT project extended the detailed design phase in order to consider the recommendations of the E-ELT Design Review. The main goals were the reduction of risk by optimising the cost and constraining the schedule in order to ensure that ESO can further expand its leading role in astronomy by constructing the world's first extremely large telescope. In June 2011 ESO Council endorsed a revised baseline design for the E-ELT. The E-ELT project is now not only technically ready to enter the construction phase, but is also backed by a solid funding scenario. Preparatory construction work on some of the E-ELT's first elements will commence in early 2012. The final approval of the whole E-ELT programme by ESO Council is expected in mid-2012, which will enable the E-ELT to start operations as an integrated part of the Paranal Observatory early in the next decade.

HARMONI: The first light spectrograph for the E-ELT

Author: Fraser Clarke

University of Oxford

Co-Authors: N Thatte (Oxford), M Tecza (Oxford), R Houghton (Oxford), D Lunney (UKATC), R Bacon (CRAL), S Arribas (CSIC), E Mediavilla (IAC), The HARMONI consortium.

Session: INS2: The European Extremely Large Telescope

Presentation type: Talk *12:10 Thursday 29th 11:45-13:00*

Summary:

HARMONI is an optical/near-IR integral field spectrograph designed for the E-ELT. The current design will form the basis of the first light spectrograph on the telescope, with work on detailed design due to start soon after telescope approval, hopefully later this year. HARMONI is designed to be a work-horse instrument, addressing many of the key science cases of the E-ELT early in the telescopes career. The instrument covers 470nm (V band) to 2.5 microns (K band), with a range of spectral resolving powers from 4000 to 20,000. The spatial field is ~1 arcsecond at the diffraction limit of the E-ELT, up to 10x5 arcsecond in the coarsest mode. Fed by an LGS adaptive optics system, it will be ideally suited to detailed studies of individual "cornersstone" objects in many fields of astronomy. I will give an overview of the key science cases behind HARMONI, and an update on the current status of the instrument design.

The EAGLE instrument for the E-ELT, developments since delivery of Phase A

Author: Prof Simon L Morris

Durham University

Co-Authors: S. L. Morris (Durham University), J-G. Cuby (LAM, Marseille), C. Evans (UKATC), T. Fusco (ONERA), P. Jagourel (GEPI, Paris), P. Parr-Burman (UKATC), G. Rousset (LESIA, Paris), H. Schnetler (UKATC)

Session: INS2: The European Extremely Large Telescope

Presentation type: Talk *12:20 Thursday 29th 11:45-13:00*

Summary:

The EAGLE instrument is a Multi-Object Adaptive Optics (MOAO) fed, multiple Integral Field Spectrograph, working in the Near Infra-Red, on the European Extremely Large Telescope (E-ELT). A phase A design study was delivered to the European Southern Observatory in October 2009. Since that time there have been a number of developments, which we summarise here. The science case for the instrument, while broad, highlighted in particular: understanding the stellar populations of galaxies in the nearby universe, the observation of the evolution of galaxies during the period of rapid stellar build-up between redshifts of 2-5, and the search for 'first light' in the universe at redshifts beyond 7. In the last 2 years substantial progress has been made in these areas, and we have updated our science case to show that EAGLE is still an essential facility for the E-ELT. This in turn allowed us to revisit the science requirements for the instrument, confirming most of the original decisions, but with some minor modifications. The original location considered for the instrument (a gravity invariant focal station) is no longer in the E-ELT Construction Proposal, and so we have performed some preliminary analyses to show that the instrument can be simply adapted to work at the E-ELT Nasmyth platform. Since the delivery of the Phase A documentation, MOAO has been demonstrated on-sky by the CANARY experiment at the William Herschel Telescope.

AOLI: Adaptive Optics Lucky Imager - Diffraction limited imaging on large ground-based telescopes

Author: Jonathan Crass

Institute of Astronomy, University of Cambridge

Co-Authors: Craig Mackay (Institute of Astronomy, University of Cambridge), David King (Institute of Astronomy, University of Cambridge), Bruno Femenía (Instituto de Astrofísica de Canarias & Universidad Politécnica de Cartagena), Rafael Rebolo (Instituto de Astrofísica de Canarias & Consejo Superior de Investigaciones Científicas), Lucas Labadie (I. Physikalisches Institut, Universität zu Köln), Marc Balcells (Instituto de Astrofísica de Canarias & Isaac Newton Group of Telescopes)

Session: INS2: The European Extremely Large Telescope

Presentation type: Talk *12:35 Thursday 29th 11:45-13:00*

Summary:

The highest resolution astronomical images ever taken at visible wavelengths were obtained by combining the techniques of lucky imaging and low order adaptive optics (AO). Current AO systems require the use of very bright reference objects to determine atmospheric distortions due to the techniques of wavefront measurement, typically using Shack-Hartmann sensors. A new type of curvature wavefront sensor using photon counting CCD detectors has been previously shown to offer significant improvements in sensitivity. This method will allow reference stars as faint as 18.5-19 magnitude to be used, allowing the use of natural guide stars over virtually the entire sky. The Adaptive Optics Lucky Imager (AOLI) instrument, under development for deployment on the WHT 4.2 meter and GTC 10.5 meter telescopes on La Palma, employs this new wavefront sensor in combination with a lucky imaging based science instrument comprising 2×2 array of 1024×1024 photon counting, EMCCDs to give a wide field of view and a very fast frame rate. We present an overview and current status of the project with particular emphasis on the optical design, system performance and curvature wavefront sensor technology.

Possibilities for Wide-FIeld multi-object spectroscopy at the E-ELT

Author: Gavin Dalton

RALSpace/University of Oxford

Co-Authors: F. Hammer (GEPI); L. Kaper (UVA); P. Bonifacio (GEPI); R. Navarro (ASTRON)

Session: INS2: The European Extremely Large Telescope

Presentation type: Talk *12:45 Thursday 29th 11:45-13:00*

Summary:

I will present an outline of the EVE concept for multi-object spectroscopy at the E-ELT with an update of the concept since the original Phase A study and some considerations as to further possibilities that could be included into an optimal E-ELT facility instrument.

SCUBA-2: an overview and early on-sky performance

Author: Wayne Holland

UK Astronomy Technology Centre

Co-Authors: SCUBA-2 Project Team

Session: INS3: First Science from SCUBA-2

Presentation type: Talk *11:45 Tuesday 27th 11:45-13:00*

Summary:

SCUBA-2 is an innovative 10,000-pixel camera operating at submillimetre wavelengths on the James Clerk Maxwell Telescope in Hawaii. It images the sky simultaneously in wavebands at 450 and 850 microns, and has a wide field-of-view of 43 square arcminutes. The instrument is now in regular operation and a comprehensive survey programme, the JCMT Legacy Survey, has recently commenced. After a brief overview of the instrument, I will describe the observing modes and present the initial on-sky performance.

First results from SCUBA2 - cold pre-stellar cores

Author: Derek Ward-Thompson

Cardiff University

Co-Authors: JCMT Gould Belt Legacy Survey Team

Session: INS3: First Science from SCUBA-2

Presentation type: Talk *12:05 Tuesday 27th 11:45-13:00*

Summary:

We present some early results from SCUBA2 taken during shared risks observing, science verification, and the first scheduled observing run of the JCMT Gould Belt Legacy Survey. We show SCUBA2 images of nearby molecular clouds at 850 and 450 microns. SCUBA2 picks out the coldest and densest pre-stellar cores in these clouds. We derive some preliminary conclusions from the data.

New views of debris discs with SCUBA-2

Author: Jane Greaves

University of St Andrews

Co-Authors: SONS team

Session: INS3: First Science from SCUBA-2

Presentation type: Talk *12:20 Tuesday 27th 11:45-13:00*

Summary:

The SCUBA-2 survey of nearby stars (SONS) began taking data in January. Here we present initial images from science verification, for known discs of a range of submillimetre brightness. Highlights include completion of a submm-bright sample out to 60 pc, recovery of a very nearby faint system, and a first image of a disc not previously seen at long wavelengths. The survey goals for characterising debris systems will be discussed.

First results from the SCUBA-2 Ambitious Sky Survey

Author: Mark Thompson

University of Hertfordshire

Co-Authors:

Session: INS3: First Science from SCUBA-2

Presentation type: Talk *12:35 Tuesday 27th 11:45-13:00*

Summary:

I will present some of the first results from the Science Verification Phase of the SCUBA-2 Ambitious Sky Survey (SASSy). SASSy is designed to make a wide-area sky survey, focusing on searching for cold molecular cores in the Outer Galaxy. Here I will present the results obtained around the NGC 7538 star forming complex.

Deep sub-mm imaging of the nearby galaxy NGC 7331 with SCUBA-2

Author: Volker Heesen

U Hertfordshire

Co-Authors: M. Fich (U Waterloo), C. Wilson (McMaster), R. Tilanus (JAC), F. Israel (Leiden), S. Serjeant (Open University), E. Brinks (U Hertfordshire)

Session: INS3: First Science from SCUBA-2

Presentation type: Talk *12:50 Tuesday 27th 11:45-13:00*

Summary:

The nearby galaxy NGC 7331 is imaged with SCUBA-2 at wavelengths of 450 and 850 mu as part of the science verification program. We present first

results from the observations that were carried out in fall 2011. With 17h integration time this is one of the deepest SCUBA-2 maps of a nearby galaxy obtained so far. We compare our maps with HERSCHEL data to and briefly discuss implications. This project serves as preparation for the nearby galaxy legacy survey (NGLS) at the JCMT, for which first observations with SCUBA-2 recently began.

INS4 - Opening and Welcome

Author: M.M. Bisi

Institute of Mathematics and Physics, Aberystwyth University

Co-Authors:

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *10:00 Thursday 29th 10:00-11:15*

Summary:

A 1-minute opening and welcome to the INS4: "LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results" session.

LOFAR: Current Status and Opportunities for Early Science (Context)

Author: Michael Wise

ASTRON (Netherlands Institute for Radio Astronomy)

Co-Authors:

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *10:01 Thursday 29th 10:00-11:15*

Summary:

LOFAR, the Low Frequency Array, is a new and innovative radio telescope designed to open up the relatively unexplored low frequency radio regime from 30-240 MHz to a broad range of astrophysical studies. As one of the first of a new generation of radio instruments, the International LOFAR Telescope (ILT) will provide a number of unique capabilities for the astronomical community. These include wide-field, high dynamic range imaging, high time resolution, dynamic real-time system response, buffered retrospective all-sky imaging and the ability to provide multiple, simultaneous observing programs. LOFAR is moving steadily through its commissioning phase towards early science results and its first open international call for observing proposals. In this presentation, I will give an overview of the current status of the array as well as its current and planned scientific capabilities. I will summarize the ongoing commissioning process and conclude with a discussion of the upcoming Announcement of Opportunity for observing proposals in early 2012.

The LOFAR Transients Key Science Project: image plane transients and multiwavelength follow-up

Author: Rob Fender

University of Southampton

Co-Authors: J. Broderick (Southampton), B. Stappers (Manchester), R. Wijers (Amsterdam) on behalf of the LOFAR Transients Key Science Projecy

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *10:25 Thursday 29th 10:00-11:15*

Summary:

In this talk I will summarise the searches for radio transients and variables in the image plane with LOFAR. I will present early results from targetted observations of known variable sources, such as SS433. I will also present the first results from very wide field blind searches for radio transients in both the LOFAR high and low bands. The former may have turned up the first strong LOFAR transient candidate, and the latter is already the highest cadence blind radio transient search to date, with over 1000 images of the same ~100 sq deg field. Finally, I will conclude by summarising our plans for rapid multiwavelength follow up of transient events via a network of automated optical and radio telescopes.

Radio Detection of Cosmic Particles and Fast Radio Transients with LOFAR

Author: Heino Falcke

Radboud Univ. Nijmegem/ASTRON/MPIfR Bonn

Co-Authors: LOFAR Cosmic Ray and Transients Key Science Projects

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *10:41 Thursday 29th 10:00-11:15*

Summary:

The digital nature and large field of view of LOFAR makes innovative searches for fast radio flashes of astrophysical origin possible. As a first stepping-stone in this direction LOFAR has begun to regularly observe high-energy cosmic rays. Once a cosmic ray hits the Earth atmosphere, a shower of secondary particles is created, rushes though the geomagnetic field, and produces a bright radio flash for some tens of nanoseconds. The LOPES (LOFAR

secondary particles is created, rushes though the geomagnetic field, and produces a bright radio flash for some tens of nanoseconds. The LOPES (LOFAR Prototype Station) experiment already detected this emission and showed that radio is a good tracer of particle energy. Models of the emission suggest that radio is also a potentially good tracer of particle composition. As a consequence, the new LOFAR radio telescope has UHECRs detection built in: All ~2500 individual antenna elements in LOFAR come with a memory ring buffer (Transient Buffer Board, TBB) and real-time pulse detections, allowing particles above 10^17 eV to be detected. Moreover, a small particle detector array, LORA (LOFAR-Radboud Airshower array), provides cross-calibration and external triggers when desired. Using first commissioning data, the radio emission of UHECRs has been detected with unprecedented detail. As a

follow-up step the TBBs can also be used to search for sub-second astrophysical transients such as giant pulses from pulsars, stellar and planetary flares, cosmic ray impacts on the moon, and other exotic events. A trigger system has been developed and tested with giant pulses from pulsars, which can detect dispersed pulses and dump the buffer. Offline processing of TBB data can then reconstruct pulse direction and verify the extra-terrestrial origin of these pulses. This will open an entirely new parameter space for real-time detection of sub-second radio transients.

Ionospheric impact and calibration for LOFAR (Invited)

Author: Ilse van Bemmel

ASTRON

Co-Authors: Ger de Bruyn (ASTRON); Mark Aartsen (Univ of Adelaide); John McKean (ASTRON); Ronald Nijboer (ASTRON); Huib Intema (NRAO); Maaike Mevius (KVI); Bas van der Tol (Leiden Observatory); Stefan Wijnholds (ASTRON); Jan Noordam (ASTRON)

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *10:57 Thursday 29th 10:00-11:15*

Summary:

LOFAR is rapidly picking up speed and producing magnificent first results in many fields. In this process we are learning new things about aperture array systems every day. LOFAR requires a new approach to calibration, if we want to optimize the use of its broad continuous frequency coverage and large field of view. A significant problem in calibration is the Earth's ionosphere. Due to small changes in ionospheric electron density, radio sources appear to move and distort. This affects the ability to make very deep observations, which require hours or even days of observing time. In order to optimize the science return from LOFAR, we need to understand and remove these effects from the observations. In my talk, I discuss the impact of ionospheric effects on LOFAR and why it is essential to correct for them. In the framework of the 'historical' development of ionospheric calibration methods in low frequency radio astronomy, I present the methods which are being considered to remove the ionospheric effects in LOFAR. Last but not least, I show several independent recent observations of the ionosphere with LOFAR.

Heliospheric Observations on LOFAR: First Solar Wind Obs. & Planned Future Investigations (Invited)

Author: Richard Fallows

ASTRON

Co-Authors: A.Asgekar (ASTRON); M.M.Bisi (Aberystwyth University); A.R.Breen (Aberystwyth University)

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *11:45 Thursday 29th 11:45-13:15*

Summary:

The solar wind – the Sun's extended atmosphere expanding through interplanetary space – has been studied for many years using observations of interplanetary scintillation (IPS). IPS is the scintillation of radio signals from compact radio sources due to the solar wind. The extremely-long baseline (ELB) IPS experiment, where simultaneous observations are made with two antennas spaced several-hundred kilometres apart was developed at Aberystwyth University and has been used to probe the solar wind in greater detail than was previously possible. The LOw Frequency ARray (LOFAR) offers a number of advantages as an instrument for observing IPS: Multiple international ‘stations’ spread around the central core enable the ELB IPS experiment to be extended and enhanced, while the large bandwidth of up to 48 MHz, and high frequency resolution enable dynamic spectra to be calculated which will undoubtedly provide a mine of new information on solar wind micro structure. Here, we present the first IPS solar wind and dynamic spectrum results from LOFAR, as well as an insight into other planned future heliospheric investigations using LOFAR.

KAIRA - Deploying LOFAR systems in the Arctic

Author: Derek McKay-Bukowski

Rutherford Appleton Laboratory

Co-Authors:

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *12:03 Thursday 29th 11:45-13:15*

Summary:

The Kilpisjärvi Atmospheric Imaging Receiver Array (KAIRA) is a new cross-disciplinary instrument that is currently under construction in Arctic Finland. Using LOFAR technology for its primary receiver system, this novel application demonstrates the importance of robust design and the ability to use local techniques to apply a global system. The presentation not only gives the latest update on the science and engineering within the KAIRA project, but also outlines some of the experimental ambitions that are planned.

High-resolution, wide-field mapping of supernova remnant Cassiopeiea A in continuum & RRLs (Invited)

Author: Dr. Ashish Asgekar

ASTRON, the Netherlands Institute for Radio Astronomy

Co-Authors: S. Yatawatta (the Netherlands Institute for Radio Astronomy, & Kapteyn Institute, University of Groningen, P.O. Box 800, 9700 AV Groningen, the Netherlands); R. Oonk (the Netherlands Institute for Radio Astronomy,); R. van Weeren (ASTRON, the Netherlands Institute for Radio Astronomy, & Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands)

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *12:19 Thursday 29th 11:45-13:15*

Summary:

The LOw Frequency ARray (LOFAR) is a next-generation radio telescope operating at frequencies from 10 to 250 MHz. Along with a large field of view (15 x15 deg) and fractional bandwidths (25-100%), the overall configuration of LOFAR antennas offers high collecting area coupled with > 2000 instantaneous baselines. Such an instrument offers new challenges in calibration and imaging. LOFAR imaging pipeline involves various new strategies, softwares and tools designed to address many of these challenges. We use the pipeline and Sagecal package to calibrate the brightest source in the LOFAR sky, Cassiopeiea A. We present resultant deep, high-resolution maps of this supernova remnant. With the same data we detected Carbon Radio Recombination Lines in absorption towards the supernova remnant. Previously reported lines were detected along with several others elsewhere in our band. These results demonstrate that LOFAR has desired spectral stability and sensitivity to study ionized gas in the Milky Way using RRLs.

Early Pulsar Science with LOFAR

Author: Tom Hassall

University of Southampton

Co-Authors: Ben Stappers (University of Manchester) and the LOFAR Pulsar Working Group (various institutions)

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *12:37 Thursday 29th 11:45-13:15*

Summary:

LOFAR is revolutionising the observation of pulsars at the lowest radio frequencies. At low frequencies, pulsed signals are especially prone to propagation effects like dispersion, scattering and refraction. Through wide-band pulsar observations, these propagation effects can be used to probe, e.g., the interstellar medium and the pulsar magnetosphere. LOFAR's large fractional bandwidth also means that pulse profile shapes change significantly across the observing band. Observations of this pulse profile evolution can be used to glean information about the pulsar magnetosphere, and the pulsar emission mechanism. LOFAR is also an excellent wide-field pulsar survey instrument. For instance, at it's lowest frequencies, LOFAR can complete a shallow survey of the entire Northern sky (560 pointings at 50 MHz with 60-minute integration times) in 25 days. I will summarise these topics and give highlights of early pulsar results from LOFAR's ongoing commissioning period.

A year of pulsar polarimetry with LOFAR

Author: Charlotte Sobey

Max-Planck-Institut fuer Radioastronomie

Co-Authors: A.Noutsos (Max-Planck-Institut fuer Radioastronomie); J.Hessels (ASTRON); M.Kramer (Max-Planck-Institut fuer Radioastronomie); for the LOFAR Pulsar Working Group

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *12:53 Thursday 29th 11:45-13:15*

Summary:

In the past year, we have made great strides towards developing LOFAR's polarimetric pulsar observing mode. LOFAR's large fractional bandwidth and vast collecting area combine to provide the highest-quality polarisation profiles of pulsars ever produced at these low frequencies, as well as unprecedented precision on Rotation Measures (RMs). I aim to give an overview of these recent polarimetric pulsar observations. I will also focus on scientific results obtained thus far, specifically investigations into ionospheric TEC variations, ISM scattering and magnetospheric phenomena, with a view towards using polarised pulsars to study the structure of the Galactic magnetic field.

INS4 - Poster Summary Presentations

Author: INS4 Poster Authors

Co-Authors:

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *13:09 Thursday 29th 11:45-13:15*

Summary:

Summary presentations to be given by those presenting posters in INS4: "LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results" - up to a maximum of 1 minute for each poster. McKean et al. Nichols et al. Girard et al. Vocks et al. Asgekar et al. Bisi et al. McKay et al.

McKay et al.

Solar Observations with LOFAR

Author: Christian Vocks

Leibniz-Institut für Astrophysik Potsdam

Co-Authors: F. Breitling; G. Mann

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *00:00 Poster Session B*

Summary:

During the first commissioning phase of the LOw Frequency ARray (LOFAR), the Key Science Project "Solar Physics and Space Weather with LOFAR" has developed a pipeline for solar imaging. Solar radio radiation in the LOFAR frequency range of 30 - 240 MHz emanates from the outer layers of the Sun's hot atmosphere, the corona. Strong scattering of radio waves due to coronal turbulence limits the angular resolution of any radio image to a few 10s of acrseconds. This corresponds to baselines between the core and the nearest remote stations of LOFAR. Solar imaging is largely based on the standard imaging pipeline, but the Sun as a bright, extended, and temporally variable source poses special challenges for the calibration of LOFAR data. Different calibration strategies, e.g. using only the shortest baselines or solution transfer from external calibration sources, will be discussed. Radio images of the Sun will be shown, both for LOFAR's low and high frequency band, that were taken during commissioning runs in the year 2011. This includes the first LOFAR observation of a solar radio burst. Observation plans for LOFAR's first operational phase will be presented.

Interference Mitigation schemes for LOFAR dynamic spectra

Author: Dr. Ashish Asgekar

ASTRON, Netherlands Institute for Radio Astronomy

Co-Authors: R.A. Fallows (ASTRON, the Netherlands Institute for Radio Astronomy, & Institute of Mathematics and Physics, Aberystwyth University, Penglais Campus, Aberystwyth, SY23 3BZ, Wales, UK); S. ter Veen (Department of Astrophysics, University of Nijmegen, P.O. Box 9010, 6500 GL Nijmegen, The Netherlands)

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *00:00 Poster Session B*

Summary:

We present details of LOw Frequency ARray (LOFAR) dynamic spectrum data pipeline, focussing on the mitigation of Radio Frequency Interference (RFI) in the data sets. RFI can be categorised in two forms: persistent interference where entire frequency channels can be regarded as contaminated, and brief pulses where single spikes of RFI can exist at more random times and frequencies. The worst-affected frequency channels are identified using median filters. Most of the persistent interference can be identified in this way, allowing the median of each frequency channel to be interpolated in frequency across the 'bad' channels. This creates an estimate of the telescope response across the pass-band, which is used to 'flatten' the data. Two-dimensional (2-D) median filters are then employed to locate the remaining (more random) spikes of RFI. We also describe a method of "random substitution" to obtain 'clean' time-frequency data after RFI identification and mitigation. This may allow the calculation of bi-spectra and the development of novel ways to study interplanetary scintillation (IPS) and solar wind micro structure.

The First Detection of a Coronal Mass Ejection (CME) with LOFAR

Author: M.M. Bisi

Institute of Mathematics and Physics, Aberystwyth University

Co-Authors: R.A. Fallows (Institute of Mathematics and Physics, Aberystwyth University/ASTRON, the Netherlands Institute for Radio Astronomy), and A. Asgekar (ASTRON, the Netherlands Institute for Radio Astronomy).

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Poster *Poster Session B*

Summary:

Interplanetary scintillation (IPS) is a powerful means of observing the Sun's extended atmosphere – the solar wind – through remote sensing. IPS – the twinkling of radio waves from a distant, compact, astronomical natural radio source – results from density inhomogeneities traversing the interplanetary medium moving outward from the Sun. Using the newly-developed IPS experiment on the novel European-based radio telescope, the LOw Frequency ARray (LOFAR), we have our first detection of a coronal mass ejection (CME) passing through one of our preliminary observations of IPS during the ongoing commissioning phase of the LOFAR system. Here, we identify the CME in white-light imagery, and briefly discuss and compare its characteristics/properties with other sources of data where available. We also note how such work will be taken forward with on-going test observations of IPS using LOFAR, and look to the future to fully combine LOFAR observations of IPS with those taken using other systems worldwide, including the European Incoherent SCATter (EISCAT) radar and the Multi-Element Radio-Linked Interferometer Network (MERLIN) which are also located within Europe along with LOFAR.

LOFAR, Weather and the implications for EISCAT_3D and the SKA.

Author: Derek McKay-Bukowski

Rutherford Appleton Laboratory

Co-Authors:

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Poster *Poster Session B*

Summary:

The LOFAR (Low-Frequency Array) system makes use of mass-produced, relatively-cheap antennas deployed in a wide variety of different site environments. Apart from the challenges of varying local geology, layout and infrastructure, each presents its own unique weather conditions. With several years of experience (and some failures and damage), we are now in a position to assess the physical performance of the design and look at the implications of our findings on long-term LOFAR operations as well as other planned phased-array systems such as EISCAT_3D and the Square Kilometre Array (SKA).

LOFAR Imaging of Cygnus A

Author: John McKean

ASTRON

Co-Authors: the LOFAR collaboration

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Talk *00:00 Poster Session B*

Summary:

The nearby radio galaxy Cygnus A is the brightest source in the low frequency sky that will be observed with LOFAR. Therefore, Cygnus A provides an excellent commissioning target to test the LOFAR system and also to produce the first science results. I will present new imaging of Cygnus A with LOFAR between 30 and 240 MHz, with baselines of up to ~100 km. These data provide the highest angular resolution images of Cygnus A at low frequencies to date. I will present a preliminary spectral analysis of the source, including the properties of the lobes, hot-spots and their interaction with the intergalactic medium surrounding the galaxy.

Lightning at Saturn and Jupiter radiation belts emission seen by LOFAR

Author: Julien Girard

LESIA - Observatoire de Paris, France

Co-Authors: Griessmeier J.-M. (LPC2E - Université d'Orléans, France); Hess S. (LATMOS/IPSL, France); Majid W. (JPL Caltech, USA); Tasse C. (GEPI - Observatoire de Paris, France); Zarka P. (LESIA - Observatoire de Paris, France)

Session: INS4: LOFAR, the LOw Frequency ARray: Ongoing Developments and Early Results

Presentation type: Poster *Poster Session B*

Summary:

The Planetary Working Group of the LOFAR Transient Key Project: "Planets & exoplanets" currently works with the LOFAR radiotelescope time-frequency data taken in phased array mode and interferometer mode. Commissionning observations were performed on Saturn lighting and on Jupiter emissions in meter-decameter range. Along with the detection of Saturn lightning (Saturn Electrostatic Discharges - SED) in the LBA band (30-90 MHz) at high time resolution, the characterization of SED (burst duration, power spectrum, etc.) will deepen our understanding of these events as compared to their terrestrial counterparts (Farrell et al., 2007 and ref. therein). In addition, Jupiter was observed in the HBA band (110-250 MHz) in interferometer mode. The exploitation of these interferometric data leads to the first high resolution images of Jupiter's synchrotron emission from its radiation belts that will reveal the spatial structure of this emission at low frequencies (see also de Pater, 2004). An update on current work will be presented.

SCUBA-2: A 10,000 pixel bolometer camera for the JCMT

Author: Wayne Holland

UK Astronomy Technology Centre

Co-Authors: SCUBA-2 Project Team

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Talk *10:00 Friday 30th 10:00-11:15*

Summary:

SCUBA-2 is an innovative 10,000-pixel camera operating at submillimetre wavelengths on the James Clerk Maxwell Telescope. The detectors are superconducting transition-edge sensors, arranged in 4 sub-arrays at each waveband, and operating at temperatures close to 100mK to provide sky background-limited sensitivity. The instrument is now in regular operation on the telescope and is currently undertaking a Legacy Survey programme. In this talk I will present details of the construction and characterisation of the detector arrays, and how stable thermal operation is critical to obtain the most optimum instrument performance.

Complete refractive optical design for an instrument to detect the B-mode component

Author: Massimo Candotti

Experimental Physics Department - NUI Maynooth - Ireland

Co-Authors: A. Challinor (Institute of Astronomy, Cambridge, UK); P. Hargrave (Department of Physics & Astronomy, Cardiff University, Cardiff, UK); A. J. Murphy (Experimental Physics Department, NUI Maynooth, IRL); T. Peacocke (Experimental Physics Department, NUI Maynooth, IRL); G. Savini (Dept. of Physics and Astronomy, University College London, London, UK); S. B. Sørensen (TICRA, Copenhagen, DK); N. A. Trappe (Experimental Physics Department, NUIM Maynooth, IRL); I. Walker (Department of Physics & Astronomy, Cardiff University, Cardiff, UK);

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Talk *10:15 Friday 30th 10:00-11:15*

Summary:

COMPLETE TITLE: "Complete refractive optical design for an instrument to detect the B-mode component of the polarized Cosmic Microwave Background (CMB) anisotropy" In this paper we present a refractive optical design for a receiver potentially capable of detecting the B-mode component of the polarized Cosmic Microwave Background (CMB) anisotropy. The major challenge of such an optical design is represented by measurement of polarisation with a high degree of purity, together with a large focal surface area to maximise the number of detectors. As part of an European Space Agency TRP programme a complete refractive optical design has been analysed. We outline our design based on a camera design meeting the stringent scientific requirements on dual orthogonal beam purity. The instrument design presented here provides a separate telescope barrel for each of the 5 frequency bands (70, 100, 143, 217 and 353 GHz) with a half field of view of 9.5° on the sky. The optical design can accommodate sufficient detectors to meet or exceed the instrument sensitivity requirements for a four-year mission scenario, assuming the incorporation of ultra-Gaussian feed-horns. Finally we highlight the need of very precise experimental measurements of refractive index variation in a dielectric material and describe customised experimental test set-ups essential to validate the simulation process.

The C-Band All Sky Survey Digital Backend

Author: Charles Copley

University of Oxford

Co-Authors: M.E Jones, J.J John, J. Leech, A Taylor, J.Zuntz, (Oxford), Yaser Hafez (KACST), R.Davis, C.Dickinson, M. Irfan, P.Leahy (Manchester), D.Jones, R.Keeney, O.King, S. Muchovej, T. Pearson, M.Stevenson (Caltech/JPL), R. Booth, J.Jonas (Rhodes/HartRAO)

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Talk *10:30 Friday 30th 10:00-11:15*

Summary:

The C-Band All Sky Survey (C-BASS) is a 5GHz survey of the sky foreground in both intensity and polarization with a 1GHz bandwidth. The primary science aim is to provide a low frequency all sky intensity and polarization map to augment the WMAP surveys and aid in the accurate subtraction of foreground contamination from CMB maps. Two instruments, deployed in the Owen's Valley Observatory (California) and the MeerKAT Astronomy Area (South Africa) provide full sky coverage. The Northern Hemisphere instrument (using an analog radiometer/polarimeter) has completed a commissioning period and is currently capturing data. The Southern Hemisphere instrument will use a FPGA based backend (specifically two ROACH boards from the CASPER Collaboration), providing both power and polarization measurements across the full 1GHz band. This new digital backend provides useful spectral information across the band, improved rejection of systematic effects, and simplifies RFI rejection.

A new approach to high speed digital sampling and it

Author: Adam Coates

Oxford University

Co-Authors:

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Talk *10:45 Friday 30th 10:00-11:15*

Summary:

Radio telescopes are now being designed which deliver RF bandwidths of tens of GHz, but digitization technology for such high bandwidths is expensive and remains a technological bottleneck. The electronics industry has been putting appreciable research into producing ever faster digital communications techniques to accommodate the developing data transmission requirements of computing and the internet. We have been using the high speed serial interfaces incorporated into Xilinx FPGAs as fast RF sampling devices, with the processing elements of the chip being used to perform correlations and other data processing. This means that very large bandwidth correlators can be built on a single chip without the need for external samplers, reducing complexity, power requirements and data interconnection. We have demonstrated single-bit correlation at a sampling rate of 3.125 GS/s, and plan to extend this work to provide increased precision with multi-level sampling, and larger bandwidths using higher speed interfaces and interleaving techniques.

A dual polarised wideband planar phased array for radio astronomy

Author: Yongwei Zhang

The University of Manchester

Co-Authors: A.K. Brown (The University of Manchester)

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Talk *11:00 Friday 30th 10:00-11:15*

Summary:

This paper describes a recently developed low profile planar aperture array named Octagonal Ring Antenna (ORA). The ORA demonstrates its unique robustness in large scale applications and represents a novel and potentially breakthrough technology based on a planar, easily fabricated, structure. It is expressly designed to be a low cost, low loss, wideband array. Based on initial large scale finite array studies prototypes with different geometries have been fabricated and measured. The basic electromagnetics has been confirmed. The integrated ORA with Low Noise Amplifiers have been measured with a promising result. Its potential use in phased array feed will also be explored.

Investigation of Optimised Horns for use in Future Arrays, as an Alternative to Corrugated Horns

Author: Darragh McCarthy

National University of Ireland, Maynooth

Co-Authors: N.Trappe(National University of Ireland, Maynooth); B.Maffei(University of Manchester)

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Poster *Poster Session B*

Summary:

At present, space and ground based sub-millimetre systems are based on a single pixel model, utilising a corrugated horn at the front end of the instrument to couple the incident radiation to the optics. While these systems function very well, the natural progression is to extend them to multiple pixels to allow more efficient observations to be made. This becomes critical for space based missions in which the instrument has a finite lifetime. Such instruments would require arrays of horns, one for each pixel. Corrugated horns are time and cost intensive to produce, which makes them less ideal for arrays containing potentially hundreds of horns, particularly if the technology is to be introduced in a commercial sense (security and medical imaging, for example). The goal therefore, is to produce a feed horn with similar performance to that of a corrugated horn, but with a limited number of corrugations, or ideally none. We investigate the performance of a Pickett-Potter horn when its design is optimised subject to a number of degrees of freedom, in order to achieve specified levels of performance similar to those of a corrugated horn, under specific headings such as cross polar power, gaussicity and mode content. We also investigate using smooth walled Gaussian profiled horns for this purpose.

Instrumental systematic effects of quasi-optical components for astronomical instruments

Author: Ho-Ting Fung

JBCA, The University of Manchester

Co-Authors: H.Fung(JBCA, The University of Manchester); F.Ozturk(JBCA, The University of Manchester); B.Maffei(JBCA, The University of Manchester); G.Pisano(JBCA, The University of Manchester)

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Poster *Poster Session B*

Summary:

Astrophysical experiments dedicated to millimetre-wave polarimetry, in particular COrE and QUBIC, are in need of well defined antenna beam shapes. Such beams not only have to be modelled with care, but they must also be characterised accurately. Some of the quasi-optical components within these instruments (such as interference filters and half wave plates) can modify the shape of the antenna beams. We present here, the measurements and simulations of such effects (co- and cross- polarisation radiation patterns) on a corrugated horn antenna beam, using a Vector Network Analyser at W–band (75 – 110 GHz).

Generation of vortex beams in the W-band: design and testing of a dielectric q-plate.

Author: Stefania Maccalli

JBCA

Co-Authors: G. Pisano (JBCA); R. Ng (JBCA)

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Poster *Poster Session B*

Summary:

It has been discovered recently that light can carry not only the usual Spin Angular Momentum (SAM), associated with circular polarization states of the field, but also Orbital Angular Momentum (OAM): light beams carrying quantized values lħ of OAM are called optical vortices. This kind of radiation has a wide range of applications: from quantum encryption and telecommunications to non-contact manipulation of matter and astrophysics. The goal of our project is to develop instrumentation able to discern different OAM states in the laboratory, at millimetre wavelengths (W-band). This can be achieved by designing devices such as q-plates: artificial birefringent plates designed for production/detection of particular OAM states. Here we present the RF

characterisation of one prototype of dielectric q-plate that has been designed to produce/detect POAM beams with charge l=+/-2. All the measurements were carried out using a Vector Network Analyser (VNA). The measured beam pattern resulted in very good agreement with the finite-element analysis predictions (HFSS) showing both the expected intensity annular shape and the phase change of 4pi across a close loop around the propagation axis.

The Manchester University Student Telescope (MUST)

Author: Monika Obrocka

Jodrell Bank Centre for Astrophysics

Co-Authors: P. Wilkinson; B. Stappers; MUST Collaboration

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Poster *Poster Session B*

Summary:

The first phase of a low cost radio telescope known as the Manchester University Student Telescope (MUST) is under construction. The design requirement and science goals, such as pulsar searches and fast radio transients, are presented in this poster. MUST is a phased array system that will be able to survey the radio sky due to its multi-beaming capabilities. The Phase 1 prototype will consist of one tile of 20 m^2 and operate at a centre frequency of 590 MHz with 5 to 10 MHz bandwidth.

Lens antenna system study for future CMB polarisation projects.

Author: Fahri Ozturk

The University of Manchester, JBCA

Co-Authors: B. MAFFEI (1) G. PISANO (1) H.T. FUNG (1) M.W. NG (1) V. HAYNES (1) (1) JBCA, School of Physics and Astronomy, The University of Manchester, UK

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Poster *Poster Session B*

Summary:

The next generation of instruments dedicated to the Cosmic Microwave Background Radiation (CMBR) polarisation measurement will require large focal planes including several thousand of pixels. Future lens-based telescope configurations (such as LSPE, SPIDER) might be a strong alternative to the reflector based ones (Planck, WMAP). However, their readiness level is deemed low in term of RF performance knowledge and hence they are being studied in order to understand their systematic effects such as aberrations and cross-polarisation. The work presented here introduces RF simulations using different optical models such as Method of Moments (MOM) and Finite Element Method (FEM). These simulations are also compared to experimental data gathered on a representative lens system (lens and feed-horn) for which the co- and cross-polarisation beam pattern has been measured.

A 19-pixel L-band receiver array for FAST.

Author: Bruno Maffei

Jodrell Bank Centre for Astrophysics

Co-Authors: Rendong Nan (NOAC), Jin Chengjin (NAOC), Graeme Carrad (CSIRO) and the FAST collaboration.

Session: INS5: Radio to sub-millimeter technology developments for receiver arrays

Presentation type: Poster *Poster Session B*

Summary:

The FAST (Five hundred meter Aperture Spherical Telescope) project is being developed by China. This approved mega-science currently under construction will be the largest single dish telescope ever built. This facility, planned to be commissioned in 2016, will largely surpass the capabilities of the famous Arecibo telescope leading to a formidable tool for the study of pulsars, HI regions and more generally Cosmology. Several receivers will be installed at its focus on a common platform. A consortium of three institutes (JBCA-UK, NAOC-China and CSIRO- Australia) has been formed in order to develop the first set of receivers for this world leading facility. This 19-pixel L-Band receiver array (0.95 – 1.45 GHz), which will be ready for the telescope commissioning, will give the first light of this facility which is expected to be a new milestone for the pulsar search and pulsar timing study. We present the design of the telescope together with the expected performance of the L-Band receiver array.

Is molecular gas necessary for star formation?

Author: Paul Clark

ITA/ZAH Universität Heidelberg

Co-Authors: Simon Glover (ITA, Universität Heidelberg)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *14:15 Tuesday 27th 14:15-15:30*

Summary:

The fact that star formation appears to take place only within molecular clouds can be easily explained if one assumes that the cooling provided by molecular gas is a necessary prerequisite to the onset of star formation. However, there is growing evidence that this explanation is incorrect, and that the efficient formation of molecular gas is simply a consequence of the same dynamical processes that also lead to the formation of stars. In this contribution, I will discuss a number of recent numerical simulations of cloud formation and evolution that follow the detailed chemistry and thermodynamics of the gas and that provide strong support for this picture. I will also discuss the consequences of this picture for our understanding of star formation in extreme environments.

The initial conditions of star formation in galaxies: cosmic rays as the fundamental regulators

Author: Padelis P. Papadopoulos

Max Planck Institute for Radioastronomy

Co-Authors: Wing-Fai Thi (Un. of Grenoble) - Francesco Miniati (ETH Zurich) - Serena Viti (UCL)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *14:31 Tuesday 27th 14:15-15:30*

Summary:

I will describe the fundamental role of cosmic rays as regulators of the initial conditions of star formation deep inside the UV/optically-shielded regions of molecular clouds and the dramatic effect they can have on the star-forming ISM of the extreme CR-dominated Regions (CRDRs). The latter are expected in all merger-driven star formation. It may well be that finally a physically motivated mechanism for a bimodal stellar Initial Mass Function (IMF) has been discovered.

Planck Early Results: New Light on anomalous microwave dust emission

Author: Clive Dickinson

University of Manchester

Co-Authors: Planck collaboration

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *14:43 Tuesday 27th 14:15-15:30*

Summary:

I will give an overview of the Planck mission and the recent Early Planck Results papers. I will present the results of the Galactic papers from these early papers, focussing on the Anomalous Microwave Emission (AME). Data from Planck, combined with ancillary data (WMAP, radio data, DIRBE etc.), has allowed us to construct precise spectra for Galactic regions such as Perseus and Rho Ophiuchus molecular clouds. The spectra show strong evidence for AME, which can be readily fitted by electric dipole radiation from small spinning dust grains. If I'm allowed, I'll also give a glimpse of new AME results from Planck that will be published in the near future.

Polarised Galactic emission at 43 GHz as observed by QUIET.

Author: Matias Vidal

Jodrell Bank Centre for Astrophysics

Co-Authors:

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *14:55 Tuesday 27th 14:15-15:30*

Summary:

The characterisation of the polarised anisotropy of the CMB is one of the current challenges of observational cosmology. Important efforts are being made by several groups in order to detect primordial B-modes, a polarisation signal in the CMB which could confirm and quantify the energy of the inflationary paradigm. Polarimetric observations by different experiments are made in the frequency range (~30-200 GHz) where foreground contamination is reduced. In addition to the cosmological importance of these observations, they provide a powerful tool to study the Milky Way galaxy's structure and magnetic field. The Q/U Imaging Experiment (QUIET) is a CMB polarization experiment observing at 43 GHz and 95 Ghz. Its goal is to measure the E-modes spectra and to detect, or place competitive limits on, the primordial B-modes. Observing in 2 frequency bands is crucial to address the problem of foreground contamination (mainly synchrotron) which is one of the main difficulties in CMB studies. QUIET observed regions with very little foreground contamination for CMB analysis and also, two regions in the Galactic plane for foreground characterisation and Galactic studies. In this talk I will show polarimetric observations at 43 GHz from QUIET of the two fields in the Galactic plane. Polarised emission from the Galaxy is detected in both fields. I will discuss some properties of the emission like polarisation fractions, spectral indexes and polarisation angles.

ISM properties in a localized field with the inversion technique. Results from l = 30° Hi-GAL field

Author: Alessio Traficante

School of Astronomy and Astrophysics, Univ. of Manchester

Co-Authors: R. Paladini (IPAC-Caltech); M. Compiegne; M.I.R. Alves (IAS, Orsay); L. Cambresy (CDS, Strasbourg) et al.

Session: ISM1: Interstellar medium and star formation

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *15:07 Tuesday 27th 14:15-15:30*

Summary:

The Open Time Key project Hi-GAL has mapped the inner Galaxy in the coordinates range |l| ≤ 70○ , |b| ≤ 1○ , and for wavelengths from 70μm to

500μm. Hi-GAL has detected cold structures and thousands of star formation regions. The recent release of these high-resolution data also allows detailed investigations of the properties of the Interstellar Medium (ISM). Here, I present the results obtained from the study of the Galactic ISM in a 2*2 square degrees region corresponding to one of the Hi-GAL Science Demonstration fields, centered on (l,b) = (30,0). This field encompasses the tangent point to the Scutum-Crux spiral arm and identifies a region, in Galactocentric radii, between 4.25 and 5.6 kpc. Using an inversion technique, we have isolated the dust emission which originates from this region. Combining the Hi-GAL data with the velocity information provided by gas tracers of hydrogen in the atomic (HI), molecular (H2) and ionized phase (H+), we have disentangled - at each wavelength - the dust emission associated to the gas in these different regimes. As well as to the Hi-GAL data, we have applied the inversion technique to the MIPSGAL 24μm and GLIMPSE 8μm. The synergy between the Hi-GAL and the MIPSGAL/GLIMPSE data allow us to probe all known populations of dust grains. We have used the DUSTEM model to build and interpret the Spectral Energy Distributions (SEDs) for dust in the atomic, molecular and ionized gas phase. I also discuss the potential of this inversion technique in the light of the new regime of spatial resolutions now accessible in the FIR with Herschel and in the radio with the new tracers data, with a look in particular to the new kinematic information regarding the ionized component obtained with the Radio Recombination Lines data.

The structure of HI in galactic disks: Simulations vs observations

Author: David Acreman

University of Exeter

Co-Authors: C. L. Dobbs (University of Exeter); Christopher M. Brunt (University of Exeter); K. A. Douglas (Arecibo Observatory/NAIC)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *15:19 Tuesday 27th 14:15-15:30*

Summary:

By converting simulations of spiral galaxies into synthetic observations in the 21cm atomic hydrogen line we determine how the ISM of a model galaxy would appear to an observer within the galaxy. We find that including stellar feedback processes results in more realistic ISM structure, such as the scale height of HI and the presence of supernova driven shells. In Galactic plane surveys the cold, dense material associated with molecular cloud formation is seen in HI self-absorption. Our synthetic data reproduce this effect and we find that the the density and temperature of the material responsible for HI self-absorption are consistent with observationally determined values.

First results from the Herschel Gould Belt Survey in Taurus

Author: Jason Kirk

Cardiff University

Co-Authors: D. Ward-Thompson (Cardiff University), V. Konyves (CEA, Saclay), P Andre (CEA, Saclay), M.J. Griffin (Cardiff University), P.J. Hargrave (Cardiff University), D.J. Nutter (Cardiff University), P. Palmeirim (CEA Saclay), B. Sibthorpe (UK ATC, Edinburgh), and the Herschel Gould Belt Survey consortium

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *17:00 Tuesday 27th 17:00-18:15*

Summary:

The Herschel Gould Belt Survey (HGBS) is a Herschel Guaranteed Time Key Programme designed to map all sites of low-mass star formation within 500 parsecs of the Sun. In this talk we will present early results from HGBS and the first HGBS results from the Taurus star formation region. The SPIRE and PACS instruments on Herschel were used to map an area of 52 sq. deg. at wavelengths of 70, 160, 250, 250, and 500 microns. We will present the first Herschel from this region and will focus on an analysis of the Barnard 18 and L1536 filaments. Extended sources were extracted from the filaments using a tree-based extraction algorithm (csar) and plotted on a mass-size diagram. They appear to fill in the gap in this diagram between gravitationally bound prestellar cores and unbound starless cores. This suggests that these two populations of cores are actually all part of one larger population of cores, and gives the first clear supporting evidence for the theory that unbound cores evolve into prestellar cores.

Molecular Cloud Structure and its Relationship to Star Formation

Author: Rowan J. Smith

ZAH/ITA University of Heidelberg

Co-Authors: R. Shetty, Ralf Klessen (ZAH/ITA Heidelberg), Amelia Stutz (MPIA Heidelberg), Ian Bonnell (St. Andrews)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *17:16 Tuesday 27th 17:00-18:15*

Summary:

Observations are revealing the ubiquity of filamentary structures in molecular clouds. Collapsing cores form along the filaments and massive stars are formed where multiple filaments converge. In this contribution I examine how the dynamics of such systems impact directly on the star formation within

them. I then critically compare simulations to observations by carrying out radiative transfer modelling to obtain molecular line profiles. Filaments are found to typically exhibit low linewidths and have mild velocity gradients of a few km/s across their length. In dense clustered regions the velocity structure of filaments can interfere with the observed line profiles from their embedded collapsing cores in up to 50% of cases. In simulations of massive star forming regions there are large scale convergence motions towards the locations where massive stars are formed. Such motions are the result of massive stars forming at the bottom of the proto-clusters potential well. The resulting line profiles are less variable with viewing angle than their low mass analogues, and often display a characteristic “saw-tooth” line profile instead of the predicted double peaked blue asymmetric profile.

Prestellar evolution in Ophiuchus

Author: Oliver Lomax

Cardiff University School of Physics and Astronomy

Co-Authors: A. P. Whitworth (Cardiff University School of Physics and Astronomy); A. Cartwright (Cardiff University School of Physics and Astronomy)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *17:32 Tuesday 27th 17:00-18:15*

Summary:

We model the evolution of prestellar cores in Ophiuchus using initial conditions informed as closely as possible from observational surveys of the region. The aim is to provide insight into the relationship between the present-day core mass function and the stellar initial mass function. Observational data provides estimates on core masses, line of sight velocity dispersions and projected spatial extent; three dimensional spatial and velocity information needs to be inferred by modeling. We constrain the intrinsic three-dimensional extent of cores by comparing the observed distribution of projected ellipses to those of a Monte Carlo model. Here we invoke a three-parameter ensemble of triaxial ellipsoid cores defined by a log-normal distribution of sizes and a scale factor through which the intrinsic axes vary. Assuming isotropic variation in the line of sight we constrain the parameters using Monte Carlo Markov chain methods. We argue that given current observational constraints, it is difficult to justify more sophisticated models and we provide statistical evidence to support this point. We explore the form of core velocity fields using SPH with various prescriptions of turbulence. Here we present results from simulations demonstrating the profound effects of triaxiality and turbulence on prestellar evolution.

A detail investigation of the HII region RCW175: from radio to mid-IR wavelengths

Author: Christopher Tibbs

IPAC/Caltech

Co-Authors: R. Paladini (IPAC/Caltech), C. Dickinson (Jodrell Bank Centre for Astrophysics), M. Compiegne (IPAC/Caltech)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *17:43 Tuesday 27th 17:00-18:15*

Summary:

Using infrared, radio continuum and spectral observations, we performed a detailed investigation of the HII region RCW175. We determined that RCW175, which actually consists of two separate HII regions, G29.1-0.7 and G29.0-0.6, is located at a distance of 3.2 +/- 0.1 kpc. Based on the observations we infer that the more compact G29.0-0.6 is less evolved than G29.1-0.7 and was possibly produced as a result of the expansion of G29.1-0.7 into the surrounding interstellar medium. We compute the star formation rate of RCW175 to be 12.6 +/- 1.3x10^ M_sun/yr, and identified 6 possible YSO candidates within its vicinity. RCW175 has previously been identified as a source of anomalous microwave emission~(AME), an excess of emission at cm wavelengths often attributed to electric dipole radiation from the smallest dust grains. We find that the AME previously detected in RCW175 is not correlated with the smallest dust grains (polycyclic aromatic hydrocarbons or small carbonaceous dust grains), but rather with the excitation of the interstellar radiation field within the region. This is a similar result to that found in the Perseus molecular cloud, another region that harbours AME, suggesting that the radiation field may play a pivotal role in the production of this new Galactic emission mechanism.

Radio Emission from YSOs : Tackling the (Reverse) Luminosity Problem

Author: Anna Scaife

University of Southampton

Co-Authors:

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *17:54 Tuesday 27th 17:00-18:15*

Summary:

The ‘classic luminosity problem’ has been known for some time, where the minimum accretion luminosities produced by the standard spherical collapse model are up to several orders of magnitude larger than those observed for embedded protostars. The solution to this problem has been proposed as non-steady or episodic accretion rate onto such objects, and recent radiative transfer simulations have demonstrated that a combination of these effects can indeed reproduce the observed luminosity distribution. However, this work has also predicted a ‘reverse luminosity problem’, whereby an overabundance of objects is expected at very low luminosities relative to those observed. Although this effect is currently ascribed to observational completeness issues, further accurate comparison will not be possible without directed observational studies. Unfortunately, such low luminosity sources are difficult to identify in the infra-red as they are typically heavily embedded in thick dust cores, and the molecular emission from their outflows is frequently so weak that it is not easily or consistently detected. Radio emission from these objects provides a reliable alternative method for detection, as the dense dust cores are optically thin to the longer wavelength emission. I will present results from a number of recent radio surveys specifically targeted at low and very low

are optically thin to the longer wavelength emission. I will present results from a number of recent radio surveys specifically targeted at low and very low luminosity objects and discuss the new physical insights into star formation processes which can be drawn from these data.

New Evidence That Pre-Main-Sequence Stars Are Older Than We Thought

Author: Cameron Bell

University of Exeter

Co-Authors: Tim Naylor (University of Exeter); N. J. Mayne (University of Exeter); R. D. Jeffries (Keele University); S. P. Littlefair (University of Sheffield)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *18:05 Tuesday 27th 17:00-18:15*

Summary:

We have developed a self-consistent set of pre-main-sequence (pre-MS) model isochrones with empirical bolometric corrections. These show that the ages of young (< 20 Myr) pre-MS clusters have been underestimated by a factor of approximately two. For many of the clusters in our sample, we have also derived an age based on the young main-sequence population and find consistency between the pre-MS and main-sequence ages. Main-sequence isochrones have been used to derive main-sequence ages, distances and reddenings, with statistically meaningful uncertainties. We also fitted each cluster with three sets of new semi-empirical pre-MS model isochrones. These new isochrones comprise stellar interior models, empirical colour-Teff relations and bolometric corrections, and model dependent log(g) corrections. Of the three sets of pre-MS isochrones studied, we find agreement between the pre-MS ages derived using the Baraffe et al. 1998 interior models and the main-sequence ages. These revised ages suggest that pre-MS clusters are older than previously thought and may help explain the discrepancy between formation times required by planet formation models and the estimated protoplanetary disc lifetimes.

Positive and negative ionizing feedback in molecular clouds

Author: James Dale

Excellence Cluster, Munich

Co-Authors: B. Ercolano, I.A. Bonnell

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *10:00 Wednesday 28th 10:00-11:15*

Summary:

I will present the results of an SPH parameter study of the impact of photoionizing radiation from O-type stars on initially bound and unbound molecular clouds of a range of masses (10^4-10^6 solar masses) and radii (~1 - ~100 pc). I will show that photoionization acting alone can expel significant fractions of the mass of the lower-mass and lower-density clouds, and that the cloud escape velocity is the main determinant of how much damage such feedback can do. I will also show that negative feedback is accompanied by positive feedback in the form of triggered star formation, which significantly effects the structure of the embedded clusters formed in the clouds, and their stellar IMF.

Collapse and outflows in molecular clouds: Ionisation feedback

Author: Stefanie Walch

Co-Authors: A.Whitworth (Cardiff University); T. Bisbas (UCL); D. Hubber (Sheffield University); R. Wunsch (Academy of sciences of the Czech Republic)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *10:16 Wednesday 28th 10:00-11:15*

Summary:

The role of feedback from massive stars is believed to be a key element in star formation, and in the evolution of the interstellar medium in galaxies. We use high-resolution 3D SPH simulations to explore the development of HII regions due to ionisation feedback from a single O star and in particular to study the evolution and dispersal of the surrounding molecular cloud, and the energetics of the ionisation feedback. We assume the initial molecular cloud to be fractal, which means that their density structure is characterised by a fractal dimension, 2.2 <= D <= 2.8, and the standard deviation of the (log-normal) density PDF. By analysing the evolution of the density PDFs we clearly show that ionisation can compress the gas and trigger star formation on a short timescale. However, on timescales > 1 Myr the molecular clouds are eroded and dispersed. Thus, feedback has a negative net effect. The net rate of dispersal of the cloud, > 10^ M_sun/yr, is approximately independent of D, and therefore the cloud will be destroyed after < 10 Myr. Moreover, ionisation is driving turbulent gas motions in the molecular clouds. The conversion of radiative energy into kinetic energy is highly ineffcient (only a fraction of < 0.01%), however, radiative energy input is still dominating over gravitational energy input. For high D there is an abundance of pillars bordering the HII region. In fact pillars are so frequent that we call the structure 'pillar-dominated'. For low D pillars are much less frequent and the cold gas is swept up in a few partly coherent shells. Therefore clouds with low D appear 'shell-dominated'. The transition between 'pillar-dominated' and 'shell-dominated' HII regions occurs at D ~2.4. Finally, we find the clustering properties of triggered stars to change as a function of D. For low D, stars form in few small subclusters, whereas star formation is distributed over the whole surface of the HII region in case of high D.

Protostars in extreme environments: A Herschel study of the Carina Nebula

Author: Benjamin Gaczkowski

Universitäts-Sternwarte München

Co-Authors: Ratzka, T., Preibisch, T. and Roccatagliata, V. (Universitäts-Sternwarte München)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *10:32 Wednesday 28th 10:00-11:15*

Summary:
The Carina Nebula plays host to some of the most massive and luminous stars in our galaxy and represents an ideal arena in which to study in detail the physics of violent massive star formation and the resulting feedback effects of cloud dispersal and triggering of star formation. We have used Herschel to obtain the first spatially complete far-infrared maps of the entire Carina Nebula that are sensitive enough to detect the youngest and most deeply embedded protostars (that are yet invisible in the mid-infrared). Our analysis of the Herschel maps reveals 631 point-like sources, clearly demonstrating a high level of star formation activity. We combine the Herschel fluxes with Spitzer- and near-infrared photometry to construct the spectral energy distributions of 201 protostars. Radiative transfer modeling provides crucial information about the protostellar luminosities, masses, and the amount of circumstellar material. Our analysis shows that the currently forming generation of stars is restricted to low- and intermediate mass stars, i.e. considerably lower masses than present in the older generation of stars, suggesting that the current process of triggered star formation is a qualitatively different star formation mode. We interpret this difference as a consequence of the triggered star formation process in the irradiated clouds. Our further analysis will also include the disk masses of the low-and intermediate-mass protostars.

Radiation hydrodynamics of triggered star formation: the effect of the diffuse radiation field

Author: Thomas Haworth

University of Exeter

Co-Authors: T. J. Harries (University of Exeter

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *10:43 Wednesday 28th 10:00-11:15*

Summary:

Radiation hydrodynamics models of triggered star formation routinely neglect the contribution of diffuse field radiation under the assumption that it has negligible effect on the global ionization structure. We have directly included the diffuse field in models of radiatively driven implosion and demonstrated that the effect is in fact significant; altering the morphology and compression rate of bright rimmed clouds, therefore impacting star formation rates and efficiencies.

Feedback from Winds and Supernovae in Massive Stellar Clusters

Author: Hazel Rogers

University of Leeds

Co-Authors: J.M.Pittard (University of Leeds)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *10:54 Wednesday 28th 10:00-11:15*

Summary:

We simulate the effects of massive star feedback, via winds and supernovae, on inhomogeneous molecular material left over from the formation of a massive stellar cluster. We use 3D hydrodynamical models with a temperature dependent average particle mass to model the separate molecular, atomic and ionized phases. We find that the winds blow out of the molecular clump along low-density channels, and gradually ablate denser material into these. However, the dense molecular gas is surprisingly long-lived and is not immediately affected by the first star in the cluster exploding.

3D Hydrodynamics Simulations and Energetics of Emerging Superbubbles

Author: Martin Krause

Universe Cluster, Technische Universität München

Co-Authors: R. Diehl (Max-Planck-Institut für extraterrestrische Physik); A. Burkert (Univertsitätssternwarte München); Katharina Fierlinger (Universe Cluster, Garching); Rasmus Voss (Radboud University Nijmegen)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *11:05 Wednesday 28th 10:00-11:15*

Summary:

We present 3D simulations of the bubbles due to winds and supernovae from massive stars. We find that individual wind shells show a filamentary pattern due to the combined action of Vishniac and thermal instabilities, similar to some observed cases. We simulate the case of three merging bubbles, and vary their distances. We study the net energy input into the ISM. We find that more energy may be doposited for more extended energy injection, lower background density, and smaller distances between the bubbles. For any finite distance configuration we simulate, the retained energy is bounded by the non-interacting (infinite distance) case and the zero distance case.

The ISM in distant star-forming galaxies: going after extreme turbulence at z=2

Author: Padelis P. Papadopoulos

Max Planck Institute for Radioastronomy

Co-Authors: Mark Swinbank (Durham) - Pierre Cox (IRAM) -- Ian Smail (Durham) et al.

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

I will describe how a combination of strong gravitational lensing and sensitive mm and cm interferometric imaging of molecular lines allowed a detailed glimpse into the molecular ISM of a distant star-forming galaxy at z=2.2. The effects of high turbulent pressure, the cloud scaling relations, and a dramatic resetting of the star formation initial conditions come into an unexpectedly sharp focus, opening the gates for such investigations across cosmic epoch, with ALMA and the EVLA

Stability of self-gravitating discs under irradiation

Author: Ken Rice

Institute for Astronomy, University of Edinburgh

Co-Authors: P.J. Armitage (University of Colorado, Boulder) G.R. Mamatsashvili (Observatorio Astronomico di Torino) G. Lodato (Universita degli Studi di Milano) C.J. Clarke (Institute of Astronomy, Cambridge)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Self-gravity becomes competitive as an angular momentum transport process in accretion discs at large radii, where the temperature is low enough that external irradiation likely contributes to the thermal balance. Irradiation is known to weaken the strength of disc self-gravity, and can suppress it entirely if the disc is maintained above the threshold for linear instability. However, its impact on the susceptibility of the disc to fragmentation is less clear. We use two-dimensional numerical simulations to investigate the evolution of self-gravitating discs as a function of the local cooling time and strength of irradiation. Fragmentation requires short cooling times and is found to be a weak function of the level of irradiation. We find that the cooling time boundary increases by approximately a factor of two, as irradiation is increased from zero up to the level where instability is almost quenched. The numerical results imply that irradiation cannot generally avert fragmentation of self-gravitating discs at large radii; if other angular momentum transport sources are weak mass will build up until self-gravity sets in, and fragmentation will ensue.

How stars grow massive despite radiation pressure, triggering star-bursts; insights from gravitation

Author: Miles F Osmaston

Woking, UK (retired)

Co-Authors:

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Although high-mass stars range up to >100Msun they are evidently shedding up to 90% of their mass at very high rates. This has been attributed to radiation pressure, the only mechanism apparently available. But thermonuclear light-up occurs at well below one solar mass, so why doesn't radiation pressure inhibit accretionary growth to that high mass in the first place? New work on the physics of the gravitation mechanism [1], outlined on this poster, has revealed an expectation that the Newtonian force of any gravitationally-retained assemblage is inescapably accompanied by a radial positive-body-repelling electric field, the Gravity-Electric (G-E field). So this may be responsible for much of the mass loss, primarily of highly ionized material, with radiation pressure playing a smaller rôle. In that case, accretionary infall of very dust-opaque materials will not be opposed by the G-E field until stellar heat evaporates the dust and ionizes it, very close-in. The Newtonian force will prevail and the star will grow. So the ability to build a high-mass star now depends upon the source cloud's opacity. But the rapid evolution and mass loss of those stars will further increase that opacity - a positive feedback mechanism that could be the trigger for the starburst phenomenon. [1] Osmaston MF. (2006) GCA 70(18S), A465:- — (2009a) EPSC Abstr. 4, EPSC2009-264:- — (2009b) Geophys.Res. Abstr. 11, EGU2009-12204:- — (2010) In JENAM 2010 (ed. A. Moitinho et al) Abstract Book (Version 2.0) 159-160. — PSS (submitted).

Radio continuum observations of low mass young stars driving outflows

Author: Rachael E. Ainsworth

Dublin Institute for Advanced Studies

Co-Authors: A. M. M. Scaife (University of Southampton); T. P. Ray (Dublin Institute for Advanced Studies)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Summary:

We present 16 GHz deep radio continuum observations of a sample of classic low-mass young stars driving jets with the Arcminute Microkelvin Imager Large Array (AMI-LA). We compile and examine spectral energy distributions (SEDs) for each source using data from an extensive literature search and calculate both radio and sub-mm spectral indices in two different scenarios: (1) fixing the dust temperature according to evolutionary class; (2) allowing the dust temperature to vary. We use these derived spectral indices to place constraints on the physical mechanisms responsible for the radio emission and find that 80% of the objects in this sample have spectral indices consistent with free-free emission from a partially ionized outflow. We examine correlations between the radio luminosity and bolometric luminosity, envelope mass, and outflow momentum force and investigate the error contributions of different spectral parameters to constraining the radio luminosity of these objects. Based on AMI Consortium: Ainsworth et al. 2012, in prep

A New Method to Determine Star Cluster Distances?

Author: Anne Buckner

Univeristy of Kent

Co-Authors: D.Froebrich (University of Kent)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Determining cluster distances is essential to analyse their properties and distribution throughout the Galaxy. In particular it is desirable to have a reliable, purely photometric method for large samples of newly discovered (candidate) clusters (e.g. from 2MASS, UKIDSS-GPS, VISTA-VVV). This would allow us to estimate distances independent of isochrone fits and cluster properties (age and reddening). Here we present our attempt to 'calibrate' such a method, based on a set of about 100 star clusters with known distances. Our method relies on the photometric decontamination of cluster and field stars, based on the colour and position of a star relative to the cluster, to determine cluster membership probabilities. We then estimate the total number of foreground stars to the cluster (per unit area) based on the colours of low probability cluster members. These are then compared to predictions from the Besancon Galaxy Model by Robin et al. to estimate the cluster distance. The poster will show our preliminary results on the accuracy of such distance calculations. We will discuss which parameters of the photometric decontamination are required to achieve the best calibration, and if the accuracy depends on e.g. the age of the cluster or its position in the Galaxy.

Feedback Regulated Star Formation: From Star Clusters to Galaxies

Author: Sami Dib

Imperial College London

Co-Authors:

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

I will summarise results from a model which describes star formation in protocluster clumps of different metallicities. In this model, gravitationally bound cores form uniformly in the clump following a prescribed core formation efficiency per unit time. After a contraction timescale which is equal to a few times their free-fall times, the cores collapse into stars and populate the IMF. Winds from the newly formed OB stars remove gas from the clump until core and star formation are quenched. The power of the radiation driven winds has a strong dependence on metallicity and increases with increasing metallicity. Thus, winds from stars in the high metallicity models lead to a rapid evacuation of the gas from the protocluster clump and to a reduced star formation efficiency, SFE_exp, as compared to their low metallicity counterparts. By combining SFE_exp with the timescales on which gas expulsion occurs, we derive the metallicity dependent star formation rate per unit time in this model as a function of the gas surface density Sigma_g. This is combined with the molecular gas fraction in order to derive the dependence of the surface density of star formation Sigma_SFR on Sigma_g in galactic disks. This feedback regulated model of star formation reproduces very well the observed star formation laws extending from low gas surface densities up to the starburst regime. Furthermore, the results show a dependence of Sigma_SFR on metallicity over the entire range of gas surface densities.

Lonely Cores Observed In Molecular Lines

Author: Ciara Quinn

Cardiff University

Co-Authors: T. Bourke (Harvard-Smithsonian Centre for Astrophysics); D. Ward-Thompson (Cardiff University)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Isolated star-forming cores are the ideal laboratory for the study of the low-mass star formation process. They have a relatively simple nature and are free from the confusing effects experienced in larger, more crowded molecular clouds and clusters, where multiple star formation events lead to a more complicated picture that is harder to interpret. The Spitzer legacy program “From Molecular Clouds to Planet-Forming Disks” and its follow-up program “Lonely Cores” mapped more than 100 nearby, isolated cores across a range of evolutionary stages. To study the cores in detail, however, complementary high-resolution spectral-line mapping is needed. Using the ATNF Mopra Telescope, a 22-m radio telescope, situated in NSW, Australia, we have mapped the 12CO(J=1-0), 13CO(J=1-0) and C18O(J=1-0) emission from ~40 southern cores from the Lonely Cores sample, primarily targeting low density starless cores that may or may not be gravitationally bound, to study possibly the youngest cores. By conducting an LTE analysis, we have calculated

starless cores that may or may not be gravitationally bound, to study possibly the youngest cores . By conducting an LTE analysis, we have calculated excitation temperatures, optical depths, column densities and masses of the most isolated subset of these cores. By comparing our column density maps with mid-infrared extinction maps, we find that 13CO and C18O are excellent tracers of extinction conditions within these dense cores.

Herschel HIFI water observations of low-mass protostellar envelopes in the WISH survey

Author: Joseph Mottram

Leiden Observatory

Co-Authors: Lars Kristensen (Leiden Observatory), Ewine van Dishoeck (Leiden Observatory)

Session: ISM1: Interstellar medium and star formation

Presentation type: Talk *00:00 Poster Session A*

Summary:

Herschel observations are revolutionising our understanding of water, a key probe of the temperature, density and kinematics of the warm gas in star formation regions. Recent results from the ``Water in Star-forming regions with Herschel'' (WISH) HIFI Guaranteed Time Key Programme have revealed that embedded YSOs have diverse, rich and complex water line profiles, often containing multiple components tracing different physical processes within a single beam. These different components can be placed in a tentative evolutionary scenario, such that the relative importance of different processes can be explored with time. A specific example is that inverse P-Cygni profiles are much more common in water in deeply embedded low-mass protostars than other chemical species previously studied. 1-D multi-transition radiative transfer modelling of WISH HIFI water observations towards these Class 0 protostars is used to quantify the infall velocities and envelope physical properties in a self-consistent manner. This example will be used to show that water is uniquely sensitive to the dynamics of material around YSOs. The WISH survey is thus providing a valuable legacy, which will shape our understanding of star formation for decades to come.

Numerical simulations of a shock interacting with multiple clouds

Author: Robertas Aluzas

University of Leeds

Co-Authors: J.M.Pittard (University of Leeds) T.W.Hartquist (University of Leeds) S.A.E.G. Falle (University of Leeds)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

In self-propagating star formation feedback from massive stars induces further star formation in the galaxy. However, flows and shocks created by the massive stars can also destroy surrounding clouds. In order for a shock front to provide positive feedback in star formation the shock needs to evolve considerably, perhaps as a result of destroying some "sacrificial" clouds on its way. I will present the insights gained from numerical simulations where a shock encounters systems of clouds. As the clouds evolve they affect the flow and are mixed into it. Clouds further downstream then evolve differently as they interact with the shock and mass-loaded flow. I investigate the role of different cloud geometries and number densities and use a sub-grid turbulence model.

Spitzer characterisation of dust in an anomalous emission region: the Perseus Cloud - IRAC and MIPS

Author: Christopher Tibbs

IPAC/Caltech

Co-Authors: N.Flagey (JPL/Caltech); R.Paladini (IPAC/Caltech); M.Compiegne (IPAC/Caltech); S.Shenoy (NASA Ames Research Center); S.Carey (IPAC/Caltech); A.Noriega-Crespo (IPAC/Caltech); C.Dickinson (Jodrell Bank Centre for Astrophysics); Y.Ali-Haimoud (Caltech); S.Casassus (Universidad de Chile); K.Cleary (Caltech); R.Davies (Jodrell Bank Centre for Astrophysics); R.Davis (Jodrell Bank Centre for Astrophysics); C.Hirata (Caltech); R.Watson (Jodrell Bank Centre for Astrophysics)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Anomalous microwave emission is known to exist in the Perseus Molecular Cloud, as recently observed by the Planck satellite, and one of the most promising candidates to explain this excess emission is that of electric dipole radiation from rapidly rotating very small dust grains, commonly referred to as spinning dust. Photometric data observed with the Spitzer Space Telescope have been completely reprocessed and used in conjunction with the dust emission model DUSTEM to characterise the properties of the dust within the cloud. This analysis allowed us to constrain spatial variations in the strength of the interstellar radiation field, the abundances of the PAHs and VSGs relative to the BGs, the column density of hydrogen and the equilibrium dust temperature. These parameter maps were used to investigate the dust properties in regions both with, and without, anomalous emission, and we find that in regions of anomalous emission, the abundances of the PAHs, the strength of the interstellar radiation field and the equilibrium dust temperatures are enhanced, while the column density of hydrogen is decreased. This type of analysis opens a new perspective in the field of anomalous emission studies, and represents a powerful new tool for constraining spinning dust models.

An analysis of the Herschel data of the star-forming regions Mon R1 and Mon R2

Author: Thomas Rayner

Cardiff University

Co-Authors: M. Griffin (Cardiff University) D. Ward-Thompson (Cardiff University) J. Kirk (Cardiff University) The SPIRE SAG-3 Team

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Reflection nebulae are usually good indicators of sites of current or recent star formation, as they are formed when the output from a star or stars opens up the parent cloud. In many cases, the clouds will contain yet younger stars and protostars, which are even more valuable to star formation studies. These, however, cannot be observed in visible light, and so must be studied in the infrared part of the spectrum. Using data from both the Herschel PACS and SPIRE instruments and SCUBA-2 on the JCMT, we study two star-forming regions; the reasonably quiet Mon R1 (part of the Mon OB1 association), and the much denser, brighter Mon R2. We identify the locations and properties of dense clumps in the clouds and characterise these clumps via a mass-size plot, which is used to determine what proportion of them are likely to become stars. We also study the structure of the regions, including that of the filaments in which star formation occurs, and the cores themselves.

The Milky Way Project

Author: Robert Simpson

Oxford University

Co-Authors: M.S.Povich (Pennsylvania State University); S.Kendrew (Max Planck Institute for Astronomy); C.J.Lintott (Oxford University); E.Bressert (ESO, Exeter); K.Arvidsson (University of Chiacgo); C.Cyganowski (Harvard CfA); S.Maddison (Swinburne); K.Schawinski (Yale University); R.Sherman (University of Chicago); A.M.Smith (Adler Planetarium); G.Wolf-Chase (Adler Planetarium)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

We present the first results of the online citizen science website 'The Milky Way Project. Principally we describe a new catalogue of 5,106 infrared bubbles created through visual classification via the site. Bubbles in the new catalogue have been independently measured by at least 5 individuals, producing consensus parameters for their position, radius, thickness, eccentricity and position angle. Citizen scientists - volunteers recruited online and taking part in this research - have independently rediscovered the locations of at least 86% of three widely-used catalogues of bubbles and H II regions whilst finding an order of magnitude more objects. Also outlined is the creation of a 'heat map' of star-formation activity in the Galactic plane. This online resource provides a crowd-sourced map of bubbles and arcs in the Milky Way, and will enable better statistical analysis of Galactic star-formation sites. The project has also been collecting data on the locations and sizes of other objects, including star clusters, galaxies and compact H II regions.

Large Scale Infrared Dark Filaments

Author: Clare Lenfestey

University of Manchester

Co-Authors:

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

The galactic plane contains long strings of IRDCs with very high aspect ratios, for example the ‘Nessie’ nebula (Jackson et al. 2010) is 80pc long with an aspect ratio of 150:1. The formation of such filaments is poorly understood; their size implies that it is unlikely that such filaments are formed by turbulence alone, but that cloud-cloud collisions or the interaction of shocks with molecular clouds play an important role. In order to investigate the possible processes behind the formation of such large-scale filaments and the role they play in star formation, a systematic search of the galactic plane has been undertaken. Using the Spitzer IRDC catalogue and minimum spanning trees, 102 candidate filamentary structures have been identified and further investigated using the Herschel HIGAL data to look at their thermal dust emission. This not only provides additional support that the structures detected are indeed coherent, spatially connected filaments, but also allows us to look in greater detail at the fragmentation of the filaments, allowing us to further understand the processes that initiate star formation. The morphologies of infrared dark filaments are varied, ranging from hub-filaments to bubble-like features, but the majority of the structures are long and narrow, similar to Nessie. One of the most intriguing characteristics of the filaments is that the do not appear to be randomly aligned with respect to the galactic plane; they are instead aligned so that they lie parallel to the disc. This could provide evidence that the passage of the spiral arms through the ISM compresses the gas, causing infrared dark filaments to condense and fragment, triggering star formation along the leading edge of the spiral arms.

Testing the universality of star formation - the 73% solution?

Author: Robert King

University of Exeter

Co-Authors: R. J. Parker (ETH, Zurich); J. Patience (Exeter); S. P. Goodwin (Sheffield)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

One of the major unsolved problems in star formation is the universality of the process: is the difference between small, local star-forming regions such as Taurus, and massive starburst clusters like 30 Doradus merely one of the level of star formation, or is there something fundamentally different between these two extremes? Binary star populations provide an important probe of the star formation process. I will present our recent comparison of multiplicity data for five nearby star-forming regions (Taurus, Chamaeleon I, Ophiuchus, IC348, and the ONC) in which we impose identical sensitivity criteria. Within this carefully controlled study, we find no significant trend of decreasing binary fraction with increasing cluster density. Only Taurus is distinct from the remaining regions which span a factor of nearly 20 in density. Through a comparison with N-body simulations tailored to the size, density and morphology of our target clusters, we find that the only possible universal initial condition capable of reproducing all of the observations is an initially clumpy (fractal) distribution with a total binary fraction of ~73%. I will also discuss our ongoing comparison of the separation distributions of these regions.

Direct Observation of the Transition to Coherence and Isothermal Filaments in a Dense Core

Author: Jaime E Pineda

JBCA, University of Manchester and ESO

Co-Authors: A. Goodman (Harvard-Smithsonian CfA), H. Arce (Yale University), P. Caselli (University of Leeds), J. Foster (Boston University), P.C Myers (Harvard-Smithsonian CfA), E. Rosolowsky (University of British Columbia at Okanagan), S. Longmore (ESO), S. Corder (NRAO)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

We present NH3 observations of the B5 region in Perseus obtained with the GBT and EVLA. The GBT map covers a region large enough (11'×14') that it contains the entire dense core observed in previous dust continuum surveys. The dense gas traced by NH3(1,1) covers a much larger area than the dust continuum features found in bolometer observations. The velocity dispersion in the central region of the core is small, presenting subsonic non-thermal motions which are independent of scale. However, it is thanks to the coverage and high sensitivity of the observations that we present the detection, **for the first time**, of the transition between the coherent core and the dense but more turbulent gas surrounding it. This transition is sharp, increasing the velocity dispersion by a factor of 2 in less than 0.04 pc (the 31" beam size at the distance of Perseus, 250 pc).The change in velocity dispersion at the transition is ~3 km s−1 pc−1. The existence of the transition provides a natural definition of dense core: the region with nearly-constant subsonic non-thermal velocity dispersion. The EVLA observations (27 pointing mosaic) are combined with the GBT map to achieve a 6" beam. This map (~6.8'x8') covers the region of subsonic non-thermal velocity dispersion observed with the GBT. These observations reveal, for the first time, the presence of striking filamentary structure (20" wide or 5,000 AU at the distance of Perseus) in this low-mass star forming region. The integrated intensity profile of this structure is consistent with models of an isothermal filament in hydrostatic equilibrium. Also, the observed separation between the B5–IRS1 young stellar object (YSO), in the central region of the core, and the northern starless condensation matches the Jeans length of the dense gas. This suggests that the dense gas in the coherent region is fragmenting. The region observed displays a narrow velocity dispersion, where most of the gas shows evidence for subsonic turbulence, and where little spatial variations are present. It is only close to the YSO where an increase in the velocity dispersion is found, but still displaying subsonic non-thermal motions. Finally, we'll discuss the implications of these results on the "core" identification/definition and the importance of the region of subsonic turbulence in the formation process of low-mass stars.

Template fitting of WMAP 7-year data: anomalous dust or flattening synchrotron emission?

Author: Michael Peel

Jodrell Bank Centre for Astrophysics, University of Manchest

Co-Authors: M. W. Peel [1], C. Dickinson [1], R. D. Davies [1], A. J. Banday [2], T. R. Jaffe [2], J. L. Jonas [3] [1] Jodrell Bank Centre for Astrophysics, University of Manchester [2] Centre d'Etude Spatiale des Rayonnements, Toulouse [3] Department of Physics and Electronics, Rhodes University

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Anomalous microwave emission at 20-40GHz has been detected across our Galactic sky. It is highly correlated with thermal dust emission and hence it is thought to be due to spinning dust grains. Alternatively, this emission could be due to synchrotron radiation with a flattening (hard) spectral index. We cross-correlate synchrotron, free-free and thermal dust templates with the WMAP 7-year maps using synchrotron templates at both 408MHz and 2.3GHz to assess the amount of flat synchrotron emission that is present, and the impact that this has on the correlations with the other components. We find that there is only a small amount of flattening visible in the synchrotron spectral indices by 2.3GHz, of around \Delta \approx 0.05, and that the significant level of dust-correlated emission in the lowest WMAP bands is largely unaffected by the choice of synchrotron template, particularly at high latitudes (it decreases by only ~7 per cent when using 2.3 GHz rather than 408 MHz). This agrees with expectation if the bulk of the anomalous emission is generated by spinning dust grains. (MNRAS, submitted; arXiv:1112.0432)

The Structure and Kinematics of NGC 2068 in Orion B

Author: Samantha Walker-Smith

University of Cambridge

Co-Authors: J. S. Richer, J. V. Buckle, J. S. Greaves, I. A. Bonnell

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

We have carried out a survey on the NGC 2068 region in the Orion B molecular cloud with HARP on the JCMT, using 13CO and C18O (J=3-2) and H13CO+ (J=4-3). We used 13CO to map the outflows in the region, and have attempted to match them up with previously defined SCUBA cores. Using

the gaussclumps algorithm, we have broken down the C18O and H13CO+ into clumps, finding 29 and 18 clumps respectively. The average deconvolved radii of these clumps is 5400+/-2100AU and 2800+/-900AU for C18O and H13CO+ respectively. We have also obtained virial and gas masses for these clumps, and hence determined how bound they appear. We find that the C18O clumps appear to be more bound than the H13CO+ clumps (average gas-virial ratio of 2.6 compared to 1.1). This can be explained by C18O contributions from gas in the infalling envelope, compared to H13CO+ which traces only the denser core. We have obtained core-to-core velocity dispersions for the clumps of 0.43 +/- 0.17 km/s and 0.71 +/- 0.11 km/s for C18O and H13CO+ respectively. We use these values to investigate the kinematics of fragmentation of prestellar cores.

Molecular cloud disruption and chemical enrichment of the ISM caused by massive star feedback

Author: Katharina Fierlinger

University Observatory Munich

Co-Authors: A.M. Burkert (University Observatory Munich); R. Diehl (Max Planck Institute for Extraterrestrial Physics); C. Dobbs (University of Exeter); D.H. Hartmann (Clemson University); M. Krause (Max Planck Institute for Extraterrestrial Physics); E. Ntormousi (University Observatory Munich); R. Voss (Radboud University Nijmegen)

Session: ISM1: Interstellar medium and star formation

Presentation type: Poster *Poster Session A*

Summary:

Massive stars shape the interstellar medium and enrich it with freshly-produced heavy elements by means of Wolf-Rayet winds and supernovae explosions. In this work we focus on the feedback efficiency in homogeneous GMCs, turbulent GMCs, as well as irregularly-structured GMCs taken from global disc simulations. Also the enrichment of the ISM with 26Al, a radioactive trace element that decays with an average lifetime of 1 Myr after being ejected from the stars, is studied. For our hydrodynamic simulations we use the RAMSES code and the Geneva grids of stellar evolution models. In all our simulations, a superbubble is formed after break-out from the MC, and then the massive-star outputs rather rapidly disrupt the molecular cloud. The feedback is most disruptive for a homogeneous molecular cloud, whereas the clouds with an irregular density structure have longer lifetimes, since more of the energy from the feedback is channelled into low density surroundings. We find that for structured clouds, the stellar feedback naturally reproduces cavities with asymmetric morphologies, similar to the Orion-Eridanus bubble. Finally we use our calculations to predict the distribution of 26Al, thus providing an important constraint on the timescales for the propagation of stellar winds and supernovae in the ISM.

Fullerenes in circumstellar and interstellar environments

Author: Jan Cami

The University of Western Ontario

Co-Authors: J. Bernard-Salas (Institut d'Astrophysique Spatiale); E. Peeters (University of Western Ontario); E. Micelotta (University of Western Ontario); A.P. Jones (Institut d'Astrophysique Spatiale)

Session: ISM2: Cosmic carbon

Presentation type: Talk *11:45 Wednesday 28th 11:45-13:15*

Summary:

We have recently discovered the unmistakable spectral signatures of the fullerene species C60 and C70 in Spitzer observations of a young planetary nebula; this represents the first identification of large aromatics in astrophysical environments, and these species are now the largest molecules known to exist in space. Since our discovery, fullerenes have been reported in a wide variety of astronomical objects at abundances of typically ~0.3% of the cosmic carbon. They are formed in carbon-rich evolved stars, survive in the interstellar medium and are also detected in the disks surrounding young stars. Fullerenes have many interesting properties and could play a unique role in the physics and chemistry of the interstellar medium. In this talk, I will give an overview of what we have learned so far from observational analyses, theoretical models and laboratory efforts with a special focus on the surprising aspects that have challenged our understanding of some of the physics and chemistry involved ? in particular about the formation and the state of fullerenes in space. I will also discuss how fullerenes compare to polycyclic aromatic hydrocarbon (PAHs) in these environments.

Detection of C60 in embedded young stellar objects, a Herbig Ae/Be star and an unusual post-AGB star

Author: Professor Peter Sarre

The University of Nottingham

Co-Authors: K.R.G.Roberts; K.T.Smith

Session: ISM2: Cosmic carbon

Presentation type: Talk *12:05 Wednesday 28th 11:45-13:15*

Summary:

The first detection of the C60 molecule in massive embedded young stellar objects (YSOs) is described. Observations with Spitzer IRS reveal the presence of C60 in YSOs ISOGAL-P J174639.6-284126 and SSTGC 372630 in the Central Molecular Zone in the Galactic centre, and in a YSO candidate, 2MASS J06314796+0419381, in the Rosette nebula. The first detection of C60 in a Herbig Ae/Be star, HD 97300, is also reported. These observations extend the range of astrophysical environments in which C60 is found to include YSOs and a pre-main sequence star. C60 excitation and formation mechanisms are discussed.

Astrochemistry of Acetonitrile Ices

Author: ALI ABDULGALIL

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Co-Authors: D. Marchione, A. Rosu-Finsen, M.P. Collings, M. R. S McCoustra F. Islam, M .E. Palumbo

Session: ISM2: Cosmic carbon

Presentation type: Talk *12:15 Wednesday 28th 11:45-13:15*

Summary:

Interstellar ices are a reservoir of simple chemical species in space (e.g. H2O, CO, CO, etc) as well as the main source in the gas phase of complex chemical species via processes induced by photons and charged particles. Acetonitrile (CH3CN) is the simplest organic nitrile and is thought to be a precursor of glycine. This paper will report on a collaboration between HWU and INAF Catania, which seeks to understand the processing of solid CH3CN by energetic protons and electrons. Transmission infrared spectroscopy (TIRS) and reflection-absorption infrared spectroscopy (RAIRS) were used to monitor the effect of protons and electron impact on the solid CH3CN. The results indicate that acetonitrile desorbs efficiently under low energy electron irradiation while new molecular species were detected under medium energy proton impact.

Experimental studies on condensation and properties of carbonaceous matter

Author: Cornelia Jäger

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Session: ISM2: Cosmic carbon

Presentation type: Talk *12:25 Wednesday 28th 11:45-13:15*

Summary:

Carbonaceous grains represent a major component of cosmic dust. In order to understand their formation pathways, as well as their structural, compositional, and spectral properties in different astrophysical environments, dedicated laboratory experiments combined with structural analyses are necessary. Nanometer- and subnanometer-sized carbonaceous grains were prepared in the laboratory by gas-phase condensation reactions such as laser pyrolysis of gaseous hydrocarbons and laser ablation of graphite in quenching gas atmospheres. Two formation pathways with different precursors have been analyzed by studying the by-products and the structure of the final condensates. In a low-temperature (LT) condensation (below 1700 K), polycyclic aromatic hydrocarbons (PAHs) are found to be precursors and building blocks for condensing carbonaceous grains. Therefore, these condensates consist of a mixture of PAHs and grains. The laboratory experiments demonstrated that a big variety of PAHs are produced in LT gas-phase condensation reactions. In the interstellar radiation field, a part of the condensed molecules such as smaller and less compact ones are likely destroyed. A mixture of remaining large PAHs and a few freshly produced smaller ones eventually contribute to the observed spectral signatures of cosmic carbonaceous matter. In the high-temperature condensation (above 3500 K), carbon chains, fullerene snatches and fullerenes are precursors for grain formation. Consequently, condensation products in cool and hot astrophysical environments, such as cool and hot AGB or Wolf Rayet stars, should be different.

The chemistry of extragalactic carbon stars

Author: Paul M. Woods

University College London

Co-Authors: C. Walsh (Queen's University Belfast); M.A. Cordiner (NASA Goddard); F. Kemper (ASIAA)

Session: ISM2: Cosmic carbon

Presentation type: Talk *12:45 Wednesday 28th 11:45-13:15*

Summary:

Prompted by the recent interest in Spitzer Infrared Spectrometer spectra of carbon stars in the Large Magellanic Cloud, we have investigated the circumstellar chemistry of carbon stars in low-metallicity environments. By modelling the envelopes of these stars with chemical models we find that, as indicated by observations, acetylene is particularly abundant in the inner regions of carbon-rich AGB stars -- more abundant than carbon monoxide. Since C2H2 and C2H drive the hydrocarbon chemistry of carbon stars, this means that larger hydrocarbons are more abundant at the metallicities of the Magellanic Clouds than in stars with solar metallicity. An implication of this is that PAHs and fullerenes could potentially be very abundant in these environments. We also find that oxygen and nitrogen chemistry is suppressed at lower metallicity, as expected. Finally we produce some simulated ALMA spectra, which show that molecular lines in Magellanic carbon stars should be readily detectable with this new instrument.

Evolved carbon stars in the Magellanic Clouds: photometric versus spectroscopic IR identification

Author: Paul Ruffle

Jodrell Bank Centre for Astrophysics

Co-Authors: F. Kemper (Academia Sinica, Institute of Astronomy and Astrophysics); P. M. Woods (University College London).

Session: ISM2: Cosmic carbon

Presentation type: Talk *12:55 Wednesday 28th 11:45-13:15*

Summary:

The SAGE-LMC and SAGE-SMC surveys have mapped the Magellanic Clouds in the infrared using the Spitzer Space Telescope. Using Spitzer's InfraRed Array Camera (IRAC) and Multiband Imaging Photometer for Spitzer (MIPS), these surveys detected and catalogued 8.5 million point sources in the Large Magellanic Cloud (LMC) and 2.5 million point sources in the Small Magellanic Cloud (SMC). Photometric analysis of these data, together with those from the 2MASS survey, reveal large populations of evolved carbon stars in both clouds. The Spitzer archive also contains 1,000 InfraRed Spectrograph (IRS) staring mode observations within the LMC and 250 in the SMC. SAGE-Spectroscopy classifications of these bright infrared point sources provide spectral profiles for each type of evolved carbon star, e.g. AGB, post-AGB and PN. I compare these spectroscopic results with those for the same objects using several photometric classification schemes, i.e. Boyer et al. (2011), Matsuura et al. (2009), Marengo et al. (2007), Blum et al. (2006), Cioni et al. (2006). I discuss the robustness of relying on photometric colours when identifying evolved carbon stars and the implications of misidentification when calculating dust inputs to the ISM.

Benzene in a mixed-chemistry object

Author: Kyle Roberts

The University of Nottingham

Co-Authors: P.J.Sarre (The University of Nottingham)

Session: ISM2: Cosmic carbon

Presentation type: Talk *13:05 Wednesday 28th 11:45-13:15*

Summary:

The well studied object IRAS 19566+3423 is classified in SIMBAD as a star with an envelope of OH/IR type, most of the observations being of OH and H20 maser emission lines and silicate dust absorption. However, Spitzer IRS spectra between 10 and 18 microns reveal a very rich spectrum of vibrational absorption features due to carbon molecules including acetylene and HCN and their longer chain analogues, ethene, and the simplest aromatic ring molecule, benzene. This represents only the third astronomical detection of benzene, the others being the Egg Nebula and SMP LMC 11. Molecular rotational temperatures are derived and possible routes to the formation of benzene are discussed in the context of this mixed-chemistry object.

Laboratory Investigations of Carbonaceous Molecules

Author: Sandra Brünken

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Co-Authors: O. Asvany (Universität zu Köln); C. Endres (Universität zu Köln); T.F. Giesen (Universität zu Köln); J. Krieg (Universität zu Köln); S. Schlemmer (Universität zu Köln); S. Thorwirth (Universität zu Köln)

Session: ISM2: Cosmic carbon

Presentation type: Talk *17:00 Wednesday 28th 17:00-18:00*

Summary:

Small carbonaceous molecules are the chemical link between atomic carbon produced in stars and large carbonaceous dust grains. Understanding their chemical evolution in space is based in large parts on gas-phase laboratory investigations. These provide accurate spectral data for the identification of new molecular species, and chemical reaction rates under conditions prevalent in space. The detection of the first molecular (carbon-chain) anions in space is one recent example demonstrating a strong interplay between observational and laboratory astrochemistry. The identification relied on high resolution rotational spectroscopy in the cm- and mm-wavelength bands. The advent of highly sensitive and broadband radio-, FIR and IR telescopes dictates the need for laboratory data in these spectral regions also of rare isotopic and vibrationally excited pure and mixed carbon clusters. Examples discussed here are astronomical observations and high resolution mm-wave to IR absorption spectroscopy of C3 and SiC2. In addition, IR action spectroscopy based on bimolecular ion-molecule reactions in temperature-variable ion traps has been developed in recent years in the Cologne laboratory group, providing another sensitive method to obtain high resolution ro-vibrational spectra as well as chemical kinetics data of small astrophysically relevant carbocations (e.g., C2H2+, CH3+, CH5+). We will also report on the development of a new ion trap apparatus intended for IR and UV spectroscopy of cold PAH ions.

Complex Organic Molecules in Protoplanetary Disks

Author: Catherine Walsh

Queen

Co-Authors: T. J. Millar (Queen's University Belfast); Hideko Nomura (Kyoto University); Eric Herbst (University of Virginia); Susanna Widicus-Weaver (Emory University)

Session: ISM2: Cosmic carbon

Presentation type: Talk *17:20 Wednesday 28th 17:00-18:00*

Summary:

Protoplanetary disks are vital objects in star and planet formation. In addition to aiding mass accretion onto the star and angular momentum dissipation away from the protostellar system, they also contain all material which may go into forming an orbiting planetary system. We explore the synthesis of large complex organic molecules (COMs) in protoplanetary disks which encompass young stars. We use a chemical network primarily developed for use in hot core models to calculate the abundance and distribution of gas-phase and grain-surface COMs and discuss the potential of observing these species with facilities such as ALMA.

Formation of polycyclic aromatic hydrocarbon (PAH) molecules on crystalline silicate grain surfaces

Author: Mark Hammonds

University of Nottingham

Co-Authors: M.Tian(University of Hong Kong); N.Wang (University of Hong Kong); B.S.Liu (Tianjin University); A.S.-C.Cheung (University of Hong Kong); P.J.Sarre (University of Nottingham)

Session: ISM2: Cosmic carbon

Presentation type: Talk *17:30 Wednesday 28th 17:00-18:00*

Summary:

PAH molecules are found in a wide range of interstellar and circumstellar environments but their formation mechanism is not well understood. Evidence for PAHs comes from the assignment of numerous infrared emission features that match, approximately, vibrational transitions of PAHs that are thought to be excited by UV/visible radiation. They have been observed in proto-planetary, planetary and reflection nebulae, HII regions, young stellar objects, in the general interstellar medium of our Galaxy, and also in external galaxies. In this work we explore experimentally the possible role of crystalline silicates in the formation of small PAHs through a catalytic mechanism. An experiment was designed to investigate whether small PAHs might form by passing acetylene over heated olivine crystals in order to simulate conditions that hold for regions such as the inner part of the circumbinary disc of the Red Rectangle. This is one of a number of objects with a mixed oxygen-carbon chemistry. For a temperature of e.g. 500 C strong peaks with m/z of 178 and 202 were found which are due to the anthracene (C14H10) and pyrene (C16H10) PAH molecules, along with other 2-4 ring PAH compounds and polyacetylenes, so establishing that this chemical reaction does indeed occur efficiently.

The formation of highly superhydrogenated PAHs and their catalytic role in H2 formation

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Co-Authors: Bjarke Jørgensen (Aarhus University); Emil Friis (Aarhus University); Louis Nilsson (Aarhus University); Andrew Cassidy (Aarhus University); Richard Balog (Aarhus University); Mie Andersen (Aarhus University); Bjørk Hammer (Aarhus University); Mario Accolla (Universitá degli Studi di Napoli Parthenope); Vito Mennella (Istituto Nazionale di Astrofisica - Osservatorio Astronomico di Capodimonte); Liv Hornekær (Aarhus University)

Session: ISM2: Cosmic carbon

Presentation type: Talk *17:40 Wednesday 28th 17:00-18:00*

Summary:

We present mass spectrometry measurements that demonstrate the formation of highly superhydrogenated derivatives of the polycyclic aromatic hydrocarbon molecule coronene through H atom addition reactions. We show that the observed product mass distribution furthermore provides evidence for abstraction reactions resulting in H2 formation, in agreement with IR measurements. Complementary density functional theory (DFT) calculations confirm the stability of the observed superhydrogenated species towards spontaneous H and H2 loss indicating that abstraction reactions may be the dominant route to H2 formation involving neutral PAHs. The results indicate that highly superhydrogenated PAHs could well be formed and could act as efficient catalysts for H2 formation in the interstellar medium in low UV flux regions.

The electronic absorption properties of PAHs in view of the observed interstellar UV-vis extinction

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Co-Authors: C. Jäger, G. Rouillé, Y. Carpentier, F. Huisken (Laboratory Astrophysics and Clusterphysics Group of the Max Planck Institute for Astronomy, Heidelberg at the Institute of Solid State Physics, FSU Jena), H.-J. Räder (Max Planck Institute for Polymer Research), J. Bouwman (Raymond and Beverly Sackler Laboratory for Astrophysics, Leiden Observatory, Leiden University), Th. Henning (Max Planck Institute for Astronomy, Heidelberg)

Session: ISM2: Cosmic carbon

Presentation type: Talk *17:50 Wednesday 28th 17:00-18:00*

Summary:

As revealed by recent high-resolution spectral investigations in the wavelength range between 300 and 400 nm, the interstellar extinction curve does not display any sharp electronic absorption bands characteristic for large polyatomic molecules, like polycyclic aromatic hydrocarbons (PAHs), which belong

to the most abundant interstellar molecules. Applying laboratory techniques, we tried to verify whether the absorption curves of mixtures of medium-sized PAHs (20 - 40 C atoms) are compatible with these astronomical observations [1]. The PAH mixtures were synthesized by infrared laser pyrolysis and subsequent chemical extraction and size separation. The matrix isolation technique was used to study the absorption spectra of isolated molecules at low temperature. Our experimental results demonstrate that the UV-visible absorption curves of PAH mixtures can be very smooth, displaying no sharp bands, if the molecular diversity is sufficiently high. Hence, it can be concluded that the interstellar PAH population must be at least as diverse as our laboratory samples in order to prevent the astronomical observation of electronic fingerprints of individual species in the wavelength range between 300 and 400 nm [1]. Based on new UV-visible spectra of selected large PAHs in their neutral and singly ionized form [2], we will also discuss the possible connection of

these molecules with the interstellar UV bump at 217.5 nm and the diffuse interstellar bands, which appear at wavelengths longer than 400 nm. [1] M. Steglich, Y. Carpentier, C. Jäger, F. Huisken, H.-J. Räder, Th. Henning: On the smoothness of the interstellar extinction curve in the UV. Comparison with recent laboratory measurements of PAH mixtures; submitted to A&A [2] M. Steglich, J. Bouwman, F. Huisken, Th. Henning: Can neutral and ionized polycyclic aromatic hydrocarbons be carriers of the ultraviolet extinction bump and the diffuse interstellar bands?; ApJ 742 (2011) 2

Nonlinear surface chemistry analysed with XUV pump - XUV probe at FLASH

Author: Björn Siemer

Physikalisches Institut Westfälische Wilhelms-Universität Ms

Co-Authors: R. Frigge, H. Zacharias (Westfälische Wilhelms-Universität Münster); R. Mitzner (Helmholtz Zentrum Berlin); Stefan Düsterer (Hasylab, DESY, Hamburg)

Session: ISM2: Cosmic carbon

Presentation type: Poster *Poster Session A*

Summary:

For a better understanding of the formation of interstellar molecules a D_2O ice covered highly-oriented pyrolytic graphite (HOPG) surface is investigated. This analog of interstellar ice covered dust grains, is irradiated with XUV radiation (hν = 38 eV), provided by the free electron laser at Hamburg (FLASH). In a so far unknown reaction cascade O_2^+ ions are formed and emitted with a highly nonlinear dependence on the FLASH intensity proportional to I^3. To investigate the formation process of the desorbing molecular oxygen ions a non-linear XUV pump - XUV probe measurement with a beamsplitter and delay-line device for the energy range of 24 – 200 eV is used. A two-pulse autocorrelation curve of desorbing O_2^+ ions is measured. The time constants for the fitted asymmetric Gaussian points to an electronic process initiating the reaction and long decay time of the O_2^+ - signal suggests a motion of molecular constituents during the reaction.

Thermal desorption spectroscopy of small molecules on interstellar interesting surfaces

Author: Björn Siemer

Physikalisches Institut Westfälische Wilhelms-Universität Ms

Co-Authors: N. Heming, T. Suhasaria, R. Frigge and Helmut Zacharias (Physikalisches Institut Westfälische Wilhelms-Universität Münster)

Session: ISM2: Cosmic carbon

Presentation type: Poster *Poster Session A*

Summary:

Chemical surface reactions on dust grains are a possible way of molecule formation in the Interstellar Medium (ISM). These grains typically consists of graphitic and silicate particles embedded in icy mantels which are formed by molecules like CO, CO_2, H_2O or CH_4. Temperature programmed desorption (TPD) is used to investigate the binding energy and reaction order of several interstellar interesting molecules like D_2, CO, CO_2, CH_4, and D_2O on different interstellar silicate analogues like Forsterit (Mg2SiO4) and Olivine (Mg

Desorption of O2, CO and N2 from Astronomically Relevant Surfaces

Author: Dr Jerome Lasne

Heriot-Watt University

Co-Authors: V.L. Frankland; M.P. Collings; M.R.S. McCoustra

Session: ISM2: Cosmic carbon

Presentation type: Poster *Poster Session A*

Summary:

In the interstellar medium, a range of molecules have been observed in the gas phase or condensed on the icy surface of dust grains. Oxygen (O2), carbon monoxide (CO) and nitrogen (N2) are predicted to be among the most abundant small molecules in dense cores. Although the concentrations of most species, such as CO, agree well with the observed molecular abundance using gas-phase chemistry, the models are unable to explain the formation and abundance of several molecules, including O2 and N2. Then, the models need to include the adsorption and desorption processes of these species from the icy grains to match the observed abundances. To this aim, we performed Temperature-Programmed Desorption (TPD) experiments to study the desorption kinetics of O2, CO and N2 sub-monolayers and multilayers from amorphous silica. The desorption of O2 from compact and porous amorphous solid water is also reported. Our results show that the morphology of the underlying silica surface affects the desorption kinetics of O2, CO and N2.

CARMA observations of methanol in NGC2264

Author: Jane Buckle

University of Cambridge

Co-Authors: J.S. Richer (University of Cambridge) G.A. Fuller (University of Manchester), N. Peretto (SAp CEA-Saclay)

Session: ISM2: Cosmic carbon

Presentation type: Poster *Poster Session A*

Summary:

The NGC2264 star forming region is an ideal astrochemical laboratory for clustered star formation. The NGC2264 protoclusters contain embedded sources with masses ranging from 1 to 50 solar masses. The physical parameters of the embedded sources have been well-characterized at high resolution. Since the system is young, with the potential still gas-dominated, we have used CARMA observations of methanol to probe the physical characteristics of the gas. Methanol is known to trace a clumpy, turbulent medium. The high number of transitions, and the volatility of methanol make the molecule a versatile tracer of star forming regions. We present results from CARMA observations of several methanol transitions, tracing a range of physical conditions, temperatures of 7 K to 430 K, and densities of 10^4 to 10^6 per cubic cm.

Small TiC molecular clusters as precursors of dust grains in extended atmospheres of AGB stars

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Co-Authors: Ch. Chang; D. Suelzle (Zentrum für Astronomie und Astrophysik, TU Berlin)

Session: ISM2: Cosmic carbon

Presentation type: Poster *Poster Session A*

Summary:

In circumstellar environments around cool, late-type stars on the asymptotic giant branch (AGB) dust particles are effectively formed via the formation and subsequent growth of small molecular clusters in the gas phase. The details of the dust formation process and the nature of the condensed material depend decisively on the chemical composition as determined by the elemental mixtures of the circumstellar envelopes. As verified by many studies of pre-solar grains enclosed in meteorites dust grains formed in circumstellar outflows of carbon-rich AGB stars are a mixture of several chemical elements such as silicon or titanium in addition to the main component carbon. In this contribution we focus on the investigation of the properties of small molecular titanium carbide clusters, which have been estimated within density functional theory (DFT) approaches. The molecular properties, thus obtained, are necessary prerequisites for the study of dust nucleation in circumstellar environments of AGB stars, to determine the required data of the mircophysical processes involved. Implications regarding the formation of dust particles especially in view of the 'condensation sequence' under carbon-rich conditions are discussed.

Results from the HOPS + MALT90 + HiGAL Galactic Plane Surveys

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ESO

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Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *17:00 Wednesday 28th 17:00-18:15*

Summary:

With the HOPS, MALT90 and HiGAL Galactic plane surveys we are mapping a significant fraction of the dense, star-forming, molecular gas in the Galaxy. I will present results from two projects based on this combined dataset, namely, i) looking for variations in the star formation (SF) rate across the Galaxy as a function of environment, and ii) searching for molecular cloud progenitors of the most extreme (massive and dense) stellar clusters. We find the SF rate per unit mass of dense gas in the inner 250pc of the Galaxy is at least an order of magnitude lower than that in the disk, directly challenging proposed universal column/volume density thresholds for SF to occur. I will present one molecular cloud we have studied as part of project ii) which is clearly extreme compared to the rest of the Galactic population. With a mass of 10^5 Msun, a radius of only ~3pc and almost no signs of star formation it appears to be the progenitor of an Arches-like stellar cluster. We speculate this may be a local-universe-analogue of the initial conditions of a super star cluster or potentially even a small globular cluster. This object appears to be unique in the Galaxy, making it extremely important for testing massive cluster formation models. We have been awarded 6 hours of ALMA Cycle 0 observing time to study this object in detail.

The effect of spiral arms on star formation in the Galaxy

Author: Toby Moore

Liverpool John Moores University

Co-Authors: J.S. Urquhart (MPIfR Germany); L.K. Morgan (LJMU UK); M.A. Thompson (University of Herts, UK).

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *17:15 Wednesday 28th 17:00-18:15*

Summary:

We present the results of a study of the large-scale star-formation efficiency as a function of Galactocentric radius in the Galactic Ring Survey region using Red MSX Source survey data. The results indicate that 60-80% of the observed increases in the star-formation rate density associated with spiral-arm features are due to source crowding within the arms. Of the remainder, most of the increase in the Sagittarius arm is due to an enhancement in the simple star-formation efficiency, i.e. in the number of RMS sources per unit molecular gas mass. In the Perseus arm, the residual increase is due to a higher than average mean source luminosity and this is entirely due to the presence, in the GRS region, of the W49 star-forming complex, which appears to be exceptional in its nature. The evidence suggests that there is little or no increase in the star-formation efficiency in the Scutum tangent region. The possible role played by the spiral arms in influencing the star-formation efficiency is discussed.

Star formation towards the Scutum tangent and the effects of Galactic environment

Author: David Eden

Liverpool John Moores University

Co-Authors: T.J.T. Moore (Liverpool John Moores University); R. Plume (University of Calgary); L.K. Morgan (Liverpool John Moores University)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *17:30 Wednesday 28th 17:00-18:15*

Summary:

The Galactic Plane at l=30° contains several major features of Galactic structure at different distances, mainly mid-arm sections of the Perseus and Sagittarius spiral arms and the tangent of the Scutum-Centarus arm, which is coincident with the end of the Galactic Long Bar. By positional matching to the Galactic Ring Survey molecular clouds, I have been able to separate the dense Bolocam Galactic Plane Survey clumps into these three main line-of-sight components and, as a result, investigate how the large-scale star-formation properties (the clump mass functions and clump formation efficiencies) vary with relation to different Galactic environments. I will also discuss the implications of our results on the view that W43 is a mini-starburst.

Milky Way Project: Tracing massive star formation in the Galactic plane with infrared bubbles

Author: Sarah Kendrew

Max Planck Institute for Astronomy

Co-Authors: R. Simpson (Oxford University), C. Lintott (Oxford University), E. Bressert (ESO, University of Exeter), M. Povich (Penn State University), C. Cyganowski (Harvard Center for Astrophysics), G. Wolf-Chase (University of Chicago/Adler Planetarium), R. Sherman (University of Chicago)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *17:45 Wednesday 28th 17:00-18:15*

Summary:

The Milky Way Project citizen science initiative (Simpson et al, 2012) has recently increased the number of known infrared bubbles in the inner galactic plane by an order of magnitude. With a sample of 5000, galactic-scale investigations of these objects as signposts of massive star formation now become more scientifically meaningful than was previously possible. We present here the distribution of bubbles in the inner galaxy and compare and contrast this with that of young stellar objects and cold cores. The global structure ofthe Milky Way galaxy can be recovered from the distribution. In addition, we investigate the potential prevalence of triggered star formation through a correlation analysis of bubbles and massive young stars. In contrast with earlier findings, we find no overdensities of young sources associated with bubble rims; possible reasons for the discrepancy in these recent results and resulting implications for triggered star formation in the Galaxy are discussed.

Massive YSOs associated with mid-infrared bubbles: evidence for triggered star formation?

Author: Mark Thompson

University of Hertfordshire

Co-Authors: J.S. Urquhart (MPIfR); T.J.T. Moore (LJMU), L.K. Morgan (LJMU)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *18:00 Wednesday 28th 17:00-18:15*

Summary:

The concept of triggered star formation has been familiar to the star formation community for decades, although the precise nature of the triggering process, the detailed end results, and indeed the fraction of stars in the Milky Way that may have been triggered are all details that still elude us. Much recent effort has been focused on infrared bubbles discovered by the Spitzer GLIMPSE survey, and in particular on the recent discovery of over 5000 of these bubbles by the citizen science Milky Way Project. Here, we present a detailed statistical study of the star formation around these bubbles, updated to include the Milky Way Project first data release.

Star Formation in Spitzer Infrared Dark Clouds

Author: Gary Fuller

Jodrell Bank Centre for Astrophysics, Uni. of Manchester

Co-Authors: N. Peretto (CEA Saclay)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *10:00 Thursday 29th 10:00-11:15*

Summary:

Using a catalogue of about 15,000 infrared dark clouds (IRDCs) derived from the Spitzer GLIMPSE data, together with the Spitzer MIPSGAL 24$micron data, we have carried out a statistical study of the star formation in IRDCs. Performing PSF fitting on more than a 100,000 24micron sources, we have defined criteria to determine which objects are associated with a cloud based on both distance from the cloud and the object's 8micron-24micron spectral index. Overall 27% to 36% of the Spitzer dark clouds show some star formation activity. However, the fraction of star-forming clouds is a function of the size and mass of the clouds, reaching more than 80% for IRDCs with masses larger than about 300 Msol. The Herschel HiGAL data have been used to probe the nature of these stars associated with the IRDCs and in particular identify the best candidate massive young stars. In this presentation we will discuss the results of this analysis of the star formation activity in IRDCs and the nature of the sources being formed.

High-resolution observations of the internal kinematics of infrared-dark clouds

Author: Sarah Ragan

MPIA

Co-Authors: F. Heitsch (UNC-Chapel Hill); E. Bergin (U. Michigan), D. Wilner (SAO)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *10:15 Thursday 29th 10:00-11:15*

Summary:

Infrared-dark clouds (IRDCs) contain a range of the earliest phases of cluster formation. Infrared observations have established that IRDCs often host deeply embedded protostars, the local heating from which can be seen in both the dust and gas. Using interferometric maps of high-density molecular tracer, NH$_3$, we examine the kinematic structure and energy content of a sample of IRDCs with differing geometries and varying levels of protostellar activity. In our sample, protostellar feedback -- seen in enhanced linewidths near the sites of embedded protostars -- contributes only moderately to the global energetics in IRDCs. The velocity fields are otherwise smooth and well-organized. Overall, the kinetic energy content is drastically insufficient to support the IRDCs against collapse, and the spatial distribution of energy is inconsistent with the turbulent cloud support scenario. We interpret the organized velocity fields as a signature of active global collapse and fragmentation.

APEX (sub)mm study of the filamentary IRDC G304.74+01.32

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Department of Physics, University of Helsinki

Co-Authors: J. Harju (Finnish Centre for Astronomy with ESO (FINCA); Department of Physics, University of Helsinki)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *10:30 Thursday 29th 10:00-11:15*

Summary:

Infrared dark clouds (IRDCs) are promising sites to study the earliest formation stages of stellar clusters and high-mass stars, and the physics of molecular-cloud formation and fragmentation. We have employed the APEX 12-m telescope to observe the 870-μm dust continuum emission, and transitions of several molecular species towards the filamentary IRDC G304.74+01.32 (Miettinen & Harju 2010; Miettinen 2012). Our primary aim was to investigate the kinematics and dynamical state of the cloud and clumps within it, and the amount of CO depletion. The analysis suggests that the cloud fragmentation into clumps is caused by “sausage”-type instability, in agreement with results from other IRDCs. The clumps show trans- to supersonic non-thermal motions, and virial-parameter analysis suggests that most of them are gravitationally bound. However, ambient turbulent ram pressure may be an important factor in the cloud dynamics. Blue asymmetric 13CO(2–1) line profiles were detected towards the clumps in the southern part of the filament, indicating large-scale infall motions. The CO molecules do not appear to be significantly depleted in the clumps. The star-formation activity in the cloud, such as outflows, is likely responsible in releasing CO from the icy grain mantles back into the gas phase.

Kinematics in Filamentary IRDC

Author: Matias Lackington

University of Manchester

Co-Authors: G.Fuller (University of Manchester), N.Peretto (CEA Saclay, France), and C. Lenfestey (University of Manchester).

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *10:45 Thursday 29th 10:00-11:15*

Summary:

Infrared Dark Clouds (IRDCs), dense regions observed in absorption against the galactic mid-infrared background, provide candidates for the initial stages of massive star formation. One striking feature of star forming molecular clouds is that they show ubiquitous filamentary structure. This can be seen in

optical extinction images as well as sub-millimeter emission from the dust and in the molecular emission from the gas. In this presentation we will describe the initial results from a study of the kinematics of the gas associated with filamentary structures identified from the recent catalog of IRDCs detected with Spitzer. These regions have been mapped in a range of spectral lines using the ATNF Mopra telescope. In some regions the velocity and line-width structure of the gas suggest that it is possible to feed mass into a core even after the core has started to form stars and thus a filamentary structure may be fundamental to the process of massive star formation.

Multi-wavelength and wide-area observations of the massive star forming region G305

Author: Luke Hindson

University of Hertfordshire

Co-Authors: M.A. Thompson; J.S.Urquhart; A. Faimali; J.S. Clark; B. Davies

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *11:00 Thursday 29th 10:00-11:15*

Summary:

Massive stars are one of the principal driving forces behind the mechanical and chemical evolution of the ISM and galaxies as a whole. For these reasons an understanding of their life cycle is of importance to many areas of astronomy. Unfortunately a number of questions regarding massive stars remain unanswered with the nature of their formation mechanism(s) and feedback being particularly opaque. In an effort to shed light on the massive star forming process and impact on the evolution of Giant Molecular Clouds (GMCs) we have undertaken, as part of an international collaboration, a multi-wavelength study over the extent of the GMC G305. Located at a distance of ~4 kpc and extending ~100 pc G305 is centered on the young open clusters Danks 1 & 2 which appear to of blown a cavity in the surrounding molecular material and are now surrounded by multiple lobes of emission which exhibit numerous signs of ongoing star formation (Clark et al 2004, Davies et al 2012). The overall morphology of the complex is strongly indicative of multiple epochs of sequential star formation initiated and sustained by the actions of the two central clusters. The results of Mopra 3 & 12 mm and ATCA 3 & 6 cm observations, designed to study the early stages of massive star formation and the surrounding environment, will be presented. In addition on overview of results of near-infrared observations of the two central star clusters Danks 1 & Danks 2, using HST+NICMOS imaging and VLT+ISAAC spectroscopy, LABOCA 870 um observations of cold dust cores and Herschel far-infrared data will be presented. In combination with surveys such as RMS, MMB, Hi-GAL, GLIMPSE and MIPS and future surveys such as MALT90, CORNISH we hope to build a detailed picture of the star formation history of the region and so understand the impact of massive stars on the evolution of the G305 GMC.

An Infrared Spectral Evolutionary Sequence for Massive Protostars

Author: Stuart Lumsden

University of Leeds

Co-Authors: H. Cooper (Leeds), M. Hoare (Leeds), R.Oudmaijer (Leeds), J. Urquhart (MPIfR)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *11:45 Thursday 29th 11:45-13:00*

Summary:

The Red MSX Source Survey has catalogued the properties of nearly 500 massive YSOs in our galaxy. As part of this we have obtained near infrared spectroscopy of approximately half of these. Our results show evidence for a sequence which we have identified with the evolution of the source. Young sources show evidence for shocked jets through molecular hydrogen, but this gradually fades through the sequence to be replaced by increasingly strong ionised hydrogen emission. I will comment on how this constrains models for the structure of young protostars, and in the broader context of how massive stars form.

The Lifetimes of Massive Young Stellar Objects and Compact HII Regions

Author: Joseph Mottram

Leiden Observatory

Co-Authors: The RMS Survey Team

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *12:00 Thursday 29th 11:45-13:00*

Summary:

We present the first determination of the lifetimes of massive young stellar objects (MYSOs) and compact (C) HII regions within the Milky Way as a function of luminosity using the large, well-selected sample of these sources identified by the Red MSX Source survey. The MYSO phase has a duration ranging from 4×10^5 yr for 10^4 L sun to ~7×10^4 yr at 10^5 L sun, while the CHII region phase is lasts of order 3×10^5 yr independent of luminosity. MYSOs are distinct from HII regions as they are massive but do not display the radio continuum or near-IR HI recombination line emission indicative of an HII region. This is consistent with MYSOs being swollen due to high rates of recent or ongoing accretion. Above ~10^5 L sun the MYSO phase lifetime becomes comparable to the main-sequence Kelvin-Helmholtz timescale. At this point the central star can rapidly contract onto the main sequence, even if still accreting, and ionise a CHII region. This therefore explains why few highly luminous MYSOs are observed. The lifetimes obtained for these early phases of the massive star formation process suggest that such stars form and evolve significantly faster than their low-mass counterparts.

H2 Outflows in Serpens and Aquila with the UWISH2 Survey

Author: Georgios Ioannidis

University of Kent

Co-Authors: Dirk Froebrich (university of Kent)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *12:15 Thursday 29th 11:45-13:00*

Summary:

Jets and outflows from Young Stellar Objects (YSOs) are important signposts of currently ongoing star formation. In order to study these objects we are conducting an unbiased survey along the Galactic Plane using the UK Infrared Telescope (UWISH2). The survey is centred on the 1-0S(1) ro-vibrational line of H2 at 2.122mu, a proven tracer of hot, dense molecular gas in star-forming regions. The median seeing in our images is 0.73arcsec. The images have a 5-sigma detection limit of point sources of K~18 mag and the surface brightness limit is 1E-19Wm-2arcsec-2 when averaged over our typical seeing. The observations complement existing and upcoming photometric surveys (Spitzer-GLIMPSE, UKIDSS-GPS, JCMT-JPS, AKARI, Herschel Hi-GAL, etc.), though we probe a dynamically active component of star formation not covered by these broad-band surveys. In this presentation we will focus on our results in a 33 square degree sized region in Serpens and Aquila (18deg

The interplay between molecular and ionized gas surrounding the massive embedded star AFGL 2591

Author: Katharine Johnston

MPIA, Heidelberg, Germany

Co-Authors: D. S. Shepherd; T. P. Robitaille; K. Wood; H. Beuther

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *12:30 Thursday 29th 11:45-13:00*

Summary:

In order to investigate whether feedback processes such as photo- and shock ionization have an important effect on the geometry of the circumstellar dust and gas around forming massive stars, we have modelled the near-IR to sub-millimetre SEDs and IR images of the embedded massive star AFGL 2591, using the standard envelope plus disc geometry commonly applied to low-mass protostars. In combination with our Monte Carlo radiation transfer dust code, we have used a genetic search algorithm to explore parameter space and find the best fitting model, allowing us to get a handle on the source geometry and its physical properties, as well as their uncertainties, showing it is a powerful method to explore and understand the large parameter space encountered while fitting SEDs of massive embedded stars. In addition, we have new high sensitivity VLA 3.6cm observations of AFGL 2591 that uncover a collimated jet towards VLA3, the source coincident with the central illuminating object of AFGL 2591 at infrared wavelengths. We also present C18O(1-0) CARMA observations which trace the densest parts of the outflow from AFGL 2591, as well as a flattened structure perpendicular to the outflow direction at the rest velocity of the cloud. The blue-shifted C18O(1-0) emission shows a Hubble law relationship, with the dense gas increasing in velocity away from the source, as well as higher collimation at higher velocities, hence showing many similarities to the properties of outflows around low-mass protostars.

Ionised and molecular gas dynamics in K3-50A

Author: Pamela Klaassen

Leiden Observatory

Co-Authors:

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Talk *12:45 Thursday 29th 11:45-13:00*

Summary:

Despite great strides in the field, it is still not clear how high-mass protostars continue to accrete material once an HII region has formed. Some models suggest that infalling material self shields in a torus, some, that material continues along its trajectory regardless of ionisation state. Tests for this second option are becoming more feasible as (sub)mm interferometers are becoming more sensitive. We can now characterize the dynamics of both the molecular and ionised gas components. To trace the ionised gas, we use Radio Recombination lines, which are much less pressure broadened at these wavelengths than in the cm regime. There is mounting evidence for a relationship between the ionised and molecular gas dynamics. In W51e2, velocity gradients in the ionised (H53a) and warm molecular (SO2) gases show consistent rotational velocities. In G10.6-0.4, the ionised (H66a) and molecular (CO) infall signatures are also consistent. Previous observations suggest an ionised outflow towards K3-50A. Here, we present the results of a study of the ionised (H41a) and molecular (HCO+) gas in K3-50A using CARMA observations at a resolution of ~ 2". We present how the ionised and molecular gasses are moving and discuss both the similarities and differences between them.

The G305 star-forming complex: Embedded Massive Star Formation Discovered by Herschel Hi-GAL

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Interplanetario); S. Molinari (INAF-Istituto Fisica Spazio Interplanetario); S. Carey (Spitzer Science Center, California Institute of Technology); S. Shenoy (Space Science Division, NASA Ames Research Center); and J. S. Clark (The Open University).

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

The G305 complex is one of the nearest, and most massive star forming sites within the Galactic plane at l=305°, b=0°, providing an excellent opportunity to study the nature of massive star formation. Here we present a far-IR study towards the complex, utilising PACS 70, 160 μm and SPIRE 250, 350, and 500 μm observations from the Herschel Hi-GAL survey. The focus of this study is to identify the sites of embedded massive star formation within G305, by combining our far-IR data with ATCA radio continuum, ATNF Mopra H2O maser, MMB methanol maser, Spitzer MIPSGAL, and RMS data. From these associations we identify some 16 candidate embedded massive star-forming regions, and derive a far-IR selection criterion from this sample, to identify a further 31 embedded massive star forming candidates with no associated emission. Using this result we can build a picture of the present day star-formation of the complex, and by using a Salpeter IMF, find a SFR of 0.01-0.02 M⊙ yr−1. Comparing to the Galactic SFR, we find that a few tens to hundreds of G305 complexes are analogous to the entire star formation rate of the Milky Way. This resolved Galactic SFR is contrasted to more extragalactic SFR indicators to test whether the two regimes are consistent with one another. We find the star formation activity is underestimated by a factor of > 2 in total when using typical extragalactic SFR tracers, suggesting fundamental differences in the way both regimes are measured.

Peering into the Heart of Massive Star formation with the Herschel EPoS survey

Author: Sarah Ragan

MPIA

Co-Authors: H. Beuther (MPIA); T. Henning (MPIA); J. Pitann (MPIA); J. Tackenberg (MPIA); H. Linz (MPIA)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

The centerpiece of decades of star formation studies has been the characterization of the earliest phases, known to reside deeply embedded in molecular cloud complexes. This has been a particular challenge for the high-mass regime, because such regions are more distant than their low-mass brethren. Because of its high angular resolution in the far-infrared wavelength regime, Herschel has enabled us to peer into the dense regions of infrared-dark clouds (IRDCs), the birthplaces of high-mass stars and clusters. The Earliest Phases of Star Formation (EPoS) Herschel key program has surveyed 45 IRDCs, and we find that IRDCs harbor a population of point sources (r < 0.2pc) along the cold filaments, about half of which are detected at 70 micron for the first time. These deeply embedded objects are pre- and proto-stellar cores which link the cold filaments to the clusters which ultimately will form there. We characterize these sources based on blackbody fits to their spectral energy distributions (SEDs) in the far-infrared, which give estimates of the core temperature, luminosity, and mass. These results provide a more complete census of star formation within our sample and allow us to probe the efficiency with which IRDCs form (massive) stars.

Radio Continuum Sources associated with 6.7GHz methanol masers.

Author: Dr Adam Avison

UK ARC Node, Jodrell Bank Centre for Astrophysics

Co-Authors: The MMB Survey.

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

We present the results of 8.64 GHz continuum observations made toward class II methanol masers in regions of massive star formation. Made simultaneously Methanol Multibeam Survey (MMB) observations for high accuracy maser positioning these observations were conducted at the Australia Telescope Compact Array (ATCA). The target sources in the sample are 6.7GHz maser sources newly discovered during MMB Survey. The resulting HII region sample have been categorised based on their size (e.g. Hyper-compact or Ultra-compact HII regions). Evolutionary traits such as the size of the HII region compared with the maser/HII region separation have been investigated. For the more spatially separated HII regions we investigate their GLIMPSE colours, finding that our HII region sample inhabits a distinct region of GLIMPSE colour space from the region inhabited by class II methanol masers.

Tracing the Mass Distribution in Star-Forming Cores Using Ammonia

Author: Lawrence Morgan

ARI

Co-Authors: T.J.T.Moore (ARI), James Alsopp (ARI), David Eden (ARI)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

Through the assumption of a slowly varying partition function for ammonia in the temperature regime typically found in star forming regions, we have mapped the mass distribution around a number of cores in W3. This assumption allows us to determine the column density of ammonia using only the (1,1) inversion transition rather than the typical combination of the (1,1) and (2,2) transitions. We present the resulting column density maps along with a comparison to the corresponding maps created using the established method. We suggest that this method is a useful tool in studying the distribution of mass around YSOs, particularly in the outskirts of the envelope where the (2,2) ammonia line is not always detectable on the short timescales necessary for large area mapping.

The W51 Main/South SFR complex seen through 6-GHz OH and methanol masers

Author: Sandra Etoka

JBCA - The University of Manchester

Co-Authors: Malcolm Gray (JBCA - The University of Manchester); Gary Fuller (JBCA - The University of Manchester)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

W51 Main/South is one of the brightest and richest high-mass star-forming regions (SFR) in the complex W51. It is known to host many ultra-compact HII (UCHII) regions thought to be the site of massive young stellar objects. Maser emission from various species is also found in the region. We have performed MERLIN astrometric observations of excited-OH maser emission at 6.035 GHz and Class II methanol maser emission at 6.668 GHz towards W51 to investigate the relationship between the maser emission and the compact continuum sources in this SFR complex. Here we present the astrometric distributions of both 6.668-GHz methanol and 6.035-GHz excited-OH maser emission in the W51 Main/South region. The location of maser emission in the two lines are compared with that of previously published OH ground-state emission. The interesting coherent velocity and spatial structure of the masers and their relationship to infall or outflow in the region will be discussed. It appears that the masers are excited by multiple objects potentially at different stages of evolution.

Modelling CO bandhead emission in massive young stellar objects

Author: John Ilee

University of Leeds

Co-Authors: R. D. Oudmaijer (University of Leeds) H. E. Wheelwright (MPIfR, Bonn)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

High resolution spectra over the CO first overtone bandhead of twenty massive young stellar objects (MYSOs) are presented. The MYSOs are drawn from the Red MSX source (RMS) survey which represents the most complete population of such objects to date. CO bandhead emission traces hot, dense gas, exactly the conditions expected in circumstellar disks. Therefore, our observations of a relatively large sample of MYSOs allows the scenario of massive star formation featuring accretion disks to be tested. Furthermore, we fit the high spectral resolution data with models of accretion disks to determine the MYSOs' accretion rates, which are currently unknown. Therefore these observations provide a unique view of massive star formation.

IRDCs in the Herschel HiGAL Survey in the range l=300-330

Author: Derek Ward-Thompson

Cardiff University

Co-Authors: Lucy Wilcock (Cardiff University) and the HiGAL Team

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

We have observed over 3000 infrared dark cloud (IRDC) candidates in the Herschel HiGAL survey, in the range l=300-330. We find that only around 1200 of them are Herschel-bright in the far-infrared and less than 1000 of these contain distinct cores that are visible in emission at 250 microns. Based on the statistics of those cores that contain sources at 8 and 24 microns respectively, we are able to postulate an evolutionary sequence, with associated timescales, for cores within IRDCs.

Infall and Outflows in Massive Star Forming Regions.

Author: Catherine McGuire

University of Manchester

Co-Authors: G. A. Fuller (University of Manchester); N. Peretto (CEA, Saclay)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

The exact mechanism by which high mass stars form is not fully understood. One of the main questions concerning the formation of high-mass stars is whether or not they gain their mass through accretion in a similar way to their low-mass counterparts. Recent surveys towards high mass protostellar objects (HMPOs) have found signatures of infall in the form of excess blue asymmetric molecular line profiles in dense gas tracers. However this evidence, based on observations towards single positions, is not sufficient to confirm the presence of infall on its own, since such profiles can also be associated with rotation and outflow motions.Fuller, Williams and Sridharan (2005) identified 22 infall candidates in a molecular line survey of 77

HMPOs. I will present the current results of work to investigate the presence of infall in these objects using a) maps of the spatial distribution of the blue asymmetry and the outflows associated with the sources and b) models of the infall to determine its physical properties.

HARP 12CO J=3-2 Submillimeter Observations of the Cygnus X Giant Molecular Cloud

Author: David Carretero

University of Cambridge

Co-Authors: J.Richer (University of Cambridge); E.Curtis (University of Cambridge); J.Buckle (University of Cambridge); N. Schneider (Universite Paris Diderot); S.Bontemps (Universite Bordeaux); T.Csengeri (Universite Paris Diderot)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

We present results from a large submillimeter survey of the J=3-2 rotational transition of 12CO, covering a 10 square degree area of the Cygnus X Giant Molecular Cloud (GMC) using HARP on the James Clerk Maxwell Telescope. The data were reduced using the ORAC-DR data reduction pipeline and analyzed using Starlink software. We searched for outflows in the region originating from the millimeter continuum cores detected in the 1.2 mm continuum survey by Motte et al. (2007), which identifies high mass protostellar candidates. Of the 42 possible protostellar cores identified in Motte et al., we did not have data towards 3 of the cores and have detected outflows and calculated outflow masses, momentums and energetics for 29 of the remaining 39 and an additional outflow attributed to a previously unknown protostellar core. In addition, we compare our data with Spitzer Galactic Legacy Infrared Mid-Plane Survey Extraordinaire (GLIMPSE) 4.5 micron emission to test whether extended 4.5 micron emission (Extended Green Objects, or EGOs) trace outflows specifically from massive protostars.

MOLECULAR OUTFLOWS TOWARD METHANOL MASERS: Detection methods and calculations of their properties

Author: Lientjie (H.M.) de Villiers

University of Hertfordshire

Co-Authors: M.A.Thompson (University of Hertfordshire); A.Chrysostomou (Joint Astronomy Centre); D.B. van der Walt (North West University)

Session: ISM3: Massive Star Formation in the Milky Way

Presentation type: Poster *Poster Session B*

Summary:

Interstellar methanol exhibits maser emission toward star-forming regions. There exist two types of methanol masers: Class I methanol masers, which trace distant parts of molecular outflows from young stellar objects (YSO's) and Class II methanol masers (MMII), which are in the vicinity of massive YSO's, uniquely associated with high mass star formation regions. MMII's exhibit strong emission at 6.7 and 12.1 GHz, and since the Galaxy is transparent at 6.7 GHz, they are ideal tracers of massive star formation sites. These MMII's occupy probably a brief phase in the development of a massive YSO (~10^4 years) – the stage immediately before the ultracompact HII region, a stage where molecular outflows are expected to occur. MMII's could therefore also be useful tracers of molecular outflows. A subset of the MMB Survey's maser coordinates were observed as position-position-velocity (p-p-v) cubes in 13CO and C18O and matched with 12CO images from the JCMT HARP 12CO Galactic Plane Survey. These images were initially used to examine CO line spectrum profiles in a search for broadened line wings, indication of possible CO outflows. Different 1D outflow detection techniques are expanded by investigating three dimensional isosurface representations of the p-p-v cubes, in search for extended velocity features. Once outflows were selected, their physical parameters were calculated. Future work involves a broad search for these outflows by developing automated 3D detection methods. This could cast some light on the association between MMII's and molecular outflows associated with YSO's.

Radio emission from giant exoplanets: Theory and observation

Author: Jean-Mathias Griessmeier

LPC2E

Co-Authors:

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *10:00 Tuesday 27th 10:00-11:15*

Summary:

The planetary magnetic field plays an important role in the evolution of a planet. It determines the protection of its atmosphere against the stellar wind and against stellar coronal mass ejections (CMEs). One of the few methods to study a the magnetosphere of a distant planet remotely is to look at its auroral radio emission. Jupiter's auroral radio emission is among the brightest radio sources in the solar system, allowing detailed studies with high precision. Its

intensity also quickly gave rise to the question whether an analog coherent emission would be detectable from the magnetospheres of exoplanets. However, only an emission at least 1000 times more intense than that of Jupiter has a chance of being detected at stellar distances. Recently, a number of quantitative models have been suggested for the radio emission of giant extrasolar planets. We will compare the underlying hypotheses and discuss the results for the two main parameters, which are the maximum emission frequency and the intensity of the radio emission. The predicted values should allow the detection of exoplanetary radio emission with modern of low-frequency radio telescopes. In particular, the Low Frequency Array (LOFAR) has the potential to bring consideable advances to this field of science.

Magnetosphere-ionosphere coupling at Jupiter-like exoplanets: configuration & detection

Author: Jonathan Nichols

University of Leicester

Co-Authors: S. W. H. Cowley (University of Leicester), and N. M. Pilkington (University of Leicester)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *10:20 Tuesday 27th 10:00-11:15*

Summary:

We consider the magnetodiscs of Jupiter-like exoplanets which posses magnetosphere-ionosphere coupling current systems associated with the radial mass outflow of internally-generated plasma. Specifically, we use the jovian magnetodisc model of Nichols (2011), which combines the magnetic field model of Caudal (1986) with the Hill-Pontius theory of jovian magnetosphere-ionosphere coupling, and adapt it to the cases of various configurations of exoplanets. We present results regarding the structure of the magnetic field, the nature of the plasma flows and currents, and the size of the magnetospheres. In addition, we present the best candidates for detection of the radio emissions from Jupiter-like exoplanets by estimating the maximum spectral flux density expected from planets orbiting stars within 25 pc using data listed in the NASA/IPAC/NExScI Star and Exoplanet Database (NStED).

Jovimagnetic secular variation: the main field and the inner magnetosphere

Author: Victoria Ridley

University of Liverpool

Co-Authors: R. Holme (University of Liverpool)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *10:31 Tuesday 27th 10:00-11:15*

Summary:

Data collected by 6 NASA missions, between 1973-2003, are used to investigate time variation of Jupiter's internally generated magnetic field, as previous attempts have been inconclusive or ineffective. We extend analysis to consider all data within 12RJ, follow a regularised minimum norm approach and undertake a comprehensive analysis of external fields and their associated possible time variability. Within the inner magnetosphere of Jupiter, the primary external field is generated by an equatorial current sheet (magnetodisk). Many previous studies have considered this field to be constant; we calculate disk configuration and corresponding field for each individual orbit using the Connerney et al (1981) model. Successfully modelled disks possess half-thicknesses of between 2.7-3.1RJ and current densities of between 145-200A/m, respectively greater and less than the Connerney et al (1981) preferred values for Voyager-1. The inner and outer magnetodisk boundaries are generally poorly constrained by the data. Disk longitude aligns with the planetary dipole; however, disk colatitude is consistently lower than modelled dipole colatitudes, tending toward alignment with the planetary rotation axis. Our favoured model of Jupiter's internally generated field indicates ~0.042%/yr decrease in the dipole magnetic moment between 1973-2003; this value is comparable with Earth (~0.06%/yr).

Indirect Observations of Mercury's Magnetosphere by MESSENGER XRS

Author: Simon Lindsay

University of Leicester

Co-Authors: G.W.Fraser (University of Leicester) A.Martindale (University of Leicester) E.J.Bunce (University of Leicester) N.P.Bannister (University of Leicester)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *10:42 Tuesday 27th 10:00-11:15*

Summary:

We have studied X-ray Spectrometer (XRS) observations in the first release of MESSENGER data onto the Planetary Data System archive, and find a significant spatial correlation between background spectral features (i.e. peaks unrelated to the planetary surface) and the structure of Mercury's magnetosphere. Data from the first two months of orbital operations show characteristic strong peaks in XRS count rates in the majority of orbits shortly before and after periapsis; the locations of these features coincide with the predicted position of key magnetospheric features. Of the two distinct zones of XRS background enhancement, the first lies on the spacecraft's inbound trajectory at high latitudes and relatively high altitudes, while the second corresponds to the outbound trajectory at low altitudes close to the magnetic equator. We interpret the first region as MESSENGER's crossing of the bow shock and magnetopause and the second as the crossing of the equatorial plasma sheet. XRS energy spectra during these events show strong evidence of instrumental self-fluorescence, including the K-shell lines of Al and Mg (from the bandpass filters in two of the XRS counters), Cu (from the collimator blocks) and Ti (from the detector bodies), all presumably excited by a low-energy trapped charged particle population.

How can the mini-magnetospheres formed by the lunar crustal magnetic anomalies be so small?

Author: Dr Ruth Bamford

RAL Space, Space Plasmas Group, Rutherford Appleton Lab

Co-Authors: B. Kellett (RAL Space); R. Bingham (RAL Space and Uni. of Strathclyde)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *10:53 Tuesday 27th 10:00-11:15*

Summary:

Unlike the Earth, the Moon has no overall dipole magnetic field to form a planet-sized magnetosphere. Several very small regions of crustal magnetic fields have been known to exist since Apollo. In-situ observations from orbital spacecraft including Lunar Prospector, Chandryaan-1, KAGUYA and others have confirmed that the small magnetic regions on the surface, create mini-magnetospheres just 100's of km across. The general theory of magnetospheric barriers developed for planetary sized magnetospheres, lacks the detail to account for the overall size and internal fine structures observed by the spacecraft. The overall size of the magnetic features are of the same order or much smaller than the Larmor or radius of gyration of thermal solar wind ions about the interplanetary magnetic field. The introduction of collisionless kinetic effects, such as charge separation, ponderomotive force, Landau damping and micro-instabilities, can account for all the in-situ observations. Following a review of some of the key observations, a conceptual (rather than exclusively mathematical) account is presented of the differences encountered within the finite Larmor orbit scale. The overall size of the mini-magnetospheres, narrow barrier width, electrostatic fluctuations and changes in the particle species distributions will then be quantifiably compared to observational values.

Recurring flux ropes at the southern terminator of Mars

Author: Mat Beharrell

Lancaster University

Co-Authors: M.J. Beharrell (Lancaster University) J.A. Wild (Lancaster University)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *11:04 Tuesday 27th 10:00-11:15*

Summary:

Flux ropes have long been observed in the upper atmosphere of Venus, and more recently at Mars. Here we present magnetic field measurements of flux ropes encountered by Mars Global Surveyor downstream from crustal field sources, and compare them to a simple force-free model. This allows several parameters of each flux rope to be inferred. Remarkably similar flux ropes are met repeatedly over a period of the Martian year at the same solar zenith angle, indicating that they are most likely stationary and attached to upstream crustal magnetic fields. Periodic structures in the electron flux are observed in the wake of our example flux ropes. A preliminary comparison of the structures with a model wake is made, and they are found to be consistent.

Pulsar Radio Emission and Magnetospheric Currents

Author: Axel Jessner

MPIfR

Co-Authors:

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *11:45 Tuesday 27th 11:45-13:15*

Summary:

Radio emission of pulsars led to their discovery in 1967 and since then pulsars have become an indispensable tool for astronomers. However useful the pulsar radio emission may have become by now, our understanding of how it comes about is still in its infancy. The radio emission varies strongly on timescales ranging from nanoseconds to weeks and its spectrum has been seen to span ten octaves from above a few 10 MHz up to 90 GHz in some cases. This may be a hint, that a close connection between localised plasma processes and the global large scale structure of the magnetosphere may be involved. Modelling the emission process as part of the magnetosphere clearly requires an inhomogeneous, non-stationary and non-linear approach, combining large lengths scales with high resolution, something that is only now becoming feasible as a consequence of the current progress in affordable computer technology. We will attempt to show a few examples of how localised short time instabilities can lead to observable consequences in giant pulses and the pulsar radio spectrum.

Mapping the Pulsar Radiation Pattern

Author: Phrudth Jaroenjittichai

University of Manchester

Co-Authors: Michael Kramer (MPIfR, Germany & JBCA, UK) Patrick Weltevrede (JBCA, UK) Ben Stappers (JBCA, UK)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *12:05 Tuesday 27th 11:45-13:15*

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Summary:

Understanding the observed properties of radio pulsars depends sensitively on our ability to determine the a priori unknown geometry of the sources, i.e., the inclination angles between the spin and magnetic axes and the relative orientation to the observer. In this work, we present an improved technique which combines the so called Rotating Vector Model (RVM) with a model based on a dipole-field-lines structure. Using Least-squares fit, apply this method and derive improved constraints for a large sample of pulsars. Our results are used to study a possible alignment of spin and magnetic axis with age. We also produce an average pulsar beam map to investigate any existing systematic beam structure. At this stage, it seems that the accuracy of our results is limited by deficiencies of the model itself. Therefore, we plan to explore a possibility for better constrained geometry by applying a new model by Beskin & Philipove (2011), which takes propagation effects in the magnetosphere into account.

Poster presentation summaries

Author: MAG1 Poster presenters

Co-Authors:

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *12:16 Tuesday 27th 11:45-13:15*

Summary:

1-minute presentations for those presenting posters.

Cassini multi-instrument observations of Saturn

Author: Dr Emma Bunce

University of Leicester

Co-Authors: E.J. Bunce(Department of Physics & Astronomy, University of Leicester), D. Grodent(Laboratoire de Physique Atmosphérique et Planétaire, Université de Liège), D.J. Andrews(Swedish Institute of Space Physics-Uppsala), C.S. Arridge(Mullard Space Science Laboratory, University College London), S.V. Badman(JAXA Institute of Space and Astronautical Science), S.W.H. Cowley(Department of Physics & Astronomy, University of Leicester), M.K. Dougherty(Space and Atmospheric Physics, Imperial College), W.S.Kurth(Department of Physics and Astronomy, University of Iowa), D.G.Mitchell(Applied Physics Laboratory, Johns Hopkins University), and G.Provan(Department of Physics & Astronomy, University of Leicester)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *12:20 Tuesday 27th 11:45-13:15*

Summary:

During recent years we have benefitted greatly from the first in-orbit multi-wavelength images of Saturn’s polar atmosphere from the Cassini spacecraft. Specifically, images obtained from the UltraViolet Imaging Spectrograph (UVIS) on board the Cassini spacecraft provide an excellent view of the planet's auroral emissions, which in turn give an account of the large-scale magnetosphere-ionosphere coupling and dynamics within the system. However, obtaining a simultaneous view of the auroral regions with measurements of the magnetic field and plasma populations at high-latitudes is more difficult to routinely achieve. Here we present an unusual example, during Revolution 99 in 2009, where UVIS images the entire northern UV auroral oval while Cassini traverses the magnetic flux tubes connecting to the auroral oval on the nightside sampling the related magnetic field and particle signatures present. We will discuss the relationship of the field-aligned currents (derived from the magnetic field), radio waves, and associated plasma electron and ion signatures to the properties of the auroral oval. The mapped equatorial magnetospheric location of the auroral oval and related electric current systems, and inter-hemispheric (a)symmetry will be discussed in the context of the “planetary period oscillations” and previous field-aligned current studies.

Saturn’s field aligned currents and their relationship to the phases of the planetary period oscilla

Author: Gabrielle Provan

University of Leicester

Co-Authors: D. J. Andrews(1), E. J. Bunce(1), A. J. Coates(2,3), S. W. H. Cowley(1), M. K. Dougherty(4) 1 Department of Physics & Astronomy, University of Leicester, Leicester LE1 7RH, UK. 2 Mullard Space Science Laboratory, University College London, Dorking RH5 6NT, UK. 3 Centre for Planetary Sciences at UCL/Birkbeck, Gower Street, London WC1E 6BT, UK. 4 Blackett Laboratory, Imperial College London, London SW7 2BZ, UK

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *12:31 Tuesday 27th 11:45-13:15*

Summary:

During 2008 Cassini performed a sequence of highly inclined polar orbits, traversing north-south through Saturn’s nightside field-aligned current systems. We have studied magnetic field data from these periapsis passes, focussing on the varying azimuthal field component which is indicative of field aligned currents. We examine the effect of planetary period oscillation signatures on the observed field aligned current. We show that southern hemisphere field aligned currents are well organized by the southern phase, but with possible addition of northern oscillatory perturbations in the equatorial regions. Northern hemisphere field aligned current are well organized by the northern phase in the polar region, in the equatorial region the oscillatory signal is a superposition of oscillations at the northern and southern period.

A theory of magnetosphere-ionosphere-atmsophere coupling at Saturn

Author: David Southwood

Imperial College

Co-Authors:

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *12:42 Tuesday 27th 11:45-13:15*

Summary:

The special magnetic/rotational configuration of Saturn allows a separation of the effects of coupling between magnetospheric circulation and the northern and southern ionised atmospheres. The Saturnian magnetosphere is very different from Earth because the rotation and magnetic axes align. Nonetheless, there are rotating magnetic signals and thus field aligned current systems whose asymmetry, however, cannot be attributed to an internal field asymmetry. Here we suggest that there are distinct northern and southern signals both of which are powered by an internal magnetospheric circulation system associated with the interchange transport of material originating at the moon Enceladus. The current sources are external and we propose that they are linked not only to the coupling between magnetosphere and the northern and southern ionospheres but also arise from the ionospheric behaviour in the vicinity of the open-closed field line boundary.

Investigating the influence of magnetic cycles on planets: the case of Tau Boo

Author: Aline Vidotto

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Co-Authors: A. A. Vidotto (St Andrews), R. Fares (St Andrews), M. Jardine (St Andrews), J.-F. Donati (U. Paul Sabatier), M. Opher (Boston U.), C. Moutou (U. de Provence), C. Catala (Obs. de Paris), T. I. Gombosi (U. Michigan)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *12:53 Tuesday 27th 11:45-13:15*

Summary:

Tau Boo is an intriguing planet-host star that is believed to undergo magnetic cycles similar to the Sun, but with a duration that is about one order of magnitude smaller than that of the solar cycle. With the use of observationally derived surface magnetic field maps, we simulate the magnetic stellar wind of Tau Boo by means of 3-D MHD numerical simulations. Using the results of our wind models, we investigate the interaction between the stellar wind and the planet by estimating radio emission from the hot-Jupiter Tau Boo b that orbits at 0.0462 AU from its host star. We show that, for a planet with a magnetic field similar to Jupiter (~14 G), the radio flux is estimated to be about 0.9-2.3 mJy, occurring at an emission bandwidth of 34 MHz. Although detection of small fluxes, such as the ones found in this study, are certainly challenging, modern-day instruments, such as LOFAR, have great potential to detect radio emission from exoplanets. Radio observations of Tau Boo b is, therefore, a valuable exercise.

Maser radio emission from CU Virginis

Author: David C. Speirs

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Co-Authors: B.J.Kellett (Rutherford Appleton Laboratory); V.G.Graffagnino (Rutherford Appleton Laboratory); R.Bingham (Rutherford Appleton Laboratory); T.W.B.Muxlow (Jodrell Bank Centre for Astrophysics); A.G.Gunn (Jodrell Bank Centre for Astrophysics); R.A.Cairns (University of St-Andrews); S.L.McConville (University of Strathclyde); K.M.Gillespie (University of Strathclyde); I.Vorgul (University of St-Andrews); A.D.R.Phelps (University of Strathclyde); A.W.Cross (University of Strathclyde); K.Ronald (University of Strathclyde)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Talk *13:04 Tuesday 27th 11:45-13:15*

Summary:

Non-thermal radio emission from stars and planets has attracted considerable interest and debate over the last 40 years. Recent observations of such sources, including the flare star UV Ceti and magnetic chemically perculiar star CU Virginis show intense, spectrally well defined, narrow beamed radio emission at ~1->90GHz with a high degree of polarisation [1][2]. This has led to the strong belief that such emissions are generated by an electron cyclotron maser instability [3]. Previous work has focussed on a loss cone generation mechanism and cavity ducting model for radiation beaming, however recent theory and simulations guided by observations suggest an alternative model comprising radiation generated by a horseshoe instability [1], emitted tangentially to the plasma cavity boundary and refracting upwards due to plasma density inhomogeneity. Here we present the results of beam-plasma simulations that confirm the model and agree with Jodrell Bank observations of pulsed, narrowly beamed radio emission from the oblique rotator CU Virginis [2]. These observations combined with the oblique rotator nature of the star confirm that the radiation is continuous. [1] R. Bingham et al., Astron. Astrophys., 370, 1000 (2001). [2] B.J. Kellett et al., ArXiv Astrophysics, 0701214 (2007). [3] D. C. Speirs et al., Phys. Plasmas, 17, 056501 (2010).

Numerical and laboratory studies of auroral cyclotron emission processes

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Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Poster *Poster Session A*

Summary:

Electron cyclotron radio emissions, known as Auroral Kilometric Radiation (AKR) originate in the X-mode from regions of locally depleted plasma in the terrestrial polar magnetosphere. A laboratory experiment was constructed to study the emission mechanism of AKR scaled to microwave frequencies [1-2]. 3D PiC simulations of the experiment were conducted to study resonant energy transfer with non-azimuthally symmetric modes of the bounding radiation structure. These 3D simulations show the backward-wave resonance to be resilient to Doppler broadening of the beam-wave coupling [3]. It would suggest that the auroral process may emit with backward-wave coupling giving a spectral downshift and thus avoiding the upper hybrid stop-band [4]. Simulations have shown the influence of electron beam current and cyclotron-wave detuning on mode excitation within the interaction region and the saturated rf output power. The results also demonstrate that cyclotron-wave coupling becomes weaker as the resonant wave moves away from near transverse propagation (kz□> 0). Experiments have tested these results and the potential for relatively efficient emission into an R-X mode at close to the cyclotron frequency. This may be particularly interesting where ducting of the radiation signal is relevant, e.g. chorus. [1] McConville S.L et al, Plasma Physics And Controlled Fusion, 50, Art: 074010, 2008. [2] Ronald K et al, Plasma Physics and Controlled Fusion, 53, Art: 074015, 2011. [3] K. M. Gillespie et al, Plasma Phys. Control. Fusion, 50, 12403, 2008. [4] A.V. Savilov et al, Phys. Plasmas, 14, 113104, 2007.

Laboratory investigation of background plasma effects on cyclotron radiation emission

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Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Poster *Poster Session A*

Summary:

The auroral density cavity (a region of partial plasma depletion at an altitude of ~3200km at the Earth's pole) has a background plasma density ~10^6m^-3, and plasma frequency ~9kHz. Auroral Kilometric Radiation (AKR) is produced when particles descend through this region and are magnetically compressed as they approach the Earth's magnetosphere and through conservation of the magnetic moment, a horseshoe shaped velocity distribution is formed as the particles sacrifice axial for rotational momentum. Theory has shown this type of distribution to be unstable to cyclotron emissions in the X-mode [1]. Satellites have observed that the AKR is emitted at frequencies that extend down to the local electron cyclotron frequency with a spectral peak at ~300kHz, powers ~109W and emission efficiency ~1% of the total precipitated electron kinetic energy. Scaled laboratory experiments [2] have allowed investigation of the naturally occurring process of AKR to take place. Addition of a Penning trap [3] allowed generation of a background plasma, enhancing the comparison between experimental and theoretical/numerical results [DC Speirs and KM Gillespie at these proceedings] and magnetospheric data. Plasma diagnostics gave fpe ~150-300MHz, ne ~10^14-10^15m^-3, Te ~10^5K and a corresponding ratio of fce/fpe~19-40. The plasma background affected the microwave generation, characterised by lower-level intermittent radiation emission compared to the stable emission observed in the absence of plasma. 1. Gurnett DA et al, 1974, J. Geophys. Res., 79, 4227-4238 2. Ronald et al 2011, Plasma Phys. Control. Fusion, 53, 074015 3. McConville SL et al 2011, Plasma Phys. Control. Fusion, 53, 124020

Conjugate observations of Saturn

Author: Calum J Meredith

University of Leicester

Co-Authors: S.W.H. Cowley (University of Leicester), J.D. Nichols (University of Leicester)

Session: MAG1: Magnetospheres throughout the Universe

Presentation type: Poster *Poster Session A*

Summary:

We present an analysis of a unique dataset of Hubble Space Telescope images of Saturn's UV auroras obtained close to equinox in 2009, such that both northern and southern dayside auroras were observed simultaneously. Here we focus on the north-south conjugacy, or otherwise, of propagating and transient auroral features, and discuss the implications of the findings for the physical mechanisms involved.

Magnetic field and plasma in the atmospheres of the Sun and stars

Author: Hardi Peter

Max Planck Institute for Solar System Research

Co-Authors:

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *14:15 Tuesday 27th 14:15-15:30*

Summary:

The magnetic field on the surface of a star is structured through magneto-convective processes. Produced in the interior by a dynamo process, the convective flows near the surface reshape the magnetic patterns and can even enhance the magnetic field locally. The motions at the surface also lead to disturbances of the magnetic field that are carried into higher parts of the atmosphere where they shape and sustain the hot corona observed around cool stars. In the photosphere and (in parts of) the chromosphere the plasma is generally dominating by the magnetic field. Nonetheless, there the magnetic field is pivotal to understand various plasma properties that ultimately govern the appearance and irradiance of the star. In the higher atmosphere, where the magnetic field is dominating, on also has to consider interaction of the magnetic field with the plasma in order to provide the necessary diagnostic tools to study the structure and evolution of the magnetic field. This talk will present observations and models that can help to shed light on the nature of the energy transfer in a stellar atmosphere, in which the magnetic field plays a key role. Here the Sun is pivotal to understand the properties found in the photospheres and coronae of other stars.

The behaviour of the stellar wind through the magnetic cycle of Tau Boo

Author: Aline Vidotto

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Co-Authors: A. A. Vidotto (St Andrews), R. Fares (St Andrews), M. Jardine (St Andrews), J.-F. Donati (U. Paul Sabatier), M. Opher (Boston U.), C. Moutou (U. de Provence), C. Catala (Obs. de Paris), T. I. Gombosi (U. Michigan)

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *14:40 Tuesday 27th 14:15-15:30*

Summary:

Tau Boo is an intriguing planet-host star that is believed to undergo magnetic cycles similar to the Sun, but with a duration that is about one order of magnitude smaller than that of the solar cycle. With the use of observationally derived surface magnetic field maps, we simulate the magnetic stellar wind of Tau Boo by means of 3-D MHD numerical simulations. As the properties of the stellar wind depend on the particular characteristics of the stellar magnetic field, we show that the wind varies during the observed epochs of the cycle. Although the mass loss-rates we find vary less than 3 per cent during the observed epochs of the cycle, the derived angular momentum loss-rates vary by a factor of two during the cycle. We also compute the emission measure from the (quiescent) closed corona and show that it remains approximately constant through these epochs. This suggests that a magnetic cycle of Tau Boo may not be detected by X-ray observations.

The Evidence for Taylor Relaxation in Simulations of Kink-unstable Coronal Loops

Author: Michael Bareford

University of St. Andrews

Co-Authors: A. W. Hood; P. K. Browning

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *14:52 Tuesday 27th 14:15-15:30*

Summary:

Relaxation theory offers a straightforward method for determining the energy released from a magnetic field when it undergoes an instability. Thus, an upper limit to the heating caused by ensembles of coronal loops can be estimated and compared with the million-degree coronal heating requirement. We present the results obtained from the nonlinear magnetohydrodynamic (MHD) simulations of a sample of idealised coronal loops that are known to be linearly kink unstable. The principle aim is to determine whether or not these results agree with helicity-conserving Taylor relaxation. A three-dimensional (3D) MHD Lagrangian-remap code is used to simulate the evolution of specific line-tied field configurations based on a cylindrical coronal loop model. Initially, all configurations carry zero net current and are in ideally unstable equilibrium. Helicity is conserved to an acceptable level for all numerically-stable simulations. In addition, the energy release and final field profiles produced by the numerical simulations are in agreement with the predictions of relaxation theory: the relaxed field approximates a linear force free state. Magnetic energy dissipation predominantly occurs within thin currents sheets. We also present the results of simulated photospheric driving, where initially stable loops are 'driven' to instability and continue to be driven during the relaxation process. The results presented here support the use of relaxation theory: specifically, when calculating the heating-event distributions produced by ensembles of loops undergoing kink instability, as a consequence of photospheric driving.

Heating of braided coronal loops

Author: David Pontin

University of Dundee

Co-Authors: A.L. Wilmot-Smith, G. Hornig (University of Dundee); A.R. Yeates (University of Durham)

Co-Authors: A.L. Wilmot-Smith, G. Hornig (University of Dundee), A.R. Yeates (University of Durham)

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *15:04 Tuesday 27th 14:15-15:30*

Summary:

We investigate the relaxation of braided coronal loops in order to find out how the type of braiding via footpoint motions affects resultant heating of the loop. Two magnetic loops, braided in different ways, are used as initial conditions in resistive MHD simulations and their subsequent evolution is studied. The fields both undergo a resistive relaxation in which current sheets form and fragment and the system evolves towards a state of lower energy. In one case this relaxation is very efficient with current sheets filling the volume and homogeneous heating of the loop occurring. In the other case fewer current sheets develop, less magnetic energy is released in the process and a patchy heating of the loop results. The two cases, although very similar in their setup, can be distinguished by the mixing properties of the photospheric driver. The mixing can be measured by the topological entropy of the plasma flow, an observable quantity.

MHD Simulations of Solar Coronal Dynamics: Effects of Parameter Variations on Local Energy Budget

Author: Eric Adamson

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Co-Authors: J. Buechner (Max-Planck-Institut fuer Sonnensystemforschung, Katlanburg-Lindau, Germany) A. Otto (Geophysical Institute, University of Alaska Fairbanks, Fairbanks, Alaska, USA)

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *15:16 Tuesday 27th 14:15-15:30*

Summary:

LINMOD3D is a three-dimensional numerical simulation code designed for the investigation of solar coronal plasma dynamics in the framework of MHD. Due to the strong inhomogeneities and inter-scale coupling effects inherent to the system, large grids and parallel computing are required in order to ensure proper numerical solution of the field and fluid equations. The simulation code has recently been optimized for efficient use on parallel computer architectures. This improvement allows a high spatial resolution and a stable run to track a long evolution of the solar atmosphere. We present recent results from LINMOD3D simulations addressing the effects of various parameter variations on the energy budget of the solar corona in the vicinity of a bright point region.

The diverse nature of stellar magnetic fields

Author: Moira Jardine

SUPA, University of St Andrews

Co-Authors:

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *17:00 Tuesday 27th 17:00-18:15*

Summary:

Magnetic fields appear to be ubiquitous in almost all types of stars, but the nature of these fields and their role in influencing the structure and evolution of the star and its environment can vary significantly. This is particularly relevant when considering if exoplanets may be habitable, as magnetic activity in the form of X-ray emission, winds or mass ejections can be extremely damaging for planetary atmospheres. Recent advances in spectropolarimetry have revealed the diversity of stellar magnetic fields and have presented modellers with some interesting challenges. In this talk I will review these results and illustrate the role that advances in MHD modelling can make in tackling the most significant science questions for stellar magnetic fields.

A Non-Linear Force-Free Field Model for the Solar Magnetic Carpet

Author: Karen Meyer

University of St Andrews

Co-Authors: D. H. Mackay (University of St Andrews); A. A. van Ballegooijen (Harvard-Smithsonian Center for Astrophysics)

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *17:25 Tuesday 27th 17:00-18:15*

Summary:

We present the results of our recent simulations of the solar magnetic carpet. A series of synthetic magnetograms produced from our 2D photospheric model provide the lower boundary condition to drive the continuous evolution of a non-linear force-free coronal field. We study various aspects of the resultant coronal field, in particular, quantities such as the magnetic energy that is stored and dissipated within the non-potential corona.

A generalised flux function for three-dimensional reconnection

Author: Anthony Yeates

Durham University

Co-Authors: G. Hornig (University of Dundee)

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *17:37 Tuesday 27th 17:00-18:15*

Summary:

We present a novel method for measuring reconnection in a 3-dimensional magnetic field without null points (i.e., with a strong "guide field"). Ubiquitous examples of such fields include the interiors of individual flux tubes in, for example, the Sun's atmosphere or the Earth's magnetosphere. Our basis is to generalise the familiar two-dimensional concept of a "flux function" to 3 dimensions, and use it to define a unique flux partition of the magnetic field. This partition is more complex than the corresponding (well-known) construction in a 2-dimensional field, owing to the possibility of chaotic magnetic regions. Nevertheless, the reconnection rate between regions of this partition is readily measured with the generalised flux function. This rate can be related to the common definition of 3-dimensional reconnection in terms of integrated parallel electric field.

Small-scale magnetic fields in active regions and solar flares

Author: Mykola Gordovskyy

University of Manchester

Co-Authors: V.G. Lozitsky (Astronomical Observatory, Kyiv University)

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *17:49 Tuesday 27th 17:00-18:15*

Summary:

There are strong evidence that photospheric magnetic field is very inhomogeneous at sub-telescopic scale. Magnetographic observations suggest that the field consists of at least two components with intense magnetic fluxtubes embedded into a weak ambient field. In the present study high resolution echelle spectra are used to examine the magnetic field in sunspots, plages and in flaring photosphere. This is done by comparing magnetic field strengths measured using different spectral lines as well as by examining the fine structure of I+/-V Stokes profiles. Based on syntetic spectral line profiles we estimate the strength of different field components. In addition, we discuss implications of sub-telescopic magnetic field structure for magnetographic measurements.

The new method of 3D magnetic field reconstruction based on frequency filtering of torsional Alfvén

Author: Viktor Fedun

The University of Sheffield

Co-Authors: R.Erdelyi (The University of sheffield)

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Talk *18:01 Tuesday 27th 17:00-18:15*

Summary:

Title: The new method of 3D magnetic field reconstruction based on frequency filtering of torsional Alfvén waves By implementing a full nonlinear 3D MHD numerical simulation with a realistic vortex driver, we demonstrate how the plasma structure of chromospheric magnetic flux tubes can act as a spatially dependent frequency filter for torsional Alfvén waves. Importantly, for solar magnetoseismology applications, this frequency filtering is found to be strongly dependent on magnetic field structure of the flux tube. With reference to an observational case study of propagating torsional Alfvén waves produced in Hα using spectroscopic data from the Swedish Solar Telescope (SST), we demonstrate how the observed two-dimensional spatial distribution of maximum power Fourier frequency shows a strong correlation with our forward modelling. This opens the possibility of beginning an era of chromospheric magnetoseismology, to complement the more traditional methods of mapping the magnetic field structure of the solar chromosphere.

X-ray activity and rotation of the young stars in IC 348

Author: Frauke Alexander

Universitäts-Sternwarte München

Co-Authors: Thomas Preibisch (Universitäts-Sternwarte München)

Session: MAG2: Structure and Dynamics of Solar and Stellar Magnetic Fields

Presentation type: Poster *Poster Session A*

Summary:

The physical origin of the strong magnetic activity in T Tauri stars and its relation to stellar rotation is not yet well-understood. We investigate the relation between the X-ray activity, rotation, and Rossby number for a sample of 82 young stars in the ~3 Myr old cluster IC 348. We use the data of four Chandra observations of IC 348 to derive the X-ray luminosities of the young stars. We compare the dispersion of fractional X-ray luminosities of the stars in the saturated rotation regime in IC 348 to that seen in younger and older stellar populations. The scatter seen in the ~3 Myr old IC 348 is considerably smaller than for the ~1 Myr old ONC, but, at the same time, considerably larger than the dispersion seen in the ~30 Myr old cluster NGC 2547 and in main-sequence stars. Our results suggest that the scatter of X-ray activity levels shown by the rapidly rotating members of young clusters decreases with the age

sequence stars. Our results suggest that the scatter of X-ray activity levels shown by the rapidly rotating members of young clusters decreases with the age of the stellar population. We interpret this as a signature of the changing interior structure of PMS stars and the consequent changes in the dynamo mechanisms that are responsible for the magnetic field generation.

In situ measurement of the magnetic reconnection diffusion region in the Earth's magnetotail

Author: Dr. Jonathan Eastwood

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Co-Authors: M. A. Shay (University of Delaware), T. D. Phan (UC Berkeley), M. Oieroset (UC Berkeley), A. Borg (Norwegian Defense Research Establishment)

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Talk *10:00 Thursday 29th 10:00-11:15*

Summary:

Magnetic reconnection is a universal plasma process that is important in solar, space and astrophysical plasmas. At Earth, it allows the solar wind to enter the magnetosphere and also enables the explosive release of stored magnetic energy in the lobes of the magnetotail, powering substorms and storms. Magnetic reconnection in the magnetosphere is collisionless, a condition which is hard to reproduce in the laboratory. As such, space observations are crucial and one benefit of studying reconnection in the magnetosphere is that observations can be made in situ, providing highly detailed data which can be quantitatively compared with theory and simulations. Significant progress has been made in recent years using data from Cluster and THEMIS. Observations summarising what we now know about magnetic reconnection, and particularly the ion diffusion region will be presented. A new result is the discovery of super-Alfvenic flows of energy associated with kinetic electrons dynamics near the magnetic separatrices. This generates a substantial Poynting flux which can exceed that due to the bulk ion flows and may have significant implications for understanding how the aurora is powered. Finally we will consider how the reconnection process partitions energy in the reconnection outflow jets.

Evolution of magnetic flux in separator reconnection

Author: A. L. Wilmot-Smith

University of Dundee

Co-Authors: G. Hornig (University of Dundee)

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Talk *10:15 Thursday 29th 10:00-11:15*

Summary:

In three dimensions one of the main locations of current sheet formation and reconnection is the separator, a field line connecting two nulls and hence lying at the intersection of four distinct flux domains. Separator reconnection is of crucial importance in flux transfer events at the dayside magnetopause, has been observed (by Cluster) in the magnetotail and is thought to be relevant for flux emergence in the solar corona. Several fundamental details of how separator reconnection takes place are not yet well understood and in an effort to better understand the basics of the process we present a model for a single reconnection process in the neighbourhood of a separator, paying particular attention to the way magnetic flux evolves in the process. We find that a sufficiently strong reconnection event generates new separators which leads to a complex system of magnetic flux tubes connecting regions of previously separated flux. We also consider how the reconnection rate should be measured and interpreted in such a system, one finding being that in a three dimensional situation the topology of the magnetic field must be known before a meaningful reconnection rate can be determined.

Seasonal and clock angle control of the location of flux transfer events signatures at the magnetopa

Author: Robert Fear

University of Leicester

Co-Authors: M. Palmroth (Finnish Meteorological Institute); S. E. Milan (University of Leicester)

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Talk *10:30 Thursday 29th 10:00-11:15*

Summary:

Most models of flux transfer event (FTE) formation produce pairs of structures, which in general move away from the subsolar region and give rise to signatures which can be observed in both the northern and southern hemispheres. However, the multiple reconnection line (X-line) model and some 3D reconnection mechanisms are capable of producing a single flux rope, allowing a different number of FTE signatures to be observed in the northern and southern hemispheres. Raeder [2006] reported the results of an MHD simulation where he studied the effect of the Earth's dipole tilt on reconnection at the dayside magnetopause for a southward IMF orientation; in his simulations, flux ropes were formed by the sequential formation of X-lines, and flux ropes moved preferentially towards the winter hemisphere. However, subsequent simulations (including one invoking truly three dimensional reconnection [Dorelli & Bhattacharjee, 2009]) have found no dependence upon dipole tilt. In this presentation, we examine the seasonal distribution of flux transfer event signatures observed by Cluster. We find that there is a seasonal dependence in this data set; once the seasonal bias is taken into account, we find that the IMF clock angle controls the location of FTE signatures.

Nonlinear wave propagation and reconnection at an X-point in Hall MHD

Author: James Threlfall

University of St Andrews

Co-Authors: I.De Moortel (University of St Andrews), C.E.Parnell (University of St Andrews), K.G.McClements (EURATOM/CCFE), T.D.Arber (University of Warwick).

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Talk *10:41 Thursday 29th 10:00-11:15*

Summary:

We investigate the role of the Hall term in the propagation and dissipation of waves which interact with 2D magnetic X-points, in order to determine how the evolution of a nonlinear fast magnetoacoustic wave pulse, and the oscillatory reconnection which results from its interaction with a line-tied 2D magnetic X-point, is affected by the inclusion of the Hall term in the generalised Ohm's law. A Lagrangian remap shock-capturing code (Lare2d) is used to study the evolution of an initial fast magnetoacoustic wave annulus for a range of values of ion skin depth (di) in resistive Hall MHD. In general, the fast wave is coupled to a shear wave and to whistler and ion cyclotron waves. Dispersive whistler effects cause rapid oscillations of the X-point, leading to the creation of magnetic islands and multiple null points under the influence of the Hall term. At later times, competition of local Lorentz and gas pressure forces return the system to a near-equilibrium state. The rate of oscillatory reconnection recovered during this relaxation phase appears to be unaffected by the value of di. This work was partly funded by the RCUK Energy Programme under grant EP/I501045 and the European Communities under the contract of Association between EURATOM and CCFE. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

Non-steady reconnection at a 2D non-force-free current layer

Author: Jorge Fuentes-Fernandez

University of St Andrews

Co-Authors: C. E. Parnell; A. W. Hood; E. R. Priest (University of St Andrews); D. W. Longcope (Montana State University)

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Talk *10:52 Thursday 29th 10:00-11:15*

Summary:

In solar, space and astrophysical plasmas, energy release by reconnection is likely often to take place, not in a steady fashion, but in a sporadic manner. We present a study on the sudden reconnection in a non-force-free current layer, triggered by the onset of an anomalous resistivity. An initial transient reconnection regime, during which the current is rapidly dispersed, generates a family of plasma and magnetic pulses that leave the diffusion region at the local fast and slow magnetosonic speeds. Left behind, in the wake of these pulses, is a stagnation type flow pattern that leads to an impulsive bursty reconnection regime, in which fast reconnection is repeatedly turned on and off in a turbulent manner as the current density is built up until it exceeds a critical value, then falls below following the onset of microturbulence. Interestingly, the majority of the magnetic energy converted during the two reconnection regimes (transient and impulsive bursty) goes into internal energy via ohmic heating. These results are of potential importance for the coronal heating problem, and understanding the problem of non-steady 2D reconnection is crucial for future 3D studies.

3D particle acceleration effects in the PIC approach and their diagnostics from the HCS observations

Author: Prof. V.Zharkova

University of Bradford

Co-Authors: Zharkova V.V. (1) and Khabarova O. (2) 1 - Department of Mathematics, University of Bradford, UK 2 - IZMIRAN, Troitsk, UK

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Talk *11:03 Thursday 29th 10:00-11:15*

Summary:

In this paper we discuss particle acceleration in 3D heliospheric current sheet derived from PIC simulations. The dynamics of electrons and protons at acceleration in a reconnecting current sheet is shown to be affected by polarization (Hall) electric field induced by electrons and protons at their separation towards the current sheet midplane. The simulated dynamics of accelerated particles at lower densities is probed by high-resolution measurements of the sector boundary, or the HCS crossings (SBSs) in the solar wind at 1 AU. A likehood of the observed plasma parameters, simulated profiles of velocity and density of accelerated electrons and ions across the HCS as well as the radio frequencies of plasma turbulence are discussed in association with the effects of polarization and turbulent electric fields induced by accelerated particles. Implications of findings for the interpretation of the solar wind observations are also discussed.

Magnetopause Reconnection Across Wide Local Time.

Author: Malcolm Dunlop

RAL

Co-Authors: Q.-H Zhang (PRIC), Y. Bogdanova (MSSL), Z. Pu (PKU), H. Hasegawa (ISAS), K-H. Trattner (Lockheed Martin), M. Lockwood (Reading U), M. G. G. T. Taylor (ESA), J. Berchem (IGPP), D. Constantinescu (TU-BS), B. Lavraud (IRAP), J. Eastwood (ICL), H. Frey (SSL), J Wild (Lancaster U), C. Shen (NSSC), J-K Shi (NSSC), M. Volwerk (SRI), A. N. Fazakerley (MSSL), D. Sibeck (GSFC), P. Escoubet (ESA).

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Poster Poster Session B

Presentation type: Poster *Poster Session B*

Summary:

The operation and extent of magnetic reconnection (MR) across the Earth's magnetopause has recently benefitted from an unprecedented growth in complexity of multi-point, in situ measurements, on the small and meso-scale, from Earth-bound space missions. Recent findings in active sites of MR have increased the theoretical understanding of the detailed structure within the ion diffusion region surrounding the magnetic X-line or null field, nevertheless, direct measurements of this small region in space are still relatively rare, owing to the time variable nature of the near-Earth space environment. During April to July 2007 a combination of 10 spacecraft (Cluster, THEMIS and TC-1) provided simultaneous monitoring of the dayside magnetopause across a wide range of local times. Here, we report direct evidence, taken from a conjunction of the THEMIS-A spacecraft and the Double Star, TC-1 spacecraft, of the X-line structure resulting from the operation of MR at two widely (~9 RE) separated locations along the expected sub-solar merging line (line of maximum current) on the Earth's magnetopause. The near simultaneous conjunctions of all 10 spacecraft also identify an extended magnetic reconnection X-line, tilted in the low latitude, sub-solar region, which extends to (anti-parallel) locations on the dawn-side flank. The observed global pattern of FTE's is consistent with the initially strong, but changing, IMF By conditions and supports the result that reconnection activity may occur simultaneously across the sub-solar and flank magnetopause, linked to the (large-scale) extended configuration of the merging line. The occurrence of MR is therefore consistent with a 'component' driven scenario and independent of guide field conditions.

Bluesky Solutions to the Magnetohydrodynamic Trigger Problem

Author: Dr Wayne Arter

United Kingdom Atomic Energy Authority

Co-Authors:

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Poster *Poster Session B*

Summary:

The trigger problem in magnetohydrodynamics~(MHD) concerns the timescale for the release of a significant fraction of the energy in a magnetic field. The problem is to explain how the timescale of field evolution can change suddenly from months to twenty minutes or less in the case of Solar Coronal Mass Ejections (a factor of at least 2000). Even larger factors, millions plus, approximately the ratio of thermal diffusion timescale to the Alfven timescale, are sometimes seen in tokamak laboratory experiments. As in the case of some Solar flares, repeats of abrupt events are observed, resulting in the sawtooth oscillation. It has long been realised that the likeliest mathematical explanation of the abrupt change in growth rate is to be found in catastrophe theory. The novelty of this work is in starting to tie the generic mathematics to a specific model of an ideal MHD instability (fast timescale) coupled to a slow dissipative background evolution. The specific ANAET model considered (Axisymmetric-NonAxisymmetric ExTended) exploits the symmetries to be expected in a near MHD-equilibrium situation to generate a low order dynamical system. For a wide range of parameters, ANAET exhibits a blue-sky catastrophe, and for a smaller range, numerical results suggest the existence of a blue-sky bifurcation, implying periodic or quasi-periodic catastrophes. Unfortunately for more detailed work, the results indicate that accurate numerical modelling may be very challenging.
Acknowledgement: Work funded by UK EPSRC.

Spine-Fan Reconnection: The Influence of Temporal and Spatial Variation in the Driver

Author: Peter Wyper

Sheffield University

Co-Authors: R.Jain

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Poster *Poster Session B*

Summary:

Three dimensional (3D) neutral points are important locations in the solar corona for energy release and magnetic topology change through magnetic reconnection. Recent theoretical studies of the reconnection process at 3D null points suggests that the most common scenario of current sheet formation is a collapsed region between the Spine and Fan known as Spine-Fan reconnection. Previous studies of the Spine-Fan reconnection process use temporally symmetric driving of a fixed spatial extent. However, from observations the atmosphere of the Sun has been shown to be highly dynamic with perturbations of the magnetic field often lacking temporal or spatial symmetry. We present here results from numerical simulations of the Spine-Fan reconnection process driven by more generic perturbations with temporal asymmetry and varying spatial extent. The qualitative and quantitative effects on current sheet growth and reconnection rate are discussed. Our results demonstrate the many degrees of freedom available in interpreting observational signatures of reconnection in three dimensions. We find that additional knowledge of the surrounding flows is essential for a clear interpretation of the reconnection process.

High latitude observations of magnetotail plasma-sheet plasma in conjunction with a transpolar arc

Author: Robert Fear

University of Leicester

Co-Authors: S. E. Milan (University of Leicester) & R. Maggiolo (Belgian Institute for Space Aeronomy)

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Poster *Poster Session B*

Summary:

Transpolar arcs (TPAs) are auroral features which extend into the polar cap from the night side of the main auroral oval. A major candidate mechanism for TPA formation invokes the closure of lobe flux in a twisted magnetotail, where the closed flux is prevented from returning to the dayside as the twist causes the northern and southern hemisphere footprints of the closed field lines to straddle the midnight meridian. In this mechanism, closed flux builds up on the night side, so plasma similar to typical plasma sheet distributions should be observed at high latitudes embedded within the lobe. We present preliminary observations of three cases where the Cluster spacecraft observes plasma-sheet plasma embedded within the lobes, and at much higher latitudes than those at which the plasma sheet is usually observed. The locations of the spacecraft map to points on the TPA that are significantly poleward of the main auroral oval. These observations are consistent with TPAs being formed by the proposed reconnection/twisted magnetotail mechanism.

Collisionless distribution function for the relativistic force-free Harris sheet

Author: Thomas Neukirch

Mathematics & Statistics, University of St. Andrews

Co-Authors: C.R. Stark (Mathematics & Statistics, University of St. Andrews)

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Poster *Poster Session B*

Summary:

A self-consistent collisionless distribution function for the relativistic analogue of the force-free Harris sheet is presented. This distribution function is the relativistic generalization of the distribution function for the non-relativistic collisionless force-free Harris sheet recently found by Harrison and Neukirch [Phys. Rev. Lett. 102, 135003 (2009)] as it has the same dependence on the particle energy and canonical momenta. We present a detailed calculation which shows that the proposed distribution function generates the required current density profile (and thus magnetic field profile) in a frame of reference in which the electric potential vanishes identically. The connection between the parameters of the distribution function and the macroscopic parameters such as the current sheet thickness is discussed.

Simulations of Magnetic Reconnection in the Turbulent Solar Wind

Author: Christopher Haynes

Queen Mary University of London

Co-Authors:

Session: MST1: Magnetic Reconnection in Space and Astrophysical Plasmas

Presentation type: Poster *Poster Session B*

Summary:

Magnetic reconnection is a universal process which can play a controlling role in large-scale interactions such as at the magnetopause. Recently interesting questions have arisen on the role of reconnection in turbulence, motivated by MHD simulations and observations of possible reconnection in large amplitude turbulence behind the Earth's quasi-parallel shock. We analyze previous PIC simulation work (Camporeale et al 2010) for signatures of magnetic reconnection, and find electron scale reconnection is occurring in the turbulent plasma simulation. We also analyze plasma temperature in more detail revealing many localised temperature variations, indicating particle acceleration events are occurring at scales near the electron gyroradius. We present new results from 2D fully-kinetic Particle-in-Cell (PIC) simulations of decaying electromagnetic fluctuations, with the guide magnetic field out of the simulation plane. The computational box is such that wavelengths ranging from the electron to ion gyroradius are resolved. The parameters used are typical for the solar wind, with realistic ion to electron mass ratio. We investigate the role of these reconnection events in the turbulent cascade. The work demonstrates that, in contrast to dissipation mechanisms based on linear modes, non-linear magnetic reconnection may be an important energy dissipation mechanism in turbulent solar wind plasma.

Swarm Satellite Constellation Application and Research Facility: Status and Plans

Author: Alan W P Thomson

British Geological Survey

Co-Authors: Patrick Alken (2,8), Ciaran Beggan (3), Arnaud Chulliat (2), Eelco Doornbos (4), Rune Floberghagen (5), Eigil A Friis-Christensen (1), Brian Hamilton (3), Gauthier Hulot (2), Jose van den IJssel (4), Alexei V Kuvshinov (6), Vincent Lesur (7), Hermann Luhr (7), Susan Macmillan (3), Stefan Maus (8), Nils Olsen (1), Poul Erik H Olsen (1), Jaeheung Park (7), Gernot Plank (9), Patricia Ritter (7), Martin Rother (7), Terence J Sabaka (10), Claudia Stolle (1), Erwan Thebault(2), Lars Tøffner-Clausen (1), Jakub Velimsky (11), Pieter N Visser (4) 1. DTU Space, Technical University of Denmark, Copenhagen, Denmark. 2. IPGP, Paris, France. 3. BGS, Edinburgh, United Kingdom. 4. DEOS, Delft, Netherlands. 5. ESRIN, ESA, Frascati, Italy. 6. ETH, Zurich, Switzerland. 7. GFZ, Potsdam, Germany. 8. NOAA, Boulder, CO, United States. 9. ESTEC, ESA, Noordwijk, Netherlands. 10. GSFC, Greenbelt, MD, United States. 11. CUP, Prague, Czech Republic.

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *14:15 Tuesday 27th 14:15-15:30*

Summary:

Scientific use of data from the Swarm mission will benefit significantly from derived products, the 'Level-2' products, which take into account the features of the constellation. For this reason ESA has established a “Satellite Constellation Application and Research Facility” (SCARF), in the form of a consortium of several research institutions. A number of Level-2 data products will be offered by this consortium, including various models of the core,

lithospheric, ionospheric and magnetospheric fields. In addition, derived parameters like mantle conductivity, thermospheric mass density and winds, field-aligned currents, an ionospheric plasma bubble index, the ionospheric total electron content and the dayside equatorial zonal electrical field will be calculated. This service is expected to be operational for a period of 5 years after the launch of Swarm, which is scheduled for summer 2012. All products will be available through the Swarm Payload Data Ground Segment (PDGS), located at ESRIN, the ESA Centre for Earth Observation in Frascati, Italy. In this presentation I review progress on the SCARF (on behalf of the consortium) and discuss the BGS role within it. BGS plans for the mission cal/val and exploitation phases of the mission are also discussed.

Directly measuring ionospheric midlatitude current density with a magnetic satellite constellation

Author: Rob Shore
The University of Edinburgh

Co-Authors: K.Whaler (The University of Edinburgh); S.Macmillan (British Geological Survey); C.Beggan (British Geological Survey); A.Aruliah (University College London); T.Spain (University College London); N.Olsen (Technical University of Denmark)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *14:45 Tuesday 27th 14:15-15:30*

Summary:

The magnetic fields from ionospheric current systems contribute significantly to magnetometer measurements made by low Earth orbit (LEO) satellites. The accurate characterisation of these spatially and temporally varying fields is important in order to make effective use of the abundance of high-precision satellite magnetic data collected over the last decade. With the launch of ESA's Swarm satellite constellation mission in 2012, the future of LEO satellite exploration of the geomagnetic field will be driven by constellation missions. We report on advances in processing techniques for measurements made with a constellation of satellites in LEO for extracting new information on current systems flowing in the ionosphere. We apply Ampère's law integral to closed loops formed by two overlying satellites at different altitudes but at same local and universal times. The CHAMP and Ørsted LEO magnetic satellites are used for this purpose. Throughout 2000-2005, we solve for ionospheric current flow between the two satellites at discrete intervals. Comparisons of our results with predictions of zonal current density values from the CTIP (Coupled Thermosphere-Ionosphere Plasmasphere) model show good spatial agreement, but offsets in magnitude. Possible sources of error in our method are discussed. We highlight the direct applicability of this method to Swarm.

Developing data selection techniques to improve geomagnetic field models at high latitudes

Author: Gemma Kelly

British Geological Survey

Co-Authors: R. Holme (University of Liverpool); A. W. P. Thomson (BGS)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *15:00 Tuesday 27th 14:15-15:30*

Summary:

The availability of high-quality data during the past decade has allowed the development of geomagnetic field models which correlate well with the observed field at low to mid latitudes. However, the highly variable nature of field sources in the magnetosphere and ionosphere causes significant residuals between data and models at high latitudes. Signatures of high latitude currents show up clearly in the residuals for several recent models in both amplitude and direction, and so are not easily interpretable as field-aligned currents. Motivated by this we are identifying techniques to allow more, and better quality, data to be selected for use in field modelling at high latitudes. We investigate the Polar Cap (PC) and Auroral Electrojet (AE) indices as tools for identifying quiet data in the polar regions. We also test a method to identify the location of the auroral oval, and use this to define the region where only scalar data should be selected. The use of multiple satellites in the up-coming swarm mission has the potential to provide a far clearer definition of the auroral oval. This will ultimately lead to greatly improved models of the geomagnetic field at high latitudes.

Poster Presentations

Author: Mike Hapgood

Co-Authors:

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *15:15 Tuesday 27th 14:15-15:30*

Summary:

2-minute presentations to be given by those presenting posters on SWARM science work

Opportunities for the Swarm mission: The effect of the Ring Current

Author: Malcolm Dunlop

RAL

Co-Authors: Q. -H. Zhang (PRIC), H. Luhr (GFZ), I. Dandouras (IRAP), C. Shen (NSSC), R. Holme (U Liverpool), J. Cao (BUAA), Y. Bogdanova (MSSL), J. Eastwood (ICL), M. Lockwood (U Reading), Y. Kamide (PRIC), W. Baumjohann (SRI).

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *17:00 Tuesday 27th 17:00-18:15*

Summary:

The combined magnetic effect of the Earth's ring current (RC), the system of connecting field aligned currents (FACs) and the ionospheric polar currents, forms the dominant external influence on the measured Geomagnetic field. These induced magnetic signals have significant effect at low Earth orbit (LEO), and will be surveyed by the three Swarm spacecraft. SWARM observations will benefit from other spacecraft information, however, and present indices, such as Dst, are presently not good indicators (the RC can be different during storm development and recovery for similar Dst). A space based indicator is needed, for example, which maps RC response, in particular, to better define these influences and provide corrections to the main geomagnetic field models. In anticipation of the direct comparison of SWARM and other spacecraft, preliminary study of the influence of the RC using Cluster, Champ and other LEO data is in progress, including a full-circle determination of the RC vector directly from Cluster 4-spacecraft perigee observations, under non-storm conditions (Dst > -30 nT). The results confirm that the in situ average measured current density (in the radial range 4–4.5RE) is asymmetric in MLT, ranging from 9 to 27 nAm−2 (growing from 10 to 27 nAm−2 as azimuth reduces from about 12:00MLT to 03:00 and falling from 20 to 10 nAm−2 less steadily as azimuth reduces from 24:00 to 12:00MLT). This result is consistent with the operation of region-2 field aligned-currents (FACs), which are expected to flow upward into the ring current around 09:00MLT and downward out of the ring current around 14:00MLT. We note, however, that it is also consistent with a possible asymmetry in the radial distribution profile of current density and that part of the enhanced current could reflect an increase in the mean AE activity (during the periods in which Cluster samples those MLT). A specific problem is therefore to match the interpretation of the magnetic signals seen at LEO and those measured directly within the central RC region, where dawn-dusk RC asymmetries, seen both under storm and non-storm conditions, have some discrepancy between near-Earth and in-situ estimates. This could result from FAC connectivity, but at least call for a new consideration of the Dst correction in main field modeling.

Role of large-scale magnetospheric current systems for main field modelling

Author: Hermann Lühr

GeoForschungsZentrum, GFZ, Potsdam

Co-Authors: P. Ritter (GeoForschungsZentrum, GFZ, Potsdam); M. Dunlop (Rutherford-Appleton Laboratory, Chilton); G. Le (NASA Goddard Space Flight Center, Greenbelt)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *17:15 Tuesday 27th 17:00-18:15*

Summary:

Traditionally, the Dst index is used to parameterise the large-scale external field effect. But this index has (a) its intrinsic problems and (b) does not differentiate between contributions from the various sources. Thus estimating external field contributions from Dst for other latitudes and for satellite heights has turned out to be problematic. We need to obtain a better understanding separately of all the main current systems contributing to Dst. Traditionally, Dst is related on first order to the magnetospheric ring current. In-situ measurements of the ring current intensity by the Cluster satellites have revealed that the current strength becomes significantly larger in the early morning sector when magnetic activity increases. Conversely, the low-Earth satellite C/NOFS records for the same conditions an increase in magnetic effect from the magnetosphere in the time sector around 1800 LT. For resolving this conflict additional current systems have to be considered. Our favoured explanation is the magnetic effect of large-scale R2 field-aligned currents circuits connecting parts of the ring current with the auroral currents. So far poloidal currents have not been given much of attention in main field modelling. In this talk we will focus on the near-Earth effect of magnetospheric currents that should be determined routinely by the fleet of Swarm satellites possibly aided by ground-based and Cluster measurements.

Swarm: Status and plans for the scientific validation

Author: Gernot Plank

ESA-ESTEC

Co-Authors: R. Floberghagen (ESA-ESRIN), G. Ottavianelli (ESA-ESRIN), R. Haagmans(ESA-ESTEC), Y. Menard(ESA-ESTEC)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *17:30 Tuesday 27th 17:00-18:15*

Summary:

Swarm is the fifth Earth Explorer mission in ESA’s Living Planet Programme, and is scheduled for launch in July 2012. The objective of the Swarm mission is to provide the best-ever survey of the geomagnetic field and its temporal evolution using a constellation of 3 identical satellites. The mission shall deliver data that allow access to new insights into the Earth system by improved scientific understanding of the Earth’s interior and near-Earth electromagnetic environment. After launch and triple satellite release at an initial altitude of about 490 km, a pair of the satellites will fly side-by-side with slowly decaying altitude, while the third satellite will be lifted to 530 km to complete the Swarm constellation. High-precision and high-resolution measurements of the strength, direction and variation of the magnetic field, complemented by precise navigation, accelerometer and electric field measurements, will provide the observations required to separate and model various sources of the geomagnetic field and near-Earth current systems. The mission science goals are to provide a unique view into Earth core dynamics, mantle conductivity, crustal magnetisation, ionospheric and magnetospheric current systems and upper atmosphere dynamics - ranging from understanding the geodynamo to contributing to space weather. This presentation will focus on two main aspects: (1) A brief overview of the current status of the mission including the preparation for launch, and (2) the plans for the scientific validation during the commissioning and exploitation phase including the key role of the scientific community in this task.

CINEMA/TRIO: A three-spacecraft magnetospheric CubeSat mission

Author: Tim Horbury

Imperial College London

Imperial College London

Co-Authors: P. Brown, J. P. Eastwood, M. Archer (Imperial College London, UK), R. P. Lin, T. Immel, D. Glaser (Space Science Lab, University of California, Berkeley, CA, USA), D.-H. Lee, J. Seon, H. Jin (School of Space Research, Kyung Hee University, Yongin, Republic of Korea)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *17:45 Tuesday 27th 17:00-18:15*

Summary:

CINEMA/TRIO (CubeSat for Ions, Neutrals, Electrons and Magnetic fields) is a mission of three identical CubeSats in high inclination low Earth orbits, carrying two instruments: a suprathermal electron, ion and neutral sensor (STEIN) and a magnetometer from Imperial College (MAGIC). The spacecraft will provide multi-point measurements of near –Earth space including: stereoscopic energetic neutral atom imaging of the ring current with 1keV energy resolution; direct measurement of ion precipitation in the auroral regions including pitch angle distributions, from just a few keV; full energy characterisation of electron microbursts; and high cadence measurements of magnetospheric waves and transients. The mission is a collaboration of UC Berkeley, Kyung Hee University and Imperial College London; CINEMA passed acceptance testing in January 2012 and will launch in mid-2012, with two more spacecraft launching in late 2012. We discuss the potential of the multi-point magnetic field measurements of CINEMA/TRIO for providing complementary information to ESA's SWARM mission on space weather effects such as magnetospheric transients.

SuperDARN and Swarm: Opportunities for co-ordinated research

Author: Mark Lester

University of Leicester

Co-Authors: M. Dunlop (RAL Space); M.P. Freeman (British Antarctic Survey)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Talk *18:00 Tuesday 27th 17:00-18:15*

Summary:

Although primarily designed to measure the geomagnetic field, the Swarm mission will also measure the perpendicular ion velocity at the three spacecraft simultaneously between 400 and 550 km altitude, in order to better understand the electrodynamics of the external magnetic field. It has been proposed that the Super Dual Auroral Radar Network (SuperDARN) can be used to help calibrate these measurements and augment the scientific research. SuperDARN is ideally suited to this because it routinely measures the line-of-sight component of the ExB velocity at Swarm altitudes in the ionospheric F-region from 18 radars in the northern hemisphere and 8 radars in the southern hemisphere, extending from the polar cap to the sub-auroral regions. This paper will discuss how co-ordinated measurements between the spacecraft and radar network will enable a range of scientific studies to be undertaken.

A new methodology to improve modelling of the internal magnetic field

Author: Virginie Penquerc'h

University of Liverpool

Co-Authors: R. Holme (University of Liverpool)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Poster *Poster Session A&B*

Summary:

The geomagnetic field is generated by several sources, involving various temporal and spatial scales which overlap each other. It is difficult to separate the different contributions, and models of the internal field often suffer from contamination of the external fields. With the upcoming Swarm mission, it is necessary to understand how this contamination contributes to uncertainties and to develop new methods to minimise it in order to improve the resolution of models of the internal field. We propose here a new methodology. For every orbital track of CHAMP data, the residuals (correlated mainly according to the geometry of the mismodelled external field) between vector measurements and a model are calculated. An external field model is estimated from these residuals, which provides an estimate of the dominant data uncertainty. Data are decimated to calculate a new model, but where a covariant error weighting is applied which gives lesser weight to the data component in the direction of the contamination. This methodology follows past methods, for example to take account of the effect of the spacecraft attitude uncertainty in the Ørsted satellite (Holme, Earth Planets Space, 52, 1187-1197, 2000). We will here discuss preliminary results and possible implications for the Swarm mission.

Solar cycle trends in ground activity indices

Author: Philip Hush

CFSA, PUniversity of Warwick

Co-Authors: S. C. Chapman (CFSA, Physics Department, University of Warwick), M. W. Dunlop (RAL-Space)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Poster *Poster Session A&B*

Summary:

Geomagnetic indices provide a measure of geomagnetic activity over several solar cycles, allowing long term trends to be analysed. SuperMAG is a recent

worldwide collaboration of organizations and national agencies that currently operate over a hundred ground based magnetometers. These can be used to create geomagnetic indices in the same manner as the 'traditional' geomagnetic indices AE AU AL, but with an order of magnitude greater number of stations. [1] We have performed a statistical analysis of trends in these indices over the solar cycle, with particular focus on comparing SME with AE etc. We find that activity is correlated, but are not in phase, with solar cycle activity as measured by sunspot number or other indicators. We further investigate the correspondence with the source of the ground indices such as the MLT and latitude locations of the SML and SMU ground stations. Comparisons are made between AE and SME to investigate the geographic pattern of activity, and thresholds on activity levels are used to separate large scale and small scale processes. Work is in progress to investigate Dst trends and to compare results to solar wind key parameters. We would like to acknowledge SuperMAG, the World Data Center for Geomagnetism, Kyoto and STFC for their support.

What the Swarm mission may tell us about the South Atlantic Anomaly

Author: Susan Macmillan

British Geological Survey

Co-Authors: S. Casadio (IDEAS, SERCO, Frascati)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Poster *Poster Session A&B*

Summary:

The South Atlantic Anomaly (SAA) is often simply mapped using total intensity values taken from spherical harmonic models of the Earth's magnetic field. These models are derived from magnetic field observations taken by satellites and observatories and it is expected that data from the forthcoming Swarm mission will make a significant contribution to them. However, the location of the SAA as it affects Low Earth Orbiting (LEO) satellites is more completely determined by considering charged particle trajectories in the Earth's magnetic field. To include the effects of solar wind variations and magnetic storms dynamic radiation belt models are used, and they generally assume that the Earth's magnetic field is like that from a dipole. In order to quantify the effect of the omission of the non-dipolar terms and how it is changing with time, we calculate loss cones for trapped particles in the SAA region at typical LEO altitudes using full spherical harmonic models and simplified models comprising only degree 1 and 2 spherical harmonic terms. We also compare the results with SAA peak locations through time as derived from the along-track scanning radiometer series of instruments on board the ERS-1, ERS-2 and ENVISAT satellites.

The role of neutral atmospheric dynamics in cusp density and ionospheric patch formation

Author: Anasuya Aruliah

University College London

Co-Authors: Amy Ronksley (UCL); Herbert Carlson (Utah State University, USA); Ian McWhirter (UCL); Tim Spain (UCL); Jøran Moen (University of Oslo, Norway); Kjellmar Oksavik (University of Bergen, Norway); John Meriwether (Clemson University, USA)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Poster *Poster Session A&B*

Summary:

The prediction of satellite orbits relies on the quality of models of the upper atmosphere. Until recently it has been assumed that the neutral gas is a slowly and smoothly varying medium, with scale sizes of hours and several hundred to thousands of kilometres. Then in 2004 Lühr et al. reported that the CHAMP satellite observed large increases (doubling) in thermospheric density over small distances of only a few hundred kilometres, seen nearly every time the satellite crossed the cusp. Since then it has become a challenge for the scientific community to determine a mechanism to account for this localised upwelling phenomenon. Critically it has become a challenge for the modellers who need to reconsider thermospheric scale sizes and, in particular, the role of the so-called "passive" thermosphere in the magnetosphere-ionosphere-thermosphere system. From a recent set of experiments on Svalbard in January 2012, EISCAT radar measurements of the ionosphere provide measurements of the heating effect, which are compared with direct measurements of the response of the thermosphere using a combination of a narrow field-of-view Fabry-Perot Interferometer and all-sky Scanning Doppler Imager. An important further bonus with these experiments is to make a quantitative test of the Carlson (2007) theory which proposes a polar patch formation mechanism caused by these density bulges that invokes an important thermospheric role for the first time. The presence of ionospheric patches is of interest to the study of signal propagation. The observations will be used to constrain and test existing models, and will inevitably lead to significant improvements that will benefit the satellite and satellite communications industry.

Coordinated operations between Swarm and Cluster: scientific potential

Author: Andrew Fazakerley

MSSL-UCL

Co-Authors: M.W.Dunlop (Rutherford Appleton Laboratory) M.G.G.T.Taylor (ESA-ESTEC) R. Haagmans (ESA-ESTEC)

Session: MST2: New exploration of the geomagnetic field: opportunities with the ESA SWARM mission

Presentation type: Poster *Poster Session A&B*

Summary:

The four spacecraft Cluster mission has been studying the Earth's magnetosphere and the solar wind since 2001. The initial polar orbit, which had a perigee height of order 20,000 km, has evolved during the mission. Today the orbit plane has tilted over and the perigee height has fallen, reaching a minimum value below 1500 km at latitudes below 50 degrees. In the coming years the perigee height will rise and the orbit plane will become increasingly tilted, so that the spacecraft cross the auroral regions at the altitudes associated with the auroral acceleration region in 2013 and 2014. The SWARM mission which will be launched shortly will provide information about current systems and electric fields from a near-polar orbit at low altitudes of a few

mission which will be launched shortly will provide information about current systems and electric fields from a near-polar orbit at low altitudes of a few hundred km. We will report on a preliminary examination of the kinds of magnetic conjunction between Cluster and SWARM that are likely to occur over the nominal 4 year lifetime of the SWARM mission, and consider their scientific potential.

The Met Office Unified Model and its extension to the thermosphere

Author: David Jackson

Met Office

Co-Authors:

Session: MST3: Vertical Coupling through planetary atmospheres and ionospheres

Presentation type: Talk *10:00 Friday 30th 10:00-11:15*

Summary:

The Met Office Unified Model (UM) is used widely for both weather forecasting and climate studies. It includes a comprehensive representation of atmospheric dynamics, physics and chemistry, and currently has an upper boundary near 85 km. In order to develop an improved capability for space weather forecasts, it is desirable to develop a coupled system of models representing the domain from the Sun to the Earth's surface. Much space weather forecast research is focused on the thermosphere and ionosphere, since that is where many space weather impacts are seen. While the thermosphere and ionosphere are largely driven from above, recent research has shown that the coupling between this region and the lower atmosphere is also important. For example, non-migrating tides forced in the tropical troposphere have been linked to variations in the ionospheric F region. Therefore, representation of such coupling is important. An attractive way of doing this is by building a "whole atmosphere" model, which spans the neutral atmosphere from the Earth's surface to the exobase (around 600 km) and represents the coupling between different atmospheric levels in a self-consistent manner. The UM is suitable for such a development since its dynamical core is non-hydrostatic and uses a deep atmosphere approximation. In this presentation, the UM is described and the research challenges and opportunities associated with its upward extension are outlined.

Vertical Coupling by Ultra-Fast Kelvin Waves in the Equatorial Atmosphere

Author: Nicholas Mitchell

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Co-Authors: R. N. Davis (1), Y.-W. Chen (2), S. Miyahara (2) 1. Centre for Space, Atmospheric and Oceanic Science, Department of Electronic and Electrical Engineering, The University of Bath, BA2 7AY, UK 2. Department of Earth and Planetary Sciences, Kyushu University, Fukuoka 812-8581, Japan

Session: MST3: Vertical Coupling through planetary atmospheres and ionospheres

Presentation type: Talk *10:15 Friday 30th 10:00-11:15*

Summary:

Wind measurements from a meteor radar on Ascension Island (8S, 14W) and simultaneous temperature measurements from the Aura MLS instrument are used to characterise ultra-fast Kelvin waves (UFKW) of zonal wavenumber 1 (E1) in the mesosphere and lower thermosphere (MLT) in the years 2005–2010. These observations are compared with some predictions of the Kyushu-general circulation model. Good agreement is found between observations of the UFKW in the winds and temperatures, and also with the properties of the waves in the Kyushu-GCM. UFKW are found at periods between 2.5–4.5 days with amplitudes of up to 40 m/s in the zonal winds and 6 K in the temperatures. The average vertical wavelength is found to be 44 km. Amplitudes vary with latitude in a Gaussian manner with the maxima centred over the equator. Dissipation of the waves results in monthly-mean eastward accelerations of 0.2–0.9 m/s/day at heights around 95 km, with 5-day mean peak values of 4 m/s/day. Largest wave amplitudes and variances are observed over Indonesia and central Africa and may be a result of very strong moist convective heating over those regions. Rainfall data from TRMM are used as a proxy for latent-heat release in an investigation of the excitation of these waves. No strong correlation is found between the occurrence of large-amplitude mesospheric UFKW events and either the magnitude of the equatorial rainfall or the amplitudes of E1 signatures in the rainfall time series, indicating that either other sources or the propagation environment are more important in determining the amplitude of UFKW in the MLT. A strong semiannual variation in wave amplitudes is observed. Intraseasonal oscillations (ISOs) with periods 25–60 days are evident in the zonal background winds, zonal-mean temperature, UFKW amplitudes, UFKW accelerations and the rainfall rate. This suggests that UFKW play a role in carrying the signature of tropospheric ISOs to the MLT region.

The cosmic dust input to the earth

Author: John Plane

University of Leeds

Co-Authors:

Session: MST3: Vertical Coupling through planetary atmospheres and ionospheres

Presentation type: Talk *10:30 Friday 30th 10:00-11:15*

Summary:

This paper will address a fundamental problem – the size of the cosmic dust input to the earth's atmosphere. Zodiacal cloud observations and spaceborne dust detection indicate a daily input of 100 – 300 tonnes, in agreement with the accumulation rates of cosmic elements (Ir, Pt, Os and super-paramagnetic Fe) in polar ice cores and deep-sea sediments. In contrast, measurements in the middle atmosphere – by radars, lidars, high-flying aircraft and satellite remote sensing – indicate that the input is only 5 - 50 tonnes. There are two major reasons why this huge discrepancy matters. First, if the upper range of estimates is correct, then vertical transport in the middle atmosphere must be considerably faster than generally believed; whereas if the lower range is correct, then our understanding of dust evolution in the solar system, and transport from the middle atmosphere to the surface, will need substantial

revision. Second, cosmic dust particles enter the atmosphere at high speeds and in most cases completely ablate. The resulting metals injected into the atmosphere are involved in a diverse range of phenomena, including: formation of layers of metal atoms and ions; nucleation of noctilucent clouds; impacts on stratospheric aerosols and O3 chemistry; and fertilization of the ocean with bio-available Fe, which has potential climate feedbacks.

Stratospheric gravity wave activity above the Antarctic Peninsula and Falkland Islands

Author: Dr Tracy Moffat-Griffin

British Antarctic Survey

Co-Authors: R.E. Hibbins (University of Trondheim) M.J. Jarvis (British Antarctic Survey) S.R. Colwell (British Antarctic Survey)

Session: MST3: Vertical Coupling through planetary atmospheres and ionospheres

Presentation type: Talk *10:45 Friday 30th 10:00-11:15*

Summary:

It is known that atmospheric gravity waves propagating up from the stratosphere and troposphere play a critical role in atmospheric circulation. Observations from satellites have shown an area of intense gravity wave activity in the stratosphere above region that covers the tip of South America to the Antarctic Peninsula. Radiosondes have been used for many gravity wave studies in the troposphere and stratosphere, examining the variations in gravity wave activity and identifying potential gravity wave source regions. High vertical resolution radiosonde data is recorded at both the British Antarctic Survey research station at Rothera (67°34′S, 68°05′W) and the UK Met Office site on the Falkland Islands (51°49′S, 58°26′W). These sites are located on either side of the gravity wave hotspot, and are likely to have different sources of gravity waves due to their different topography and locations. Stratospheric gravity-wave parameters are derived for both datasets over the 8 year period from 2002 to 2010 using the standard analysis techniques. Their seasonal variations are compared and the potential gravity wave sources and their possible contribution to the gravity wave hotspot are discussed.

Observations of atmospheric discharges with a small scale interferometric network of radio receivers

Author: A.Mezentsev

University of Bath

Co-Authors: M.Fullekrug (University of Bath)

Session: MST3: Vertical Coupling through planetary atmospheres and ionospheres

Presentation type: Talk *11:00 Friday 30th 10:00-11:15*

Summary:

Recent observations show that powerful positive cloud-to-ground discharge can lead to the development of sprites above thunderclouds which may be associated with runaway electron beams (REBs). REBs emit broadband electromagnetic radiation characterized by its flat spectrum according to numerical simulations and recent observations. These radio emissions occur several milliseconds after the parent lightning discharge and can be detected by low frequency radio receivers. This work is based on using wide band digital radio receivers which record vertical electric field strengths in the frequency range from ~4 Hz to ~400 KHz, with a sampling frequency of 1 MHz. Eight of these radio receivers are used to form a small scale interferometric network where individual instruments are separated by distances ranging from ~1 km up to ~30 km. The network was deployed in Southern France and operated from July to September 2011. The network operated successfully during several nearby sprite producing thunderstorms. The recorded waveforms are very consistent and exhibit small time delays which reflect the propagation of the electromagnetic waves across the network. These time delays are used to determine the bearing and elevation angle of the arriving electromagnetic energy. The first results obtained with the interferometric network are presented.

Sensitivity studies of mesospheric metal layers using a whole atmosphere community climate model

Author: WUHU FENG

UNIVERSITY OF LEEDS

Co-Authors: John Plane(School of Chemistry, University of Leeds, UK); Martyn Chipperfield (School of Earth and Environment, University of Leeds, UK); Dan Marsh (Atmospheric Chemistry Division, NCAR, USA); Diego Janches (GSFC/NASA, USA); Chester Garner (University of Illinois at Urbana-Champaign, USA); Josef Hoeffner(Leibniz-Institute of Atmospheric Physics, Germany); Anne Smith (Atmospheric Chemistry Division, NCAR, USA)

Session: MST3: Vertical Coupling through planetary atmospheres and ionospheres

Presentation type: Poster *Poster Session B*

Summary:

The mesosphere / lower themosphere (MLT) region (~80-120 km) connects the atmosphere below with space above, and is a region of increasing scientific and practical interest. For instance, recent studies show that weather forecasts are significantly improved by extending Numerical Weather Prediction models from the stratosphere to the upper mesosphere. The ablation of interplanetary dust particles entering the atmosphere provides a source of metal atoms in the MLT, and the resulting layers of metal atoms and ions offer a unique way to understand the coupling of atmospheric chemistry and dynamical processes, as well as testing the accuracy of climate models in the MLT. Recently we have successfully incorporated the chemistry of Na, Fe and Mg into the NCAR Whole Atmosphere Community Climate Model (WACCM). This model has detailed dynamics/physics and chemical processes from the surface to ~140 km, and also includes parameterisations for other key processes (e.g., ion chemistry, solar cycle and solar proton events). A series of six long-term model runs were conducted to investigate the sensitivity of the simulated Fe layer to the meteoric input function (MIF) and the presence of polar mesospheric clouds. Here we will evaluate: WACCM temperature and ozone against TIMED/SABER measurements; the electron

density against the International Reference Ionosphere; and the Fe and Na layers against lidar and satellite measurements.

Digital Radio Camera

Author: Martin Fullekrug

University of Bath

Co-Authors: Andrew Mezentsev (University of Bath)

Session: MST3: Vertical Coupling through planetary atmospheres and ionospheres
Presentation type: Poster *Poster Session B*

Summary:

This contribution reports the design, realization and operation of a novel digital low frequency radio camera towards an exploration of the Earth's electromagnetic environment with particular emphasis on lightning discharges and subsequent atmospheric effects such as transient luminous events. The design of the digital low frequency radio camera is based on the idea of radio interferometry with a network of radio receivers which are separated by spatial baselines comparable to the wavelength of the observed radio waves, i.e., ~1-100 km which corresponds to a frequency range from ~3-300 kHz. The key parameter towards the realization of the radio interferometer is the frequency dependent slowness of the radio waves within the Earth's atmosphere with respect to the speed of light in vacuum. This slowness is measured with the radio interferometer by using well documented radio transmitters. The first application of the digital low frequency radio camera is to characterize the electromagnetic energy emanating from sprite producing lightning discharges, but it is expected that it can also be used to identify and investigate numerous other radio sources of the Earth's electromagnetic environment.

Antarctic access to the Middle Atmosphere

Author: Andrew J. Kavanagh

British Antarctic Survey

Co-Authors: M. J. Jarvis (British Antarctic Survey)

Session: MST3: Vertical Coupling through planetary atmospheres and ionospheres

Presentation type: Poster *Poster Session B*

Summary:

The British Antarctic Survey is a leading environmental research centre with a remit to address fundamental questions best answered by studies in the Polar Regions. BAS has a wide-ranging research portfolio which includes atmospheric science ranging from the surface through the middle atmosphere into the geospace region. The Middle Atmosphere Dynamics work-package at BAS uses long-term observations and modelling to determine the global scale dynamical links between the polar middle atmosphere and surface climate. This includes determining how these links are influenced both from above and below. To support this work BAS (sometimes in partnership with other institutions) operates a number of key instruments at its stations at Halley and Rothera, including middle atmosphere radars, airglow imagers, spectrometers and radiosondes. In this poster we provide details of some of the instrumentation available for middle atmosphere research at BAS.

Combined Incoherent Scatter Radar and Optical Observations of Naturally Enhance Ion Acoustic Echoes.

Author: Brendan Goodbody

University of Southampton

Co-Authors: B.S.Lanchester (University of Southampton), B.Gustavsson (University of Southampton), S.Tuttle (University of Southampton), V.Belyey (University of Tromsø), H.Vickers (University of Tromsø) N.Schlatter (KTH Royal Institute of Technology)

Session: MST4: Recent results in MIST science

Presentation type: Talk *11:45 Friday 30th 11:45-13:00*

Summary:

Analysis of the first observed Naturally Enhanced Ion Acoustic Line spectra with the EASI radar system on Svalbard is presented. The event is viewed in 3D using aperture synthesis imaging by applying a new iteratively truncated single value decomposition method. The incoherent scatter radar data is combined with high spatial and temporal resolution optical images in selected spectral emissions from the ASK facility to connect the non thermal radar back-scatter to the dynamic auroral structures.

Determination of the threshold flux to stimulate upper hybrid resonance using artificial auroral...

Author: Carl Bryers

Lancaster University

Co-Authors: M.Kosch(Lancaster University), A.Senior(Lancaster University), M.Rietveld(EISCAT, Ramfjordmoen)

Session: MST4: Recent results in MIST science

Presentation type: Talk *12:00 Friday 30th 11:45-13:00*

Summary:

...observations. We analyse optical emissions induced by high power HF radio waves as a function of power flux. The experiment, using the EISCAT heater, was performed on 8 November 2001 operating in O-mode at 6.2 MHz in a power stepping mode. The Digital All Sky Imager (DASI) recorded the intensity of the induced optical emission at 630.0 nm. Accounting for D-region absorption and ray divergence we quantify the radio wave flux in W/m^2 reaching the upper hybrid resonance (UHR) altitude and calculate the O(1D) excitation rate as a function of heater power flux. We determine the threshold flux at which the excitation rates and the auroral intensities begin to increase which is in good agreement with UHR theory. We determine the efficiency of the plasma heating process to be 60-100% at high pump powers and 20-40% at low pump powers and find the increase in efficiency occurs above the threshold flux needed to stimulate UHR.

A new model to predict large-scale structuring in the high-latitude ionosphere in real time

Author: Alan Wood

University of Liverpool

Co-Authors: Eleri Pryse (Aberystwyth University)

Session: MST4: Recent results in MIST science

Presentation type: Talk *12:15 Friday 30th 11:45-13:00*

Summary:

The polar ionosphere is highly complex containing structures in electron density with a wide range of spatial scale sizes. Of relevance to the current study are density enhancements on horizontal scales of ~100 s to 1000 s km in the E- and F-regions. These enhancements exhibit variation with season, solar cycle, geomagnetic activity, interplanetary magnetic field magnitude and orientation, local time and universal time. Whilst the processes influencing this plasma are well understood, their relative importance is a more open question. Statistical modelling has been extensively used in road safety studies for predicting accident frequencies and this method is readily be applied to the ionosphere. In essence this technique generates a model from observational data which is used to identify the dominant driving processes. The amount of structuring within more than 3,000 3-hour intervals of observations made by the EISCAT Svalbard Radar was determined and a statistical model was derived. This model was used to make real time predictions of ionospheric variability on 3-hr timescales. These predictions were compared to observations to determine the accuracy of the method.

Conjugate observations of mid-latitude travelling ionospheric disturbances by HF radars

Author: Adrian Grocott

University of Leicester

Co-Authors: K. Hosokawa (University of Electro-Communications, Tokyo, Japan); S. E. Milan (University of Leicester, UK); N. Sato (National Institute of Polar Research, Tokyo, Japan); A. S. Yukimatu (National Institute of Polar Research, Tokyo, Japan)

Session: MST4: Recent results in MIST science

Presentation type: Talk *12:30 Friday 30th 11:45-13:00*

Summary:

We present a survey of travelling ionospheric disturbances (TIDs) observed at mid-latitudes in the northern and southern hemispheres by the Wallops Island and Falkland Islands SuperDARN HF radars. Observations were made during the 18 month operational interval of the Falkland Islands radar between March 2010 and September 2011. Statistics of the radar ground backscatter, in which the signatures of TIDs are manifest, will be presented along with an analysis of the TID spectral and propagation characteristics. Observed periods were in the range 30 - 60 minutes, corresponding to frequencies of 0.3 - 0.6 mHz. Wavelengths were generally in the range 250 - 400 km with phase speeds in the range 50 - 200 m/s. These values are within the ranges typically associated with medium-scale gravity waves. We discuss these results in terms of hemispheric, seasonal and diurnal variations, as well as in terms of their relationship to the local topography and large-scale geomagnetic activity.

Investigating the Importance of Viscous Interactions on Ionospheric Convection

Author: James Hutchinson

University of Leicester

Co-Authors: S. E. Milan (University of Leicester); D. M. Wright (University of Leicester); A. Grocott (University of Leicester); P. D. Boakes (Austrian Academy of Sciences)

Session: MST4: Recent results in MIST science

Presentation type: Talk *12:45 Friday 30th 11:45-13:00*

Summary:

Geomagnetic storms cause large global disturbances in the Earth's magnetosphere, during which large amounts of energy are deposited in the magnetotail and inner magnetosphere, producing an enhanced ring current and energising plasma to relativistic levels by poorly-understood excitation mechanisms. A previous study by Hutchinson et al. [2011] identified 143 geomagnetic storms over the last solar cycle (1997-2008) from the global SYM-H index and associated solar wind (SW) data from the Advanced Composition Explorer (ACE) spacecraft. Current work continues to use this dataset to investigate the characteristic ionospheric convection during both magnetic storms and quiet times via radar backscatter observed by the Super Dual Auroral Radar Network (SuperDARN). The map potential technique of Ruohoniemi and Baker [1998] is used to complete a superposed epoch analysis of this dataset. Complementary analysis is performed on auroral images from the IMAGE and POLAR spacecraft mission during the same storm and quiet time periods. Results from the comparison of the convection reversal boundaries (derived from the SuperDARN data) and open-closed boundaries (from the auroral imagery) are presented to investigate the significance of a possible viscous interaction between the solar wind and the magnetosphere in addition to the normal reconnection driven interaction. Open-closed boundaries are shifted as per the statistical results of Boakes et al. [2008] and Cowley et al. [2003] to

normal reconnection-driven interaction. Open-closed boundaries are shifted as per the statistical results of Boakes et al. [2008] and Carbary et al. [2003] to adjust auroral image derived OCB locations to that of in-situ satellite DMSP derived OCBs. This comparison of OCB-CRB boundaries is further broken down to investigate the dependence on the intensity of various solar wind properties, such as speed, density and ram pressure, as seen during the different phases of geomagnetic storms and quiet time periods. Estimates are given of the increase in cross-cap potential that such a viscous interaction would yield. The additional analysis of quiet time periods suggest that a viscous interaction is always present, and hence an important addition to the usual reconnection-driven convection.

Magnetospheric and Ionospheric Response to Solar Wind Variability at Mars

Author: Hermann Opgenoorth

Swedish Institute of Space Physics

Co-Authors: H. J. Opgenoorth(1, 2), D. Andrews (1), N. Edberg(1), M. Lester(3), A. Williams (3) M. Fraenz (4) , O. Witasse (5), F. Duru (6), and D. Morgan (6) (1) Swedish Institute of Space Physics, Uppsala Division, 75121 Uppsala Sweden (2) International Space Science Institute, ISSI, 3012 Bern, Switzerland (3) Dept. of Physics and Astronomy, University of Leicester, Leicester LE1 7RH, UK (4) MPS, Katlenburg-Lindau, Germany (5) RSSD, ESTEC, Noordwijk, NL (6) Dept. of Physics, University of Iowa, Iowa, USA

Session: MST4: Recent results in MIST science

Presentation type: Talk *14:15 Friday 30th 14:15-15:30*

Summary:

At planets with induced magnetospheres the coupling between the ionosphere, the small draped magnetosphere and the solar wind is very direct in comparison to Earth. On the other hand it is more complicated as the weak induced magnetosphere itself is created by and in its shape and strength dynamically depending on the prevailing Solar wind conditions. In early 2010 Mars was located behind Earth in the Solar wind. In this study we utilized coordinated data from multiple near-Earth spacecraft (Stereo, ACE) to evaluate what kind of Solar wind disturbances have passed by Earth and might hit Mars consecutively (and when). We use plasma data from the ESA Mars- Express mission (mainly from the ASPERA particle instrument and the MARSIS topside ionospheric sounder) to investigate, for a number of isolated events in March and April 2010, how the induced magnetosphere at Mars develops and decays in response to Solar wind variability in the magnetic field, density and velocity, and what kind of ionospheric dynamics are produced in association with such events.

Temporal (and spatial) variations of temperature, density and emission within Saturn's aurorae

Author: James O'Donoghue

University of Leicester

Co-Authors: T.Stallard (University of Leicester); H.Melin (University of Leicester); S.Miller (University College London)

Session: MST4: Recent results in MIST science

Presentation type: Talk *14:30 Friday 30th 14:15-15:30*

Summary:

We report the findings of high resolution ground-based data using the NIRSPEC instrument on the Keck telescope: looking at Saturn's southern auroral H3+ emissions. For the first time, a detailed temporal and spatial profile of the properties of the upper atmosphere on Saturn has been produced. In previous work there has only been one measurement of these properties (temperature, density, emission) for an entire night of observations for an entire dataset, limiting our ability to assess how the thermosphere is effected by magnetospheric interactions. Here we show significant changes in the auroral and thermospheric conditions over a period of ~3 hours, indicating the interaction between the thermosphere and magnetosphere via the ionospheric H3+ which we are measuring. The extent to which these properties correlate over the period also appears to change with time, the data appears to suggest the thermosphere is both heated and cooled via auroral generation through magnetospheric interactions. This heating and cooling is seen by the emission of our in-situ probe, H3+. This data, in short, provides essential new clues into the Saturnian auroral system, far beyond what has previously been available.

Dawn-Dusk Asymmetries in Average Magnetotail Pitch Angle Distributions

Author: Andrew Walsh

MSSL/UCL

Co-Authors: A.N. Fazakerley (MSSL/UCL); C.J. Owen (MSSL/UCL); C. Forsyth (MSSL/UCL); I. Dandouras (IRAP/CNRS)

Session: MST4: Recent results in MIST science

Presentation type: Talk *14:45 Friday 30th 14:15-15:30*

Summary:

We present the results of a survey of Cluster PEACE and CIS-CODIF data taken in the 2001-2006 tail seasons, building on the work of Walsh et al. (GRL, 2011). We examine the average pitch angle distributions of protons and electrons in the magnetotail as a function of proton plasma beta, restricted to times when the magnetosphere was exposed to steady (on a 3 hour timescale) IMF conditions and focussing in particular on dawn-dusk asymmetries. We confirm that, on average, the 2 component proton plasma sheet exists duskward of the noon-midnight meridian under steady northward IMF. An associated population of cold electrons is also observed. Dawnward of the noon-midnight meridian there are no significant fluxes of the cold component of protons and much reduced fluxes of the cold electron component, implying transport across the dusk magnetopause is the dominant formation mechanism of the two component plasma sheet for both protons and electrons. Under southward IMF, dawn-dusk asymmetries in the protons are controlled by the Y component of the IMF. For the electrons higher fluxes of high energy, field-aligned, particles are observed at dusk than at dawn. This suggests a link to a duskward offset of the tail neutral line and the preferential observation of substorm-related tail signatures in the premidnight sector.

Survey of anisotropic electron moments in Saturn's magnetosphere

Author: Chris Arridge

UCL

Co-Authors: G.R. Lewis (UCL); A.J. Coates (UCL); M.K. Dougherty (Imperial College)

Session: MST4: Recent results in MIST science

Presentation type: Talk *15:00 Friday 30th 14:15-15:30*

Summary:

The standard approach used to estimate the electron density and temperature of electrons in Saturn's magnetosphere from the Cassini Plasma Spectrometer Electron Spectrometer is to numerically integrate the observed fluxes from a single anode assuming the distribution is isotropic in the spacecraft frame (Lewis et al., 2008; Arridge et al., 2009). In this paper we remove the isotropic assumption and integrate fluxes organised by pitch angle to produce anisotropic moments, assuming the distribution function is gyrotropic in the spacecraft frame. Missing segments of the distribution function are filled using a number of different strategies. There are numerous science drivers for such a study, for example to understand plasma transport, facilitate diffusive equilibrium calculations and understand pressure anisotropies in the ring current. In this paper we present our method for calculating n, T∥ and T⊥ and discuss the limitations in our technique, paying particular attention to the validity of the isotropic assumption made by Rymer (2004), Lewis et al. (2008), Schippers et al. (2008), Arridge et al. (2009), and others. We then present a synoptic study of these moments from the entire Cassini mission at Saturn.

Evidence for Intermittent Heating in the Solar Wind

Author: Kareem Osman

University of Warwick

Co-Authors: W.H. Matthaeus, M. Wan, F. Rappazzo, (University of Delaware, USA) S.C. Chapman, and B. Hnat (University of Warwick)

Session: MST4: Recent results in MIST science

Presentation type: Talk *15:15 Friday 30th 14:15-15:30*

Summary:

An active magnetohydrodynamic (MHD) turbulence cascade dissipates energy which heats the surrounding plasma. This could account for a number of astrophysical phenomena such as the non-adiabatic expansion of heliospheric protons. We present evidence that this heating is highly inhomogeneous, occurring in localized structures (e.g. current sheets) which are dynamically generated by the turbulence. Using measurements from the ACE and Wind spacecraft, enhancements in proton temperature, electron temperature, and electron heat flux are found near current sheets. The most pronounced temperature elevations are found near the most intense current sheets, which are candidate magnetic reconnection sites. These current sheets collectively contribute 50% of the total plasma internal energy, despite only constituting 19% of the data. Our results suggest MHD turbulence drives inhomogeneous dissipation through a hierarchy of current sheets, which collectively could be a significant source of solar wind heating

Spatial fine-structure in trapped and precipitating medium-energy electrons in the noon sector

Author: Martin Birch

University of Central Lancashire

Co-Authors: J.K.Hargreaves(1,2) & M.J. Birch(2) (1) Department of Physics, Lancaster University, UK. (2) Jeremiah Horrocks Institute, University of Central Lancashire, UK.

Session: MST4: Recent results in MIST science

Presentation type: Poster *Poster Session B*

Summary:

Data from Polar Orbiting Environmental Satellites (POES) during auroral zone overpasses in the noon sector have been studied in order to investigate the relationships between the trapped and precipitating components of the electron flux at 10 km resolution. Three classes of behaviour have been identified, two of which are consistent with strong and weak diffusion. In the third class the precipitating flux shows variations up to 2 orders of magnitude while the trapped flux is almost constant. These properties are compared for electron energies exceeding 30 keV and 100 keV, which are relevant to the phenomena of auroral radio absorption.

A Comparison of Geomagnetic Storm and Quiet Time Periods Seen in Superposed SuperDARN Data

Author: James Hutchinson

University of Leicester

Co-Authors: D. M. Wright (University of Leicester); S. E. Milan (University of Leicester); A. Grocott (University of Leicester)

Session: MST4: Recent results in MIST science

Presentation type: Poster *Poster Session B*

Summary:

Summary:

Geomagnetic storms cause large global disturbances in the Earth's magnetosphere, during which large amounts of energy are deposited in the magnetotail and inner magnetosphere, producing an enhanced ring current and energising plasma to relativistic levels by poorly-understood excitation mechanisms. A previous study by Hutchinson et al. [2011a] identified 143 geomagnetic storms over the last solar cycle (1997-2008) from the global SYM-H index and associated solar wind (SW) data from the Advanced Composition Explorer (ACE) spacecraft. Current work continues to use this dataset to investigate the characteristic ionospheric convection during both magnetic storms and quiet time periods via radar backscatter observed by the Super Dual Auroral Radar Network (SuperDARN). A superposed epoch analysis is completed using the map potential technique of Ruohoniemi and Baker [1998]. Complementary analysis is completed on both storm and quiet time auroral images from the IMAGE and POLAR spacecraft missions, with superposed auroral keograms presented along with the cross-cap potential derived from the superposed SuperDARN results to better constrain the storm time coupling between the solar wind and magnetosphere. Here we use the Latitude-Time-Velocity plot technique previously presented (Hutchinson et al. [2011b]) to demonstrate statistical differences in the location and characteristics of storm time and quiet time convection. Initial results are compared to those of Kane & Makarevich [2009] and Gillies et al. [2011] who have undertaken similar studies using different superposition methods. Also presented is a comparison of the results of the superposition with recent geomagnetic storms seen in specific radars; done to investigate the validity of using the statistically average radar scatter as an indication of what individual radars would see during different sized storms, phase progression and varying MLT onsets.

A critical examination of accelerated particle spectra in the auroral acceleration region

Author: Colin Forsyth

UCL/MSSL

Co-Authors: A.N.Fazakerley (UCL/MSSL); A.P.Walsh (UCL/MSSL); C.J.Owen (UCL/MSSL)

Session: MST4: Recent results in MIST science

Presentation type: Talk *00:00 Poster Session B*

Summary:

Quasi-static magnetic-field-aligned electric potential drops at altitudes between 1000 and 12000 km are able to accelerate charged particles into and out of the ionosphere above the aurora. Since 2008, Cluster has made regular passes through this so-called auroral acceleration region (AAR), facilitating studies of both the temporal evolution and spatial structure of these regions. Whilst the spacecraft can pass over this region with their foot-points separated by only fractions of a degree, this still translates to 10s km in the ionosphere, and this is comparable to the scale size of some auroral arcs. Consequently, the validity of assumptions made concerning magnetic conjugacy, or that the spacecraft are passing through the same acceleration region at different times, may be severely tested and must be closely examined. In this study, we examine a number of AAR crossings by the 4 Cluster spacecraft and compare the accelerated particle spectra recorded by the different spacecraft in order to determine the likelihood of their being conjugate or passing through the same feature at different times. From this, we attempt to understand the uncertainty in determining the temporal evolution and spatial structure of quasi-static potential drops in the AAR.

ULF Waves Generated By Energetic Particle Injection

Author: Matthew James

University of Leicester

Co-Authors: T.K.Yeoman (University of Leicester)

Session: MST4: Recent results in MIST science

Presentation type: Poster *Poster Session B*

Summary:

A previous case study (Yeoman et al., 2010) observed a ULF wave with an eastward and equatorward phase propagation (an azimuthal wave number of m~13) generated during the expansion phase of a substorm. The eastward phase propagation of the wave suggested that eastward drifting energetic electrons were responsible for driving this particular wave. In this study a population of 44 similar ULF wave events also thought to have been driven by substorm-injected particles have been identified using the Hankasalmi SuperDARN radar in Finland between August 2000 and December 2002. The wave events identified in this study exhibit azimuthal wave numbers ranging in magnitude from 3 to 44, with both westward and eastward propagation. The drift resonance mechanism implies this population of waves may be generated by either eastward drifting electrons or westward drifting protons, with predictions of the associated particle energies ranging from ~1 – 120 keV.

Statistical study of EMIC waves using Cluster satellites

Author: Ivan Pakhotin

The University of Sheffield

Co-Authors: S.N. Walker (The University of Sheffield), M. A. Balikhin (The University of Sheffield)

Session: MST4: Recent results in MIST science

Presentation type: Poster *Poster Session B*

Summary:

Electromagnetic Ion Cyclotron(EMIC) waves play an important role in the dynamics of energetic electrons within the inner magnetosphere. 11 years of Cluster data enable a multipoint, statistical study of EMIC waves, their polarization and propagation properties. The results of this study are presented.

Plasmoids in solar flares and their radio and X-ray diagnostics

Plasmoids in solar flares and their radio and X-ray diagnostics

Author: Marian Karlicky

Astronomical Institute AS CR, 25165 Ondrejov, Czech Republic

Co-Authors:

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Talk *11:45 Thursday 29th 11:45-13:00*

Summary:

After introduction about a role of plasmoids in solar flare reconnection, a concept of the successive merging of plasmoids and fragmentation in the current sheet in the standard flare model is presented. Using a 2.5-D electromagnetic particle-in-cell model these processes are simulated. We recognized a formation of plasmoids and their mutual interactions. During these interactions the electrons are very effectively accelerated and heated. Simultaneously, the electromagnetic emission is produced. Relevant radio and X-ray signatures of these processes are discussed. Finally, a unique example of the solar flare with plasmoid ejection is presented.

Long-Duration Solar Flares: Acceleration Without Heating

Author: Ivan Zimovets

Space Research Institute (IKI) of RAS, Moscow, Russia

Co-Authors: A.B.Struminsky (Space Reseacrh Institute (IKI) of RAS, Moscow, Russia)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Talk *12:05 Thursday 29th 11:45-13:00*

Summary:

On the base of two particular long-duration solar flares of 2003 October 26 and 2005 January 19 it is shown that efficiency of accelerated electrons to heat the active region plasma can change significantly in course of an event. This was extremely brightly seen in the flare of 2003 October 26 event, when strong burst of hard X-ray and microwave emissions have been observed hour and a half after start of the impulsive phase. A case of such strong peak of non-thermal emission without response in the soft X-ray range was not seen before. Three possible interpretations of this phenomenon are discussed: 1) strong increase of the low-energy cutoff of non-thermal electrons in course of an event, 2) appearance of a lock, which blocks precipitation of non-thermal electrons from an acceleration site; 3) involvement of higher and higher loops in process of energy release. Preference is given to the third scenario.

A solar burst with double radio spectrum observed up to 212 GHz

Author: Paulo Simoes

University of Glasgow

Co-Authors: C.G. Giménez de Castro (CRAAM, Mackenzie University, Brazil) G.D. Cristiani (CONICET, FCEN, University of Buenos Aires, Argentina) C.H. Mandrini (CONICET, FCEN, University of Buenos Aires, Argentina) E. Correia (INPE, Brazil) P. Kaufmann (CRAAM, Mackenzie University, Brazil; CCS, UNICAMP, Brazil)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Talk *12:16 Thursday 29th 11:45-13:00*

Summary:

We study a solar flare that occurred on September 10, 2002, in active region NOAA 10105 starting around 14:52 UT and lasting approximately 5 minutes in the radio range. The event was classified as M2.9 in X-rays and 1N in H-alpha. Solar Submillimeter Telescope observations, in addition to microwave data give us a good spectral coverage between 1.415 and 212 GHz of the burst. We combine these data with ultraviolet images, hard and soft X-rays observations and full-disk magnetograms. Images obtained from Ramaty High Energy Solar Spectroscopic Imaging data are used to identify the locations of X-ray sources at different energies and to determine the X-ray spectrum, while ultra violet images allow us to characterize the coronal flaring region. The magnetic field evolution of the active region is analysed using Michelson Doppler Imager magnetograms. The burst is detected at all available radiofrequencies. X-ray images (between 12 keV and 250 keV) reveal two compact sources and 212 GHz data, used to estimate the radio source position, show a single compact source displaced by 25" from one the hard X-ray footpoints. We model the radio spectra using two homogeneous sources, and combine this analysis with that of hard X-rays to understand the dynamics of the particles. Relativistic particles, observed at radio wavelengths above 50 GHz, have an electron index evolving with the typical soft-hard-soft behaviour.

Characteristics of flare acceleration regions using combined X-ray and Radio Observations

Author: Hamish Reid

Paris Observatory

Co-Authors: N. Vilmer (Paris Observatory) E. Kontar (University of Glasgow)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Talk *12:27 Thursday 29th 11:45-13:00*

Summary:

Summary:

Using emission in X-ray and radio wavelengths, we infer properties of accelerated electrons to indirectly obtain estimates about flare acceleration regions. We have selected a list of events using the RHESSI flare catalogue and the PHOENIX 2 radio burst list that show temporally correlated X-ray and radio emission. We find some events show a very good anti-correlation between the hard X-ray spectral index and the starting frequency of type III bursts. We use this information to constrain the distance an outwardly propagating electron beam can travel before it undergoes the bump-in-tail instability. By assuming the height dependence of the background electron density we are able to observationally estimate the height and vertical extent of a variety of different solar flare acceleration regions. We verify the feasibility of these predictions by using kinetic simulations to check the Langmuir wave-particle instability distance for electron beam.

Particle Acceleration at Reconnecting 3D Null Points

Author: Adam Stanier

JBCA, University of Manchester

Co-Authors: P. K. Browning (University of Manchester); S. Dalla (University of Central Lancashire)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Talk *12:38 Thursday 29th 11:45-13:00*

Summary:

Hard X-ray observations from the RHESSI spacecraft indicate that a significant fraction of solar flare energy release is in non-thermal energetic particles. A plausible acceleration mechanism for these particles is the strong electric field associated with magnetic reconnection, a process that can be particularly efficient for unmagnetised particles near magnetic null points. Two-dimensional nulls have been well studied, but it is not yet known whether a 3D magnetic null point is an efficient particle accelerator. We use a test particle code to study particle trajectories in electromagnetic fields that are exact solutions to the steady-state, incompressible and resistive MHD equations near 3D null points (eg. Craig and Fabling 1996). We compare the resistive spine and fan reconnection models with the results of Dalla and Browning (2005), which considered only the outer ideal regions. We find that the fan model is very efficient due to an increasing "guide field" that stabilises particles against ejection from the current sheet. However, the spine model, which was the most promising in the ideal case, gives weak acceleration as the reconnection electric field is localised to a narrow cylinder about the spine axis. Craig, I.J.D & Fabling, R.B. 1996, ApJ, 462, 969 Dalla, S., & Browning, P. K. 2005, A&A. 436, 1103

Energetic particle diffusion in structured turbulence

Author: Timo Laitinen

University of Central Lancashire

Co-Authors: Silvia Dalla (University of Central Lancashire); James Kelly (University of Central Lancashire)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Talk *12:49 Thursday 29th 11:45-13:00*

Summary:

Solar energetic particles, accelerated in solar eruptions, are typically observed with in-situ instruments near the Earth, far from the acceleration region of the particles. Thus, in order to understand their relation to the eruption phenomena, we must understand how the particles propagate through the turbulent heliospheric plasmas. In most studies, turbulence is modelled as a superposition of infinite linear Fourier modes. In this study we introduce structure in the description of turbulence and analyse its effect on particle diffusion by means of full-orbit particle simulations. This aims to better model inhomogeneities due to transient structures and the nonlinear nature of solar wind plasma turbulence. We use a model of spatially distributed, superposed turbulence envelopes and we calculate diffusion coefficients parallel and perpendicular to the mean magnetic field. We find that in this turbulence model the cross-field transport is significantly reduced, when compared to the results obtained with homogeneous turbulence. The reduction can reach an order of magnitude when the enveloping breaks the wave phase coherence along the mean magnetic field direction.

A classification scheme for stochastic acceleration

Author: Nicolas Bian

glasgow university

Co-Authors: Eduard Kontar (Univeristy of Glasgow); Gordon Emslie (University of West Kentucky)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Poster *Poster Session B*

Summary:

A classification of stochastic acceleration models for solar flares is presented. The scheme takes into account both the nature of the force accelerating the particles and the nature of their transport inside the acceleration region. These models are called resonant or non-resonant depending whether the particle trajectories are regular or chaotic.

The effect of turbulent density fluctuations on solar flare X-ray spectrum

Author: Iain Hannah

University of Glasgow

Co-Authors: E.P. Kontar (University of Glasgow); H.A.S. Reid (Observatoire de Paris)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Poster *Poster Session B*

Summary:

The unprecedented RHESSI observations of solar flare hard X-rays (HXR) has forced us to consider mechanisms in addition to the traditional collisional view of coronal electron transport. The self-consistent generation of Langmuir waves by the electron beam is one such process, thought to be the source of

the reverse drift decimetric radio emission seen in some flares. We have previously shown that the inclusion of Langmuir waves flattens the electron spectrum and produces a spectral index difference between the coronal and footpoint sources closer to observations. However the wave growth also results in fainter HXR emission requiring a higher flux of electrons to be accelerated, compounding the “number” problem. In this work we show that the addition of the interaction of the Langmuir waves with turbulent density fluctuations in the background plasma greatly alleviates this problem. We demonstrate the consequences of this self-consistent treatment in the context of the observable HXR spectrum for a variety of forms of the density fluctuations.

Spatial properties of hard X-ray (HXR) coronal sources due to magnetic diffusion

Author: Natasha Jeffrey

University of Glasgow

Co-Authors: E.P.Kontar (University of Glasgow)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Poster *Poster Session B*

Summary:

During solar flare events, high energy electrons (> 10 keV) are produced in the Sun's corona. Accelerated electrons interact with the surrounding plasma, producing hard X-ray (HXR) bremsstrahlung emission. Most HXR emission is produced by electrons travelling into denser chromospheric layers, but HXR's are also emitted from high density coronal regions and hot thermal loops. Using instruments such as the Ramaty High Energy Solar Spectrometer Imager (RHESSI), we can measure properties such as position and size of HXR coronal sources. RHESSI observations show increases in coronal source size with time and energy, in both the directions parallel and perpendicular to the magnetic field. While electron transport along the magnetic field can account for the parallel source size increase, the perpendicular expansion is harder to explain, since electrons are unable to cross magnetic field lines easily. Recently, magnetic diffusion has been suggested to account for the perpendicular growth, a property thought to be important for coronal acceleration and transport. Using Monte Carlo simulations, we model the transport and acceleration of electrons in the solar corona and hence the resulting HXR emission. As with previous simulations, we model energy changes and pitch angle scatterings due to Coulomb collisions and magnetic trapping, but also include magnetic diffusion. The properties of our simulated HXR coronal sources will be compared with RHESSI results, allowing us to determine the role of magnetic diffusion within the corona.

Effect of Langmuir wave diffusion on flare-accelerated electrons in the inhomogeneous coronal plasma

Author: Heather Ratcliffe

University of Glasgow

Co-Authors: E.P.Kontar (University of Glasgow); N.Bian (University of Glasgow)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Poster *Poster Session B*

Summary:

Beams of electrons accelerated by solar flares produce Langmuir waves as they propagate through the inhomogeneous solar corona. The interaction between these Langmuir waves and density fluctuations, in the limit of fluctuations with spatial scale much larger than the Langmuir wavelength, can be described by a diffusion equation. The case of elastic scattering has been extensively treated, and leads to purely angular diffusion in k-space, while relaxing this assumption introduces diffusion in the magnitude of k. We evaluate this diffusion coefficient for various spectra of density fluctuations, considering both those due to waves with a defined dispersion relation, and those with arbitrary frequency and wavenumber spectra. Simulations for the case of a 1-dimensional electron beam generating Langmuir waves which then diffuse, showed a reacceleration effect on the electrons, increasing the number at high energies in the time-integrated distribution. The magnitude and form of the diffusion coefficient may therefore be important for the interpretation of HXR observations of non-thermal electrons, as the increased number of electrons at high energies could lead to an overestimate of the total number and energy of the originally accelerated electrons.

the role of electron beam pitch angles and density gradients in solar Type III radio bursts

Author: Roman Pechhacker

Queen Mary, University of London

Co-Authors: D.Tsiklauri (Queen Mary, University of London)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Poster *Poster Session B*

Summary:

Accelerated particles are the driving force for solar type III bursts, generating (electromagnetic) emission via the bump-in-tail instability, which refers to a 'bump' in the electron distribution function in phase space. We are presenting results of PIC-simulated injection of mildly relativistic electron beams into magnetised plasma for solar parameters, commensurate with type III bursts. Varying the injection angle with respect to the background magnetic field and the background plasma density profile, we investigate the role of both pitch angle and density gradient on the resulting emission. Special focus is put on the case where the pitch angle reaches 90 degrees, for which we obtain the highest emission intensity, suggesting a link between the perpendicular component of the beam injection momentum and radiation intensity. We establish that (i) the existence of a density gradient enables the EM emission generation, (ii) different initial pitch angles only affect the strength of the EM emission (keeping its time evolution un-altered), (iii) the EM emission is

elliptically polarised, (iv) the distribution function at time zero appears similar to that of Dory-Guest-Harris (DGH) [Dory et al., 1965], (v) Plots of the perpendicular components of the electron distribution function for different times show an oscillation at the relativistic electron cyclotron frequency, while the emission itself is near the electron plasma frequency.

Influence of binary collisions on fast electrons in solar flares

Author: Alec MacKinnon

University of Glasgow

Co-Authors: C Burge (University of Glasgow); P Petkaki (University of Cambridge)

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Poster *Poster Session B*

Summary:

Test particle studies in prescribed electromagnetic fields yield insight into flare particle aceleration. Depending on ambient density, binary collisions may modify particle trajectories. We describe a code that follows test electrons in the presence of both Lorentz (deterministic) and binary collision (stochastic) forces. As a first application we study collision-driven cross-field mobility of fast electrons. We also show how electron trajectories in model reconnection fields are modified by collisional energy loss and pitch-angle scattering.

Modelling Solar Energetic Particle Propagation for the COMESEP Alert System

Author: Michael Marsh

University of Central Lancashire

Co-Authors: S. Dalla; J. Kelly; T. Laitinen

Session: MST5: Particle acceleration and transport at the Sun and in the heliosphere

Presentation type: Poster *Poster Session B*

Summary:

Forecasting the arrival of Solar Energetic Particles (SEPs) and their intensities at a given location in space is a key objective of a space weather alert system. We model SEP propagation within the interplanetary magnetic field, with the eventual aim of a rapid and reliable warning system for SEP events. This will be implemented within the FP7 COMESEP (Coronal Mass Ejections and Solar Energetic Particles: Forecasting the Space Weather Impact) Alert System. We present simulations of particle propagation obtained via a full-orbit test particle numerical code, including the effects of cross-field transport, for various configurations of the large-scale interplanetary magnetic field and additional perturbations across multiple scales. We study a variety of particle injection functions and investigate their effect on SEP intensities measured e.g. near Earth. This work will lead to the development of an optimised rapid-response modelling system of SEP events, crucial for space weather impact warnings. This work has received funding from the European Commission FP7 Project COMESEP (263252).

A Possible Astronomically Aligned Monolith at Gardom's Edge

Author: Dr. Daniel Brown

Nottingham Trent University

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

Gardom's Edge forms part of the Peak District National Park, close to Manchester. This region has ancient remains including a Neolithic enclosure, rock art, and standing stone. A singular standing stones is rare and is ideal to study its setting in its original orientation. Results of a survey analysing the orientation of the stone are presented. The stone was found to be triangular in shape and supported by packing stones at its base. The stone has been selected for its flat side that is slanted up towards geographic south. The orientation and inclination of the slope is aligned to the altitude of the Sun at mid-summer. During the winter half-year the slanted side of the stone would remain in permanent shadow; during most of the summer half-year it would only be illuminated during the morning and afternoon; close to midsummer it would be illuminated all day. The striking seasonal illumination is used to enhance its meaning and importance. This standing stone may predate the surrounding settlements and would have been a focus point for seasonal gatherings of a widely dispersed community. It is proposed to interpret the wider Gardom's Edge landscape with astronomy and Dark Sky Discovery in

mind.

Science with APEX-SZ

Author: Sandra Burkutean

Argelander Institute for Astronomy

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

The APEX-SZ experiment is a collaboration between Berkeley, University of Bonn, MPIfR, Onsala and ESO, which operated a 280 element bolometer camera at the APEX telescope in Chile at an altitude of 5100 meters during 2007-2010. Targeted observations of over 40 X-ray selected galaxy clusters were made via the Sunyaev-Zel'dovich (SZ) effect. The APEX-SZ group in Bonn has focused its research on non-parametric cluster modeling with APEX-SZ data and its combination with X-ray and weak-lensing results. A joint SZ/X-ray analysis has already been made for individual clusters and a combined analysis with the full APEX-SZ sample is currently under way. In addition, we are developing and optimizing techniques for combining high resolution interferometric measurements with APEX-SZ data to extract information on the thermodynamic state of the intracluster gas at a wide range of spatial scales.

Size differences in red and blue globular clusters

Author: Jonathan M. B. Downing

Astronomisches Rechen-Institut, ZAH

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

Observations show that metal-poor (blue) globular clusters have larger half-light radii than metal-rich (red) globular clusters. It is not clear as to weather this difference truly represents the sizes of blue and red clusters or weather it is simply a product of mass segregation and stellar evolution. I present a set of simulations which confirm that blue and red globular clusters do indeed have different sizes but also show that the half-light radii of globular clusters do not have a simple relationship with their sizes as measured by their half-mass radii.

Cosmology and Galactic Foregrounds at 11-30 GHz with the Q-U-I JOint Tenerife Experiment

Author: Stuart Harper

University of Manchester

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

The Q-U-I JOint Tenerife Experiment (QUIJOTE) is currently a two instrument experiment in the northern hemisphere based on Mount Teide, Tenerife. The first instrument is a galactic foreground experiment with five pixels in the range of 11 to 30GHz which will survey a 10000 sq. degree region in polarised and total intensity emission. The current objectives of the first instrument is to allow for effective component separation of the foregrounds from cosmological signals with a specific focus on measuring spinning dust emission. The second instrument is a 31 pixel cosmological experiment at 30GHz. Using the first instruments data, along side PLANCK and other survey results, it will measure the upper limit on the scalar-tensor ratio of cosmic microwave background (CMB) primordial B mode emission to about 0.1. This poster intends to show via simulations what can be expected from QUIJOTE in terms of both cosmological science and galactic microwave foregrounds. Also the advantages of a potential third future QUIJOTE instrument at a higher frequency will be discussed and how this will contribute to measuring the CMB B mode emission with greater sensitivity.

Virialised galaxy groups and optical substructure

Author: Richard Pearson

University of Birmingham

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

Most X-ray studies of galaxy groups and clusters are subject to significant selection effects whereby only the most X-ray luminous systems tend to be

Most X-ray studies of galaxy groups and clusters are subject to significant selection effects whereby only the most X-ray luminous systems tend to be studied. This results in poor knowledge about the properties of low mass, low luminosity systems, and also makes it impossible to get an unbiased estimate of the distribution of gas entropy in groups, which is a key indicator of cosmic feedback. With the use of large optical surveys it is possible to select groups and clusters without prior knowledge of their x-ray properties, however this may result in the inclusion of groups that are not fully virialised. Since we would like to establish the properties of an unbiased sample of virialised groups, we have been investigating the ability of substructure tests, applied to the distribution of group galaxies, to discriminate systems which are in virial equilibrium. Our substructure analyses have been calibrated on mock data provided by the GAMA consortium, and applied to select targets for X-ray observation with Chandra. We discuss our methods and present some initial results from our X-ray observations.

24-160 micron images of nearby galaxies from the Spitzer archive

Author: George J. Bendo

Jodrell Bank Centre for Astrophysics, Univeristy of Manchest

Co-Authors: F. Galliano (Laboratoire AIM, CEA, Universite Paris Diderot, IRFU/Service d'Astrophysique, Bat. 709, 91191 Gif-sur-Yvette, France); S. C. Madden (Laboratoire AIM, CEA, Universite Paris Diderot, IRFU/Service d'Astrophysique, Bat. 709, 91191 Gif-sur-Yvette, France)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

We have reprocessed Spitzer Space Telescope 24, 70, and 160 micron images of galaxies covered in several Herschel Space Observatory surveys. Although high-quality versions of some of these Spitzer images have been published before, most Spitzer data have only been available in the form of lower-quality images from the Spitzer archive. We are currently in the process of publishing global photometric for these data, and we will also be distributing our reprocessed images to the general public.

Hubble Deep Field observations with e-MERLIN

Author: Nick Wrigley

Jodrell Bank Centre for Astrophysics

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

The Hubble Deep Field North region was originally surveyed by the Hubble Space Telescope in the mid 1990s and is regarded as an iconic image revealing thousands of galaxies across cosmic timescales. It has since been observed extensively at multiple wavelengths in what became known as the Great Observatories Origins Deep Survey North. A combination of two types of emission mechanisms appeared to be present in galaxy populations in varying proportions; accretion mechanisms giving rise to the observed Active Galactic Nuclei type galaxies (quasars), or more diffuse emissions characteristic of star formation processes - which became known as 'starbursts'. The UK's newly upgraded e-MERLIN radio telescope array, based at Jodrell Bank, probes ever deeper into these populations of starburst and AGN galaxies captured within the field. New detailed observations are presented for selected objects illustrating the instrument's unique combination of sensitivity and high angular resolution. e-MERLIN generates essentially unimpeded views of these ancient sources given the property that radio waves have of penetrating intervening gas and dust. Furthermore the high resolution imaging derived from the array's wide bandwidth permits spectral features to be examined in combination with their morphology. These early results mark the beginning of an unprecedented view into the structures of starburst and AGN galaxies, essential for assembling the evolutionary history of galaxies in the Universe.

Using data from the GAIA-ESO survey to advance knowledge of young star-forming regions.

Author: Amy Dobson

Keele University

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

The GAIA-ESO public spectroscopic survey is a ground-based project, aiming to study approximately 100 clusters in the Milky Way, along with the thick and thin disks, halo and bulge. The project uses the FLAMES multi-object spectrograph on the VLT, to retrieve large amounts of data, covering components of the Milky Way including young star forming regions. With this data, the understanding of early stellar evolution can be improved, hence the timescale in which stellar and planetary systems are formed can be more accurately estimated. The data will be used to study the pre-main sequence stellar population in the Milky Way, and particularly to estimate age spreads of young star forming regions. The Thorium-Argon calibration spectra allows very accurate radial velocity measurements, which are used to determine age spreads of stellar populations. Here, an overview has been presented of the GAIA-ESO survey, focusing on potential areas of research concerning young star-forming regions, and methods that have been used to improve the accuracy of the data reduction.

Optimizing future dark energy surveys for model selection goals (ArXiV: 1111.1870)

Author: Catherine Watkinson

Imperial College London

Co-Authors: A.R.Liddle (University of Sussex), P.Mukherjee(University of Sussex), D.Parkinson (University of Queensland)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session A*

Summary:

My poster will be about a paper written with the above co-authors, in which we demonstrate a methodology for optimizing the ability of future dark energy surveys to answer model selection questions, e.g. 'Is acceleration due to a cosmological constant or a dynamical dark energy model?'. Model selection Figures of Merit are defined, exploiting the Bayes factor, and surveys optimized over their design parameter space via a Monte Carlo method. We present implementations based on the Savage–Dickey Density Ratio that are both accurate and practical for use in optimization. It is shown that whilst the optimal surveys using model selection agree with those found using the Dark Energy Task Force (DETF) Figure of Merit, they provide better informed flexibility of survey configuration and an absolute scale for performance; e.g. we find survey configurations with close to optimal model selection performance despite their corresponding DETF Figure of Merit being at only 50% of its maximum. This Bayes factor approach allows us to interpret survey configurations that will be good enough for the task at hand, vital especially when wanting to add extra science goals and in dealing with time restrictions or multiple probes within the same project.

Mysteries of the North Star: Stellar Evolution Modelling, Period Change and Mass Loss˜

Author: Hilding Neilson

Argelander Institute for Astronomy

Co-Authors: S.G. Engle (Villanova U.); E. Guinan (Villanova U.); N. Langer (AIfA); R. Wasatonic (Villanova U.); D. Williams (AAVSO)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

Polaris is one of the most observed stars in the night sky, with recorded observations spanning more than 150 years. From these observations, one can study the real-time evolution of Polaris via the secular rate of change of the pulsation period. However, the measurements of the rate of period change do not agree with predictions from state-of-the-art stellar evolution models. We show that this may imply that Polaris is currently losing mass at a rate of about 10^ solar masses per year based on the difference between modeled and observed rates of period change, consistent with pulsation-enhanced Cepheid mass loss. A relation between the rate of period change and mass loss has important implications for understanding stellar evolution and pulsation, and provides insight into the current Cepheid mass discrepancy.

The First Public Data Releases from the VISTA Science Archive.

Author: Nicholas Cross

Institute for Astronomy, Edinburgh)

Co-Authors: R.S. Collins (IfA, Edinburgh); M.A. Read (IfA, Edinburgh); E.T.W. Sutorius (IfA, Edinburgh); R.P. Blake (IfA, Edinburgh); M.S. Holliman (IfA, Edinburgh); N.C. Hambly (IfA, Edinburgh); R.G. Mann (IfA ,Edinburgh)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Talk *00:00 Poster Session B*

Summary:

VISTA is the fastest near-infrared survey telescope and has been surveying the Southern hemisphere in 6 Public Surveys - VHS, VVV, VMC, VIKING, VIDEO and Ultra-VISTA - since the beginning of 2010. These surveys vary from wide, shallow surveys, to very deep pointed surveys and many have a multi-epoch component. These will shortly become the largest near-infrared surveys of the sky in terms of data volume. The VISTA Science Archive (VSA) uses a sophisticated relational database to store and serve out the data to scientists across the world. Images, catalogue and advanced science products: such as cross matches with other public survey source catalogues, including SDSS, 2MASS, XMM, Galex; and variability tables are available to the whole community for the first time, having been limited to the survey science teams beforehand. The user interface allows complex queries to be created allowing the selection of different types of objects and contains quality control information to aid in this selection. In this presentation, we describe which data are being released, describe the main products available in the VSA and show how users can query the VSA to do some quite sophisticated science. The VSA is derived from the WFCAM Science Archive that has been the main repository for the UKIDSS data.

Are the constant Kepler A-stars chemically peculiar?

Author: Simon Murphy

University of Central Lancashire

Co-Authors: D.W.Kurtz (University of Central Lancashire); K.Uytterhoeven (Instituto de Astrofisica de Canarias)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

The delta Scuti instability strip lies at the junction between the classical Cepheid instability strip and the main sequence. Amongst the delta Scuti stars in this region lie the metallic-lined (Am) stars, which are less prone to pulsation. Am stars represent a significant fraction of A-stars: up to 50% at A8 (Smalley et al. 2011). Of the ten known Am stars in the Kepler field, six are known to pulsate (Balona et al. 2011). Now that it is known that some Am stars do not pulsate, we must question whether the constant A-stars all have Am spectra. Given that 70% of non-chemically peculiar stars are delta Scuti stars and are therefore variable (based on pre-Kepler sensitivity levels; Turcotte et al. 2000), we might expect almost all of the non-variable A-stars in the Kepler field of view to be chemically peculiar. The unprecedented precision of the Kepler spacecraft allows stars to be studied photometrically at the micro-magnitude variability level. Stars that are constant at this level are unusual indeed. Pulsation, spots and activity all contribute to the total variability, hence these A-stars are probably the only stars in the HR-diagram that are truly constant.

CO Excitation Temperatures in the Winds of Betelgeuse

Author: Sarah Kennelly

Astrophysics Research Group, Trinity College Dublin

Co-Authors: Graham Harper (Astrophysics Research Group, Trinity College Dublin), Nils Ryde (Lund Observatory, Sweden)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

Spatial variations of the 4.6 μm CO fundamental lines in the winds of Betelgeuse are investigated. Excitation temperatures are estimated from line ratios in the Phoenix spectra obtained on the 8 metre Gemini-S (Smith et al, 2009). These spectra map the circumstellar shell via wind scattered ro-vibrational lines of CO and were obtained at distances of 0.5″ and 1″ from the star. Excitation temperatures estimated from these measurements are compared to those obtained in the classic 1979 Bernat et al study, and to Phoenix/Kitt Peak results reported by Ryde et al(1999), which are spatially resolved and were obtained at the greater projected distance of 4″ from the star.

A study of particle energisation in kinematic MHD models of CMTs in the relativistic regime

Author: Solmaz Eradat Oskoui

University of St Andrews

Co-Authors: T. Neukirch & K. Grady

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

We present the results of a detailed investigation of particle energisation in the Collapsing Magnetic Trap (CMT) model of Giuliani et al.(2005) using for the first time relativistic guiding centre test particle orbits. The results are compared with the non-relativistic calculations previously under taken by Grady et al.(2012).

Integral field spectroscopy on small aperture telescopes

Author: Samuel Richards

University of Hertfordshire

Co-Authors: M.E.Martin (University of Hertfordshire) H.R.Jones (University of Hertfordshire) M.Gallaway (University of Hertfordshire) D.Campbell (University of Hertfordshire) E.Brinks (University of Hertfordshire) M.Sarzi (University of Hertfordshire) D.J.B.Smith (University of Hertfordshire) J.Bland-Hawthorn (University of Sydney) S.G.Leon-Saval (University of Sydney) J.J.Bryant (University of Sydney) L.Fogarty (University of Sydney) J.Lawrence (Australian Astronomical Observatory) M.Goodwin (Australian Astronomical Observatory)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

The art of integral field spectroscopy is one that has come on in leaps and bounds over the last decade, and is really pushing our understanding of galaxy formation and evolution. Of the of the 30 such instruments around the world, all but one are on 2+metre class telescopes. It is now possible to exploit recent advancements in small aperture telescopes (<0.5m) to enable an integral field spectrograph with a performance that allows taxonomy via optical emission line analysis (Hβ to SII). An integral field spectrograph on this class of telescope warrants its use for teaching, though its ability to obtain data on 10^2–10^3 nearby galaxies in 100 nights enables it to probe a new parameter space to aid our understanding of galaxies.

ACAM - A New Imager / Spectrograph at the William Herschel Telescope

Author: Chris Benn

Isaac Newton Group, La Plma

Co-Authors: K. Dee (Engineering and Project Solutions), Tibor Agocs (ASTRON), Lilian Dominguez (Isaac Newton Group)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

ACAM is a highly-versatile wide-field imager/spectrograph mounted permanently at a folded-Cassegrain focus of the 4.2-m William Herschel Telescope. The field of view in imaging mode is 8.3 arcmin. In spectroscopic mode, the resolution is R ~ 600 in the red. ACAM is ideal for programmes requiring high throughput (up to twice that of ISIS), unusual (e g custom) filters, rapid response (e g supernovae), or observations over several nights (e g exoplanet transits) During the first two years of operation ACAM has proved popular with observers, and has been used for imaging or spectroscopy of a broad range of objects from comets and exoplanets to supernovae and gamma-ray bursts.

Remote observing with the ING telescopes

Author: Ian Skillen

Isaac Newton Group

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

The advent of high-bandwidth, low-latency networks allows the possibility of observing remotely from an observatory's sea-level base, or indeed from farther afield. We describe our experiences of intrument setup and troubleshooting, astronomer training, and remote observing from the ING sea-level offices, using a VNC client to operate the telescope and instrument control systems, and a high-quality, two-way audiovisual link for communicating with mountain staff.

Enhancements to AF2/WYFFOS on the WHT

Author: Ian Skillen

Isaac Newton Group

Co-Authors:

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

Multiplexed spectrographs on 4m-class telescopes, with their large fields-of-view, excel in complementing and playing a supporting role to the 10m-class telescopes such as GTC. We describe a programme of enhancements to AF2/WYFFOS on the WHT which will allow it to remain competitive until the proposed new wide-field fibre spectrograph, WEAVE, begins operations on the WHT in 2017

Student training at the telescope in the 10-m era

Author: Chris Benn

ING, La Palma

Co-Authors: L. Dominguez (ING), R. Karjalainen (ING)

Session: OTH1: Other Topics - Posters ONLY

Presentation type: Poster *Poster Session B*

Summary:

The ING studentship programme has for more than 10 years now offered European astronomy students the opportunity to train as an observer on a medium-sized ground-based optical telescope. This is particularly important in the era of very large telescopes and their queue-scheduled observing. This limits direct access by young astronomers, and is giving rise to a generation of astronomers with much reduced experience of observing.

Public Engagement at Jodrell Bank

Author: Teresa Anderson

Jodrell Bank Discovery Centre

Co-Authors: T.J.O'Brien (Jodrell Bank Observatory)

Session: OUT1: Public Astronomy

Presentation type: Talk *10:10 Wednesday 28th 10:00-11:15*

Presentation type: Talk *10:10 Wednesday 28th 10:00-11:15*

Summary:

The Lovell Telescope at Jodrell Bank is a Grade 1 listed structure and in 2011 it was announced that Jodrell Bank Observatory is on the UK's shortlist for UNESCO World Heritage Site status. In 2011 a new Discovery Centre opened at the site and its first year has included many events and initiatives that have piloted new approaches to Public Engagement with Astronomy. This presentation sets out a review of approaches and audiences reached, contrasting them with previous audiences and examining their success in reaching new sectors of society. Future plans for the Centre are also outlined.

'Outstanding Universal Value' and UNESCO's new Astronomical Heritage Web Portal

Author: Clive Ruggles

University of Leicester

Co-Authors: Alun Salt (University of Leicester)

Session: OUT1: Public Astronomy

Presentation type: Talk *10:20 Wednesday 28th 10:00-11:15*

Summary:

UNESCO's Astronomy and World Heritage Initiative (AWHI) aims "to establish a link between science and culture [by] acknowledging the cultural and scientific values of properties connected with astronomy". The concept of 'Outstanding Universal Value', value that transcends cultural boundaries and will persist indefinitely into the future, is fundamental in UNESCO's efforts to identify sites worthy of inclusion on the World Heritage List. But where does cultural and scientific value lie? The recent ICOMOS-IAU Thematic Study on astronomical heritage identified two interrelated key issues. First is the dichotomy between 'traditional' perceptions of what makes heritage valuable, based largely upon its value as architecture, art, etc, and those that apply to science heritage, where alteration with time is inevitable and inherent and tends to add value. Secondly, only fixed tangible heritage is eligible for the World Heritage List, whereas value as science heritage is highly dependent upon the relationships between fixed and both moveable and intangible forms of heritage. The AWHI's Portal to the Heritage of Astronomy, sponsored by the RAS and IAU, will be launched for astronomy and heritage professionals at this session. This presentation introduces and explores the distinctive issues that arise in recognising Outstanding Universal Value in astronomical heritage.

Observing the 2012 Transit of Venus

Author: Prof Martin Hendry

University of Glasgow and STFC Science in Society Fellow

Co-Authors:

Session: OUT1: Public Astronomy

Presentation type: Talk *10:30 Wednesday 28th 10:00-11:15*

Summary:

Transits of the planet Venus have a long and illustrious history in astronomy, with global observations of the 18th century transits playing a key role in determining the mean distance from the Earth to the Sun. In this talk I will very briefly review the history of transit observations and preview the 2012 Transit of Venus which will be visible across the globe on June 5th/6th. In particular I will describe a project to engage schools, astronomy societies and the public around the world in observing the transit, and combining their observations to re-enact the famous 18th century measurement of the astronomical unit.

BBC Stargazing Live

Author: Tim O'Brien

University of Manchester

Co-Authors: Alan Holland, BBC

Session: OUT1: Public Astronomy

Presentation type: Talk *10:40 Wednesday 28th 10:00-11:15*

Summary:

The BBC series of Stargazing Live programmes broadcast from Jodrell Bank in Jan 2011 and 2012 have proved incredibly popular and successful in engaging a wide audience with astronomy and astronomical research. This talk will summarise the motivation, content and wider impact and reach of the programmes.

Planet Hunters and BBC Stargazing Live: Finding Exoplanets with a TV Audience

Author: Robert Simpson

Oxford University

Co-Authors: B.Carstensen(Adler Planetarium); C.J.Lintott (Oxford University); S.Lynn(Adler Planetarium); D.Miller(Adler Planetarium); M.Parrish(Adler Planetarium); M.E.Schwamb (Yale University); A.M.Smith(Adler Planetarium)

Session: OUT1: Public Astronomy

Presentation type: Talk *10:50 Wednesday 28th 10:00-11:15*

Summary:

In January 2012 the BBC ran 'Stargazing Live': a series of live primetime astronomy programmes over three nights. The TV audience was encouraged to participate in the online Zooniverse citizen science project 'Planet Hunters', a collaboration between Oxford University, Yale University and the Adler Planetarium (Fischer et. al. 2011). Around 100,000 people took part and in 48 hours the site received more than 1 million independent visual classifications of light curves from the publicly available NASA Kepler archive. This led to the discovery of a Neptune-like planet candidate around a distant star, making international headlines and briefly placing one surprised planet hunter in the media spotlight. It also generated a whole list of other

potential planet candidates, suitable for further investigation.

Public outreach through time lapse photography

Author: Tudorica Alexandru

Argelander Institute for Astronomy

Co-Authors:

Session: OUT1: Public Astronomy

Presentation type: Talk *11:50 Wednesday 28th 11:45-13:00*

Summary:

I will present a short (~10 minutes or less) time lapse movie of astronomical observatories and celestial scenes. This kind of technique is becoming increasingly popular among the general public and it has a much stronger impact than static images.

The Faulkes Pro-Am-Schools collaboration for minor planet observations

Author: Paul Roche

Faulkes Telescope Project

Co-Authors: S. Roberts (Faulkes Telescope Project), F. Lewis (Faulkes Telescope Project), N. Howes (Faulkes Telescope Project), R. Miles (BAA), L. Kurtze (Technische Universität Darmstadt, Germany), Patrick Miller (IASC, USA)

Session: OUT1: Public Astronomy

Presentation type: Talk *12:00 Wednesday 28th 11:45-13:00*

Summary:

The Faulkes Telescope Project has been carrying out various asteroid and comet observing programmes over the past ~8 years, in collaboration with professional astronomers, amateur astronomers, undergraduate students, schools and educational organisations around the world. Here we report on some of the recent successes of these “educational research programmes”, such as the discovery of P2010 TO20 (the first Jupiter-Trojan comet), 2008 HJ (the fastest rotating Near Earth Asteroid) and new asteroid discoveries made by school students. We will discuss how we have successfully linked research programmes with educational needs, and engaged a range of FT users with both ground-based observing programmes and the spin-off “Down to Earth” classroom project (impacts, cratering and meteorites). Future work on “Project Snoopy” (hunting for the Apollo 10 lunar module) and the Rosetta mission will also be discussed.

Who watches aurorae?

Author: Dr Jim Wild

Lancaster University

Co-Authors: J.A. Wild (Lancaster University); S.R. Marple (Lancaster University); F. Honary (Lancaster University); R. Massey (Royal Astronomical Society)

Session: OUT1: Public Astronomy

Presentation type: Talk *12:10 Wednesday 28th 11:45-13:00*

Summary:

The AuroraWatch UK programme exploits real-time data from the Sub-Auroral Magnetometer NETwork (SAMNET) to create a nowcast of geomagnetic activity that can alert subscribers when auroral activity is likely over the UK. Although something of a veteran in terms of public engagement projects, AuroraWatch UK continues to grow in popularity as the next solar maximum approaches and the prospect of seeing aurorae from the UK increases. It is timely to reflect on the demographic of AuroraWatch UK users, the influence that the project has on these audiences, the changes that social media have driven in terms of public interaction, and future directions for further engagement.

Astronomy in the Park

Author: Dr. Daniel Brown

Nottingham Trent University

Co-Authors: J. Tanner (Peak District National Park Authority)

Session: OUT1: Public Astronomy

Presentation type: Talk *12:20 Wednesday 28th 11:45-13:00*

Summary:

Even though recent TV programs have raised interest in astronomy, it is still thought to be carried out at night or with expensive telescopes. However, basic astronomy and inquisitive observing can be supported at ancient sites in the countryside. Our history and beliefs of our ancestors have been shaped through astronomy and are encapsulated in ancient monuments. In the presentation we outline the impact of the project Astronomy in the Park carried out by Nottingham Trent University in collaboration with the Peak District National Park Authority and the Peak District Dark Sky group. It aimed at audiences not normally engaged in astronomy and at locations not conventionally associated to astronomy. The project started in summer 2011 and demonstrated how astronomy can be a down-to-Earth topic and how spectacular objects imaged by space telescopes are visible to the naked eye. Visitors experienced how light pollution spoils the night sky and impedes a complete experience of some ancient sites within the Peak District National Park. Participants associated light pollution with a loss of cultural heritage and relevant to them, therefore helping to reduce light pollution. It has also lead to the establishment of a Dark Skies Discovery Site in the National Park.

University Continuing Education in Astronomy

Author: Alec MacKinnon

University of Glasgow

Co-Authors:

Session: OUT1: Public Astronomy

Presentation type: Talk *12:30 Wednesday 28th 11:45-13:00*

Summary:

Not so long ago, continuing education was seen as an important function of universities. In Astronomy as well as many other academic disciplines it provided an important channel for extended engagement outside the academic mainstream; and often valuable, early-career teaching experience. I will recall its ethos and agenda, glance at the damaging funding and policy changes of recent years and briefly survey remaining provision. Some Astronomy examples from the strong programme that still exists in Glasgow will illustrate its continuing value as a form of outreach.

Looking ahead - national outreach opportunities

Author: Dan Hillier

Royal Observatory Edinburgh

Co-Authors:

Session: OUT1: Public Astronomy

Presentation type: Talk *12:40 Wednesday 28th 11:45-13:00*

Summary:

This talk will look to open up discussion about ideas that national astronomy organisations are bringing together to provide a nationwide focus for future astronomy outreach.

Mapping things out: the RAS outreach survey

Author: Robert Massey

Royal Astronomical Society

Co-Authors: Q. Stanley (HPS Research); S. McWhinnie (Oxford Research and Policy); C. E. Barclay (Marlborough College)

Session: OUT1: Public Astronomy

Presentation type: Poster *Poster Session A*

Summary:

The Royal Astronmical Society commissioned a short survey of UK-based public engagement work in astronomy and geophysics that closed in January 2012. We have used these data to analyse the needs of practitioners so that the Society can support them through for example our Education Committee. We have also created a map of this provision to allow teachers and others to find and contact their nearest practitioner. In this paper we present the initial results of the survey and the map and discuss the consequences for the work of the RAS.

The Jodcast

Author: Christina Smith

University of Manchester

Co-Authors: The Jodcast Team

Session: OUT1: Public Astronomy

Presentation type: Poster *Poster Session A*

Summary:

The Jodcast is a twice-monthly astronomy podcast produced by staff and students at Jodrell Bank since 2006. Here we report a summary of our activities over the past six years, including our listening/viewing statistics, feedback and our latest forray into videocasting.

Asteroid search and follow-up in German schools

Author: Lothar Kurtze

Technische Universität Darmstadt

Co-Authors: C.Liefke (Haus der Astronomie, Heidelberg, Germany), M.Metzendorf (Lessing-Gymnasium Lampertheim, Germany), J.Schnepf (Lessing-Gymnasium Lampertheim, Germany), P.Roche (Faulkes Telescope Project), P.Miller (IASC, USA)

Session: OUT1: Public Astronomy

Presentation type: Poster *Poster Session A*

Summary:

Since October 2010, German school classes and student groups supervised by the Haus der Astronomie in Heidelberg successfully participate in the Pan-STARRS asteroid search campaigns of the International Astronomical Search Collaboration (IASC). During such a campaign, each school discovers up to 30 previously unknown asteroids. On average, for each group one of their discoveries can be confirmed by independent observations and thus gets designated by the Minor Planet Center. Within the framework of a pilot project with Faulkes Telescopes (FT), one of these teams, the Lessing-Gymnasium in Lampertheim, planned and conducted follow-up observations of their Pan-STARRS discoveries during the fall 2011 campaign in order to improve their orbital elements. The students will continue to observe these asteroids with the aim to get them numbered and named within the next few years.

Outreach at UCLan and its Effects

Author: Kathryn Harris

UCLan

Co-Authors: Kathryn A. Harris

Session: OUT1: Public Astronomy

Presentation type: Poster *Poster Session A*

Summary:

The University of Central Lancashire (UCLan) in Preston has been active in outreach for many years, using competitions, Observatory trips and talks to inspire a wide range of people from areas across Lancashire. UCLan is part of an Ogden Trust School Partnership working with a fantastic group of teachers from various different schools, running competitions and events between them and with the University. The different schools work together with the university to encourage primary school children in Physics and Astronomy, as well as other sciences. UCLan's Alston Observatory is a small teaching observatory in Longridge, Preston, which is having a large impact on the children in Preston. Also used for undergraduate teaching, this small observatory hosts a planetarium in the main building giving shows to all age groups and abilities. Though small, this facility is opening the eyes of children from under-privileged backgrounds across Preston and Lancashire.

The new view of Vesta based on the results by the Dawn Framing Camera

Author: Martin Hoffmann

Max-Planck-Institute for Solar System Research

Co-Authors: A. Nathues (1); H. Sierks (1); L. Le Corre (1); V. Reddy (1); J.-B. Vincent (1); S. Schröder (1); P. Gutierrez-Marques (1); T. Maue (1); I. Buettner (1); I. Hall (1); U. Christensen (1); and the Dawn Science Team (1) Max-Planck-Institute for Solar System Research, Katlenburg-Lindau, Germany

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *10:00 Tuesday 27th 10:00-11:15*

Summary:

The Dawn mission has resulted in a wealth of new information on the outstanding asteroid Vesta during the approach and orbiting phases of the last ten months. In particular focus are the images of the surface obtained by the Framing Camera onboard Dawn. After the suggestion of the unique differentiated nature of Vesta and the first details revealed by the Hubble Space Telescope expectations for the Dawn mission were high to learn more on the formation of planetary bodies during the early days of the solar system. Based on these expectations the results indicate both a confirmation and an unexpected modification of our view of Vesta. In particular, the latter has been evoked by new insights into the collisional evolution of Vesta, which influences the conclusions on its structure. While integrated photometry and low-resolution images from HST showed a longitudinal dependence of the albedo, the new resolved images show a strong non-uniformity of albedo in these areas, hinting to a complex evolution. The earlier indication of a giant south polar impact basin had to be expanded according to the evidence of several large and intermediate impacts. This scenario introduces a latitudinal dependence of the

morphology of the surface. Apparently it also has led to the formation of a thick layer of regolith that blankets older layers. The perspective of the analysis concerning dark, bright, and uniquely colored material, the morphological diversity and context, as well as the three dimensional structure and its evolution will be sketched.

MarcoPolo-R: Asteroid Sample Return Mission in ESA Assessment Study Phase

Author: M. Antonietta Barucci

LESIA-Observatoire de Paris

Co-Authors: M.A. Barucci (LESIA-Observatoire de Paris, CNRS, Univ. Pierre et Marie Curie, Univ. Paris Diderot, 92195 Meudon Principal Cedex, France), P. Michel (Univ. Nice, CNRS, OCA, F), A. Cheng (JHU-APL, Maryland, USA), H. Böhnhardt (MPS, Katlenburg-Lindau,, D), J.R. Brucato (INAF-Obs. of Arcetri, I), E. Dotto (INAF-Obs. of Roma, I), P. Ehrenfreund (Univ. of Leiden, NL), I.A. Franchi (Open Univ., Milton Keynes, UK), S.F. Green (Open Univ., Milton Keynes, UK), L.-M. Lara (IAA-CSIC, Granada, E), B. Marty (CRPG, Nancy, F), and D. Koschny (ESTEC, ESA, NL)

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *10:20 Tuesday 27th 10:00-11:15*

Summary:

MarcoPolo-R is a sample return mission to a primitive Near-Earth Asteroid (NEA) selected for the Assessment Study Phase at ESA in the framework of ESA's CosmicVision2 program. MarcoPolo-R is an European-led mission with a proposed NASA contribution. The baseline target of MarcoPolo-R is the primitive binary NEA (175706) 1996 FG3, which offers a very efficient operational and technical mission profile. A binary target also provides enhanced science return: the choice of this target will allow new investigations to be performed more easily. Several mission scenarios have been already studied internally by ESA (CDF - end of 2011) with two launch windows, in 2021 and 2022, and sample return in 2027 and 2029. The main goal of the MarcoPolo-R mission is to return unaltered NEA material for detailed analysis in ground-based laboratories. Only in the laboratory can instruments with the necessary precision and sensitivity be applied to individual components of the complex mixture of materials that forms an asteroid regolith, to determine their precise chemical and isotopic composition. Such measurements are vital for revealing the evidence of stellar, interstellar medium, pre-solar nebula and parent body processes that are retained in primitive asteroidal material, unaltered by atmospheric entry or terrestrial contamination.

Physical characterisation of low Delta-V NEA (190491) 2000 FJ10 with SALT

Author: Apostolos Christou

Armagh Observatory

Co-Authors: T. Kwiatkowski (Adam Mickiewicz University (Astronomical Observatory), Poland); A. Gulbis (South African Astronomical Observatory, South Africa); M. Butkiewicz, (Adam Mickiewicz University (Astronomical Observatory), Poland); T. Michalowski (Poznan Astronomical Observatory, Poland)

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *10:33 Tuesday 27th 10:00-11:15*

Summary:

We report on observations of NEA (190491) 2000 FJ10 conducted during the second half of September 2011 with the SALT telescope and SALTICAM instrument from Sutherland, South Africa. 2000 FJ10 is a near-Earth asteroid (NEA) in a moderately eccentric orbit (e~0.2) with a perihelion distance of 1 AU. This NEA ranks 114th out of ~8500 objects in terms of Delta v required to rendezvous with it (see list by L. Benner ; http://echo.jpl.nasa.gov/~lance/delta_v/delta_v.rendezvous.html) and is the second largest among all objects that outrank it. Hence, it is an attractive target for robotic or human exploration. The colour of the asteroid, as measured by us in the sloan g', r' and i' bands, indicates that it most likely belongs to a class of geologically-evolved, higher albedo objects such as an X or S type. A primitive classification such as D cannot be excluded based on our observations alone. Constraints on the asteroid's rotation period and size will also be reported during this presentation.

Spectroscopic Observations of Unbound Asteroid Pairs

Author: Samuel Duddy

School of Physical Sciences, University of Kent

Co-Authors: S.C. Lowry (School of Physical Sciences, University of Kent), S.D. Wolters (Planetary Sciences Section, Jet Propulsion Laboratory), B. Rozitis (Planetary and Space Sciences, The Open University), S.F. Green, (Planetary and Space Sciences, The Open University), A. Christou (Armagh Observatory), P. Weissman (Planetary Sciences Section, Jet Propulsion Laboratory)

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *10:46 Tuesday 27th 10:00-11:15*

Summary:

Asteroids larger than a few hundred metres in diameter are believed to be loose assemblages with little internal strength, held together by their own self-gravity. If pushed beyond their natural spin limit via rotational spin-up by YORP, these asteroids could undergo fission or equatorial mass loss producing a binary system [1,2]. Models have indicated that if the mass ratio of the components of this binary is less than 0.2 then the secondary asteroid (the satellite) can escape the gravitational potential of the primary and decouple from their mutual orbit at low relative velocity [2,3]. The result is two asteroids on very similar independent orbits about the sun. Backward integration of the orbits of the 60 proposed asteroid pairs has shown that they each have had recent (< 1 Myr), low-velocity encounters at distances smaller than the Hill Sphere of the larger of the two asteroids [4], suggesting a common parent body, that subsequently experienced YORP-induced rotation fission [5]. We have begun an observational programme to characterize this population compositionally and thermally, to look for compositional similarities and to further understand their dynamical histories. We present our latest

results from this programme, which include optical, low-resolution spectroscopy of the asteroids in a number of pairs observed using the 4.2m William Herschel Telescope and the 3.6m New Technology Telescope. We find that the asteroids of unbound pair (7343) Ockeghem - (154634) 2003 XX38 both exhibit very similar S-type spectra, while the asteroids in the unbound pair (1979) Sakharov - (13732) Woodall exhibit V-type spectra. Results for other pairs will be presented at the meeting. [1] Walsh et al., Nature 454, p188. [2] Scheeres, 2007, Icarus 189, p370. [3] Jacobson et al., 2011, Icarus, 214, p 161. [4] Vokrouhlicky et al., 2008, The AJ 136, p280. [5] Pravec et al., 2010, Nature 466, p1085.

NEOShield - A global approach to NEO Impact Threat Mitigation

Author: Alan Fitzsimmons

Queen

Co-Authors: A.W. Harris (DLR-Berlin); M.A. Barucci (LEISA/Obs. de Paris); J.L. Canoc (Deimos Space); M. Fulchignoni (LEISA/Obs. de Paris); S.F. Green (Open University), D. Hestroffer (IMCCE/Obs de. Paris); V. Lappas (University of Surrey); W. Lork (EADS Astrium GmbH); P. Michel (CNRS); D. Morrisonj (SETI Institute); D. Payson (TsNIIMash/Frauhofer Ernst Mach Institute); F. Schäferl (Frauhofer Ernst Mach Institute)

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *10:59 Tuesday 27th 10:00-11:15*

Summary:

Near-Earth objects (NEOs) currently present a scientifically well-founded threat to the future of our civilization. While past impacts on the Earth have probably altered the evolutionary course of life, asteroids and comets will continue to hit the Earth at irregular intervals in the future. On-going surveys discover several hundred new NEOs each year. NEOShield is a 3.5-year, 5.8m euro, ERC FP7-funded project to address critical scientific and technical issues that currently stand in the way of demonstrating the feasibility of space missions to prevent the collision of an NEO with the Earth. Detailed test-mission designs will be provided for the most feasible mitigation concepts, in preparation for future rapid development of actual test missions. The NEOShield concept includes laboratory experiments and associated modelling, combined with interpretation of relevant observational data and theoretical models of asteroid surfaces, to improve our understanding of the nature of NEOs and allow the feasibility of mitigation techniques and mission designs to be accurately assessed. An international response strategy will be considered for implementation when an actual impact threat arises. Account will be taken of complementary efforts currently in progress (e.g. by the UN, ESA, NASA).

Formation of the Marco Polo-R baseline binary target and physical properties of primitive bodies

Author: Patrick Michel

University of Nice, CNRS, Côte d

Co-Authors:

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *11:45 Tuesday 27th 11:45-13:00*

Summary:

I will present the possible formation mechanisms of binary asteroids, and their implications regarding the possible internal and surface properties of the baseline target of MarcoPolo-R, the binary asteroid 1996 FG3. Then, since potential backup targets maybe primitive single asteroids, I will also discuss what can be assumed regarding the internal and surface mechanical properties of single primitive objects. Since we never visited yet such a primitive body, the only information we can use to narrow down the range of possible surface states are based on ground-based observations and numerical modeling. In particular, our knowledge of the response of porous and granular materials, that are believed to compose those bodies, to various processes undergone during their dynamical history can help us to constrain the possible surface properties. I will review what we know, don't know and need to know about these properties. Such information is important to determine observational strategies from the ground that may help constraining those surface properties (eg thermal infrared and radar observations), and is even crucial for the design of efficient sampling tools.

Simulating asteroid regoliths in microgravity

Author: Naomi Murdoch

The Open University and UNS, Côte d

Co-Authors: B. Rozitis (The Open University) ; S.F. Green (The Open University) ; P. Michel (UNS, Côte d'Azur Observatory, CNRS); T-L. de Lophem; W. Losert (University of Maryland)

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *12:05 Tuesday 27th 11:45-13:00*

Summary:

The dynamics of granular materials are involved in the evolution of solid planets and small bodies in our Solar System, whose surfaces are generally covered with regolith. Understanding granular dynamics is also critical for the design and/or operations of landers, sampling devices and rovers to be included in space missions. We use a microgravity modified Taylor-Couette shear cell to investigate granular flow caused by shear forces under the conditions of parabolic flight microgravity. The aim of the experiment is to characterise the response of granular material to rotational shear forces in a microgravity environment. A particular emphasis has been put on investigating the steady state flow profiles in the different gravitational regimes. It was found that the effect of constant shearing on a granular material in a direction perpendicular to the gravity field does not seem to be strongly influenced by gravity. We have also demonstrated, for the first time, that the efficiency of granular convection may decrease in the presence of a weak gravitational field, similar to that on the surface of small bodies. This may have important implications for our interpretation of asteroid surfaces.

ATPM: A Rough Surface Thermal Model For Atmosphereless Planetary Bodies

Author: Ben Rozitis

The Open University

Co-Authors: S.F.Green (The Open University); S.D.Wolters (Jet Propulsion Laboratory); S.R.Duddy (University of Kent); S.C.Lowry (University of Kent)

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *12:18 Tuesday 27th 11:45-13:00*

Summary:

Thermal-infrared emission from atmosphereless planetary surfaces contains signatures that are diagnostic of their physical properties, which can be studied through ground- and spacecraft-based observations. Furthermore, for an irregularly shaped asteroid this radiation is emitted asymmetrically and results in a net photon force and torque. The net force causes orbital drift (Yarkovsky effect) and the net torque alters the spin state (YORP effect) of an asteroid. The Advanced Thermophysical Model (ATPM) is the first model capable of simultaneously interpreting asteroid thermal-infrared observations and for predicting the Yarkovsky and YORP effects [1,2]. The ATPM explicitly incorporates sub-surface heat conduction, shadowing, multiple scattering of sunlight, self-heating, and rough-surface thermal-infrared beaming effects. It has been successfully applied to a variety of planetary bodies including The Moon [1], asteroids [3], and comets [4] to infer their likely surface properties. It has also been used to investigate the influence of rough-surface thermal-infrared beaming on the asteroid Yarkovsky and YORP effects [2]. Current applications and developments of the model will be presented and discussed. [1] Rozitis & Green, 2011, MNRAS, 415, p2042 [2] Rozitis & Green, 2012, MNRAS, submitted [3] Wolters et al., 2011, MNRAS, 418, p1246 [4] Lowry et al., 2012, in preparation

Heat conductivity of porous dust layers

Author: Bastian Gundlach

Institute for Geophysics and extraterrestrial Physics

Co-Authors: J. Blum; Yu. V. Skorov; H. U. Keller

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *12:31 Tuesday 27th 11:45-13:00*

Summary:

Small bodies in the Solar System are either covered by regolith, a granular medium formed through the continuous bombardment by interplanetary bodies (asteroids) or even consist entirely of granular material (comet nuclei). The heat conductivity of the surface layers of such bodies plays an important role for the minimum and maximum temperature as well as for the temporal temperature evolution on the surfaces of these bodies. It also determines the amount of energy transported into deeper regions of these bodies and, thus, the temperature stratification. During this conference, we will present laboratory experiments on the determination of the heat conductivity of granular dust layers consisting of spherical particles of different sizes. Furthermore, a novel model for the heat conductivity of porous dust layers will be demonstrated and compared with the experimental results.

Reading the dynamic compaction of asteroids using mineral microstructures

Author: Paula Lindgren

University of Glasgow

Co-Authors: Martin R. Lee University of Glasgow

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *12:44 Tuesday 27th 11:45-13:00*

Summary:

Compaction and aqueous alteration were among the earliest processes that took place in the solar system following initial condensation and accretion of material to form planetesimals. Evidence of these early processes is recorded by samples of C-type asteroids that come to Earth as carbonaceous chondrite meteorites. Compaction of their parent bodies probably occurred mostly through impact “gardening”, but also to some extent via static compaction in larger asteroids. Compactional deformation can be seen in carbonaceous chondrites as a rock fabric, e.g. alignment of chondrules and phyllosilicate crystals within their fine-grained matrices, and/or as intracrystalline microstructures such as twinning. Traditionally, olivine microstructures have been used for determining deformation-histories of meteorites, but since the more primitive and aqueously altered carbonaceous chondrites are depleted in mafic silicates, the mineral calcite can be used here instead. The calcite grains formed during aqueous alteration and their micrometre-sized twins are thought to record dynamic compaction accompanying impacts. In this ongoing study we are using scanning and transmission electron microscopy and electron backscatter diffraction to analyze the twin microstructures of calcite from a range of CM1-CM2 carbonaceous chondrites that have been aqueously altered to various degrees, to determine their deformation histories during and/or after aqueous alteration.

A Herschel Survey of the trans-Neptunian Region

Author: Pedro Lacerda

Queen

Co-Authors: The Herschel Open Time Key Programme "TNOs Are Cool" Team

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *14:15 Tuesday 27th 14:15-15:30*

Summary:

I will present a summary of results from our Herschel "TNOs Are Cool" Key Programme to observe trans-Neptunian objects and other outer solar system bodies. The main goal of the programme is to measure the albedos and sizes of more than 100 TNOs. Our sample includes TNOs in different dynamical classes (Classical KBOs, Plutinos, Scattered) and a number of Centaurs. In addition to albedos/sizes, our results include thermal lightcurve observations for a few interesting targets (e.g. Haumea), and more detailed multiband (thermal to submm) characterisation of selected dwarf planets (e.g. Makemake).

Surface charging on small bodies: likely detection at Saturn's icy moon Hyperion

Author: Tom Nordheim

Mullard Space Science Laboratory, University College London

Co-Authors: G.H. Jones(1,2); A.J. Coates(1,2); J.S. Leisner(3); W.S. Kurth(3); K.K. Khurana (4);E. Roussos(5); N.Krupp(6); F.J. Crary(7) 1 - Mullard Space Science Laboratory, University College London 2 - The Centre for Planetary Sciences at UCL/Birkbeck 3 - Department of Physics and Astronomy, University of Iowa 4 - Institute of Geophysics and Planetary Physics, UCLA 5 - Max Planck Institut für Sonnensystemforschung, Germany 6 - Southwest Research Institute

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *14:30 Tuesday 27th 14:15-15:30*

Summary:

Hyperion is an irregular moon of Saturn with a longest axis measuring 360 km. Studies of this icy body can be highly relevant to our understanding of small bodies elsewhere in the Solar System. The Cassini spacecraft conducted its only targeted flyby of Hyperion on September 26, 2005. When examining data from the Cassini Plasma Spectrometer (CAPS) in the time interval around closest approach, a field-aligned electron population was discovered. It is suggested that this electron feature is associated with surface charging processes, and in fact, constitutes a remote detection of the surface potential associated with an area of Hyperion's surface. This theory will be discussed in the context of observations made using the CAPS instrument as well as complementary observations by other Cassini instruments. Surface charging is thought to be an ubiquitous process in the Solar System, affecting objects embedded within magnetospheric as well as solar wind plasma, and thought to lead to the levitation and transport of surface material under certain circumstances. Studies of surface charging at Saturn's icy moons may therefore be of direct relevance to similar processes thought to occur on other Solar System bodies, such as moons, comets and asteroids.

Collisions in Saturn's F ring

Author: Nick Attree

Queen Mary, University of London

Co-Authors: C. D. Murray; N. J. Cooper; G. A. Williams (Queen Mary, University of London)

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *14:43 Tuesday 27th 14:15-15:30*

Summary:

Saturn's F ring, located several thousand kilometres outside the main ring system, contains a myriad of complex and time varying structures ranging in scale from ~1 to ~200km. In addition to perturbations from the two `shepherd- ing' moons Prometheus and Pandora it has long been suspected of harbouring, and being influenced by, a population of small (~1km radius) moonlets. In this talk I will present some of the latest work on F-ring `jets' which are evidence of collisions between ring particles and other objects. Cassini observations of these features will help put constraints on the colliding population as well as improving our knowledge of low velocity (~m/s) impacts between icy objects.

Observing ice in our solar system

Author: Colin Snodgrass

Max Planck Institute for Solar System Research

Co-Authors:

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *14:56 Tuesday 27th 14:15-15:30*

Summary:

Our understanding of where volatile ices can be found in the Solar System is rapidly evolving. It has become clear that the old idea of dry asteroids formed inside the snow line, and wet comets from beyond it, needs to be revised. This has important implications for our understanding of how our planetary system formed and evolved. I will present a description of observational programmes which seek to describe where water can be found in small solar system bodies. These include direct searches for water ice signatures on known icy bodies (Trans-Neptunian Objects) and on large asteroids. I will present the latest results from these studies, and discuss how they constrain the presence of water on the surfaces of (and within) small bodies.

Planetesimal Formation In Self-Gravitating Discs

Author: Peter Gibbons

Institute for Astronomy, Edinburgh

Co-Authors: W.K.M. Rice G.R. Mamatsashvili

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *15:09 Tuesday 27th 14:15-15:30*

Summary:

We study particle dynamics in local simulations of self-gravitating accretion discs with a simple cooling law. It is well known that the structure which arises in the gaseous component of the disc due to a gravitational instability can have have a significant effect on the evolution of dust particles. We use the Pencil Code to solve the shearing sheet equations for gas on a fixed grid together with the equations of motion of solids coupled to the gas solely through aerodynamic drag force. We find that spiral density waves can create significant enhancements in the surface density of ~1cm sized particles, causing it to reach concentrations exceeding that of the local gas density in the crests of density waves. We also study the velocity dispersion of the particles, finding that the spiral structure can result in the particle velocities becoming highly ordered, having a narrow velocity dispersion. This implies low relative velocities between particles, which in turn suggests that collisions are typically low energy, lessening the likelihood of grain destruction. These findings suggest that the density waves that arise due to gravitational instabilities in the early stages of star formation provide excellent sites for the formation of large, planetesimal-sized objects.

Poster Presentations

Author: Colin Snodgrass

Max Planck Institute for Solar System Research

Co-Authors:

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *15:22 Tuesday 27th 14:15-15:30*

Summary:

1-minute presentations to be given by those presenting posters in "Small bodies in our Solar System".

Ocean-like water in the Jupiter-family comet 103P/Hartley 2

Author: Miguel de Val-Borro

Max Planck Institute for Solar System Research

Co-Authors: P. Hartogh; D. Bockelée-Morvan; D.C. Lis; M. de Val-Borro; N. Biver; M. Küppers; M. Emprechtinger; E.A. Bergin; J. Crovisier; M. Rengel; R. Moreno; S. Szutowicz; and G.A. Blake

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *17:00 Tuesday 27th 17:00-18:15*

Summary:

Measurements of isotopic ratios in comets provide important information about the origin of cometary materials and probe the connection with the interstellar medium. Previous measurements of the D/H ratio in water in six Oort cloud comets yielded a mean value of (2.96+/-0.25)x10-4 corresponding to twice the Earth ocean ratio. These measurements indicated that Oort cloud comets formed at similar distances from the Sun and could have contributed less than 10% of the Earth's water. Using HIFI on the Herschel Space Observatory, we have measured the D/H ratio in the Jupiter-family comet 103P/Hartley 2, which originated in the Kuiper belt. By comparing the simultaneous observations of the 1_-1_ transition of HDO at 509.292 GHz and the optically thin 1_-1_ transition of H2-18O at 547.676 GHz, we derive a D/H ratio in water of (1.61+/-0.24)x10-4, consistent with the Earth ocean ratio. This result substantially expands the reservoir of Earth ocean-like water and suggests that a higher fraction of the terrestrial water may have been delivered by cometary bombardment.

The dust coma of comet 9P/Tempel 1 detected by Stardust NExT.

Author: Simon F. Green

The Open University

Co-Authors: T. Economou (University of Chicago), B.C. Clark (Space science Institute, Boulder), D. Brownlee (University of Washington), J. Veverka (Cornell University) and the Stardust NExT Science Team.

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *17:20 Tuesday 27th 17:00-18:15*

Summary:

On 14 February 2011, the Stardust spacecraft performed its second cometary flyby, following the successful completion of its primary mission to return coma samples from comet 81P/Wild 2. Stardust NExT passed within 200 km of the nucleus of comet 9P/Tempel 1, first visited by the Deep Impact

spacecraft in 2005, providing an opportunity to make in-situ measurements of a second cometary coma with the same dust detection instruments. We present results from the Dust Flux Monitor Instrument at the Tempel 1 flyby which detected bursts of impacts consistent with measurements at Wild 2, interpreted as the fragmentation of larger aggregates of material emitted from the nucleus into smaller particles within the coma.

Shape Model and Thermal Properties of the Nucleus of Rosetta Target 67P/Churyumov-Gerasimenko

Author: Stephen Lowry

University of Kent

Co-Authors: S.R. Duddy (University of Kent); B. Rozitis (The Open University); S.F. Green (The Open University); A. Fitzsimmons (Queens University Belfast); C. Snodgrass (Max Planck Institute for Solar System Research); H.H. Hsieh (University of Hawaii); O. Hainaut (European Southern Observatory).

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *17:33 Tuesday 27th 17:00-18:15*

Summary:

Rosetta is ESA's new comet orbiter mission, launched in March 2004 and currently en route to Jupiter-family comet 67P/Churyumov-Gerasimenko. The probe will rendezvous with the comet in 2014 and remain in orbit around the nucleus for on-going detailed physical and compositional analysis. Pre-encounter observations of the target are important for characterization of the heliocentric light-curve behaviour and the physical properties of the nucleus, information that is critical for mission planning. We present our latest results from detailed observations of the nucleus from the European Southern Observatory, carried out when the comet was near aphelion. We combined our photometric lightcurves obtained between 2004-2007 with other data from the literature [1,2] to constrain its overall shape and spin state. We incorporated this model, along with published nucleus thermal flux measurements from Spitzer [3,4], into a new Advanced Thermophysical Model [5,6] to constrain its thermal properties and surface roughness. The thermal inertia was measured to be < 30 J m-2 K-1 s-1/2 (scaled to 1 AU), somewhat less than lunar regolith, which suggests its surface consists of finer grained material. [1] Tubiana, C., et al., 2008, A&A 490, 377. [2] Tubiana, C., et al., 2011, A&A 527, A113. [3] Kelley, M. S., et al., 2009, AJ 137, 4633. [4] Lamy,P.L., et al., 2008, A&A 489, p777. [5] Rozitis & Green, 2011, MNRAS 415, p2042. [6] Rozitis et al., 2012, UK-Germany NAM 2012.

Long Term Evolution of Comet Halley & the Orionid stream

Author: Aswin Sekhar

ARMAGH OBSERVATORY UK

Co-Authors: D. J. ASHER (ARMAGH OBSERVATORY, UK)

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *17:46 Tuesday 27th 17:00-18:15*

Summary:

It is well known that comet 1P/Halley has the unique distinction of having an accurate observational record (which helps in constraining the theoretical models) for a long continuous set of perihelion passages which dates back to 240 B.C. (Yeomans & Kiang 1981). In this talk, we present some interesting results about the significance of the 1:6 & 2:13 mean motion resonances of the comet & the Orionid stream with Jupiter. Earlier works (Rendtel 2007, Sato & Watanabe 2007) on 1:6 resonant Orionids showed that such dust trails could cause meteor outbursts for many years like in the case of considerably enhanced zenithal hourly rates seen during 2006-2010 & the indication of a similar activity profile between 1933-1938 from the historical records (Lovell 1954) of past observations. Our present work quantifies the timescales over which stream particles, and 1P/Halley itself, can survive in these resonances. This determines the long term dynamical evolution and stream structure. Further numerical integrations reveal analogous resonant behaviour of other solar system bodies, so that there is a lot more to be understood about this fascinating phenomenon.

The Stardust Mission to Comet Wild2 Gives a New Perspective on the Formation of Comets

Author: John Bridges

University of Leicester

Co-Authors:

Session: PL1: Small bodies in Our Solar System

Presentation type: Talk *17:59 Tuesday 27th 17:00-18:15*

Summary:

The Stardust mission successfully returned samples from the Jupiter family Comet 81P/Wild2 in 2006. Since then much progress has been made in analysing the challenging, micron-sized samples. Through transmission electron microscopy and X-ray Absorption at the Diamond synchrotron we have established the presence of fragments of high temperature (>1200 K), Al-rich melt droplets – chondrules. This information is helping to test models of the Solar System which need to account for the presence of such high temperature, chemically processed material in the comet-forming region. We have also identified the effects of space weathering by the presence of Fe metal-bearing assemblages. As we gain more information about Comet Wild2 our ideas on the origins of comets and the early Solar System are changing.

Mapping The Density Distribution In Saturn's F Ring During An Encounter By Prometheus

Author: Phil Sutton

Loughborough University

Co-Authors:

Session: PL1: Small bodies in Our Solar System

Presentation type: Poster *Poster Session A*

Summary:

Saturn's F-ring is one of the most dynamic places in the solar system with interactions between particles and its Sheppard moons taking place over short time periods. CASSINI then offers a unique opportunity to observe such a dynamic system as it evolves. Previous numerical modelling has shown that

Prometheus is responsible for generating some structures seen in the F-ring. Moonlets have been known to exist in the F-ring for many years however only recently a connection between Moonlets and Prometheus has been discovered. Here we model a multi strand F ring that is realistic in shape and size taken from CASSINI observations. For the first time we show how density in the F-ring evolves as Prometheus encounters the F-ring creating the well-known streamer – channels. We found that when the F-ring and Prometheus were at minimum separation the highest densities occurred during the first encounter. This happens when the velocity kick given to inner strand particles is large enough to move it into the central F-ring core. Moonlets formed can persist for long periods if their density overcomes the critical Roche density for ice in the F-ring. We can therefore use our models to predict that Moonlets formed solely by perturbations of Prometheus on the F-ring mostly originate in the central strand.

Dual High Speed Photometer for Detecting Edgeworth Kuiper Belt Objects by Occultation

Author: Eamonn Ansbro

Open University

Co-Authors: Eamonn Ansbro (Open University)

Session: PL1: Small bodies in Our Solar System

Presentation type: Poster *Poster Session A*

Summary:

We present the design of a high speed dual photometer to detect Edgeworth Kuiper Belt Objects. The current limitation in occultation surveys is course time resolution and poor sensitivity. We need high precision, high reliability photometry. High time resolution photometry is the only way to search for small scale variability within a star and this provides orders of magnitude more resolution than even the NGST. This time resolution allows us to be sensitive to detecting the unexplored sub-kilometer regime of EKBOs. Discovering and constraining the size distribution of EKBOs is crucial to understand solar system formation.

The unusual comet P/2010 TO20 LINEAR-Grauer

Author: Pedro Lacerda

Queen

Co-Authors:

Session: PL1: Small bodies in Our Solar System

Presentation type: Poster *Poster Session A*

Summary:

I will briefly describe an observational and dynamical study of the unusual comet P/2010 TO20 LINEAR-Grauer. Discovered in late 2010 by LINEAR, this object was first classified as a Jupiter Trojan. Subsequent observations obtained in late October 2011 revealed 2010 TO20 to be a Jupiter-family comet. LINEAR-Grauer has one of the largest perihelia (q=5.1 AU) and lowest eccentricities (e=0.09) among Jupiter-family comets. I will present optical broadband observations of this object taken on 29-31 October 2011 as well as pre-covered images taken in October 2010 as part of the Pan-STARRS survey. The latter show that LINEAR-Grauer was clearly active at the time of discovery by LINEAR. Dynamical simulations indicate the LINEAR-Grauer is in a very unstable orbit and probably originated in the trans-Neptunian region of the solar system.

Searching for asteroid collisions with Pan-STARRS 1

Author: Ev McLoughlin

Queen

Co-Authors: E. McLoughlin (Queen's University Belfast), A. Fitzsimmons (Queen's University Belfast), L. Denneau (Queen's University Belfast and Institute for Astronomy, University of Hawaii), R. Jedicke (Institute for Astronomy, University of Hawaii)

Session: PL1: Small bodies in Our Solar System

Presentation type: Poster *Poster Session A*

Summary:

The Pan-STARRS 1 (PS1) telescope in Hawaii has been surveying large areas of the sky since 2010 and the quality of astrometry and photometry together with repeated coverage of the same areas of the sky enables discovery of various interesting objects and events down to magnitude 22.5 brightness. The Main Asteroid Belt is collisionally dominated with asteroids' shapes, sizes and surface geology dominated by impacts. The brightness of impacted

asteroids will temporarily increase due to material being ejected off their surface. Two collisions observed recently have sparked interest in the phenomenon: asteroid P/2010 A2 in 2009 and asteroid (596) Scheila in 2010. Studying these events can provide insights in asteroid structure and evolution. I am using PS1 data to search for possible collision events as it is expected that there may be one observable collision per year. Both existing and current data will be analysed to look for anomalous increases in brightness of known asteroids that might be indicative of a collision. Initial results and sample data will be shown.

The Sodium Tails of Near-Sun Comets

Author: Geraint Jones

MSSL, UCL & Centre for Planetary Sciences at UCL/Birkbeck

Co-Authors: H. Osborn (Dept. of Earth Sciences, UCL), Y. Ramanjooloo (MSSL, UCL & Centre for Planetary Sciences at UCL/Birkbeck)

Session: PL1: Small bodies in Our Solar System

Presentation type: Poster *Poster Session A*

Summary:

In 1997, comet C/1995 O1 (Hale-Bopp) was found to possess a tail composed of sodium atoms accelerated anti-sunward by radiation pressure. Although sodium had long been known to exist in comets, a distinct tail had only been reported in one other comet, in 1957. Sodium is a very strong contributor to the emission spectra of sungrazing comets. Although it is known that there are at least two sodium sources, one near the nucleus, and the other in the extended dust tail, the ultimate sources of the sodium have not been identified. We present results of our survey of several sodium tails observed by the ESA/NASA Solar and Heliospheric Observatory spacecraft's LASCO coronagraph, reporting on their morphologies and brightness. We present our initial simulations of the tails; their modelling is complicated by the fact that the acceleration of sodium atoms is a strong function of the atoms' radial velocity, due to the dependence of the acceleration on the strength of the Doppler-shifted Fraunhofer sodium absorption lines in the atoms' frame of reference. We discuss the implications our results for our understanding of near-Sun comets' composition and origins.

The International Deep Planet Search (IDPS) survey (invited)

Author: Jenny Patience

University of Exeter

Co-Authors: A. Vigan (Exeter), R. Galicher (HIA), C. Marois (HIA), M. Bonavita (Toronto), R. J. De Rosa (Exeter), B. Macintosh (LLNL), I. Song (UGA), R. Doyon (Montreal), B. Zuckerman (UCLA), D. Lafreniere (Montreal), T. Barman (Lowell)

Session: PL2: Exoplanets

Presentation type: Talk *10:00 Thursday 29th 10:00-11:15*

Summary:

Breakthrough direct detections of planetary companions orbiting A-type stars confirm the existence of massive planets at relatively large separations, but dedicated surveys are required to estimate the frequency of similar planetary systems. To measure the first estimation of the exoplanet frequency at large orbital separation around A-stars, we have conducted a deep-imaging survey of young (8–400 Myr), nearby (19–84 pc) A- and F-stars to search for substellar companions in the ~10–300 AU range. The sample of 42 stars combines all A-stars observed in previous AO planet search surveys reported in the literature with new AO observations from VLT/NaCo or Gemini/NIRI and represents an initial subset of the International Deep Planet Search (IDPS) sample of stars covering M-stars to B-stars. Considering the planet detections and upper limits, we estimate the planet (1–14 MJup) frequency in the range 5–320 AU and also the brown dwarf (15–75 MJup) frequency in the range 75–300 AU. Assuming power law distributions for the mass and semimajor axis of the planet population, the AO data are consistent with a declining number of planets with increasing orbital radius which is distinct from the rising slope inferred from evolved A-star RV surveys.

Planetary companions to white dwarfs (invited)

Author: Dr Matt Burleigh

University of Leicester

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *10:15 Thursday 29th 10:00-11:15*

Summary:

I will present the latest results from our searches for planetary companions to white dwarfs through direct imaging observations and photometric surveys, including some exciting recent discoveries. I will discuss the limits on the incidence of such objects at white dwarfs, and as companions to their progenitors. I will also look to future opportunities to investigate the population of substellar and planetary companions to white dwarfs.

Detailed near-IR spectroscopy of planetary temperature atmospheres

Author: Robert King

University of Exeter

Co-Authors: J. Patience (Exeter), R. J. De Rosa (Exeter), A. Vigan (Exeter), S. Witte (Hamburg), E. Rice (College of Staten Island), Ch. Helling (St

Andrews), and P. Hauschildt (Hamburg)

Session: PL2: Exoplanets

Presentation type: Talk *10:30 Thursday 29th 10:00-11:15*

Summary:

The complexity of cloud formation in cool atmospheres is evident from our own Solar System gas giants which show banding and persistent storm systems. The next generation of planet imagers will allow the study of many more exoplanet atmospheres than is currently possible, but such observations will be very challenging and their interpretation will require a firm grounding from better-studied cool atmospheres. Brown dwarfs provide us with such atmospheres at similar temperatures to exoplanets discovered by direct imaging and those amenable to transit spectroscopy. To fully understand these cool

atmospheres and interpret exoplanet observations, we must have a physical model of condensate cloud formation and dissipation and how this varies with age/surface gravity. We have developed an empirical grid of JHK spectra of nine objects with estimated masses of ~5-20 Mjup and ages of ~2-50 Myr. These companions to young stars allow us to break the mass-age-luminosity degeneracy. The data are compared with grids of five different atmospheric models to explore the effects of different physical processes included in the models and the effects of low surface gravity. I will also present our campaign to test models of the L-to-T transition with variability monitoring of field L and T dwarfs.

The SPHERE Science Program (invited)

Author: Markus Feldt

Max Planck Institute for Astronomy

Co-Authors: J.L. Beuzit (IPAG, Grenoble); D. Mouillet (IPAG, Grenoble); G. Chauvin (IPAG, Grenoble); S. Desidera (INAF, PAdova); R. Gratton(INAF , Padova); H.M. Schmid(ETH Zurich); M. Meyer (ETH Zurich); M. Langlois (OAMP Marseille); Th. Henning (MPIA, Heidelberg); B. Biller(MPIA Heidelberg); O. Chesneau (LUAN Nice)

Session: PL2: Exoplanets

Presentation type: Talk *10:40 Thursday 29th 10:00-11:15*

Summary:

SPHERE, the ESO exo-planet finding and characterization instrument for the VLT is currently being assembled in Grenoble, and first light is now foreseen by the end of the year. The instrument comprises and extreme adaptive optics system and three focal plane imagers: the differential polarimeter ZIMPOL working in the visual, the NIR 3D spectrograph IFS, and the dual iamger and spectrograph IRDIS. In reward for producing the instrument, a total of 260 nights of guaranteed observing time will be allocated to the consortium. About 200(+20) of these will be allocated to a large, common NIR survey for finding exo-planets by direct imaging, 40 nights will serve other purposes like the search for planets in reflected light, imaging of circumstellar disks and more "exotic" scientific projects. I will explain in detail the strategies behind these projects, focusing mainly on the large survey. The task stretches from the ongoing target selection process via detailed scheduling to the validation of model predictions derived from planet formation scenarios. I will also not conceal the open points, and, last not least stress the opportunities that are still available for community scientists to benefit from SPHERE during open time.

A microlensing survey for cold exoplanets with Euclid

Author: Eamonn Kerins

University of Manchester

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *10:55 Thursday 29th 10:00-11:15*

Summary:

Euclid has been selected as a medium class space mission within ESA's Cosmic Visions programme. It is scheduled for launch in 2019 and its primary science is the study of dark energy using weak lensing and boryon acoustic oscillations. However, there is also up to two months per year available for Galactic science programmes. One programme currently under study is a high cadence infrared survey of the Galactic bulge to detect cold exoplanets using the microlensing technique. Euclid is capable of a survey of cold exoplanets down to Earth masses with host separations from 0.5 AU out to the free-floating exoplanet regime. This is a key area of exoplanet discovery space for planet formation theories and also provides an ideal complement to the discovery space of transit surveys such as Kepler.I will outline the microlensing method and the science objectives of the Euclid exoplanet survey. I will present detailed simulations by the Euclid Exoplanet Working Group of the likely exoplanet sensitivity.

Exploring hitherto uncharted planet territory with lucky-imaging microlensing observations

Author: Martin Dominik

SUPA, University of St Andrews

Co-Authors: The MiNDSTEp and RoboNet-II teams (UK: University of St Andrews, University of Manchester, Keele University, Queen Mary University of London, Liverpool John Moores University, Institute of Astronomy Cambridge; Denmark: University of Copenhagen - Niels Bohr Institute, University of Aarhus, Technical University of Copenhagen; United States of America: Las Cumbres Observatory Global Telescope Network, Space Telescope Science Institute, SOFIA Science Centre; Germany: University of Goettingen, Max Planck Institute for Solar System Research, ESO Garching, University of Heidelberg, Max Planck Institute for Astronomy; Australia: Perth Observatory; Qatar: Alsubai's Establishment for Scientific Studies; Italy: University of Salerno; Belgium: University of Liege; Iran: Sharif University of Technology; Korea: Korea Astronomy and Space Institute; China: Yunnan

Astronomical Observatory)

Session: PL2: Exoplanets

Presentation type: Talk *11:05 Thursday 29th 10:00-11:15*

Summary:

It needs a comprehensive picture of planet populations for understanding the cosmic context of planet Earth, which can only arise from combining information coming from a variety of different detection techniques. Gravitational microlensing is particularly well-suited to probe the outer regions of planetary systems, with a sensitity reaching in principle down to Lunar mass. Exploring the hitherto uncharted territory below Earth mass however requires high-precision photometry on main-sequence stars in the crowded fields towards the Galactic bulge, achievable only if these can be resolved from

nearby brighter stars. The lucky-imaging technique allows us to get around the atmospheric image blurring and to obtain a resolution near the diffraction limit. Meaningful planet population statistics will only emerge from a well-controlled experiment, where the use of a distributed telescope network for observing the transient microlensing signatures requires suitable technology for realising a response time to changing conditions as short as 5 min. We will report on the current status of the MiNDSTEp (Microlensing Network for the Detection of Small Terrestrial Exoplanets) and RoboNet-II lucky-imaging microlensing follow-up campaign, pioneered with the Danish 1.54m at ESO La Silla, and rolling out on the LCOGT/SUPAscope, SONG, and MONET 1m-class robotic telescope networks successively until 2014.

The late evolution of planetary systems (invited)

Author: Boris Gaensicke

University of Warwick

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *11:45 Thursday 29th 11:45-13:00*

Summary:

I will give a brief review of the recent progress in our understanding of the late stages of planetary evolution. It is now undisputed that planetary systems can survive the red giant phase of their host stars. Nearly three dozen examples of white dwarfs are known that have dusty and/or gaseous circumstellar discs debris that can only be explained by the tidal disruption of large asteroids, or, in some cases, minor planets. The otherwise pristine H or He atmospheres of white dwarfs are found to be polluted by accretion from this circumstellar debris, and serve as proxies for the chemical bulk composition of the debris material. High-resolution Keck/VLT/HST spectroscopy shows that O, Mg, Si, and Fe are the major constituents of the planetary debris, unambiguously demonstrating its rocky nature. Deep HST spectra of several metal-polluted white dwarfs confirm the very low abundances of volatiles (C, S) that is expected for terrestrial material. Minimum masses of accreted planetary debris range from 1e20g to 1e25g, i.e. some white dwarfs have accreted rocky material with a mass equivalent to at least that of Pluto.

The WASP-South survey for transiting exoplanets

Author: Coel Hellier

Keele University

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *12:00 Thursday 29th 11:45-13:00*

Summary:

The WASP project is the world's leading discoverer of confirmed transiting extrasolar planets. In particular WASP-South is the dominant transit-search program in the Southern Hemisphere, having found the brightest 40 transiting exoplanet systems in the Southern skies. Further, being around relatively bright stars, the WASP planets are prime targets for detailed study. I present the status report on the WASP-South survey, and the collaborations with Geneva/Coralie radial velocities and Liege/Trappist follow-up photometry. I review the planets found so far, and discuss what the WASP surveys are telling us about the distribution and evolution of exoplanets.

WTS-1 b: a hot Jupiter in a tight orbit around a low-mass star

Author: Jayne Birkby

Leiden Observatory

Co-Authors: S. Hodgkin (IoA, Cambridge), D. Pinfield (CAR, Herts), M. Cappetta (MPE), R. Saglia (MPE), D. Barrado (CAB, Madrid), P. Cruz (CAB, Madrid), N. Goulding (CAR, Herts), H. Jones (CAR, HErts), J. Koppenhoefer (MPE), G. Kovacs (IoA, Cambridge), M. Kuznetsov (MAO, Ukraine), N. Lodieu (IAC, Tenerife), E. Martin (CAB, Madrid), D. Mislis (IoA, Cambridge), F. Murgas (IAC, Tenerife), B. Nefs (Leiden Observatory), E. Palle (IAC, Tenerife), Y. Pavlenko (MAO, Ukraine), B. Sipocz (CAR, Herts), I. Snellen (Leiden Observatory), H. Stoev (CAB, Madrid), J. Zendejas (MPE), the WTS consortium and members of the EC funded RoPACS initial training network

Session: PL2: Exoplanets

Presentation type: Talk *12:10 Thursday 29th 11:45-13:00*

Summary:

Summary:

I report on the discovery of WTS-1 b, a hot Jupiter orbiting a mid K-dwarf (~K3V) in a tight 1-day orbit. It is the first planet orbiting a relatively cool star to be found with the WFCAM Transit Survey (WTS). The WTS is a large-scale, infrared photometric monitoring campaign of a vast sample of low-mass stars using the 3.8-m United Kingdom InfraRed Telescope (UKIRT). The survey operates in a unique harmony with the UKIRT observing queue schedule by observing only in poor sky conditions that other programs cannot use. WTS-1 b joins a small sample of giant planets found in very close orbits around stars less massive than the Sun, in contrast to the Kepler sample, which finds that most planets around these stars are small Neptune-size objects. The short orbital period of WTS-1 b, coupled with the measured rotation period and low-mass of the host star, provides an important observational constraint on the theory of tidal evolution and in-spiral timescales for hot Jupiters, which are expected to depend on spectral type. I will also discuss the current status of the WTS and its recent results in characterising the poorly understood, but observationally favourable, population of M-dwarf exoplanet host stars.

Planet Hunters : An independent analysis of Kepler Data

Author: Chris Lintott

University of Oxford

Co-Authors: Schwamb, Megan E. (Yale University) Smith, Arfon (Adler Planetarium) Simpson, Robert (University of Oxford) Schawinski, Kevin (Yale University)

Session: PL2: Exoplanets

Presentation type: Talk *12:20 Thursday 29th 11:45-13:00*

Summary:

Planet Hunters (http://www.planethunters.org), part of the Zooniverse collection of citizen science projects, enlists the general public to visually identify transits in the publicly released Kepler data via the World Wide Web. The human eye and brain are well suited to picking out most transits that cannot be detected in periodograms and are missed by the automated search algorithms. With over 100,000 volunteers examining the light curves on the Planet Hunters interface, we have the ability to visually inspect the entire public dataset for signatures of exoplanet transits. Planet Hunters is thus a novel and complementary technique to the automated transit detection algorithms, providing an independent assessment of the completeness of the Kepler exoplanet inventory. We present the results from analyzing the first six quarters of Kepler observations and present planet candidates identified by Planet Hunters alongside a systematic comparison to the efficiency of the Kepler team's published lists of planet candidates. In particular, we discuss the abundance of large planets (> 2 earth radii) based on Planet Hunters detections.

The Hunt for Exomoons with Kepler (HEK)

Author: David Kipping

Harvard-Smithsonian Center for Astrophysics

Co-Authors: G.A.Bakos (Princeton); L.Buchhave (Neils Bohr Institute); D.Nesvorny (Boulder); A.Schmitt (Citizen Science)

Session: PL2: Exoplanets

Presentation type: Talk *12:30 Thursday 29th 11:45-13:00*

Summary:

Extrasolar moons may be frequent, temperate abodes for life and their detection would not only have astrobiological significance but would also greatly further our understanding of planet/moon formation theories. To date, the bulk of research on this topic has been mostly theoretical, focussing on detection techniques and expected sensitivities as well as exomoon origin and evolution. Here, we introduce a new observational project which aims to change this, enabled by the fact both the theory and available instrumentation have evolved to the required level to make such a search feasible. Our project, "The Hunt for Exomoons with Kepler" (HEK), will be a systematic search for exomoons around viable planet hosts using publicly available Kepler data, with the explicit goal of determining the frequency of large exomoons in the cosmos. We will overview the observational strategy including the detection tools and target selection routines which have been developed, methods to vet false-positives, and some preliminary results from our first batch of candidates. This research is enabled by the NASA Carl Sagan fellowships for exoplanetary research.

Observation and modelling of transits and starspots in the WASP-19 planetary system

Author: Jeremy Tregloan-Reed

Keele University

Co-Authors: J.Southworth (Keele University)

Session: PL2: Exoplanets

Presentation type: Talk *12:40 Thursday 29th 11:45-13:00*

Summary:

I present an IDL code called PRISM (Planetary Retrospective Integrated Spot Model). PRISM models the transit of an exoplanet across the surface of an active host star by a pixellation approach. This allows starspots, limb darkening and gravity darkening to be included in the model. PRISM currently finds the best fit to a light curve using the Markov-chain Monte Carlo approach, and a genetic algorithm will be added soon. We model new light curves of the WASP-19 transiting exoplanetary system, which shows strong spot activity. We use these data to measure the rotation period and the angle between the stellar spin and planetary orbital axes. Our approach requires photometry of multiple transits but does not need spectroscopic observations.

YETI: search for transiting planets in young clusters

Author: christian adam

Astrophysical Institute and Observatory, FSU Jena

Co-Authors: R. Errmann (AIU Jena), St. Raetz (AIU Jena), R. Neuhäuser (AIU Jena), YETI team (worldwide)

Session: PL2: Exoplanets

Presentation type: Talk *12:50 Thursday 29th 11:45-13:00*

Summary:

We present the Young Exoplanet Transit Initiative (YETI), in which we use several 0.2 to 2.6m telescopes around the world to monitor continuously young (< 100 Myr), nearby (< 1 kpc) stellar clusters mainly to detect young transiting planets (and to study other variability phenomena on time-scales from minutes to years). The telescope network enables us to observe the targets continuously for several days in order not to miss any transit. The runs are typically one to two weeks long, about three runs per year per cluster in two or three subsequent years for about ten clusters. There are thousands of stars detectable in each field with several hundred known cluster members, e.g. in the first cluster observed, Tr-37, a typical cluster for the YETI survey, there are some 500 known young stars detected in YETI data down to R=16.5 mag with sufficient precision of 30 milli-mag rms (5 mmag rms down to R=14.5 mag) to detect transits, so that we can expect at least one or two young transiting objects in this cluster. We also observe the 25 Ori cluster. If we observe about 10 similar clusters, we can expect to detect around 10 young transiting planets with radius determinations. We aim to constrain planet formation models and their time-scales by discovering planets younger than 100 Myr and determining not only their orbital parameters, but also measuring their true masses and radii, which is possible so far only by the transit method. Here, we present an overview and first results from the Trumpler-37 and 25 Ori clusters.

Statistics of the HARPS GTO High Precision Sample Archive Data

Author: Alexander Pettitt

University of Exeter

Co-Authors: F. Pont (University of Exeter)

Session: PL2: Exoplanets

Presentation type: Talk *10:00 Friday 30th 10:00-11:15*

Summary:

We present an analysis of the HARPS GTO (Guaranteed Time Observations), specifically the High Precision Sample targeted at searching for sub-Saturn mass companions to solar type stars. This work is made independently of the HARPS team, and as such we have access to the data available on the ESO archive that spans 2003-2009. We vet the sample of some 400 FGK stars for known hosts and high activity stars to assess the detectability of planetary candidates discovered in this sample. We construct a model of detectability by using a threshold based on the CCF parameters of the target stars, rather than the traditional periodogram-based analysis. By injecting planetary signals into individual radial velocity datasets and comparing to our threshold model we produce an effective sample size for each discovered planet. This leads directly to a detectability for the published planetary candidates. The resulting frequency of low mass planets is found to be much lower than previously announced by the HARPS team, and more in line with that of other large-scale planet searches.

Terrestrial planets from Kepler - the HARPS-N spectrograph (invited)

Author: Don Pollacco

Queens University Belfast

Co-Authors: D.Pollacco (QUB), A.C.Cameron (St Andrews), K.Rice (Edinburgh)

Session: PL2: Exoplanets

Presentation type: Talk *10:10 Friday 30th 10:00-11:15*

Summary:

We will discuss the UK contributions (both technical and scientific) to the HARPS-N spectrograph, currently commissioning at the 3.5m TNG Telescope on La Palma.

Rossiter-McLaughlin analysis of WASP hot Jupiters

Author: David Brown

University of St Andrews

Co-Authors: A.C.Cameron (University of St Andrews); M.Gillon (Université de Liège); M.Lendl (Université de Genève); G.R.M. Miller (University of St Andrews); B.Smalley (Keele University); A.H.M.J.Triaud(Universite de Genève);

Session: PL2: Exoplanets

Presentation type: Talk *10:25 Friday 30th 10:00-11:15*

Summary:

We present new Rossiter-McLaughlin measurements for several hot Jupiters discovered by the WASP survey. We compare the results from both traditional radial velocity based analysis and the more recent Doppler tomography method, examining the pros and cons of the two approaches. We also consider our new results in the context of the ensemble of Rossiter-McLaughlin results, looking at the implications for both the disc migration and scattering + tidal interaction theories of planetary system formation.

Detection of thermal emission from WASP-3b

Author: John Rostron

University of Warwick

Co-Authors: P.J.Wheatley (University of Warwick)

Session: PL2: Exoplanets

Presentation type: Talk *10:35 Friday 30th 10:00-11:15*

Summary:

We present secondary eclipse detections of the transiting planet WASP-3b at 3.6, 4.5 and 8.0 microns, using the Spitzer Space Telescope. Infrared measurements of secondary eclipses separate the spectrum of the planet from that of the star, allowing us to probe the temperature structure of the planetary atmosphere and to search for molecules such as water, carbon dioxide and methane. Our initial results indicate that WASP-3b absorbs a significant amount of the incident stellar radiation making the planet extremely hot, with brightness temperatures in the range 2150-2500K. The spectral slope between 3.6 and 4.5 microns reveals the planetary spectrum deviates significantly from that of a blackbody and is suggestive of a stratospheric temperature inversion. The timing of the eclipses demonstrate that the orbit of the planet is most-likely circular.

Homogeneous studies of transiting extrasolar planets: current status

Author: John Southworth

Keele University

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *10:45 Friday 30th 10:00-11:15*

Summary:

We now know of over 700 planets orbiting stars other than our Sun. The jewels in the crown are the transiting planets, for these are the only ones whose masses and radii are directly measurable. However, their characterization is not straightforward, requiring extremely high-precision photometry as well as input from stellar theoretical models. I present a project to measure the physical properties of 100 transiting planetary systems using homogeneous techniques, with careful attention paid to the treatment of limb darkening, third light, correlated noise, numerical integration, orbital eccentricity, and systematic errors from theoretical stellar models. Complete error budgets are calculated for each system. Known correlations between orbital period, mass, surface gravity, and equilibrium temperature are investigated. I give a sneak preview of Homogeneous Studies Paper 5, which will include the properties of 40 transiting planetary systems discovered by CoRoT, Kepler, HAT and WASP, and discuss future opportunities plus remaining problems with our understanding of transiting planets.

Homogeneous study of the transit light curves of CoRoT exoplanets

Author: Anders Erikson

DLR PF

Co-Authors: Csizmadia Sz., Th. Pasternacki, A. Erikson and the CEST team

Session: PL2: Exoplanets

Presentation type: Talk *10:55 Friday 30th 10:00-11:15*

Summary:

The high-precision photometric satellite mission CoRoT was launched in 2006. It has already detected more than twenty planets and one brown dwarf. Both the data processing scheme and analyzing methods have evolved since the publication of the first discoveries: 1. newly processed data from an updated calibration pipeline; 2. a new and more sophisticated way for the contamination calculation of stars with low angular distance has been developed, 3. new limb darkening tables, specified for the CoRoT passbands have become available. We will present a homogeneous re-analysis of the currently known CoRoT-exoplanets. The aim is to refine the planetary and stellar parameters by using the newly calibrated data and by application of the aforementioned methods.

The Next-Generation Transit Survey (NGTS)

Author: Peter Wheatley

University of Warwick

Co-Authors: R.G.West (Leicester); D.Pollacco (Belfast); D.Queloz (Geneva); H.Rauer (Berlin)

Session: PL2: Exoplanets

Presentation type: Talk *11:05 Friday 30th 10:00-11:15*

Summary:

I will describe a new ground-based exoplanet transit survey due to be built at the ESO Paranal observatory later this year. The Next-Generation Transit Survey (NGTS) employs an array of twelve red-sensitive 20cm telescopes and has been designed to deliver sub-mmag photometric precision over a wide field. By exploiting the exceptional photometric conditions at Paranal we expect to discover planets in the Super-Earth to Neptune size range. By covering a larger sky area than Kepler we expect to find the brightest examples of such planets, and these will become the priority targets for planetary atmosphere studies with flagship instruments such as JWST and the E-ELT.

The PLATO mission (invited)

Author: Heike Rauer

Institut fuer Planetenforschung, DLR

Co-Authors: C. Catala and the PLATO team

Session: PL2: Exoplanets

Presentation type: Talk *11:45 Friday 30th 11:45-13:00*

Summary:

PLATO is the next generation space-based survey for transiting extrasolar planets and is proposed to ESA as a candidate for the M3 slot within the ESA Cosmic Vision 2015-2025 program. Its main objectives are the detection of Earth Analogue systems around bright stars, and to reveal the interior structure of planets and their host stars. We will present here the expected scientific impact of the PLATO mission.

The science of EChO (invited)

Author: Giovanna Tinetti

University College London

Co-Authors: P. Drossart (LESIA), G. Micela (INAF), I. Ribas (ICE), J. Cho (QMUL), A. Coustenis (LESIA), T. Encrenaz (LESIA), L. Fletcher (Un. Oxford), F. Forget (LMD), O. Grasset (Un. Nantes), T. Guillot (Obs. Nice), P. Irwin (Un. Oxford), M. Lopez-Morales (ICE), I. C F. Mueller-Wodarg (Imperial C.), E. Palle (IAC), D. J. Pinfield (UH), F. Selsis (Un. Bordeaux), A. Sozzetti (INAF), L. Stixrude (UCL), J. Tennyson (UCL), M. R. Zapatero Osorio (CAB)

Session: PL2: Exoplanets

Presentation type: Talk *12:00 Friday 30th 11:45-13:00*

Summary:

The science of extra-solar planets is one of the most rapidly changing and exciting areas of astrophysics. Since 1995 the number of planets known has increased by almost two orders of magnitude. The Exoplanet Characterisation Observatory –EChO – will take us to a new phase where we begin to fully understand the physics and chemistry of these objects and, possibly, the detection of the signatures of life on other habitable planets. The ability to repeatedly observe exoplanets over a very extended wavelength range in a single run gives EChO a unique capability unmatched by any current or proposed mission. EChO is one of the four ESA's M3 mission candidates. The baseline spectral range covers 0.4 to 11 micron with a goal of extending to 16 micron, and will allow EChO to be sensitive to a wide range important gas species that may be present in an exoplanet's atmosphere, including water vapour, methane, carbon dioxide and ozone. The instrument will be mounted behind a 1.2 class telescope, placed in a grand halo orbit around L2. In this presentation we will focus on the science that can be accomplished with EChO. In particular, we will give an overview of the work being carried out by the EChO consortium, which includes the contributions of UK, France, Italy, Spain, MPS Germany, Denmark, University of Liege and US.

The 0.81 - 2.41 micron ground-based transmission spectra of the hot jupiter HD-189733b.

Author: Camilla Danielski

UCL

Co-Authors: P. Deroo (JPL), I.P.Waldmann (UCL), G.Tinetti (UCL), M. Swain (JPL)

Session: PL2: Exoplanets

Presentation type: Talk *12:15 Friday 30th 11:45-13:00*

Summary:

We present here ground based transmission spectroscopy of the hot jupiter HD-189733b using the SpeX instrument on the NASA Infrared Telescope Facility. We obtained two nights of observation of the primary transit for the z, J, H and K band simultaneously, covering the gap between HST/ACS data of Pont el al. 2008 and HST/NICMOS data of Swain et al. 2008, from 1.05 to 1.48 microns.We analysed our data using the technique explained in Swain et al. 2010 and Waldmann et. al 2011. Furthermore we compared our results with simulated atmospheric spectra and we discussed the outcome in the light of previous results published in the literature. Our observed spectra are consistent with previous data recorded from space, showing that low resolution exoplanet spectroscopy is feasible with medium-sized telescopes on the ground (Danielski et al, in prep.).

Transmission Spectroscopy with the GTC 10.4 m

Author: Paul Anthony Wilson

Author: Paul Anthony Wilson

University of Exeter

Co-Authors: D. Sing, F. Pont

Session: PL2: Exoplanets

Presentation type: Talk *12:25 Friday 30th 11:45-13:00*

Summary:

Transiting hot-Jupiters provide an excellent opportunity to detect and characterise exoplanetary atmospheres. To be able to perform a wide scale

comparative exoplanetology however, we have to observe targets which are too faint for Hubble. To do this, we use the GTC telescope together with unique tunable filters capable of precision narrowband photometry at specific wavelengths. This technique coupled with the use of the worlds largest optical telescope allows us to obtain photon-limited sub-mmag narrowband transit spectrophotometry, capable of detecting Na, K, TiO and other important atmospheric species. In this talk I will present the technique being used as well as some of the early results from this survey. This includes the hot-Jupiters Hat-P-1 b, Tres-2 b, and XO-2 b, as well as the super-Earth GJ 1214 b.

Structure and evolution of exoplanets: some news from the theoretical front (invited)

Author: Isabelle Baraffe

University of Exeter

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *12:35 Friday 30th 11:45-13:00*

Summary:

I will examine our present understanding of the internal structure and evolution of exoplanets.The detection of transiting planets around their parent star allow the determination of their mass and radius, and thus of their mean density. Such valuable information indicates that a significant fraction of these planets are enriched in heavy elements (ice, rocks), as observed in the giant planets of our Solar System. The treatment of heavy materials in planetary interior and the resulting uncertainties on the mass-radius relationship will be discussed. I will also address the case of short-period, strongly irradiated planets and discuss some of the mechanisms which have been suggested to explain their anomalously large radii.

Evaporating planets with stellar X-rays: a potential test for migration scenarios?

Author: Alan Jackson

Institute of Astronomy

Co-Authors: Timothy A. Davis (ESO) Peter J. Wheatley (Warwick)

Session: PL2: Exoplanets

Presentation type: Talk *12:50 Friday 30th 11:45-13:00*

Summary:

We confirm that a linear cut-off of the planet distribution in the M^2/R^3 versus a^-2 plane is an expected result of population modification by evaporation and show that the known transiting exoplanets display such a cut-off. Further we find that around 1 in 5 of the transiting exoplanets known today will have lost more than 10 percent of their mass since formation. It is generally thought that Hot-Jupiter class planets did not form in-situ but migrated in from wider orbits, with a variety of migration mechanisms proposed. For a Sun-like star with an age of 4-5 Gyr almost a third of its lifetime X-ray emission will have been during the first 0.1 Gyr, and thus when planets arrive at their present orbits is very important for their evaporation histories. Different migration mechanisms lead to different timescales for arrival at the present day orbit as well as different degrees of alignment betweeen the stellar spin and planetary orbit. We suggest that evaporation may thus provide a way to test some migration mechanisms.

A lower angular momentum limit for self-gravitating protostellar disc fragmentation

Author: Dr Duncan Forgan

SUPA, Institute for Astronomy, University of Edinburgh

Co-Authors: W.K.M. Rice (SUPA, Institute for Astronomy, University of Edinburgh)

Session: PL2: Exoplanets

Presentation type: Talk *14:15 Friday 30th 14:15-15:30*

Summary:

Semi-analytic modelling of spherical molecular cloud collapse into self-gravitating protostellar discs has suggested that the cloud's angular momentum is the dominant parameter in determining whether the disc subsequently fragments. This is broadly equivalent to requiring the disc be sufficiently extended in order to fragment, in line with studies of isolated discs that do not accrete from a surrounding envelope. I will show our investigations of this claim using smoothed particle hydrodynamics (SPH) simulations with radiative transfer. We confirm that in spherical, homogeneous molecular clouds, angular

momentum is the dominant parameter. Fragmenting discs are produced if the cloud's initial ratio of rotational kinetic energy to gravitational potential energy is greater than approximately 0.005, which is relatively insensitive to the initial thermal energy of the cloud. While these conditions are highly idealised, we argue it provides a sensible lower limit for the minimum angular momentum required to fragment a disc in the absence of significant external turbulence. This condition begins to fail at higher cloud masses, suggesting that fragmenting discs require sufficient mass at large radii. This strengthens the argument that giant planets and low-mass stars produced by fragmentation must initially form at significant distances from the parent star.

Global models of planetary system formation in radiatively-inefficient protoplanetary discs

Author: Phil Hellary

Queen Mary University of London

Co-Authors: R.P.Nelson (Queen Mary University of London)

Session: PL2: Exoplanets

Presentation type: Talk *14:25 Friday 30th 14:15-15:30*

Summary:

I will present the results of recent simulations of planetary systems formation in radiatively-inefficient disc models, where positive corotation torques may counter the rapid inward migration of low-mass planets driven by Lindblad torques. Our models include prescriptions for planetary atmospheres that enhance the probability of planetesimal accretion by protoplanets, simple prescriptions for planetary migration, gas accretion onto forming planetary cores and gas disc dispersal. The simulations lead to the formation of systems containing giant planets of varying mass and with a wide range of semi-major axes.

Eccentric Planets and Lucky Horseshoes

Author: Stephen Fendyke

Queen Mary, University of London

Co-Authors: R.P.Nelson (Queen Mary, University of London)

Session: PL2: Exoplanets

Presentation type: Talk *14:35 Friday 30th 14:15-15:30*

Summary:

In the early stages of solar system evolution (< 5Myr), newly formed planets are embedded in protoplanetary discs consisting of gas and dust. Interactions between such a disc and a planet give rise to torques on each. Spiral density waves launched at Lindblad resonance locations in the disc exert torques that have the net effect of extracting angular momentum from the planet and causing it to migrate into the star. In addition, material undergoing `horseshoe' orbits in the vicinity of the planet can exert a torque: In a viscous disc with a sustained entropy gradient, there is an asymmetry between inner and outer horseshoe trajectories. The torque resulting from this asymmetry is typically positive, counteracting the inward migration. However, the epicyclic motion of eccentric planets can disrupt the horseshoe region, attenuating this second effect and giving rise to inward migration again. We are investigating the nature of the relationship between the eccentricity of an embedded planet, the disruption to the horseshoe region and the resulting torque. This has applications for understanding the the dynamical evolution of both our own and extrasolar planetary systems.

Eccentricity Growth of Embedded Giant Planets

Author: Alex Dunhill

University of Leicester

Co-Authors: R.D.Alexander (University of Leicester)

Session: PL2: Exoplanets

Presentation type: Talk *14:45 Friday 30th 14:15-15:30*

Summary:

Most extra-solar planets have eccentric orbits around their host stars. This is in stark contrast to Solar System planets, which are all in near-circular orbits, and it is unclear how exoplanets attain their eccentricities. One possible mechanism for exciting eccentricity is by resonant interactions between a young planet and its parent protoplanetary disc. We present high-resolution 3-D numerical simulations of this planet-disc interaction. We find that eccentricity is only excited in disc with very high surface densities; in realistic disc cases, the excitation is very weak and is further damped by other resonant torques. We discuss the consequences of our results, and suggest that observations of exoplanet eccentricities can set interesting limits on the conditions under which planets form.

Evolution and dynamics of the eccentric planetary system HD 181433

Author: Giammarco Campanella

Queen Mary University of London

Co-Authors: C. Agnor (Queen Mary University of London), R. Nelson (Queen Mary University of London)

Session: PL2: Exoplanets

Presentation type: Talk *14:55 Friday 30th 14:15-15:30*

Presentation type: Talk *14:55 Friday 30th 14:15-15:30*

Summary:

The detection of almost 100 planetary systems makes it necessary to interpret a broader range of properties than are shown by our solar system. Explaining the high eccentricities observed for several planets represents a key milestone on the road toward a comprehensive theory of planet formation. The three-planet extrasolar system of HD 181433 offers a test bed for the study of mechanisms capable of exciting orbital eccentricity. The best-fit solution to the observational data describes a highly unstable, self-disrupting configuration. In fact, a narrow observational window, only partially covering the longest orbital period, can lead to unrealistic solutions. Taking into account the dynamical stability as an additional observable while interpreting the RV data, we analysed the phase space in the neighbourhood of the statistical best-fit and derived dynamically stable configurations that reproduce the observed RV signal. Our Newtonian stable best-fit model survives for at least 250 Myrs. The two giant companions are found to be locked in the 5:2 MMR, and we show that a terrestrial planet in the habitable zone can remain stable. We have performed numerical simulations that include spin-down of the stellar rotation and GR to examine how the system may have evolved to its present state.

Super-Earths and Life, characterizing the atmosphere of rocky exoplanets (invited)

Author: Lisa Kaltenegger

MPIA / CfA

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *15:05 Friday 30th 14:15-15:30*

Summary:

A decade of exoplanet search has led to surprising discoveries, from giant planets close to their star, to planets orbiting two stars, all the way to the first extremely hot, rocky worlds with potentially permanent lava on their surfaces due to the star's proximity. Observation techniques have now reached the sensitivity to explore the chemical composition of the atmospheres as well as physical structure of some detected planets and find planets of less than 10 Earth masses (so called Super-Earths), among them some that may potentially be habitable. Two confirmed non-transiting planets and several transiting Kepler planetary candidates orbit in the Habitable Zone of their host star. Observing mass and radius alone can not break the degeneracy of a planet's nature due to the effect of an extended atmosphere that can also block the stellar light and increase the observed planetary radius significantly. Even if a unique solution would exist, planets with similar density, like Earth and Venus, present very different planetary environments in terms of habitable conditions. Therefore the question refocusses on atmospheric features to characterize a planetary environment. We will discuss observational features of rocky planets in the HZ of their stars that can be used to examine if our concept of habitability is correct and how we can find the first habitable new worlds in the sky. 1. Kaltenegger L. & Sasselov, D., Exploring the Habitable Zone for Kepler, ApJL 736, 2, 2011. 2. Kaltenegger L., Segura A. & Mohanty, S, Characterizing Model Spectra of the First Potentially Habitable Super-Earth—Gl581d, 733, 1, ApJ 2011 3. Kaltenegger L., Selsis F., et al., Characterization of Terrestrial Exoplanets and Detection of Biomarkers, Astrobiology, 10, 2010

The outer boundary of the HZ: The size dependent scattering greenhouse effect of CO2 ice particles

Author: A. Beate C. Patzer

Zentrum für Astronomie und Astrophysik, TU Berlin

Co-Authors: D. Kitzmann (1); H. Rauer (1,2) 1: Zentrum für Astronomie und Astrophysik, TU Berlin, Berlin, Germany 2: Institut für Planetenforschung, DLR, Berlin, Germany

Session: PL2: Exoplanets

Presentation type: Talk *15:20 Friday 30th 14:15-15:30*

Summary:

For terrestrial planets near the outer boundary of the habitable zone, condensation of CO2 can occur at low atmospheric temperatures. These CO2 ice clouds may play an important role for warming the surface and, therefore, for the question of habitability of such extrasolar planets. However, the optical properties of CO2 ice crystals differ significantly from those of water droplets or water ice particles. In this contribution we study the potential greenhouse effect due to scattering of CO2 ice clouds for atmospheric conditions of terrestrial extrasolar planets. Therefore, we calculate the scattering and absorption properties of CO2 ice particles using Mie theory for assumed particle size distributions with different effective radii and particle densities to determine the scattering and absorption characteristics of such clouds. Implications especially in view of a potential greenhouse warming of the planetary surface are discussed.

Adaptation of the Met Office Unified Model to modelling exoplanets.

Author: David Acreman

University of Exeter

Co-Authors: N. J. Mayne (University of Exeter); I. Baraffe (University of Exeter); D. S. Amundsen (University of Exeter); G. Chabrier (Ecole Normale Superieure de Lyon/University of Exeter)

Session: PL2: Exoplanets

Presentation type: Poster *Poster Session B*

Summary:

We are adapting the UK Met Office Unified Model (used for weather forecasting and climate modelling) to model exoplanets. The Unified Model solves

the full Navier-Stokes equations, without making the standard approximations used in most Global Circulation Models (GCMs). The global circulation on exoplanets can be very different to that on Earth, hence the model needs to operate well outside its normal regime. We present results from our model developement which uses benchmark cases to test the performance of the model in exoplanet-like circulation regimes.

Close-in exoplanets, but none of ours: Guidance from Triton

Author: Miles F Osmaston

Retired (Woking, UK)

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

Some 23% of all orbitally-determined exoplanets orbit their star within 12 Rsun, with a clear concentration centred on 10 Rsun. The proportion has changed little as numbers grew. Not a matter of detectability but of why they are there at all (Mercury is at 83). Triton's retrograde orbit invites a reconsideration of the main mechanism of planetary construction. Its immersion in the (56 body) prograde satellite population of the Giant Planets implies [1] that tidal capture had been the mechanism of central body accretion until the arrival of their gas-ice envelopes liquefied their interiors, destroying their tidal attribute and halting Triton's inward motion. Efficient tidal capture required nebular gas-drag during planetary growth, confirmed by the preserved low eccentricities of all except Mercury (so it alone suffered a late giant impact). The second problem of planetary construction, of long standing [2], is to equip their growth materials with their very high (orbitally prescribed) specific angular momenta relative to that of their rotating star/Sun. Nebular action is the only conceivable agent for doing this. New insight on the physical mechanism of gravitation [3] leads to the expectation that the Newtonian field of any gravity-retained assemblage is inescapably accompanied by a radial Gravity-Electric (G-E) field, providing a potentially over-riding repulsive force on sufficiently charged nebular ions. The tangential velocity pattern is then not Keplerian and we show that, in the solar system example, outward G-E field action yields an adequate a.m. growth mechanism within the frame of our new scenario for planetary system formation [3]. Its key feature is that solar/stellar passage through a second cloud gathers cold protoplanetary material whose high opacity permits protoplanetary nuclei to form very close to the star and then be pushed out successively in a G-E driven nebular disc wind, growing by tidal capture of passing objects. Apparently we see close-in exoplanets soon after their star has left the high-opacity second cloud, exposing them to us and to their star. Now, with no disc wind to drive them outward, they accumulate in number until they vanish by evaporation. [1] McCord TB. (1968) JGR 73, 1497:- Counselman CC., III. (1973) Ap.J. 180, 307. [2] Jeans JH. (1919) Adams Prize Essay, Clarendon Press. 293pp. [3] Osmaston MF. (2006) GCA 70(18S), A465:- — (2009a) EPSC Abstr. 4, EPSC2009-264:- — (2009b) Geophys. Res. Abstr. 11, EGU2009-12204:- — (2010) In JENAM 2010 (ed. A. Moitinho et al) Abstract Book (Version 2.0) 159-160.

Ground-based secondary eclipse observations of CoRoT-1b

Author: Hannah Ruth Wakeford

University of Exeter

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Poster *Poster Session B*

Summary:

I present ground-based z'-band secondary eclipse observations from CFHT of CoRoT-1b, in an effort to constrain emission spectra, albedo, and temperature redistribution in its atmosphere. The observations are part of a project to measure the brightness temperature of hot jupiters around and apparent 1800K temperature regime, where hotter planets show a very strong day to night flux contrast.

Modeling Exoplanet Transmission Spectra

Author: Alexander Pettitt

University of Exeter

Co-Authors: F. Pont (University of Exeter); D. K. Sing (University of Exeter)

Session: PL2: Exoplanets

Presentation type: Poster *Poster Session B*

Summary:

The field of transmission spectroscopy is a key area of exoplanetary science as it enables the identification of molecular species in planetary atmospheres. We present an ongoing study to model the transmission spectrum for exoplanets, with the aim of comparing this to measured spectra from such instruments as those aboard Hubble and Spitzer. Of particular interest is the IR region where the molecules H2O, CH4, CO and NA3 are believed to produce the dominant spectral features. We present our current progress as well as the necessary steps required to build a transmission spectrum from the raw constituents that are widely available.

Analysing exoplanetary data using unsupervised machine-learning

Author: Ingo Waldmann

UCL

UCL

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

The field of transiting extrasolar planets and especially the study of their atmospheres is one of the youngest and most dynamic subjects in current astrophysics. Permanently at the edge of technical feasibility, we are successfully discovering and characterising smaller and smaller planets. To study exoplanetary atmospheres, we typically require a 10e-4 to 10e-5 level of accuracy in flux. Achieving such a precision has become the central challenge to exoplanetary research and is often impeded by systematic (nongaussian) noise from either the instrument, stellar activity or both. Dedicated missions, such as Kepler, feature an a priori instrument calibration plan to the required accuracy but nonetheless remain limited by stellar systematics. More generic instruments often lack a sufficiently defined instrument response function, making it very hard to calibrate. In these cases, it becomes interesting to know how well we can calibrate the data without any additional or prior knowledge of the instrument or star. In this conference, we present a non-parametric machine-learning algorithm, based on the concept of independent component analysis, to de-convolve the systematic noise and all non-Gaussian signals from the desired astrophysical signal. Such a 'blind' signal de-mixing is commonly known as the 'Cocktail Party problem' in signal-processing. We showcase the importance and broad applicability of unsupervised machine learning in exoplanetary data analysis by discussing: 1) the removal of instrument systematics in a re-analysis of an HD189733b transmission spectrum obtained with Hubble/NICMOS; 2) the removal of time-correlated stellar noise in individual lightcurves observed by the Kepler mission.

Transmission Spectroscopy on a Blotchy Canvas: Star Spot Corrections Using Gaussian Processes

Author: Tom Evans

University of Oxford

Co-Authors: S. Aigrain (University of Oxford), F. Pont (University of Exeter), N. Gibson (University of Oxford)

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

Absorbing materials in a transiting exoplanet's atmosphere can be inferred by measuring how the apparent size of the planet varies as a function of wavelength. However, the application of this technique, known as transmission spectroscopy, is complicated by the presence of dark star spots and bright faculae on the stellar surface. In order to obtain an accurate transmission spectrum, it is necessary to correct for the effect that these active regions have on the measured transit depth. This poses a challenge, as the spot/faculae coverage cannot be observed directly. In this talk I will describe a new approach for dealing with this problem, which makes use of Gaussian process regression onto long-term photometric monitoring data of the host star. We plan to apply this technique when calibrating high precision optical transmission spectra for eight hot Jupiters that are to be observed over the next year or so using the STIS instrument on board HST (GO12473, P.I. Sing).

EChO detectability analysis using the NEMESIS radiative transfer and retrieval tool

Author: Jo Barstow

University of Oxford

Co-Authors: S. Aigrain (University of Oxford; P. G. J. Irwin (University of Oxford); J-M. Lee (University of Oxford)

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

The proposed EChO (Exoplanet Characterisation Observatory) space telescope is projected to significantly improve understanding of planets outside our solar system, and in particular their atmospheric structure and composition. We utilise the NEMESIS radiative transfer and retrieval algorithm (Irwin et al. 2008) to investigate the detectability of extrasolar planet phenomena with the proposed EChO telescope design. We build on the work of Lee et al. (2012) and begin the study of a range of hypothetical extrasolar planets, with different sizes, temperature structures and atmospheric compositions, orbiting stars of different spectral types. Giant planets, small Neptunes and super-Earths are considered. We include HD189733b and HD209458b, the two best-studied hot Jupiters, in order to determine how far EChO will extend our retrieval capability beyond that of the instruments currently available. We hope to use these results to make recommendations about the minimum spectral range, resolution and signal to noise ratio necessary to break degeneracies in the retrieval problem.

Accurate parameters of WASP planet host stars

Author: Amanda Doyle

Keele University

Co-Authors: B. Smalley (Keele University)

Session: PL2: Exoplanets

Presentation type: Poster *Poster Session B*

Summary:

A careful and detailed spectral analysis of several WASP planet host stars will be presented. A line by line differential analysis was performed relative to the Sun and the mid-F star Procyon. Spectra were obtained using the HARPS spectrograph (resolution of 115,000), and the importance of high quality spectra is investigated by comparing the results with the original discovery analyses, which mainly used the CORALIE spectrograph (resolution of 60,000). A line list was carefully constructed by selecting as many clean, unblended lines in the solar spectrum as possible, and rejecting unresolved blends. It is shown that lines should be selected with caution from the VALD database, and properly supplemented with additional data. The importance of synthesis in addition to equivalent width measurements is also shown.

Selection effects of the SuperWASP project

Author: Simon Walker

University of Warwick

Co-Authors: P. J. Wheatley (University of Warwick); R. West (University of Leicester)

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

SuperWASP is the most successful ground based survey for transiting extrasolar planets, with over 70 discoveries announced. The project is most sensitive to hot Jupiters, but the sample is limited by selection effects. In order to determine the underlying distribution, it is necessary to quantify these selection effects. We have simulated synthetic lightcurves with planetary transits with different physical parameters, and inserted into observed data. The resulting lightcurves are analysed with the SuperWASP analysis tools to determine how many would be detected, if they contained a genuine transit. The fraction of synthetic lightcurves maps the underlying detection sensitivity of the project and how this relates to both physical and observational parameters of the system.

Characterising Super Earths with the ECHO spacemission concept

Author: Marcell Tessenyi

UCL

Co-Authors: M. Ollivier (IAS Paris Sud, CNRS), G. Tinetti (UCL), B. Swinyard (UCL/RAL), and the EChO simulation team

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

Transiting Super-Earths orbiting M-dwarfs are excellent targets for studying potentially habitable exoplanets. While most of the currently known exoplanets are Hot Jupiters and Neptunes, attention is now turning to these Super-Earths. (e.g., Cancri 55e, found by Winn et al. in 2011). These candidates offer the opportunity of obtaining spectral signatures of their atmospheres in transiting scenarios, via data obtained by ground based and space observatories, compared to simulated climate scenarios. With the recent selection of the Exoplanet Characterisation Observatory mission by ESA for further studies, I present observational strategies and time requirements for the characterisation of atmospheres of a range of targets with EChO, with a study of detectability of molecular spectral features, from Habitable Zone Super-Earth to Hot Jupiter atmospheres.

An integrated payload design for the EChO Exoplanet Characterisation Observatory

Author: Neil Bowles

University of Oxford

Co-Authors: B. Swinyard (RAL/UCL);G.Tinetti (UCL);M. Ferlet (RAL);E. Pascale (Cardiff Univ.);L. Fletcher (Univ. Oxford);M. Tecza (Univ. Oxford);A. Adriani (IFSI);J. Beaulieu (IAP);T. Belenguer Davila (INTA);I. Bryson (UKATC);J. Cho (QMUL);V. Coudé de Foresto (LESIA);A. Coustenis (LEISA);M. Focardi (Univ. Florence);P. Hartogh (Max Planck Institute for Solar System Research);P. Lagage (CEA−Saclay);M. López−Morales (Institut de Ciencies de l'Espai);G. Micela (Osservatorio Astronomico di Palermo);G. Morgante (IASF Bologna);H. U. Nørgaard−Nielsen (DTU Space, Copenhagen);M. Ollivier (IAS);E. Pace (Univ. of Florence);G. Ramos Zapata (INTA);J. Reess (LESIA);I. Ribas (Institut de Ciències de l'Espai);B. Winter (MSSL);G. Wright (UKATC);M. Zapetero Osorio (CAB);

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

The Exoplanet Characterisation Observatory (EChO) is a space mission dedicated to undertaking spectroscopy of transiting exoplanets over the widest wavelength range practicable. It is based around a highly stable space platform with a 1.2 m class telescope. The mission is currently being studied by ESA in the context of a medium class mission within the Cosmic Vision programme for launch post 2020. The payload suite is required to provide simultaneous coverage from the visible to the mid− infrared and must be highly stable and effectively operate as a single instrument. In this paper we describe the approach being studied by the EChO instrument consortium to meet these demanding requirements whilst remaining within the mission's operating constraints. In particular, we will give an overview of the work being carried out in the UK to support system and mechanical design, spectral channel division, infrared detector characterisation and long wave (11-16 micron) infrared channel as part of a larger multi-national instrument payload consortium.

Microlensing planets in spiral arms

Author: Markus Hundertmark

University of St Andrews

Co-Authors:

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

In recent years, gravitational microlensing has impressively proven its capability to detect low-mass planets and free-floating planetary-mass objects. The characterisation of these events often requires an underlying Galactic model, but none of the Galactic models used for inferring planetary parameters includes the spiral arm structure. Reviewing the properties of detected microlensing planets reveals a remarkable spatial distribution and motivates studying the impact of a Galactic model. Depending on the assumed location of source and lens, the planet mass changes and thus the results for all reported planetary-mass objects can be reviewed based on such an extended model. The prominent rocky 5.5 Earth-mass planet, for instance, would differ noticeably if the lens position is located in the Centaurus arm and thus at a distance of 3 kpc from Earth. In addition to changing the lens distance, the lens-source proper motion needs to be revised as well, as the lens originates from a different stellar population.

Things that go bump in the transit: Using Kepler lightcurves to determine stellar spot-belt drifts.

Author: Joe Llama

University of St Andrews

Co-Authors: M. Jardine, (St Andrews); D. H. Mackay (St Andrews); R. Fares (St Andrews)

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

Planetary transits provide a unique opportunity to investigate the surface distributions of star spots. Using stellar evolution simulations we predict transit lightcurves of a planet whose orbital axis is misaligned with the stellar rotation axis. Such a planet could occult spots at a range of latitudes. From these lightcurves we determine if missions such as Kepler, which provide continuous observations, can be used to measure spot belt drift over time providing a further test for dynamo theory.

Opacity and spectra in hot Jupiters

Author: Nawal Husnoo

University of Exeter

Co-Authors: F. Pont (Exeter), D. Sing (Exeter), K. Heng (Zurich), S. Aigrain (Oxford), L. Fletcher (Oxford), J. Lee (Oxford), T. Evans (Oxford)

Session: PL2: Exoplanets

Presentation type: Poster *Poster Session B*

Summary:

We are developing a set of tools for generating shortwave opacities for hot Jupiter atmospheres. We focus on the visible spectrum, where we plan to use the routines for generating "frst guess" models for the upcoming transmission spectra of hot Jupiters (HST program in progress, PI: Sing). We also plan to study the atmospheric temperature-pressure profle of hot Jupiters (Heng et al. 2011), with a focus on the effects of various types of clouds.

Debris from giant impacts: signposts of terrestrial planet formation

Author: Alan Jackson

Institute of Astronomy

Co-Authors: M.C. Wyatt (Institute of Astronomy)

Session: PL2: Exoplanets

Presentation type: Poster *Poster Session B*

Summary:

The final stage in assembling terrestrial planets is thought to be driven by giant impacts between planetary scale bodies. In addition to building terrestrial planets such impacts produce large quantities of debris. Here we present a model of the evolution of debris from the Moon forming collision as an example. This shows that the debris would be bright and detectable in the mid-infrared on Myr timescales after the impact. It is thus expected that young stars hosting systems undergoing terrestrial planet formation will have detectable mid-infrared excesses for much of the final stage of formation. Indeed, the dust produced during formation of the planets would likely be substantially easier to detect than the terrestrial planets themselves. We use current searches for warm dust around young stars to provide constraints on the fraction of stars that form terrestrial planets and conclude that terrestrial planet formation is not common.

The Sun's radial velocity jitter

Author: Raphaelle D. Haywood

University of St Andrews

Co-Authors: A. C. Cameron (University of St Andrews), D. Queloz (Observatoire Astronomique de l'Universite de Geneve), R. Fares (University of St Andrews), J. Llama (University of St Andrews), M. Gillon (Institut d'Astrophysique et de Geophysique, Universite de Liege,), A. Hatzes (Thueringer Landessternwarte Tautenburg), M. Deleuil (Laboratoire d'Astrophysique de Marseille), A. Lanza (INAF - Osservatorio Astronomico di Catania), C. Lovis (Observatoire Astronomique de l'Universite de Geneve), C. Moutou (Laboratoire d'Astrophysique de Marseille), F. Pepe (Observatoire Astronomique de l'Universite de Geneve), D. Pollacco (Astrophysics Research Centre, Department of Physics and Astronomy, Queen's University Belfast), D. Ségransan (Observatoire Astronomique de l'Universite de Geneve), Y. Unruh (Astrophysics Group, Blackett Laboratory, Imperial College of Science, Technology and Medicine)

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

One of the most common methods used to discover extra-solar planets is to monitor a star's radial velocity (RV) in order to detect the reflex orbital motion caused by one or more planets orbiting the star. When looking for "small" planets (Neptune or Earth mass), the RV signals induced by these planets are entangled with the jitter arising from the star's magnetic activity. The Sun's activity is well known and it is possible to remove all RV components induced by all other bodies of the solar system. We have obtained its activity-driven RV variations over two solar rotations using HARPS by observing sunlight reflected off the bright asteroid Vesta. We aim to model the solar RV jitter in terms of the continuum lightcurve, the chromospheric Ca II H&K emission, and the line-profile distortions produced by spots drifting across the face of the Sun. By using the "ground truth" of solar observations in this way, we will identify photometric and spectroscopic proxies that will make it possible to model and remove the stellar activity RV contribution from exoplanet RV curves.

Exploring the treasure trove: PIRATE as a remotely operated exoplanets winnower

Author: Jakub J Bochinski

Open University

Co-Authors: R.Busuttil (Open University); S.Holmes (Open University); U.C.Kolb (Open University); C.A.Haswell (Open University)

Session: PL2: Exoplanets

Presentation type: Poster *Poster Session B*

Summary:

The SuperWASP consortium has to date identified several thousand exoplanetary candidates worthy of follow-up. Based on current statistics, most of these will prove to be mimics, many of which could be interesting in their own right. To deal with the large quantities of candidates, a cost effective follow-up procedure is required, to both broadly categorise all objects and identify the most interesting ones for further follow-up on high-demand telescopes. In this context, we present PIRATE Mk II (Physics Innovations Robotic Astronomical Telescope Explorer) in its current role as a second stage exoplanetary candidate winnower. Our pipeline data reduction methods are explained as well as the rationale behind the current site, instrument set-up and mode of observations. With the present rate of data acquisition it should be possible to cover several hundred targets per year, or a quarter of all "A-grade", northern hemisphere, SWASP photometric follow-up candidates. Finally, we present and discuss example light curves and results, including typical mimic and exoplanetary signals.

New measures for the detection of habitable planets

Author: Ulrike Lemke

Durham University

Co-Authors: S. Schaefer A. Reiners

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

Since the first exoplanet discovery 20 years ago, detection methods have largely improved and lead to ever finer provisions on the strive towards the required accuracies. New instrumentation utilizing the radial velocity approach is aiming at 1ms^-1 precision in order to detect Earth-like planets in the habitable zone. Current efforts at the University of Göttingen include the implementation of a Fabry-Pérot-Interferometer as a mean to produce a reliable wavelength standard and furthermore investigate the incomplete scrambling phenomenon and viable mitigation strategies to ensure the required spectrograph performance.

What a high-accurate light curve could tell us about an exoplanet ?

Author: Dimitris Mislis

Institute of Astronomy - Cambridge University

Co-Authors: S. Hodgkin (IoA)

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

We present a new approach to determine the parameters of transiting extrasolar planetary systems using photometric light curves (LCs). An analysis that combines a treatment of various phenomena in high-accuracy LCs allows a derivation of orbital and physical parameters. Our method considers the primary transit, the secondary eclipses, and the overall phase shape of a LC between the occultations. Phase variations are induced by reflected and thermally emitted light from the planet. Moreover, the ellipsoidal shape of the star due to the gravitational pull from the planet induce phase variations. Using the approach above, we are able to characterise transiting systems only from the LC, but also to discover many non-Transiting exoplanets (new or in known planetary systems). The technique has many applications to current mission (e.g. Kepler) or future missions (such as PLATO)

The atmospheric structure of the hot Jupiters

Author: Alexis Smith

Keele University

Co-Authors: D. R. Anderson (Keele); N. Madhusudhan (Yale); and the SuperWASP team

Session: PL2: Exoplanets

Presentation type: Talk *00:00 Poster Session B*

Summary:

When a transiting planet is occulted by its host star, we can detect the emergent flux from the planet. Near-infrared measurements of the occultation depth yield the brightness temperature of the system at a particular wavelength, which can provide an estimate of the efficiency of the heat redistribution to the night-side of the planet. Measurements of the occultation depth at several wavelengths allow the construction of a spectral energy distribution for the planet and enable the atmospheric composition and structure (for instance whether or not the atmosphere has a thermal inversion or stratosphere) to be inferred. In addition to using the Spitzer Space Telescope to obtain occultations redwards of 3.6 microns, we have an ongoing programme using several ground-based telescopes at shorter wavelengths. These observations are often vital to limit the range of models which can describe the atmospheric structure and composition. Of particular interest is what determines whether a particular planet's atmosphere exhibits a thermal inversion. Various parameters have been proposed as key to this question, including insolation, stellar activity and stellar metallicity. By characterising the atmospheres of hot Jupiters occupying a range of parameter space, we aim to resolve this question. Here I present our latest results.

The structure of the inner heliosphere as revealed by amateur astronomers' images of comets

Author: Yudish Ramanjooloo

UCL/ Mullard Space Science Laboratory

Co-Authors: G. H. Jones (UCL/MSSL, Centre for Planetary Science), A. J. Coates (UCL/MSSL, Centre for Planetary Science), M. Owens (University of Reading) (1) Mullard Space Science Laboratory, Department of Space & Climate Physics, University College London, Holmbury St. Mary, Dorking, Surrey RH5 6NT, UK, (yr2@mssl.ucl.ac.uk) (2) The Centre for Planetary Science at UCL/Birkbeck, Gower Street, London, WC1E 6BT, UK. (3) Dept. of Meteorology, University of Reading, UK

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Talk *10:00 Wednesday 28th 10:00-11:15*

Summary:

Comets' plasma tails have been studied as natural solar wind probes since the mid-20th century. The appearance, structure, and orientation of a plasma tail are primarily controlled by local solar wind conditions. When the observing geometry is ideal, the direction and dynamics of the tail can reveal temporal and spatial variations in the solar wind flow local to the comet. These variations can be manifested as tail condensations, kinks, and disconnection events. Amateur images of comets obtained with modern equipment and sensors are arguably better in quality than professional images obtained only 2-3 decades ago. We derive solar wind velocity estimates from amateurs' images of C/2001 Q4 (NEAT) and C/2004 Q2 (Machholz), and compare them to observed and modelled near-Earth solar wind data. We attempt to show the validity of amateur images of comets as diagnostic tools to understand solar wind variability in the inner heliosphere. Our unique analysis technique offers an opportunity to investigate historical images of comets as they provide snapshots of the variability of solar wind conditions over past solar cycles, e.g. latitudinal variations of the solar wind, heliospheric current sheet sector boundaries and the boundaries of transient features, such as coronal mass ejections and corotating interaction regions. We also include results for comet C/2011 W3 (Lovejoy) using recent images from heliospheric imagers and coronagraphs aboard STEREO A and B and SOHO. This provides the perfect opportunity to deduce the solar wind velocity close to the Sun and to validate our technique from three different vantage points.

A survey of corotating interaction regions observed by the STEREO HI imagers 2007 - 2010

Author: Thomas Michael Conlon

University of Leicester

Co-Authors: S. E. Milan (University of Leicester); A. O. Williams (University of Leicester); J. A. Davies (Rutherford Appleton Laboratory)

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Talk *10:15 Wednesday 28th 10:00-11:15*

Presentation type: Talk *10:15 Wednesday 28th 10:00-11:15*

Summary:

We present observations of corotating interaction regions (CIRs) by the heliospheric imagers (HI) aboard NASA's STEREO mission. CIRs are formed by the interaction between fast and slow solar wind streams ejected from active regions on the solar surface that rotate with the Sun. These form families of high density features that propagate out into the solar system and can be imaged by STEREO HI. These observations allow estimates of the radial velocity and trajectory of the plasma and also the position of the source regions on the solar surface. In total, from January 2007 to June 2010, 64 events were observed. By using in-situ data from the STEREO and ACE spacecraft it was possible to ascertain that the features travelled out into the solar system at the slow solar wind speed and that arrival times of the features at 1 AU could be predicted with good accuracy. HI appears to not observe all of the CIRS present in the in-situ data and possible reasons for this are discussed.

A Direct Test for Models of Magnetohydrodynamic Turbulence in the Solar Wind

Author: Andrew Turner

CFSA, University of Warwick

Co-Authors: G. Gogoberidze (Centre for Fusion, Space and Astrophysics; University of Warwick, Coventry, CV4 7AL, United Kingdom) S. C. Chapman (Centre for Fusion, Space and Astrophysics; University of Warwick, Coventry, CV4 7AL, United Kingdom)

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Talk *10:30 Wednesday 28th 10:00-11:15*

Summary:

Anisotropy is a key subject in the study of magnetohydrodynamic (MHD) turbulence. It is well known that in the presence of a background magnetic field there is a preferred direction imposed on the plasma resulting in an inherent anisotropy in the turbulent fluctuations between the parallel and perpendicular directions with respect to the background magnetic field. The solar wind provides a unique environment to study MHD turbulence and its evolution. Recent analysis of the in-situ solar wind observations have demonstrated that there is an additional anisotropy between the perpendicular directions with respect to the direction of sampling, which is not predicted by turbulence theories. This has been found to be a result of the reduced power spectral tensor. Using high resolution Ulysses magnetic field data with a cadence of 1s between days 91-146 of 1995 we will demonstrate that it is possible to use the anisotropy that results from the reduced power spectral tensor to directly test models of MHD turbulence in the solar wind. We will present the results of the test when used on the Goldreich-Sridhar model of "critical balance" and the "Slab + 2D" model. It will be shown that the Goldreich-Sridhar model alone cannot account for the observations unless an additional component is also presented. We acknowledge the instrument teams of Ulysses for the data and the funding of STFC. Related papers: A. J. Turner et al., Nonaxisymmetric Anisotropy of Solar Wind Turbulence as a Direct Test for the Models of Magnetohydrodynamic Tubulence, PRL (In press) A. J. Turner et al., Phys. Rev. Lett., 107, 095002 (2011)

Small-Scale Structure of Slow Solar Wind Transients

Author: Stuart A. Hardwick

Institute of Mathematics and Physics, Aberystwyth University

Co-Authors: M.M. Bisi (Institute of Mathematics and Physics, Aberystwyth University), J.A. Davies (RAL Space, Rutherford Appleton Laboratory), R.A. Fallows (Institute of Mathematics and Physics, Aberystwyth University & ASTRON, The Netherlands Institute for Radio Astronomy), A.R. Breen (R.I.P) (Aberystwyth University), R.A. Harrison (RAL Space, Rutherford Appleton Laboratory), and C.J. Davis (RAL Space, Rutherford Appleton Laboratory & Meteorology Department, Reading University)

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Talk *10:45 Wednesday 28th 10:00-11:15*

Summary:

The Heliospheric Imagers (HIs), aboard the Solar TErrestrial RElations Observatory (STEREO) twin spacecraft, observe the heliosphere to reveal a high degree of meso-scale solar wind structure. The high temporal resolution and large spatial coverage of the HIs allows good comparison with two-station observations of interplanetary scintillation (IPS) observing the slow solar wind on smaller spatial scales. With the combination of these techniques it is possible to determine micro-scale structure which may be embedded in meso-scale, slow solar wind transients. Similar patterns of IPS variation in the outflow speed and in the perceived magnetic-field orientation have been observed, providing evidence of micro-scale transients in the slow solar wind, questioning previous ideas on the origins of the slow solar wind itself. Two case studies will be explored and their implications discussed.

Past, Present, and Planned Heliospheric Remote-Sensing Observations at Aberystwyth Uni. (Invited)

Author: M.M. Bisi

Institute of Mathematics and Physics, Aberystwyth University

Co-Authors: R.A. Fallows (Institute of Mathematics and Physics, Aberystwyth University/ASTRON, the Netherlands Institute for Radio Astronomy), A.R. Breen (Institute of Mathematics and Physics, Aberystwyth University), E.A. Jensen (Planetary Science Institute, USA), B.V. Jackson (Center for Astrophysics and Space Sciences, University of California, San Diego), R.A. Harrison (RAL Space, Rutherford Appleton Laboratory), S. Hardwick (Institute of Mathematics and Physics, Aberystwyth University), and G.D. Dorrian (Institute of Astronomy and Astrophysics, National Observatory of Athens).

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Talk *11:00 Wednesday 28th 10:00-11:15*

Summary:

Remote-sensing studies of the inner heliosphere using radio telescopes and arrays are carried out through observations of interplanetary scintillation (IPS). These observations record radio waves from compact astronomical natural sources. Such sources can also be used for the observation of Faraday rotation (FR) as well as using spacecraft radio beacons. FR, combined with IPS or white-light imager observations, can provide essential information on the Sun's extended magnetic-field structure out into interplanetary space. Here, we give an overview of works past and present in honour of the late Dr. Andrew (Andy) R. Breen, of Aberystwyth University, and also discuss plans for the future. These will include continued remote-sensing observations using the European Incoherent SCATter (EISCAT) radio telescopes based across Northern Scandinavia, the Multi-Element Radio-Linked Interferometer Network (MERLIN) system based across the UK, and the LOw Frequency ARray (LOFAR) based across Central and Northern Europe. These employ analyses from the University of California, San Diego (UCSD) three-dimensional (3-D) tomography algorithms in addition to other remote-sensing data. The 3-D reconstruction and visualisation tools make it possible to compare multi-point in-situ measurements from various deep-space spacecraft, and allow us to learn further about the solar wind and its subsequent outflow from the Sun, and indeed insights into space-weather forecasting.

An analysis of the origin and propagation of the multiple coronal mass ejections of 1 August 2010

Author: Richard Harrison

Rutherford Appleton Laboratory

Co-Authors: J.A. Davies (Rutherford Appleton Laboratory), C. Möstl (University of California, Berkeley, USA), Y. Liu (University of California, Berkeley, USA), M. Temmer (University of Graz, Austria), M.M. Bisi (Aberystwyth University), J.P. Eastwood (Imperial College London), C.A. de Koning (Space Weather Prediction Center, Bouder, USA), N. Nitta (Lockheed Martin Advanced Technology Centre, Palo Alto, California), T. Rollett (University of Graz, Austria), C.J. Farrugia (University of New Hampshire, USA), R.J. Forsyth (Imperial College London), B.V. Jackson (University of California, San Diego, USA), E.A. Jensen (Planetary Science Institute, Tucson, USA), E.K.J. Kilpua (University of Helsinki, Finland), D. Odstrcil (NASA/Goddard Space Flight Center, Maryland, USA), D.F. Webb (Boston College, USA)

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Poster *Poster Session A*

Summary:

On 1 August 21010, a complex of active regions and adjacent filament channels in the northern solar hemisphere was the source of a four major coronal mass ejections (CMEs), the effects of which were detected at Earth and other solar system bodies. A wealth of spacecraft-borne instrumentation allowed an unprecedented capability to explore methods for CME identification and tracking, and to assess issues regarding onset and planetary impact from these events. This has generated a series of research papers and workshops focused in particular on the observations from the STEREO spacecraft. The principal results from the interpretation and analysis of the observations, in particular from the Heliospheric Imagers, is given. The consistency of the results, derived from the wide variety of methods applied to such an extraordinarily complete dataset, has allowed us to converge on robust interpretations of the CME onsets and their arrivals at 1 AU. This work provides a valuable case study for space environment applications efforts.

A self-similar expansion model for use in solar wind transient propagation studies

Author: Dr Jackie Davies

RALSpace, UK

Co-Authors: R.A. Harrison (RALSpace, UK), C.H. Perry (RALSpace, UK), C. Möstl (University of Graz, Austria; Austrian Academy of Sciences, Austria; University of California, USA), N. Lugaz (University of Hawaii, USA), T. Rollett (University of Graz, Austria), C.J. Davis (RALSpace, UK; University of Reading, UK), S.R. Crothers (RALSpace, UK), M. Temmer (University of Graz, Austria), C.J. Eyles (RALSpace, UK; University of Valencia, Spain), N.P. Savani (Nagoya University, Japan; Naval Research Laboratory, USA)

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Poster *Poster Session A*

Summary:

Since the advent of wide-angle heliospheric imaging, a number of techniques have been developed to investigate the 3D structure and kinematics of solar transients from their signatures in single- and multi-spacecraft imaging observations. In the analysis of single-spacecraft imaging observations, much use has been made of the Fixed-φ Fitting (FPF) and Harmonic Mean Fitting (HMF) techniques, in which the transient is considered a radially-propagating point source (Fixed-φ, FP, model) and a radially-expanding circle anchored at Sun-centre (Harmonic Mean, HM, model), respectively. Initially, we compare radial speeds and propagation directions derived from applying these techniques to a large set of STEREO/Heliospheric Imager (HI) observations. As the geometries on which these two techniques are founded constitute extreme descriptions of solar transients in terms of their cross sectional extent, we describe a single-spacecraft fitting technique based on a more generalised model for which the FP and HM geometries form the limiting cases. In addition to providing transient speed and propagation direction, Self-Similar Expansion Fitting (SSEF) provides, in theory, the capability to estimate a transient's angular extent in the plane orthogonal to the field of view. Using HI observations, and a Monte-Carlo simulation, we assess the potential of the SSEF technique.

Observations of kinetic plasma turbulence in the Slow Solar wind

Author: Owen Roberts

Institute of Mathematics and Physics, Aberystwyth University

Co-Authors: X. Li

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Poster *Poster Session A*

Summary:

Using the k-filtering (aka wave telescope) method and data from Cluster's fluxgate magnetometer (FGM), kinetic plasma turbulence in quiet slow solar wind is investigated. The cluster spacecraft are able to give us a unique view into the solar wind, and enable us to differentiate between spatial and temporal variations in the magnetic field. Using the four satellites and the three time series' from each craft, the wavevectors that make up the time series' can be recovered, even when the frequencies of numerous waves are similar. Using a filter this is done for several frequency intervals in the spacecraft frame, and the dispersion relation of the waves is found by Doppler shifting the frequency into the plasma frame. Using this approach and data from 2004 (where the spacecraft separations are around 200km), two distinct cases are found. Both data sets indicate the presence of Kinetic Alfven waves propagating in directions nearly perpendicular to the background magnetic field. One case shows that only these quasi-perpendicular kinetic Alfven waves exist. Whereas there is also another, rarer case which shows a population of waves propagating at less oblique angles $\theta \sim 50^{\circ}$ (the angle between the wave vector k and mean magnetic field B) in the solar wind frame and the wave power of the two populations are similar. We will discuss the sources of the two

wave populations.

CME expansion in the inner heliosphere - STEREO/SECCHI observations

Author: Volker Bothmer

University of Goettingen

Co-Authors: Eckhard Bosman, Malte Venzmer, Jonas Hesemann

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Poster *Poster Session A*

Summary:

The Sun Earth Connection Coronal and Heliospheric Investigation suite comprises two sets of five dedicated telescopes suitable for imaging coronal mass ejections (CMEs) from Sun to beyond Earth orbit. With the Heliospheric Imagers on board the two STEREO satellites, for the first time CMEs can be tracked directly all the way from Sun to beyond Earth. This presentation summarises results inferred from the analysis of CME events identified in the HI observation in order to derive basic parameters describing the dimensions and topology of CMEs at Earth's orbit for improving space weather forecasting. The analysis is carried out in the framework of the EU FP7 project AFFECTS (Advanced Forecast For Ensuring Communications Through Space).

Observations of a sequence of events on the sun and their effects on the inner planets

Author: Ailsa Prise

MSSL/UCL

Co-Authors: L.K.Harra (MSSL/UCL) A.Aylward (UCL) S.A. Matthews (MSSL/UCL)

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Poster *Poster Session A*

Summary:

On 3rd November 2011 an X1.9 flare from NOAA 11339 was observed by STEREO-B/EUVI and SDO/AIA. It was followed by a large CME erupting, with a speed of roughly 1500km/s, from a second active region on the backside of the sun. This was observed in STEREO-A and B. An EIT wave is seen propagating from the first CME on the sun, at speed of 200km/s. It extends to a third active region in the middle of the disk visible from STEREO-B, which later produces another CME. These events are investigated in detail and observed as they propagate in various directions out into the solar system. A solar energetic particle event of accelerated electrons is seen by both STEREO spacecraft and by ACE at the Earth, after the first CME. The CME itself travels towards Mercury and Venus. With this study we aim to track these events into the solar system and compare the multiple effects of these events at the different planets that they encounter.

Inclusion of Real-Time in-situ Measurements into the UCSD Time-Dependent Tomography...

Author: M.M. Bisi

Institute of Mathematics and Physics, Aberystwyth University

Co-Authors: B.V. Jackson (Center for Astrophysics and Space Sciences, University of California, San Diego), P.P. Hick (Center for Astrophysics and Space Sciences, University of California, San Diego/San Diego Supercomputer Center, University of California, San Diego), J.M. Clover (Center for Astrophysics and Space Sciences, University of California, San Diego), A. Buffington (Center for Astrophysics and Space Sciences, University of California, San Diego), and M. Tokumaru (Solar-Terrestrial Environment Laboratory, Nagoya University).

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Talk *00:00 Poster Session A*

Summary:

...and its Resultant Space-Weather Forecast and Science Improvements The University of California, San Diego (UCSD) three-dimensional (3-D) time-dependent tomography programme has been used for well over a decade to reconstruct and forecast coronal mass ejections (CMEs) from observations of interplanetary scintillation (IPS) taken using the Solar-Terrestrial Environment Laboratory (STELab) IPS arrays. Here, we demonstrate how the inclusion of in-situ data (velocity and density) from space-borne instrumentation can be used in addition to observations of IPS to better-constrain a time-dependent tomographic reconstruction solution. We also consider the forecasting of both velocity and density in the near-Earth space environment using this

tomographic reconstruction solution. We also consider the forecasting of both velocity and density in the near-Earth space environment using this incorporated method. Supplementing observations of IPS with in-situ measurements results in the largest changes within the 3-D volume around the radial direction that incorporates these in-situ measurements; their inclusion greatly reduces the uncertainty in extending the 3-D reconstructions globally which are then distant in space and time from the spacecraft. Near the Earth, this analysis provides a finely-tuned real-time result up to the latest time for which in-situ measurements are available (when using real-time data), and enables more-accurate forecasting beyond this than observations of IPS alone allow. We show examples of this new algorithm and our real-time STELab IPS data, and provide a prescription to determine the forecasting accuracy.

Multi-spacecraft Study of the Heliosphere using HELIO

Author: R.D. Bentley

University College London (MSSL)

Co-Authors: M. Hapgood (STFC), J. Brooke (Univerity of Manchester), K. Benson (UCL-MSSL), S. Zharkov (UCL-MSSL), C.H. PErry (STFC), P. Richards (STFC), A. Le Blanc (Univerity of Manchester)

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Poster *Poster Session A*

Summary:

HELIO, the Heliophysics Integrated Observatory, provides a collaborative environment where scientists can discover, understand and model the connection between solar phenomena, interplanetary disturbances and their effects on the planets. The project is designed around a service-oriented architecture with resources established as services that support metadata curation and search, data location and retrieval, and data processing and storage. HELIO provides integrated access to the data and metadata from the domains that constitute heliophysics - solar, heliospheric, geophysics and planetary. More than 50 event catalogues can be used in the search; data from more than 150 instruments from nearly 50 observatories can be accessed. A comprehensive user interface is available and the serves can be used individually or accessed through IDL/SolarSoft; a workflow tool provides the ability to combine services together and it is possible to execute programmes on demand including propagation models. We will report on the status of HELIO and the services that are available and show how these resources can be used to address use cases involving multiple spacecraft and modelling related to the solar wind and propagating phenomena in the heliosphere. HELIO is a research infrastructure funded under Capacities programme of the EC's 7th Framework Programme (FP7).

Characteristics of the Solar Wind Electron Distribution at 10AU

Author: Andrew Walsh

MSSL/UCL

Co-Authors: C.S. Arridge (MSSL/UCL, Centre for Planetary Sciences at UCL/Birkbeck); A.N. Fazakerley (MSSL/UCL); A. Masters (MSSL/UCL, Centre for Planetary Sciences at UCL/Birkbeck), G.R. Lewis (MSSL/UCL, Centre for Planetary Sciences at UCL/Birkbeck), A.J. Coates (MSSL/UCL, Centre for Planetary Sciences at UCL/Birkbeck)

Session: SP1: Interplanetary observations of the solar wind

Presentation type: Poster *Poster Session A*

Summary:

The electron distribution in the solar wind has 3 components – a Maxwellian or thermal core, which generally isotropic, a isotropic suprathermal "halo" population existing at higher energy, which can be described by a kappa distribution, and the strahl - a beam of higher-still energy electrons that travels away from the Sun along the interplanetary magnetic field. The strahl can also be described by a kappa distribution. Current theories suggest the halo population is formed through pitch angle scattering of the strahl, so the presence or otherwise of each of these three populations can provide information about the evolution of the solar wind as it propagates through the heliosphere. To date there have been few observations of the solar wind electron distribution that include the higher energy, suprathermal, components made outside the orbit of Jupiter. Here we use data from CAPS-ELS, flying on Cassini, to characterise the electron distribution that was measured upstream of Saturn while the Cassini was on approach to the planet. We find that the measured distribution does contain one or more suprathermal components measurable above instrument background levels, with a higher phase space density in the direction one would expect the strahl to be observed, although it cannot yet be confirmed that this distribution conforms to the core-halo-strahl structure observed closer to the Sun.

Force-Free and MHD Models of the Coronal Magnetic Field

Author: Duncan H Mackay

University of St Andrews

Co-Authors:

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *10:00 Friday 30th 10:00-11:15*

Summary:

With the new space missions of HINODE and SDO we now have detailed observations of the Sun's photospheric magnetic field over a wide range of spatial and temporal scales. This includes scales ranging from the magnetic carpet all the way to active regions and the global field. In this review I will discuss the wide range of theoretical models that have been developed to extrapolate photospheric magnetic field observations into the corona. To begin with non-linear force-free field techniques will be described and applications considered. Following on from this, recent developments in MHD modelling using photospheric magnetograms will be described. For each application of the models, the success of these models when compared to coronal

observations will be discussed.

Sunspot Magnetic Geometry and Energy Changes associated with a Solar Flare.

Author: Sophie A. Murray

Trinity College Dublin

Co-Authors: D. Shaun Bloomfield (Trinity College Dublin), Peter T. Gallagher (Trinity College Dublin)

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *10:17 Friday 30th 10:00-11:15*

Summary:

Solar flare precursors are still not fully understood, despite evidence of flaring being related to changes in the topology and complexity of active region magnetic fields. NOAA active region 10953 was examined using Hinode/SOT-SP observations over the course of a GOES B1.0 flare, to test currently proposed variations in field topology. Magnetic energy and free magnetic energy changes were observed in the flare brightening region, with values increasing significantly ~ 6.5 - 2.5 hours before the flare. This result could be useful for future flare forecasting efforts. After the flare, magnetic energy values decrease but do not return to pre-flare 'quiet' values, suggesting the field has not completely relaxed. Results from NLFF, LFF, and potential field loop-tracing analysis confirm the field does not fully return to a potential state after the flare, indicative of a Wöltjer-Taylor relaxation process on a short time-scale.

Comparing force-free reconstructions of the solar corona based on SDO/HMI and SOLIS/VSM magnetograms

Author: Julia Thalmann

Max Planck Institute for Solar System Research

Co-Authors: A. Pietarila (National Solar Observatory, 950 N. Cherry Avenue, Tucson, AZ 85719, USA); X. Sun (W. W. Hansen Experimental Physics Laboratory, Stanford University, Stanford, CA 94305, USA); T. Wiegelmann (Max Planck Institute for Solar System Research, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany)

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *10:27 Friday 30th 10:00-11:15*

Summary:

The magnetic structure of the solar corona, in which presently no estimations of the magnetic field vector are routinely performed, is a viable field of research. To overcome the nonavailability of routine coronal magnetic field recordings, one makes use of the phtospheric magnetic field vector which is obtained from measurements of Stokes profiles on a regular basis. Based on the photospheric field as an input, force-free field approaches are used to estimate the magnetic field configuration in the higher atmospheric layers where magnetic forces are assumed to dominate. For the success of such force-free extrapolations it is necessary to preprocess the retrieved photospheric magnetic field vector in order to achieve suitable lower boundary conditions. Moreover, measurement uncertainties, as caused by noise or the particular inversion and azimuth ambiguity removal techniques, have to be taken into account. We use SDO/HMI and SOLIS/VSM photospheric magnetic field measureme! nts to model the force-free coronal field above solar active regions. Beside searching for the optimum modelling parameters for the particular instruments we compare the total magnetic energy content and free magnetic energy of the coronal model volumes and relate the appearing distinctions to the photospheric quantities such as the magnetic fluxes and electric currents.

Structure and Instability of Active-region Magnetic Fields

Author: Bernhard Kliem

University College London/MSSL and University of Potsdam

Co-Authors:

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *10:37 Friday 30th 10:00-11:15*

Summary:

Both observations and modelling of the magnetic field in solar active regions indicate that the storage of energy in current-carrying flux is usually limited to the core field at low heights in the vicinity of a polarity inversion line. A transition of this field from the structure of a loop arcade to a flux rope is generally conjectured to occur in association with eruptions, either some time before, or beginning with their onset. A brief review of the observational and modelling efforts to infer the existence of flux ropes prior to eruption onset will be given. The instabilities of force-free fields containing a flux rope will then be characterized, and their observational support will be discussed. Some open questions relevant in this context are the role of neutralized vs. non-neutralized currents, energy storage in toroidal vs. poloidal current components, and the dominance of ideal MHD instability vs. reconnection in the close mutual feedback.

MHD model of the lift-off of magnetic flux ropes

Author: Paolo Pagano

University of St Andrews

Co-Authors: D. H. Mackay (University of St Andrews)

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *10:54 Friday 30th 10:00-11:15*

Summary:

We address the eruption of newly formed magnetic flux ropes in the solar corona as result of the shearing and rotation of a couple of bipoles in non-linear force-free assumption. We extend to a full 3D MHD model a magneto-frictional modeling of magnetic flux ropes evolution whose states are adopted for numerical simulations performed with the advanced MHD code AMRVAC. To do so, we model the plasma density in the coronal atmosphere and we study the impact of plasma and solar gravity on the evolution the flux rope. The matching of the two models leads to realistic time-scales and dynamics. Consequently, we achieved an interesting hybrid model that can describe the evolution of a flux rope from the generation to the eruption. In conclusion, we find that the effectiveness of the eruption is influenced by the presence of the plasma and that the gravity has an effect on the propagation of the flux rope, rather than the eruption.

Interpreting the cyclonic behaviour of solar prominences

Author: Huw Morgan

IMAPS, Aberystwyth University

Co-Authors: X.Li; A.J.Leonard

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *11:04 Friday 30th 10:00-11:15*

Summary:

SDO/AIA offers an unprecedented view of the intricate dynamics of filaments (or prominences), and several cases of cyclone-like behaviour have been observed (see paper by Li, Morgan & Leonard in this session). Such complex dynamics is very difficult to interpret due to the LOS integration through the complicated filament structure (parts of which are optically thick). A simple density model helps to interpret the plasma movements observed by SDO/AIA. Apparent cyclonic or rolling movement can be replicated by a density wave propagating along a tightly-wound helical structure. A basic finding of this density model is that simple movements of plasma within relatively simple geometries can lead to extremely complicated-looking images and, therefore, misinterpretation. This work will help to understand the structural relationship between a filament and the surrounding cavity, since we can track movement of plasma from the filament to the cavity. How tightly-wound are helix magnetic structures which form and/or surround filaments? What are the connections between a filament and the surrounding arcade (i.e. can we track material flowing from the filament core to surrounding low-density structure)? How 'tangled' is the helix?

Nonlinear force-free coronal magnetic field modelling with SDO

Author: Thomas Wiegelmann

Max-Planck Institut fuer Sonnensystemforschung

Co-Authors: J.K. Thalmann; B. Inhester; T. Tadesse; X. Sun; J.T. Hoeksema

Session: SP2: Solar coronal magnetic fields

Presentation type: Poster *Poster Session B*

Summary:

The SDO/HMI instrument provides photospheric vector magnetograms with a high spatial and temporal resolution. We extrapolate these measurements into the solar corona, assuming a force-free state. We use an updated version of our nonlinear force-free optimization code, which allows to incorporate measurement errors in the photospheric magnetic field vector. We evaluate the resulting 3D equilibria by means of how well the force-freeness and solenoidal conditions are fulfilled, the angle between the magnetic field and the electric current and by comparing projections of magnetic field lines with loops visible in coronal images from SDO/AIA.

Build-up of coronal magnetic gradients from observed photospheric flows

Author: Anthony Yeates

Durham University

Co-Authors: G. Hornig (University of Dundee); B.T. Welsch (University of California, Berkeley)

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *00:00 Poster Session B*

Summary:

We use a sequence of high-resolution photospheric flows derived from Hinode/SOT magnetograms to study the build-up of magnetic gradients in the Sun's corona, without recourse to magnetic field extrapolation. By integrating trajectories of the flow field, we can derive the magnetic field line mapping that would result from the observed footpoint motions, assuming an ideal evolution in the corona. We map the quasi-separatrix layers (QSLs) in the mapping, and show that these correspond to Lagrangian coherent structures in the photospheric flow field. Their spatial pattern may be interpreted with the help of a simple analytical model of photospheric convection; we also use the model to predict how the magnetic structure might change given even higher-resolution observations.

Observations of apparent solar tornados

Author: Xing Li

Aberystwyth University

Co-Authors: H. Morgan, D. Leonard

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *00:00 Poster Session B*

Summary:

We present observations of apparent rotational structures (solar tornados) above the limb of the Sun using SDO/AIA data. The phenomenon is observed mainly at coronal temperatures but the presence of cold material at chromospheric temperatures cannot be ruled out. The high resolution data of SDO/AIA allow us to reveal the vivid details of apparent motions presumably along magnetic field lines. Apparent motions are found to originate from the root of the observed structures and describe clear helical paths. The shape and position of the overall structures experience dramatic changes indicating the instability of the magnetic structure as a result of such apparent motions. A local correlation technique is used to compute the plane-of-sky velocity field of the events and a speed as high as 50~70 km/s is typically observed, which is significantly smaller than the coronal sound speed. Hence the apparent motions are most likely due to the ejection of material along a long arcade of winding magnetic field. Although faint, the ejections are seen to eventually drop back to the surface through the long helical field. It is speculated that rotational magnetic structures previously observed on the solar disc by SDO/AIA may be physically similar to the solar tornados studied here but this is not a definite conclusion. A density model of such events is presented in another paper (by Morgan, Li & Leonard).

The onset of outflows in NOAA 11117 using SDO

Author: David Shelton

MSSL/UCL

Co-Authors: L.K.Harra (MSSL/UCL) L.M.Green (MSSL/UCL)

Session: SP2: Solar coronal magnetic fields

Presentation type: Talk *00:00 Poster Session B*

Summary:

Coronal outflows have been observed using EUV imaging on TRACE (Winebarger et al. 2001). However, it has only been since the launch of Hinode that direct spectroscopic detection of persistent outflows have been made using the EUV Imaging Spectrometer (EIS, Culhane et al. 2007). These persistent outflows have larger speeds in spectral lines that are formed at T > 1 MK (Del Zanna (2007,2008b), they are found at the edges of active regions and are unchanged over a long period of time. It has been suggested that these persistent outflows could be caused by chromospheric evaporation flow magnetic reconnection (Del Zanna 2008b) and that the outflows could be related to the origin of the slow solar wind (Sakao et al. 2007; Marsch et al. 2008). EIS observations show that these outflows are associated with “open” coronal magnetic field lines (Harra et al. 2008; Doschek et al. 2008). It has recently been shown that emerging flux into an active region can produce new and enhanced outflows (Harra et al. 2010) which have been shown through simulations to be caused by a mixture of compression and magnetic reconnection (Harra et al. 2011). In this work, we choose an example of a region that emerged into quiet Sun and not into a pre-existing active region. We present the results of a study using the Solar Dynamics Observatory (SDO) of the emergence of active region NOAA 11117 which was present on the solar disk between 21st October and 31st October 2010.By using the high spatial resolution and high temporal cadence of SDO, we are able to determine when in the formation of the active region that the onset of these persistent outflows started. The outflows were delayed by 3 and a half days from the region’s first emergence. By comparing the AIA 171Å data with the HMI magnetogram data for this period, we see that the persistent outflows only start to appear after the leading polarity starts to coalesce.

Influence of an atmospheric layer with non-negligible pressure on MHS equilibria

Author: Thomas Neukirch

Mathematics & Statistics, University of St. Andrews

Co-Authors: J.D.B.Hodgson (Mathematics & Statistics, University of St. Andrews); E.R.Priest (Mathematics & Statistics, University of St. Andrews)

Session: SP2: Solar coronal magnetic fields

Presentation type: Poster *Poster Session B*

Summary:

Solar magnetic fields models are often based on potential fields for reasons of simplicity. In the present paper, we investigate the influence of a lower atmospheric layer with non-negligible plasma pressure on the result of magnetic field calculations and compare this with potential fields, using translationally and rotationally invariant magnetohydrostatic models of a single flux source. To solve the magnetohydrostatic equations a numerical continuation method is used, which is capable of calculating sequences of equilibria. The plasma pressure function is determined by assuming approximate horizontal pressure balance along the lower boundary in the non-potential field limit and a simple stratified hydrostatic atmosphere in the potential field case. We show some illustrative examples of the differences between potential field and non-potential field calculations with the same boundary conditions.

Exploration of the Heliosphere

Author: Alan Smith

Mullard Space Science Laboratory, University College London

Mullard Space Science Laboratory, University College London

Co-Authors:

Session: SP3: UKSP/MIST Missions Forum 2012

Presentation type: Talk *17:00 Wednesday 28th 17:00-18:15*

Summary:

Unmanned spacecraft are currently in orbit around the Moon, Mercury, Venus, Mars, Vesta and Saturn with missions en-route to the comet Churyumov-Gerasimenko, Ceres, Jupiter and Pluto. Solar Orbiter is planned to travel within the orbit of Mercury to establish the link between solar activity and the solar wind. These are truly exciting times and a review will be provided of current and future space mission opportunities for the space-based exploration of the Heliosphere. The future exploration will depend upon many factors, not least technology. The development of new technologies such as novel

forms of power and propulsion, inter-satellite communication and a general reduction in size means that in situ exploration is becoming cost-effective. Lunar exploration is no longer the sole province of NASA (and Russia). The presentation will look at where such new technologies can be employed and some of the mission studies that are underway in this area. In particular multi-satellite missions will be reviewed including those in which the satellite orbits are not managed, formation flying and primary/secondary satellite combinations. Space agency (UK, ESA, NASA, China, India and Russia) agendas, priorities and pragmatics will be taken into consideration.

KuaFu – exploring the Sun-Earth connection

Author: Steve Milan

University of Leicester

Co-Authors: J.Shi (National Space Science Center, Chinese Academy of Sciences, Beijing, China); M.Dunlop (Rutherford Appleton Laboratory, Didcot, UK); A.N.Fazakerley (Mullard Space Science Laboratory, UCL, UK); B.Hubert (University of Liège, Liège, Belgium); B.Lavraud (Institut de Recherche en Astrophysique et Planétologie, Toulouse, France); N.Østgaard (University of Bergen, Bergen, Norway); P.Escoubet, P.Falkner, M.Taylor, A.Wielders (European Space Research and Technology Centre, Noordwijk, The Netherlands)

Session: SP3: UKSP/MIST Missions Forum 2012

Presentation type: Talk *17:15 Wednesday 28th 17:00-18:15*

Summary:

KuaFu is a multi-spacecraft mission designed to study the Sun-Earth connection, taking measurements from the solar surface, through interplanetary space, and into the magnetosphere and ionosphere. It is expected to comprise two components: KuaFu-A, to be launched to L1 to provide solar imaging and in situ solar wind monitoring, and KuaFu-B, an Earth-orbiting component to study the Earth's auroral and magnetospheric response to solar wind disturbances. KuaFu-A will be built by the Chinese Academy of Sciences, and is expected to be launched in the 2015-2016 timeframe. The European Space Agency is currently studying the feasibility of providing KuaFu-B, for launch in 2017. The current concept for KuaFu-B calls for two auroral imaging spacecraft which will provide continuous coverage of the northern hemisphere auroras and systematic, simultaneous views of both northern and southern hemisphere auroras. This talk will describe both KuaFu-A and -B spacecraft and payloads, and discuss the Sun-Earth connection science that will be addressed.

New space weather applications and novel designs

Author: Chris Davis

STFC RAL Space / University of Reading

Co-Authors: R. Harrison (STFC - RAL Space); D.Griffin (STFC - RAL Space); S.Eckersley (Astrium);M.Pastena (SSBV Space and Ground System UK);A.Tatnall (University of Southampton);A.Kisdi (STFC - RAL Space);C.McQuirk (STFC - RAL Space);R.Parker (STFC - RAL Space);O.Poyntz-Wright (STFC - RAL Space);K.Ward (STFC - RAL Space);C.Eyles (STFC - RAL Space);S.Kemble (Astrium) Giles Case, STFC - RAL Space Alexander Elliott, Astrium Graham Viney, Astrium Matthew Stuttard, Astrium Simon George, University of Southampton

Session: SP3: UKSP/MIST Missions Forum 2012

Presentation type: Talk *17:30 Wednesday 28th 17:00-18:15*

Summary:

As far as coronal imaging and heliospheric imaging are concerned, we have demonstrated a superb capability for the imaging and tracking of coronal mass ejections and co-rotating interaction regions through our science missions – in particular the SOHO and STEREO spacecraft. Of particular note are the SOHO LASCO coronagraph and the STEREO Heliospheric Imagers (HI) which are at the forefront of international efforts to explore methods for the tracking and prediction of geomagnetic events at Earth. A number of international and national activities are beginning to explore options for deploying such instruments on speace weather applications missions and we report on these activities. Theis include strategic discussions within Europe, between the UK and US, and mission concept studies which include dedicated HI spacecraft out of the Sun-Earth line. The approach is very diferent to our usual science-driven instrumentation, often calling upon basic, robust instrumentation with the minimum of complexity, but with 24-hour-a-day operation and interpretation. as part of this outlook we intorudce the Heliospheric imaging for Assessment of Global and Regional Infrastructure Damage(HAGRID) mission study that was carried out in the RAL Space Concurrent Design Facility in early 2011, a novel space weather alert mission located 40o-60o ahead of the Earth in its orbit. This assessment study established a baseline design and found that such a system is capable of providing the required space weather services and can be implemented as a low-cost pathfinder mission.

A ROSA view for Solar Physics

Author: Mihalis Mathioudakis

Queen

Co-Authors:

Session: SP3: UKSP/MIST Missions Forum 2012

Presentation type: Talk *17:45 Wednesday 28th 17:00-18:15*

Summary:

Research topics in solar physics, in particular those related to the dynamic Sun and the heating of its outer regions, involve observations and modelling of wave phenomena and explosive events over very short timescales. Ground based solar observations can provide some of the highest spatial (0.1”), spectral (200,000) and temporal resolutions (0.1 sec). These are vital in order to link small-scale processes with the resultant large-scale phenomena, such as flares,

prominences and coronal mass ejections. We present a brief overview of highlights from the ROSA instrument and discuss the prospects for UK involvement in the 4-m class solar facilities.

The Solar-C mission

Author: Louise Harra

UCL-MSSL

Co-Authors: Saku Tsuneta (NAOJ) Luca Terica (Max-Planck-Institut fuer Sonnensystemforschung) and the Solar-C team

Session: SP3: UKSP/MIST Missions Forum 2012

Presentation type: Talk *18:00 Wednesday 28th 17:00-18:15*

Summary:

The overarching science goal behind this mission is to understand how the Sun's magnetic field drives the flow of mass and energy through the solar atmosphere. Understanding how this flow takes place requires detailed knowledge of the magnetic field and the proposed instrumentation for Solar-C will make revolutionary new measurements of the magnetic field in the chromosphere, providing the first proper boundary conditions for extrapolating the field into the corona. Solar-C instrumentation will also provide all-encompassing plasma diagnostic capabilities and, with the highest resolution observations ever taken at all temperatures present throughout the atmosphere, will produce fundamental advances in our understanding of how magnetic energy is released through reconnection, wave dissipation, and particle acceleration. The science goals have implications for fundamental questions within solar physics and for other astrophysics areas as they are dealing with basic processes that can occur throughout the universe.

The SDO data hub at UCLan

Author: S. Regnier

University of Central Lancashire

Co-Authors: D. S. Brown, S. A. Chapman, S. Dalla, C. Kay, M. S. Marsh, R. W. Walsh

Session: SP3: UKSP/MIST Missions Forum 2012

Presentation type: Poster *Poster Session A*

Summary:

In the advent of the Solar Dynamics Observatory (SDO), a data pipeline for the distribution of data and associated data products has been developed throughout the world (US, Europe and Asia). The UK node within this pipeline is located at the University of Central Lancashire (UCLan), where a data centre has been established to host a rolling SDO/AIA and SDO/HMI archive for about five consecutive months: the archive currently contains all SDO/AIA level 1 data for all wavelengths and at the full cadence, and the SDO/HMI line-of-sight magnetic field, Dopplershift and intensity maps. The data centre is providing SDO data to the large UK solar scientific community through the commonly used SolarSoft package and also through the Virtual Solar Observatory (VSO) web interface. We describe the architecture of the archive, focusing on the many ways in which everybody can retrieve the data. We also discuss the download speeds to retrieve data from the UCLan hub compared to overseas archives.

The SWARM mission opportunity

Author: malcolm Dunlop

RAL

Co-Authors: H Luehr (GFZ) and M. Dunlop (RAL)

Session: SP3: UKSP/MIST Missions Forum 2012

Presentation type: Talk *00:00 Poster Session A*

Summary:

The ESA SWARM mission is a three-spacecraft mission designed to explore both external and internal influences on the Earth's magnetic field in unprecedented detail. It is due for launch in the summer of 2012 and is the subject of a dedicated session (MST2) within NAM 2012. As both an Earth Explorer mission and an important resource for space weather science, the mission has attracted interest from the geomagnetic and MIST communities. A number of UK proposals have been submitted to an ESA call for science and mission support projects (SSVO), exploring: exploitation and data use, data

verification and modelling. These form parallel (proposed) activities to the more formal forum of the German SWARM project office. Thus, these UK plans, reflected in both Germany and the UK, highlight the crucial role of science in supporting SWARM operations, including the possible coordination with data from other spacecraft and with ground-based sensors. This presentation to the missions forum will provide a short overview of the dedicated session and will list UK plans for related projects which have been submitted to the ESA SSVO call. We will outline the relevance of the mission to a range of RAS science.

SPARK: Solar Particle Acceleration, Radiation and Kinetics

Author: Sarah Matthews

UCL Mullard Space Science Lab.

Co-Authors: The SPARK consortium

Session: SP3: UKSP/MIST Missions Forum 2012

Presentation type: Poster *Poster Session A*

Summary:

Energetic particles are critical components of plasma populations found throughout the universe. The proximity of the Sun and the range of high-resolution diagnostics available within the solar atmosphere offers unique opportunities to study the processes involved in particle acceleration through the use of remote sensing observations of the radiative signatures of accelerated particles, and of their plasma and magnetic environment. We outline a mission concept designed to target the broad range of energy, spatial and temporal scales over which particle acceleration occurs in the solar atmosphere, in order to determine how and where energetic particles are accelerated. The SPARK concept combines highly complementary imaging and spectroscopic observations of radiation from energetic electrons, protons and ions set in their plasma and magnetic context. The payload comprises focusing-optics X-ray imaging covering the range from 1 - 60 keV; indirect HXR imaging and spectroscopy from 5 to 200 keV, γ-ray spectroscopic imaging with high-resolution LaBr3 scintillators, and photometry and source localisation at far-infrared wavelengths in addition to soft X-ray imaging of the corona and vector magnetography of the photosphere and chromosphere. SPARK will additionally provide exciting new insights into the origin of particle acceleration in other regimes, including terrestrial gamma-ray flashes (TGF), the origin of γ-ray bursts, and the possible existence of axions.

Solar Orbiter: mission overview

Author: Tim Horbury

Imperial College London

Co-Authors:

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Talk *11:45 Wednesday 28th 11:45-13:15*

Summary:

Solar Orbiter is Europe's upcoming mission to explore the connection between the Sun and the heliosphere. Due to launch in 2017, it will carry a focussed payload of ten remote sensing and in situ instruments, to fully characterise the Sun's interior, surface, atmosphere and interplanetary space. We present a short overview of the mission, including its schedule, orbit and operating plans.

Solar Orbiter remote sensing instrumentation: what will we be able to measure?

Author: Louise Harra

UCL-MSSL

Co-Authors:

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Talk *12:00 Wednesday 28th 11:45-13:15*

Summary:

The Solar Orbiter mission is an encounter mission that will probe the inner heliosphere and the source of the solar wind by having a mission orbit that reaches 0.28 A.U. Both seeing the source of the solar wind and measuring its properties are performed by a range of 10 instruments. This talk aims to summarise what the 6 remote sensing instruments will measure and how these measurements will help address the mission goals.

Solar Orbiter: In-situ Instrument Capabilities and Measurements

Author: Prof Christopher Owen

UCL/Mullard Space Science Laboratory

Co-Authors: C.J. Owen (UCL/Mullard Space Science Laboratory); T.S. Horbury (Imperial College); M. Maksimovic (Observatoire de Paris Meudon); J.Rodriguez-Pacheco (University of Alcalá); R.J. Wimmer-Schweingruber (University of Kiel)

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Talk *12:15 Wednesday 28th 11:45-13:15*

Summary:

In this presentation we briefly describe the configuration and capabilities of the sensors within the group of instruments that will make in situ measurements on the Solar Orbiter mission. These will be provided within 4 suites of sensors: the Solar Wind Analyzers (SWA), the Energetic Particle Detectors (EPD), the Magnetometer (MAG) and the Radio and Plasma Waves (RPW) Experiment. SWA (C. J. Owen, PI, UK) consists of 4 sensors serviced by a central DPU and will measure and fully characterize the major constituents of the solar wind plasma (protons, alpha particles, electrons, heavy ions) between 0.28 and 1.4 AU. EPD (J. R. Pacheco, PI, Spain) is made up of 5 sensors which together will measure the properties of suprathermal ions and energetic particles in the energy range of a few keV/n to relativistic electrons and high-energy ions (100 MeV/n protons, 200 MeV/n heavy ions). MAG (T. S. Horbury, PI, UK) will provide detailed in-situ measurements of the heliospheric magnetic field, while RPW (M. Maksimovic, PI, France) will measure magnetic and electric fields at high time resolution and determine the characteristics of electromagnetic and electrostatic waves in the solar wind from almost DC to 20 MHz. A sister presentation will address the configuration and capabilities of the remote sensing group of instruments on the mission.

Solar Orbiter science goals with remote sensing instruments

Author: Thomas Wiegelmann

MPI fuer Sonnensystemforschung

Co-Authors: E. Marsch

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Talk *12:30 Wednesday 28th 11:45-13:15*

Summary:

We give an overview of several science goals of the Solar Orbiter mission that can be addressed using a suite of remote sensing instruments observing the Sun in the visible, EUV and X-ray wavelengths. Important questions are: (1) How does the solar dynamo work and drive connections between the Sun and the heliosphere? The PHI instrument will provide detailed knowledge of how the magnetic flux is transported to and reprocessed at high solar latitudes and the properties of the polar magnetic field. These measurements are also important for the understanding of the global heliospheric field. (2) Where are the sources of the solar wind and how is the solar wind accelerated? The EUV imager and the EUV spectrometer will provide plasma diagnostics of dynamic small scale structures involved in this process.

Solar Orbiter: Heliospheric science

Author: Mathew Owens

University of Reading

Co-Authors:

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Talk *12:45 Wednesday 28th 11:45-13:15*

Summary:

Solar Orbiter will carry a suite of in situ instrumentation, enabling unique measurements of the inner heliosphere and hence solar wind soon after its formation. This will help resolve a number of outstanding questions about the evolution of important heliospheric processes. This talk will briefly review the scientific issues addressable by Solar Orbiter, primarily the in situ instrumentation. Measurements of the magnetic field structure in young CMEs will aid in the interpretation of white-light images and, consequently, the evolution of solar eruptions from the Sun to the Earth. Conversely, observations of the near-Sun steady state magnetic fields will enable changing magnetic topology and solar connectivity to be inferred, which plays a role in the solar cycle. Determining the formation and properties of inner-heliosphere shocks has important implication for the generation and subsequent transport of energetic particles throughout the heliosphere. Finally, Solar Orbiter will be able to probe the sources of turbulence in the solar wind.

The origins and heliospheric evolution of homologous CMEs originating from NOAA AR11093

Author: Kimberley Steed

KU Leuven

Co-Authors: G. Lapenta (KU Leuven)

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Talk *13:00 Wednesday 28th 11:45-13:15*

Summary:

The relative locations of the STEREO, SOHO, SDO and Venus Express spacecraft in August 2010 provide an opportunity for unique multi-spacecraft observations of two homologous CMEs. On 7 August 2010, a halo CME originating from NOAA AR11093 is observed remotely by STEREO B. Seven days later this active region erupts again, and a halo CME is observed remotely by STEREO A on 14 August 2010. We show that both eruptions are associated with reverse S-shaped flux rope structures and display a number of typical large-scale features relating to CMEs, including coronal dimmings and EUV waves. By combining remote sensing and in situ observations of the ejecta, we consider the structure and heliospheric evolution of these CMEs and their interplanetary counterparts. We find that our estimate of the dimensionless expansion rate of the 14 August 2010 magnetic cloud suggests that this structure may be perturbed by a high speed stream, likely to originate from a coronal hole that is not evident during the 7 August 2010 CME eruption. Additionally, a comparison of the orientations of the axes of the erupting flux ropes near the Sun and in interplanetary space reveals that both CMEs

Additionally, a comparison of the orientations of the tips of the erupting flux ropes near the Sun and in interplanetary space reveals that such CMEs appear to undergo significant rotation as they expand into the heliosphere.

The Spectrometer/Telescope for Imaging X-rays (STIX)

Author: Marina Battaglia

University of Applied Sciences Northwestern Switzerland

Co-Authors: The STIX team

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

One of Solar Orbiter's main science goals is to address how solar eruptions produce energetic particles that fill the heliosphere. X-rays are an important diagnostic of the properties of accelerated electrons near the Sun. STIX will measure the timing, intensity, location and spectrum of thermal and non-thermal X-rays by means of imaging-spectroscopy over a wide energy range of 4 to 150 keV, with energy resolution ranging from 1 to 15 keV. With a 2 degree field of view capable of viewing the full Sun from 0.28 A.U., a spatial resolution of 7 arcseconds, and statistics-limited time resolution as short as 0.1 seconds, STIX will be able to locate and image the sites of solar flares and determine the spectrum of flare accelerated electrons. This will be particularly valuable in conjuncton with in-situ measurements of accelerated particles on Solar Orbiter. We present a short overview of the STIX instrument followed by a more detailed description of the science with a focus on collaborative studies between the different Solar Orbiter instruments.

The EUV Imager (EUI) for Solar Orbiter

Author: Louise Harra

UCL-MSSL

Co-Authors: and EUI team

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

EUI will provide image sequences of the solar atmospheric layers above the photosphere, thereby providing an indispensable link between the solar surface and outer corona that ultimately shapes the characteristics of the interplanetary medium. Scientific topics to be addressed include monitoring the low atmosphere counterparts of large-scale solar eruptive events such as CMEs and the study of fine-scale processes in the solar atmosphere. EUI will also provide the first-ever images of the Sun from an out-of-ecliptic viewpoint (up to 34° of solar latitude during the extended mission phase). The EUI instrument suite is composed of two High Resolution Imagers (HRI), one at Lyman-α and one in the extreme UV at 174 Å, and one dual band Full-Sun Imager (FSI) working alternatively at the 174 and 304 Å EUV passbands.

Solar Orbiter: The Solar Wind Analysers (SWA) Experiment

Author: Prof Christopher Owen

UCL/Mullard Space Science Laboratory

Co-Authors: C.J. Owen D.O. Kataria, B.K. Hancock, A.N. Fazakerley, C. Brockley-Blatt,(all UCL/Mullard Space Science Laboratory); P. Louarn (IRAP, Toulouse); S. Livi (Southwest Research Inc., Texas); R. Bruno (IFSI, Rome)

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

In order to achieve the Solar Orbiter mission science goals, we need high-cadence measurements of 3D velocity distribution functions of the solar wind electron, proton and aplha particles populations, abundant heavy ions such as O6+ and low iron charge states such as Fe9+ or Fe10+. These measurements are among those that will be made by the Solar Wind Analyser (SWA) suite on Solar Orbiter. This investigation is a major international hardware collaboration, led by the UK (P.I. institute: UCL/Mullard Space Science Laboratory). In addition to the overall leadership of the suite, UCL/MSSL will provide the bulk of the hardware for the Electron Analyser System, one of 3 sensor systems within the suite. The Proton-Alpha Sensor and the Heavy Ion Sensor are led by partners in France and the USA respectively, while a central data processing unit, to be built in Italy, serves all 3 sensors and completes the suite. In this poster we briefly present the science goals related to the in situ exploration of the inner heliosphere, in particular addressing the SWA sensor designs required to meet these goals under Solar Orbiters challenging measurement environment and present the progress to date on building the SWA sensors.

Observation of kinetic plasma turbulence in the solar wind

Author: XING LI

Aberystwyth University

Co-Authors: S.Y. Huang (Wuhan University), O.W. Roberts (Aberystwyth University)

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

Using Cluster data, the k-filtering technique is adopted to investigate the property of plasma turbulence at the scale of the ion gyroradius in the undisturbed solar wind conditions where the plasma beta is in the order of unity. We are able to determine the direction of wave propagation and the wave dispersion relation. Waves are found mainly propagating in directions quasi-perpendicular to the background magnetic field. We found tentative evidence that quasi-perpendicular kinetic Alfven waves, fast waves and Bernstein waves at the harmonic frequencies of alpha particles may all co-exist, although kinetic Alfven waves carry more power than the quasi-perpendicular fast waves. The study suggests that ion cyclotron resonance and Landau resonance are both operating during the period that the solar wind data in this study were taken. We will discuss the potential implications of the study to the question of the solar wind the acceleration in the near sun region where the plasma beta may be much smaller than unity.

Can we learn something new about solar prominence eruptions with Solar Orbiter?

Author: Nicolas Labrosse

University of Glasgow

Co-Authors: L. Harra (MSSL)

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

EUI (Extreme Ultraviolet Imager) will monitor the low atmosphere counterparts of large-scale solar eruptive events such as CMEs. As such it will ideally be suited to study prominence eruptions. Here we are primarily interested in investigating what we may learn from data returned by the High Resolution Imagers (HRI) in the Lyman-alpha channel, and the Full-Sun Imager (FSI) working at the 304 A EUV passband. In Labrosse & McGlinchey (2012) we showed how it is possible to exploit data at 304 A from SDO/AIA to make a diagnostic of the prominence plasma by comparing AIA observations with non-LTE radiative transfer calculations. These calculations take into account the strong Doppler dimming effect on the He II line induced by the outwards radial motion of the structure. Previous calculations have shown that the Ly-alpha line is also sensitive to the Doppler dimming effect. EUI offers a good opportunity to use both lines simultaneously at high-resolution and out of the ecliptic plane to study - among other phenomena - prominence eruptions. This paper will present new radiative transfer calculations combining results on both hydrogen and helium resonance lines, addressing the question of what we can learn from these observations.

Spectral diagnostics with SPICE

Author: Giulio Del Zanna

University of Cambridge

Co-Authors: H.E.Mason

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

We present a few spectral diagnostics available within the SPICE spectrometer on-board the Solar Orbiter mission and briefly review some aspects about the relevant atomic data. We also present a few science cases where we explore the possibility to link the remote-sensing observations of the source regions with the local in-situ measurements of the solar wind plasma parameters.

Solar Orbiter magnetometer: overview, science goals and status

Author: Tim Horbury

Imperial College London

Co-Authors: Helen O'Brien, Lee Matthews, Emanuele Cupido, Patrick Brown, Tim Oddy, Heather Lewtas (Imperial College London)

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

The magnetic field experiment on Solar Orbiter is central to all the science goals of the mission. There are 9 Co-Investigators of the instrument within the UK, at 7 institutions. It is a conventional fluxgate instrument with two sensors on a boom, in shadow, behind the spacecraft. The magnetometer was the first of the ten instruments to undergo Preliminary Design Review, which it passed in January 2012. We discuss the science goals of the instrument and how these feed into technical requirements. We present the instrument design including technical developments specific for this mission, and its current status.

Magnetic topology of Active Regions and Coronal Holes: Coronal Outflows and the Solar Wind

Author: Lidia van Driel-Gesztelyi

UCL MSSL

Co-Authors: J.L. Culhane (UCL, MSSL), D. Baker ((UCL, MSSL, UK), Demoulin, P. (Paris Obs., France), Mandrini, C.H. (IAFE, Buenos Aires, Argentina), De Rosa, M.L. (Lockheed Martin Lab., USA), Rouillard, A.P. (Univ. Toulouse, France), Opitz, A. (Univ. Toulouse, France), Stenborg, G. (George Mason Univ., USA), Vourlidas, A. (NRL, USA), Brooks, D.H. (NRL, USA)

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

When active regions are adjacent to coronal holes, interchange reconnection may lead to significant evolution of coronal hole boundaries. Reconnection can also take place between closed fields having a large connectivity gradient. Outcomes may include hot plasma outflows from active regions (ARs) with likely implications for solar wind (SW) plasma escaping along open magnetic field lines. During 2-18 January 2008 a pair of low-latitude opposite

polarity coronal holes were observed on the Sun with two ARs and the heliospheric plasma sheet located between them. We use the Hinode/ EIS to locate AR-related outflows and measure their velocities. STEREO imaging is also employed as are the ACE in-situ observations, to assess the resulting impacts on the interplanetary SW properties. Magnetic field extrapolations of the two ARs confirm that AR plasma outflows observed with EIS are co-spatial with quasi-separatrix layer locations, including the separatrix of a null point. Global potential field source-surface modeling indicates that field lines in the vicinity of the null point extend up to the source-surface, enabling a part of the EIS plasma upflows access to the SW. We find that similar upflow properties are also observed within closed field regions that do not reach the source surface. We conclude that some of plasma upflows observed with EIS remain confined along closed coronal loops, but that a fraction of the plasma may be released in the slow SW. This suggests that ARs bordering coronal holes can contribute to the slow SW. Analyzing the in-situ data, we conclude that the type of SW present (composition, temperature, speed and first ionization potential bias) depends on the type whether the AR is fully or partially enclosed by an overlying streamer. The analysis of remote sensing and in situ data in close combination is performed in preparation for the Solar Orbiter mission.

Coronal Jet, Magnetic Topology, and the Production of an Interplanetary Electron Stream

Author: Sarah Matthews

UCL Mullard Space Science Lab.

Co-Authors: Chuan Li, Lidia van Driel-Gesztelyi, Jian Sun and Chris Owen

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

Combining the in situ electron measurements and remote-sensing solar observations, as well as the calculated magnetic fields obtained from a potential-field source-surface model, we investigate the acceleration source of the impulsive solar energetic particle (SEP) events on 2007 January 24. We demonstrate that the jets associated with the hard X-ray flares and type-III radio bursts, rather than the slow and partial coronal mass ejections, are closely related to the production of interplanetary electron streams. The jets, originated from the well-connected active region (AR 10939) whose magnetic polarity structure favours the eruption, are observed to be forming in a coronal site, extending to a few solar radii, and having a good temporal correlation with the electron solar release. Our analysis enables us to propose a coronal magnetic topology relating the impulsive SEP events to their solar source. We discuss future extensions of this work with a view towards Solar Orbiter.

Science Goals of SPICE EUV Spectrometer for Solar Orbiter

Author: Andrzej Fludra

STFC Rutherford Appleton Laboratory

Co-Authors: D. Griffin (STFC RAL); M. Caldwell (STFC RAL); P. Eccleston (STFC RAL); S. Beardsley (STFC RAL); N. Waltham (STFC RAL); and the SPICE team

Session: SP4: Solar Orbiter mission - How does the Sun createand control the heliosphere?

Presentation type: Poster *Poster Session A*

Summary:

SPICE is an European-lead high-resolution imaging spectrometer with contributions from ESA member states (UK, Germany, France, Switzerland and Norway) and ESA. It is being considered by ESA as a facility instrument on the Solar Orbiter mission. SPICE will record spectra in two EUV wavelength bands, observing more than 70 emission lines over a wide range of temperatures from the chromosphere to the corona. SPICE will address the key science goals of the Solar Orbiter mission and investigate the links between the solar surface, corona and inner heliosphere. SPICE will measure plasma density and temperature, flow velocities, the presence of plasma turbulence and composition of solar plasmas. It will be observing, at all latitudes, the energetics, dynamics and fine-scale structure of the Sun's magnetized atmosphere. The SPICE instrument design, science goals and measurement capabilities are presented in this poster.

Using helioseismic oscillations to characterise the Sun's internal magnetic field

Author: Anne-Marie Broomhall

University of Birmingham

Co-Authors: W.J. Chaplin (University of Birmingham); Y. Elsworth (University of Birmingham)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *10:00 Tuesday 27th 10:00-11:15*

Summary:

The Sun's natural resonant oscillations (p modes) are trapped in well-defined volumes of the solar interior and are sensitive to the physical conditions of the gas through which they travel. Parameters of p modes, such as frequency, vary throughout the solar cycle and the size of the observed variation is related to the spatial distribution of the surface magnetic field. The presence of magnetic flux in the solar interior would affect the propagation of p modes. Therefore, p modes can be used to put constraints of the strength of any such magnetic field. For example, p modes can be used to limit the strength of the magnetic field just beneath the base of the solar convection zone. The frequencies of p modes have also, more recently, been associated with the quasi-biennial signal that is well observed in atmospheric measures of the Sun's magnetic field. In atmospheric proxies the quasi-biennial signal is observed only around solar maximum: It was, however, still visible in the p-mode frequencies during the recent, unusual solar minimum. We demonstrate that p modes have the potential to connect the solar interior with the Sun's atmosphere and to characterize the flux responsible for both the quasi-biennial signal

and the 11-yr solar cycle.

Multi-wavelength helioseismology with the Solar Dynamics Observatory

Author: Rachel Howe

University of Birmingham

Co-Authors: R.S.Bogart (Stanford University); K.Jain (National Solar Observatory); D.A.Haber (University of Colorado); C.Baldner (Stanford University)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *10:12 Tuesday 27th 10:00-11:15*

Summary:

While the Helioseismic and Magnetic Imager [HMI] aboard the Solar Dynamics Observatory [SDO] provides Doppler velocity [V], continuum intensity [Ic] and line depth observations, each of which is sensitive to the 5-minute acoustic spectrum, the Atmospheric Imaging Array [AIA] also observes at wavelengths -- specifically the 1600 and 1700 Angstrom bands -- that are formed in the lower solar atmosphere but have good sensitivity to acoustic modes. We describe the characteristics and phase relationships of the acoustic spectra in AIA and HMI observables both for Sun-as-a-Star and for local helioseismic analysis around an active region. The acoustic oscillations seen in the AIA UV bands exhibit a relationship with the Doppler velocity, and a response to surface magnetic activity, that more closely resemble the HMI line core intensity than the HMI continuum intensity; at frequencies above the acoustic cutoff these observables show an enhancement in power adjacent to the active region that is absent in the continuum intensity and is more distant from the areas of concentrated field than the well-known power enhancement in velocity observations.

MHD Sausage Oscillations in Magnetic Wave guides in the lower Solar Atmosphere

Author: Nabil Freij

University of Sheffield

Co-Authors: I. Dorotovic (Slovak Central Observatory); R. Erdelyi (University of Sheffield), V. Karlovsky (Hlohovec Observatory and Planetarium); R. J. Morton (University of Sheffield); M. S. Ruderman (University of Sheffield)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *10:24 Tuesday 27th 10:00-11:15*

Summary:

The lower solar atmosphere is host to a wide range of magnetic wave guides. From sunspots to inter-granular bright points, they are constantly buffeted by the surrounding photosphere from granulation, p-modes or by coherent sub-photospheric drivers. Here, we present the results of an observational study of MHD sausage waves in magnetic wave guides (pores and sunspots). By studying the temporal variations in area and intensity of these magnetic wave guides, it allows the observation and identification of MHD sausage waves. Using series of high-resolution intensity images with a small cadence and employing wavelet analysis in conjunction with empirical mode decomposition allows us to have a robust method for searching for and identifying characteristic periods hidden in the area and intensity data series. We found that the magnetic pore in Active Region 10968 displays three strong periods, 2-3, 8 and 13-14 minutes. The most plausible conclusion is that both the 2-3 and 8 minute periods detected are a harmonic of the fundamental 13-14 minute period. Due to the sharp gradients in the background equilibrium plasma parameters that exist at the boundaries of the photosphere and the transition region sets up a cavity that can support standing waves. This is the first observation of concurrent higher harmonics in a solar magnetic wave-guide in the lower solar atmosphere while the third reported observation of sausage modes in solar pores.

Revealing the nature of magnetic shadows of network magnetic elements with 3D-MHD simulations

Author: Oskar Steiner

Kiepenheuer-Institut für Sonnenphysik

Co-Authors: C. Nutto; M. Roth

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *10:36 Tuesday 27th 10:00-11:15*

Summary:

Summary:

We carry out three-dimensional numerical simulations of magneto-acoustic wave propagation in a solar atmospheric model that is threaded by a complexly structured magnetic field, resembling a typical magnetic network element. High frequency waves of 10 mHz are excited at the bottom of the simulation domain. On their way through the upper convection zone and through the photosphere and the chromosphere they get refracted and converted to different mode types. We apply a standard Fourier analysis for producing power maps representing a region including magnetic network elements. In the power maps of the line-of-sight velocities of the upper photosphere and the lower photosphere, we see clear signatures of the magnetic shadow. Magnetic shadows are known form observations: a seam of suppressed power surrounding magnetic network elements. We can demonstrate that the appearance of the shadow is linked to the mode conversion process. In fact, the power maps at these height levels show the oscillatory power distribution of three different magneto-acoustic wave modes.

Propagation of Alfvén Waves from the Corona to Chromosphere

Author: Alexander Russell

University of Glasgow

Co-Authors: L.Fletcher (University of Glasgow)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *10:48 Tuesday 27th 10:00-11:15*

Summary:

The corona and chromosphere are a coupled system, but how significant is this coupling? We present results from a 1D multi-fluid model, which quantify wave transmission from the corona to the chromosphere for different solar features (sunspot umbra, penumbra, facula, bright facula, plage and quiet sun). We also measure chromospheric heating due to ion-neutral friction and enhanced electron resistivity. Wave periods of one second allow energy transmission greater than 20%, with half of this energy converted to heat in the middle chromosphere by ion-neutral friction. This suggests that coronal waves could penetrate and heat the chromosphere if generated during solar flares. Transmission is substantially reduced for longer wave periods (30 seconds or more) and we confirm that losses are too low to account for observed decay of standing coronal loop oscillations.

Resonant damping of kink oscillations of cooling coronal magnetic loops

Author: Michael Ruderman

University of Sheffield

Co-Authors:

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *11:00 Tuesday 27th 10:00-11:15*

Summary:

After the coronal loop kink oscillations were first observed in 1998 by TRACE, they have received ample attention of solar physicists. One of important properties of these oscillations is its fast damping on the time scale of a few oscillation periods. A few mechanisms of this damping have been suggested, however now the most popular and comprehensively studied is resonant absorption. Another important property of oscillating coronal loops is that, very often, their temperature decreases during the oscillations, the typical timescale of the temperature variation being also equal to a few oscillation periods. We discuss the simultaneous effect of cooling and damping due to resonant absorption on the kink oscillations of coronal loops. The governing equation describing the kink oscillations is derived in the thin tube thin boundary layer approximation. The cooling time is assumed to be much larger than the oscillation period, and the WKB method is used to obtain the equation describing the dependence of the oscillation amplitude on time. This equation is solved numerically for various values of determining parameters. In particular, the question if the amplification due to cooling can balance the resonant damping and produce undamped oscillation is addressed. The conclusion is that the amplification due to cooling is not very efficient and can balance the resonant damping only when the density contrast is not very large and the cooling is very fast with the characteristic cooling time of the order of the oscillation period.

Recent results and future challenges for global helioseismology

Author: Professor William Chaplin

University of Birmingham

Co-Authors:

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *11:45 Tuesday 27th 11:45-13:00*

Summary:

In this talk I shall review the current state-of-play in global helioseismology, paying particular attention to results from the recent, unusual solar minimum and the subsequent rise toward solar maximum. I shall also discuss outstanding problems in solar (and more generally stellar) physics that the field will look to address in the coming few years.

Spatial damping of propagating kink waves

Author: David Pascoe

University of St Andrews

Co-Authors: I.De Moortel (University of St Andrews); A.W.Hood (University of St Andrews); A.N.Wright (University of St Andrews)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *12:08 Tuesday 27th 11:45-13:00*

Summary:

Observations have revealed ubiquitous transverse velocity perturbation waves propagating in the solar corona. We perform 3D numerical simulations of footpoint-driven transverse waves propagating in a low beta plasma. When density structuring is present, mode coupling in inhomogeneous regions leads to the coupling of the kink mode to the Alfvén mode. The frequency-dependent decay of the propagating kink wave is observed as energy is transferred to the local Alfvén mode. Modest changes in density are capable of efficiently converting energy from the driving footpoint motion to localised Alfvén

modes. Thus, realistic transverse footpoint motions will deposit energy to (azimuthal) Alfvén modes in the corona. Mode coupling is investigated in detail for propagating kink modes as an explanation for the observed wave damping and as a possible seismological tool. The observed strong damping of the Doppler shift oscillations indicates the presence of wide inhomogeneous layers at the edges of the loops. Our simulations (backed up by analytical calculations) show that in this regime, the traditional exp(-z/L) damping rate no longer applies. Hence, care has to be taken when seismologically inferring damping lengths from the observed oscillations.

The Effects of Line-of-Sight integration on Multistrand Coronal Loop Oscillations

Author: Ineke De Moortel

University of St Andrews

Co-Authors: D.J. Pascoe (University of St Andrews)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *12:20 Tuesday 27th 11:45-13:00*

Summary:

Observations have shown that transverse oscillations are present in a multitude of coronal structures. It is generally assumed these oscillations are driven by (sub)surface footpoint motions. Using fully 3D MHD simulations, we show that these footpoint perturbations generate propagating kink (Alfvenic) modes which couple very efficiently into (azimuthal) Alfven waves. Using an ensemble of randomly distributed loops, driven by footpoint motions with random periods and directions, we compare the absolute energy in the numerical domain with the energy that is 'visible' when integrating along the line of sight. We show that the kinetic energy derived from the line-of-sight (LOS) Doppler velocities is only a small fraction of the actual energy provided by the footpoint motions. Additionally, the superposition of loop structures along the LOS makes it nearly impossible to identify which structure the observed oscillations are actually associated with and could impact the identification of the mode of oscillation.

Line-of-sight geometrical effects on intensity perturbations by sausage modes

Author: Patrick Antolin

Centre for Plasma Astrophysics, K.U. Leuven

Co-Authors: T. Van Doorsselaere (Centre for Plasma Astrophysics, K.U. Leuven)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *12:32 Tuesday 27th 11:45-13:00*

Summary:

Interpreting observations is far from a trivial matter. It not only relies on our knowledge of what we consider there to be the correct physics and on our ability to apply a theoretical concept to a specific physical environment, but also on the response of the measuring instrument to the physical state of the latter. Translating a numerical simulation output to the observational scenario is a very delicate procedure and has become a field by itself, known as forward modeling. A clear example of this problem is the diagnostics of MHD waves, which often leads to several interpretations and heated debates in the solar community. In this talk we would like to demonstrate the several issues introduced by considering line-of-sight geometrical effects. We take a cylindrical tube simulating a loop in a low-beta coronal environment with a specific optically thin background, and let it oscillate with the sausage mode. We make a parametric study of the effects of the line-of-sight angle on the intensity, Doppler shift, width and non-Gaussianity of the spectral emission, for the sausage mode.

Longitudinal MHD Waves in Dissipative Time-Dependent Plasma

Author: Khalil Al-Ghafri

University of Sheffield

Co-Authors: R. Erdelyi

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *12:44 Tuesday 27th 11:45-13:00*

Summary:

Observations of waves in solar hot coronal loops indicate that the slow MHD mode oscillations suffer a strong damping essentially due to thermal conduction. Therefore, the influence of flow and cooling background plasma on the longitudinal standing slow magneto-acoustic waves is investigated. The cooling of hot background plasma is assumed to be dominated by the presence of thermal conduction. In a stratified atmosphere, the equilibrium of a uniform magnetised plasma is assumed to evolve as a function of time. The temperature variation of the background plasma is assumed to be in an exponential form and experiences decaying with characteristic cooling times. A 1D system of linearised MHD equations describing the upwardly standing magneto-acoustic mode generated in a hot coronal loop is derived. The WKB theory is used to find a time-dependent dispersion relation which describes the properties of standing acoustic (longitudinal) waves. The temporally varying amplitude is analytically obtained and the properties of Sturm-Liouville problems are employed to find the analytical solution. The analytically derived solutions are numerically displayed to shed light on the amplitude trend of the standing MHD waves. The resulting numerical evaluations show that the perturbed variable background plasma due to thermal conduction leads to a deep variation on the behaviour of slow standing magneto-acoustic waves. The oscillation amplitude is found to undergo a strong damping because of a dynamically cooling coronal loop.

Vorticity and surface Alfven waves in the solar corona.

Author: Tom Van Doorsselaere

KULeuven

Co-Authors: M. Goossens (KULeuven), J. Andries (KULeuven), R. Soler (KULeuven), I. Arregui (UIB), J. Terradas (UIB)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *12:56 Tuesday 27th 11:45-13:00*

Summary:

In this presentation, we consider the ubiquitously observed, transverse coronal waves (Tomczyk et al. 2007). They were first interpreted as Alfven waves, but this was later challenged by Van Doorsselaere et al. (2008), who argued that they were fast kink waves. Goossens et al. (2009) considered the ratio between the tension force and the pressure force, and pointed out that, for these modes, the tension force is always larger than the pressure force. Adding to this debate, we have studied the role of vorticity in these wave modes. We find that the vorticity is concentrated as a delta-function on the surface of Alfven speed discontinuity. Using this information, we make a connection with surface Alfven waves.

Solar Magnetoseismology

Author: Dr. Gary Verth

Northumbria University

Co-Authors:

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *14:15 Tuesday 27th 14:15-15:30*

Summary:

The Sun is the most relevant astrophysical object to study for humankind. It has a direct impact on Earth, life and society. Knowledge of our Sun's highly dynamic and magnetically dominated atmosphere is crucial towards understanding its interaction with the Earth and our local space environment. In this talk I discuss a most promising and exciting area of solar physics known as magnetoseismology. This technique, analogous to seismology here on Earth, analyses observations of waves in the Sun's dynamic and magnetically dominated atmosphere and compares them to the detailed results of mathematical models. From that comparison, crucial information about the Sun's local plasma environment can be obtained, e.g., magnetic field strength, which cannot be easily measured by other means. In the last decade, magnetoseismology of the Sun has made great leaps forward due to the advances of spaceborne telescopes. After initial success, a new generation of improved instruments primarily dedicated to detecting waves in the solar atmosphere were developed, e.g., Hinode (Japan), the Solar Dynamics Observatory(USA) and Rapid Oscillations in the Solar Atmosphere (UK). In this talk I will discuss current magnetoseismological techniques that can exploit the wealth of data from these "new generation" instruments to probe the structure of Sun's atmosphere to an unprecedented accuracy.

Propagating Disturbances in Coronal Loops: A Detailed Analysis of Propagation Speeds

Author: Greg Kiddie

University of st Andrews

Co-Authors: I. De Moortel(University of St Andrews)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *14:38 Tuesday 27th 14:15-15:30*

Summary:

Quasi-periodic disturbances have been observed in the solar atmosphere for many years now. They were first interpreted as slow magnetoacoustic waves. However, recent observations have questioned this interpretation as periodic disturbances in Doppler velocity were found to be in phase with the intensity oscillations, suggesting the disturbances could be quasi-periodic upflows. Here we conduct a detailed analysis of the velocities of these disturbances across several wavelengths using the Atomic Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO). We analysed 44 examples, including both sunspot and non-sunspot regions of the Sun, and look for a possible dependence of the propagation speed on the local plasma temperature. We also consider on what scale the underlying driver is affecting the properties of the propagating disturbances. Finally we consider the effect of removing the contribution due to the cooler ions in the 193 A wavelength line on the propagating disturbances.

On the non-existence of a cut-off frequency for the propagtion of kink-modes on a stratified tube

Author: J. Andries

KULeuven

Co-Authors:

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *14:51 Tuesday 27th 14:15-15:30*

Summary:

We recently (Andries and Cally, ApJ, 743, 164, 2011) provided a fairly general analytic theory for the dispersion and scattering of magnetohydrodynamic waves by longitudinally stratified flux tubes. The theory provides a common framework for, and synthesis of, many previous studies of flux tube oscillations that were carried out under various simplifying assumptions. In particular we illustrated the unifying theoretical framework underlying both the description of waves scattered by flux tubes and the dispersion of waves carried along flux tubes. In the present contribution we will investigate in more detail the propagation of the kink-mode on a slender flux tube in a stratified atmosphere. Spruit (A&A, 98, 155-160, 1981) has studied this situation before and discussed both the appearance of 'buoyancy' terms in the kink-mode and the reduction to a Klein-Gordon equation in the case of an isothermally stratified medium with the associated cut-off frequency preventing the propagation of kink modes towards the corona for low frequencies. We show in convincing detail why the derivation by Spruit (1983) is erroneous and conclude that there is no cut-off frequency for the vertical propagation of kink-modes along a flux tube. The non-existence of the cut-off frequency implies that, regardless of the frequency, kink-modes can propagate along a flux tube from the photosphere towards the corona. How much of the energy is effectively transmitted into the corona, however, remains subject of further study.

Propagating Disturbances in Fan Loops as seen from EIS/Hinode & AIA/SDO

Author: Dipankar Banerjee

center for Plasma Astrophysics, KULeuven, belgium

Co-Authors: S. Krishna Prasad (Indian Institute of Astrophysics) M. Goossens (Centre for Plasma Astrophysics, Department of Mathematics, K.U.Leuven, Celestijnenlaan 200B, Leuven)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *15:04 Tuesday 27th 14:15-15:30*

Summary:

Active region fan loops are studied using high cadence spectroscopic observations from EIS/Hinode combined with imaging sequences from AIA/SDO. For characterizing the nature of the propagating disturbances a combination of spectroscopy and imaging is essential. In this study we focus our attention to a high cadence observing sequence. We find two different groups of periodicities, short (<3 min) and long (>9 min) at two different locations. In the short range we find oscillations with periodicities as low as 50 s. The short periodicities show oscillations in all the three line parameters and the longer ones only show in intensity and Doppler shift but not in line width. Line profiles at both these locations do not show any visible blue-shifted component and can be fitted well with a single Gaussian. This allows us to conclude that the propagating disturbances represent waves and not flows. Mixed mode behaviour is proposed to cause the observed short period oscillations in all the three line parameters and it is suggested that the long periods are signatures of slow magneto-acoustic waves.

The measurement of the apparent phase speed of the propagating EUV disturbances

Author: Ding Yuan

CFSA, Department of Physics, University of Warwick

Co-Authors: V.M.Nakariakov (CFSA, Department of Physics, University of Warwick)

Session: SP5: Waves in the solar atmosphere

Presentation type: Talk *15:17 Tuesday 27th 14:15-15:30*

Summary:

The propagating disturbances in Extreme Ultraviolet emission intensity are commonly observed over a variety of coronal structures and interpreted as slow magnetoacoustic waves. The parameters of the waves, in particular the observed apparent (projected) propagating speed, are important tools for MHD coronal seismology. We design and test tools for reliable measurement of the apparent phase speed of the propagating EUV disturbances. We design cross-fitting technique (CFT), and the methods of 2D coupled fitting (DCF) and best similarity match (BSM) to measure the apparent phase speed of the EUV disturbances in the running differences of the time-distance plots. We applied the three methods to the dataset obtained with the Atmospheric Imaging Assembly on SDO in 171 A bandpass. We estimated the data noise propagation following all steps in the AIA image processing and got a preliminary estimation of the AIA image flux noise. Then we utilised the images and their noise information and got consistent measurements of the apparent phase speed of the propagating disturbance in good accuracy with the CFT, DCF and BSM methods. We analysed the sensitivity of the methods to the selection of samples, spatial length and regularisation. The above methods are reliable ways to measure the apparent phase speed. The average projected propagating speed is measured at V_p=49+-1.1 km/s and the period is found at P=176.9=-0.6 s combining the measurements of all three methods. The CFT is applied well in the relative larger samples. DCF with coupled fit in both temporal and spatial dimension is more suitable for samples with relative high signal-to-noise ratio. BSM is robust in all samples and tolerant to image regularisation (smoothing).

Transverse oscillations in chromospheric mottles

Author: David Kuridze

Queen

Co-Authors: D. Kuridze(1), R. J. Morton(2), R. Erd\elyi(2), G. D. Dorrian(3), M. Mathioudakis(1), D. B. Jess(1), and F. P. Keenan(1) (1) Astrophysics Research Centre, School of Mathematics and Physics, Queen's University Belfast. (2) Solar Physics and Space Plasma Research Centre (SP^2RC), University of Sheffield. (3) Institute of Astronomy and Astrophysics, National Observatory of Athens.

Session: SP5: Waves in the solar atmosphere

Presentation type: Poster *Poster Session A*

Summary:

We investigate long-lived, quiet Sun, on-disk features such as chromospheric mottles (jet-like features located at the boundaries of supergranular cells) and their transverse motions. The observations were obtained with the Rapid Oscillations in the Solar Atmosphere (ROSA) instrument at the Dunn Solar Telescope. The dataset comprises simultaneous imaging in the Halpha core, Ca II K, and G band of an on-disk quiet Sun region. We detect over 40 transverse oscillations in both bright and dark mottles, with periods ranging from 70 to 280 s, with the most frequent occurrence at ~ 165 s. Neighbouring mottles oscillating in-phase are also observed. The transverse oscillations of individual mottles are interpreted in terms of magnetohydrodynamic kink waves. Their estimated periods and damping times are consistent with phase mixing and resonant mode conversion.

Stability of Current Sheets in the Solar Corona

Author: Zimovets Ivan

Space Research Institute (IKI) of RAS, Moscow, Russia

Co-Authors: A.Artemyev (Space Research Institute (IKI) of RAS, Moscow, Russia)

Session: SP5: Waves in the solar atmosphere

Presentation type: Poster *Poster Session A*

Summary:

This work aims at investigating unstable modes of oscillation of quasi-vertical two-dimensional current sheets with sheared magnetic fields under physical conditions typical for the solar corona. We use linear magnetohydrodynamic equations to obtain sets of unstable modes related to the longitudinal inhomogeneity of the current sheet. It is shown that these modes of current sheet oscillations can modulate the current sheet thickness along the polarity inversion line. Based on the obtained results, we propose a scenario which can naturally explain both the quasi-periodic pulsations of hard X-ray emission and parallel movement of their double footpoint-like sources along the polarity inversion line observed in some eruptive two-ribbon solar flares.

Transversal oscillations in emerging flux tubes

Author: Istvan Ballai

University of Sheffield

Co-Authors: I. Ballai, B. Orza

Session: SP5: Waves in the solar atmosphere

Presentation type: Poster *Poster Session A*

Summary:

High resolution space observations revealed a very high degree of dynamicity of the solar atmospheric plasma where the dynamics is controlled by the magnetic field. Dynamical processes, such as waves, oscillations, turbulences, instabilities, allowed us to indirectly diagnose the magnetic field and plasma. As observations show (see, e.g. EUV observation by TRACE, HiNODE, SDO), magnetic structures, such as coronal loops or prominences, oscillate even in their emerging phase, most probably after encountering large-scale blast waves propagating in the chromosphere/low corona. Here we study the oscillation patterns of kink oscillations in coronal loops whose length varies with time and draw conclusions on the evolution of plasma parameters within the coronal loop. Theoretical results will be compared to EUV observations.

Geometry of acoustic wavefronts generated by a point source in the Sun: effects of cut-off frequency

Author: S. Zharkov

MSSL/UCL

Co-Authors:

Session: SP5: Waves in the solar atmosphere

Presentation type: Poster *Poster Session A*

Summary:

Acoustic waves generated by a point source in stratified plasma are considered based on Geometric Asymptotics approach. Analytical parametric solution for monochromatic source is derived for plane-parallel model of the solar interior and is used to gain insight into the properties of the generated

wavefronts as function of excitation frequency and depth. A slowly varying pressure perturbation moving in upper layers of solar photosphere with supersonic speed is also considered, showing that it can excite acoustic waves putting certain restrictions upon their geometry of the generated wavefront. The results are discussed in relation to observations of flare generated sun-quakes.

The Coronal Pulse Identification and Tracking Algorithm (CorPITA)

Author: David Long

MSSL/UCL

Co-Authors: D. Shaun Bloomfield (Trinity College Dublin) David Perez-Suarez (Trinity College Dublin) Peter Gallagher (Trinity College Dublin)

Session: SP5: Waves in the solar atmosphere

Presentation type: Poster *Poster Session A*

Summary:

The Coronal Pulse Identification and Tracking Algorithm (CorPITA) is an automated algorithm designed to systematically detect and analyse "EIT Waves" in data from the Solar Dynamics Observatory (SDO) spacecraft. CorPITA will operate as the automated coronal pulse detection system for the Heliophysics Event Knowledgebase (HEK), providing near–real–time identification of coronal pulses. Once triggered by the start of a solar flare, the algorithm uses an intensity profile technique radiating from the flare to examine the entire Sun. If a pulse is identified, the algorithm determines the kinematics and morphological variation of the pulse in all directions along the solar surface. CorPITA therefore provides a systematic and unbiased method to identify "EIT Waves" and examine their physical properties. This will allow the true nature of "EIT Waves" and their relationship to coronal mass ejections to be determined, and as a result has potential implications for space–weather forecasting.

The Source of Three-minute Magneto-acoustic Oscillations in Coronal Fans

Author: David Jess

Queen

Co-Authors: M. Mathioudakis (Queen's University Belfast); I. De Moortel (University of St Andrews); D.J. Christian (California State University Northridge); K.P. Reardon (Osservatorio Astrofisico di Arcetri); P.H. Keys (Queen's University Belfast); F.P. Keenan (Queen's University Belfast)

Session: SP5: Waves in the solar atmosphere

Presentation type: Poster *Poster Session A*

Summary:

We use images of high spatial, spectral, and temporal resolution, obtained using both ground- and space-based instrumentation, to investigate the coupling between wave phenomena observed at numerous heights in the solar atmosphere. Analysis of continuum images reveals small-scale umbral intensity enhancements, with diameters ~0.6", lasting in excess of 30 min. Intensity oscillations of ~3 min are observed surrounding these photospheric structures. Simultaneous chromospheric velocity and intensity time series reveal an out-of-phase behaviour, implying the presence of (magneto)acoustic oscillations. An average blue-shifted Doppler velocity of ~1.5 km/s confirms the presence of upwardly-propagating slow-mode waves in the lower solar atmosphere. Propagating oscillations in EUV intensity are detected in simultaneous coronal fan structures, with a periodicity of 172 ± 17 s, and a propagation velocity equal to 45 ± 7 km/s . The coronal fans are seen to anchor into the photosphere in locations where large-amplitude umbral dot oscillations manifest. Derived kinetic temperature and emission measure time series display prominent out-of-phase characteristics, and when combined with the previously established sub-sonic wave speeds, we conclude that the observed EUV waves are the coronal counterparts of the upwardly-propagating (magneto)acoustic slow-modes detected in photospheric umbral dots.

A Study of an M Class Flare Observed by ROSA and SDO

Author: Peter Keys

Queen

Co-Authors: M.Mathioudakis (Queen's University Belfast); D.Kuridze (Queen's University Belfast); D.B.Jess (Queen's University Belfast); A.F.Kowalski (University of Washington); F.P.Keenan (Queen's University Belfast)

Session: SP5: Waves in the solar atmosphere

Presentation type: Poster *Poster Session A*

Summary:

Using the Rapid Oscillations in the Solar Atmosphere (ROSA) instrument based at the Dunn Solar Telescope, we observed a M5.4 class flare that erupted from AR11121 on the 6th of November 2010 at 15:27UT for approximately one hour. The flare was observed with six synchronized cameras in the ROSA instrument using filters to produce data sets in G band (430.5nm), the continuum (417nm and 351nm), Halpha (656.2nm) and, left and right-hand circularly polarised light in FeI (630.2nm). The Interferometric BIdimensional Spectrometer (IBIS) was employed as well to sample the NaI DI line across 25 wavelength steps. Each data set obtained with ROSA and IBIS were speckle reconstructed to remove the effects of atmospheric seeing. Here we present some initial results regarding the on-set of flare related intensity enhancements across G band, the 417nm continuum and the 351nm continuum lines. We present results on the velocities of chromospheric flows, which are witnessed from an eruptive event associated with the flare. We also show a comparison of this flare as observed by the Solar Dynamic observatory (SDO) to highlight the capacity for ROSA to do fine-scale analysis of flaring active regions.

Type-II spicule heating and magnetic fields

Author: Eamon Scullion

Author: Ramon Scullion

Institute of Theoretical Astrophysics, University of Oslo

Co-Authors: L., Rouppe van der Voort (Institute of Theoretical Astrophysics, University of Oslo, Norway); J., De la Cruz Rodriguez (Department of Physics and Astronomy, Uppsala University, Box 516, SE-75120 Uppsala, Sweden)

Session: SP6: Solar Physics General session

Presentation type: Talk *11:45 Friday 30th 11:45-13:15*

Summary:

Over the past decade there has been a resurgence in the study of small-scale chromospheric jets known, classically, as spicules. Recent observations have lead us to conclude that there are two distinct varieties of spicule, namely, slower type-I (i.e. mottles, dynamic fibrils, H-alpha spicules etc.) and faster type-II (RBEs: Rapid Blue-shift Excursions on-disk). Such events dominate the dynamics of the chromosphere. Joint SDO (Solar Dynamics Observatory) and Hinode observations have revealed that fast spicules are the source of hot plasma channelling into the corona. Here we report on the properties of this widespread heating with observations from the high resolution CRISP (CRisp Imaging SpectroPolarimeter) instrument at the SST (1-m Swedish Solar Telescope, La Palma) and co-aligned SDO data. Furthermore, we reveal new insight into the formation of type-II spicules through considering the distribution of RBEs with respect to their magnetic fields rooted in the photosphere (via CRISP).

RHESSI and SDO observations of the chromospheric and coronal plasma parameters during a solar flare

Author: Marina Battaglia

University of Applied Sciences Northwestern Switzerland

Co-Authors: E. P. Kontar (University of Glasgow)

Session: SP6: Solar Physics General session

Presentation type: Talk *11:57 Friday 30th 11:45-13:15*

Summary:

X-ray and EUV observations are an important diagnostic tool of various plasma parameters of the solar atmosphere during solar flares. Soft X-ray and EUV observations often show coronal sources near the top of flaring loops, while hard X-ray emission is mostly observed from the chromospheric footpoints. Combining RHESSI with simultaneous SDO/AIA observations, it is possible for the first time to determine the density, temperature, and emission profile of the solar atmosphere during a flare, using two independent methods. We present observations of a limb flare where we find the emission measure, temperature, and density of the coronal source using soft X-ray images while the chromospheric density is found using RHESSI visibility analysis of the hard X-ray footpoints. A regularized inversion technique is applied to AIA images of the flare to find the differential emission measure DEM(T). Using DEM maps, we determine the density and temperature structure of the loop and compare it with RHESSI results.

HINODE/EIS coronal foot point blue shifts and changes with line formation temperature

Author: Keiran Burrows

Aberystwyth University

Co-Authors: Y.Taroyan (Aberystwyth University)

Session: SP6: Solar Physics General session

Presentation type: Talk *12:09 Friday 30th 11:45-13:15*

Summary:

Hinode/EIS observations show persistent blue shifts near the foot points of active region loops. The blue shifts show a correlation with the non-thermal broadenings in foot point regions. What is the temperature dependence of these blue shifted areas? To answer this, we have studied several large active regions, using 1" and 2" slit raster scans taken from the HINODE/EIS instrument. We extract a region of interest surrounding loop foot points, and create intensity, Doppler shift, and non thermal broadening maps. We calculate the change in average Doppler shift with temperature and the area of blue shifted regions with temperature. We find that the Doppler velocity is blue shifted in areas of low intensity, and in general, red shifted in areas of high intensity. We also find that largely red shifted areas occur at lower temperatures, and gradually become blue shifted with increasing temperature.

Coronal Mass Ejection Mass, Energy, and Forces using STEREO

Author: Eoin Carley

Trinity College Dublin

Co-Authors: R. T. James McAteer (New Mexico State University); Peter T. Gallagher (Trinity College Dublin)

Session: SP6: Solar Physics General session

Presentation type: Talk *12:21 Friday 30th 11:45-13:15*

Summary:

Understanding coronal mass ejection (CME) mass and dynamics has been a long-standing problem. Although previous observational estimates of the energies and forces involved in CME propagation have been made, such studies were often hindered by large uncertainties in CME mass. We use the twin

SECCHI COR1 and COR2 coronagraphs to accurately estimate the mass of the 2008 December 12 CME. Acceleration estimates derived from the position of the CME front in 3D are combined with the mass estimates in order to calculate the kinetic energy and driving force at different stages of CME propagation. The CME asymptotically approaches a mass of 3.4±1.0x10^15 g. It reaches an energy of 4.6±2.6x10^30 ergs at ~18R⊙, and experiences a peak force of 3.4±2.2x10^19 dyn at ~3 R⊙, early in its propagation.

MHD turbulence in the solar tachocline

Author: Professor Steve Tobias

University of Leeds

Co-Authors: P.H. Diamond (UCSD) D.W. Hughes (Leeds)

Session: SP6: Solar Physics General session

Presentation type: Talk *12:33 Friday 30th 11:45-13:15*

Summary:

In this talk I shall describe simulations of angular momentum transport in the solar tachocline. This region is crucial for generation of the large-scale solar magnetic field. I shall describe how even a weak magnetic field can alter the transport properties significantly. I will discuss extensions to the model including the mixing of light elements which is crucial for solar models.

Particle acceleration by dispersive Alfven waves in 2.5D and 3D solar flare plasmas

Author: David Tsiklauri

Astronomy Unit, Queen Mary University of London

Co-Authors:

Session: SP6: Solar Physics General session

Presentation type: Talk *12:45 Friday 30th 11:45-13:15*

Summary:

Dispersive Alfven waves (DAWs) offer, an alternative to magnetic reconnection, opportunity to accelerate solar flare particles in order to alleviate the problem of delivering flare energy to denser parts of the solar atmosphere to match X-ray observations. Here we focus on the effect of DAW polarisation, left, right, circular and elliptical, in the different regimes inertial and kinetic, aiming to study these effects on the efficiency of particle acceleration. We use 2.5D particle-in-cell simulations to study how the particles are accelerated when DAW, triggered by a solar flare, propagates in the transversely inhomogeneous plasma that mimics solar coronal loop. (i) In the inertial regime, fraction of accelerated electrons (along the magnetic field), in the density gradient regions is 20% by the time when DAW develops three wavelengths and is increasing to 30% by the time when DAW develops thirteen wavelengths. In all considered cases ions are heated in the transverse to the magnetic field direction and fraction of heated particles is 35%. (ii) The case of right circular, left and right elliptical polarisation DAWs, with the electric field in the non-ignorable transverse direction exceeding several times that of in the ignorable direction, produce more pronounced parallel electron beams (with larger maximal electron velocities) and transverse ion beams in the ignorable direction. In the inertial regime such polarisations yield the fraction of accelerated electrons 20%. In the kinetic regime this increases to 35%. (iii) The parallel electric field that is generated in the density inhomogeneity regions is independent of the electron-ion mass ratio and for solar flaring plasma parameters exceeds Dreicer electric field by eight orders of magnitude. (iv) Electron beam velocity has the phase velocity of the DAW. Thus electron acceleration is via Landau damping of DAWs. For the Alfven speeds of 0.3c the considered mechanism can accelerate electrons to energies circa 20 keV. (v) The increase of mass ratio from mi/me = 16 to 73.44 increases fraction of accelerated electrons from 20% to 30-35% (depending on DAW polarisation). For the mass ratio mi = me = 1836 the fraction of accelerated electrons would be > 35%. (vi) DAWs generate significant density and temperature perturbations that are located in the density gradient regions. Preliminary 3D simulation results also indicate that re-considering the problem in 3D geometry (a cylindrical, overdense magnetic flux rope in a 3D box) increases the efficiency of particle acceleration in the density inhomogeneity regions to 60-70%, commensurate to solar flare observations. In summary, DAWs propagating in the transversely inhomogeneous plasma can effectively accelerate electrons along the magnetic field and heat ions across it.

Supersonic Snowballs in Hell - Theory & hot new data on sun-plunging comet destruction

Author: JC Brown

U. Glasgow

Co-Authors:

Session: SP6: Solar Physics General session

Presentation type: Talk *12:57 Friday 30th 11:45-13:15*

Summary:

For decades coronagraphs have recorded thousands of sun-grazing comets vaporising at a few R_sun or while hidden behind the mask but recent months have brought major breakthroughs in the field - a) The first theory paper (Brown et al 2010 - A&A 535,71) addressing physical regimes of destruction as a function of comet mass, perihelion, and nucleus parameters. (E.g. Even the largest comets could never reach the photosphere where atmospheric bombardment heating is 100,000x solar radiation). b) The first direct low coronal observations (by SDO) of the gradual sublimative destruction of one comet - Comet C/2011 N3 (SOHO) - (Schrijver, Brown et al 2012 - Science 335, no. 6066, 324-328) and, by various spacecraft (see http://www.nasa.gov/mission_pages/sunearth/news/comet-lovejoy.html **), partial destruction of much larger Comet Lovejoy in 12/2011. The hunt is now on for more examples and for cases of the much faster flare-like ablative/explosive destruction of comets reaching the dense chromosphere. These

results open up new diagnostic regimes for comets but also for solar atmospheric plasmas by their response to the locally intense energy release. I will summarise the story so far in this exciting new field, including any stop-press data and theory. ** but ignore NASA's 'surprising survival in the hot corona' fallacy!

Implications for solar flare energy transport in the light of recent observations of sun-quakes

Author: S. Zharkov

MSSL/UCL

Co-Authors: L.Green (MSSL/UCL), S.A.Matthews (MSSL/UCL), V.V.Zharkova (University of Bradford)

Session: SP6: Solar Physics General session

Presentation type: Talk *14:15 Friday 30th 14:15-15:30*

Summary:

Analysis of sun-quakes induced in the solar interior in the vicinity of flares offers us an opportunity to explore the physical processes of energy transport in flaring atmospheres. Only a limited number of M and X-class flares have been found to show seismic signatures in the form of ripples or egression sources, revealing that some of the most powerful flares often do not produce any seismic signatures. In addition, the most powerful signatures were recorded from an M-class flare. This raises important questions about how the flare energy and momentum are transported to the solar surface and interior in order to produce sun-quakes. Observations of ripples associated with the first few sun-quakes suggested that hydrodynamic shocks arising from a hydrodynamic response of the ambient plasma to precipitation of energetic particles (electrons or protons) are plausible sources of the seismic emission. Later, noting that sun-quakes are often co-spatial with hard X-ray and white light, another source of seismic emission was proposed related to back-warming of the photosphere by the enhanced chromospheric and coronal radiation caused by physical processes in flares. A third mechanism proposed to account for sun-quakes is related to possible Lorentz force transients that occur as a result of the coronal restructuring of the magnetic field in flares. Recent work comparing samples of white-light flares with and without sun-quakes, and new observations with GONG, Hinode and SDO of seismic emission associated with the X-class flares of 14 December 2006 and 15 February 2011 showing links between sun-quakes and flux-rope eruptions, demonstrate inconsistencies with some existing models. In this presentation these inconsistencies are explored and possible alternative scenarios are discussed.

Break-up of filament plasma by Rayleigh-Taylor instabilities

Author: Davina Innes

Max-Planck-Institut fuer Sonnensystemforschung

Co-Authors:

Session: SP6: Solar Physics General session

Presentation type: Talk *14:27 Friday 30th 14:15-15:30*

Summary:

A prominence eruption on June 7 produced spectacular curtains of cold, dense plasma falling through the solar corona. The falling sheets were unstable to the Rayleigh-Taylor instability. Both large and small-scale occurrences of Rayleigh-Taylor fingers and cavities will be discussed. In two cases the Alfven velocity associated with the dense plasma can be estimated from the separation of the fingers.

Ubiquitous Blueshifts in multi-stranded coronal loops

Author: Stephane Regnier

University of Central Lancashire

Co-Authors: R. W. Walsh; J. Pearson

Session: SP6: Solar Physics General session

Presentation type: Talk *14:39 Friday 30th 14:15-15:30*

Summary:

Magnetic plasma loops have been termed the building blocks of the solar atmosphere. However, it must be recognised that if the range of loop structures we can observe do consist of many "sub-resolution" elements, then current one-dimensional hydrodynamic models are really only applicable to an individual plasma element or strand. Thus a loop should be viewed is an amalgamation of these strands. They could operate in thermal isolation from one another with a wide range of temperatures occurring across the structural elements. This scenario could occur when the energy release mechanism consists of localised, discrete bursts of energy that are due to small scale reconnection sites within the coronal magnetic field- the nanoflare coronal heating mechanism. These energy bursts occur in a time-dependent manner, distributed along the loop/strand length, giving a heating function that depends on space and time.An important observational discovery with the Hinode/EIS spectrometer is the existence of red and blue-shifts in coronal loops depending on the location of the footpoints (inner or outer parts of the active region), and the temperature of the emission line in which the Doppler shifts are measured. Based on the multi-stranded model developed by Sarkar and Walsh (2008, ApJ, 683, 516), we show that red and blue-shifts exist in different simulated Hinode/EIS passbands: cooler lines (OV-SiVII) being dominated by red-shifts, whilst hotter lines (FeXV-CaXVII) are a combination of both. The distribution of blueshifts depends on the energy input and not so much on the heating location. Characteristic Doppler shifts generated fit well with observed values.

Flare Observations of the EUV Continua

Author: Ryan Milligan

Queen

Co-Authors: Phillip C. Chamberlin (NASA/GSFC), Hugh S. Hudson (UCB/SSL), Thomas N. Woods (LASP), Mihalis Mathioudakis (QUB), Lyndsay Fletcher (U Glasgow), Adam F. Kowalski (U Wash), Francis P. Keenan (QUB)

Session: SP6: Solar Physics General session

Presentation type: Talk *14:51 Friday 30th 14:15-15:30*

Summary:

Recent solar flare simulations suggest that the energy deposited in the chromosphere by nonthermal electrons during a flare's impulsive phase is re-emitted in the form of recombination (free-bound) continua, in particular, the Lyman, Balmer, and Paschen continua of hydrogen, and the He I and He II continua (Allred et al. 2005). However, definitive observations of free-bound emission during solar flares have been scarce in recent years as many modern, space-based instruments do not have the required sensitivity, wavelength coverage, or duty cycle. With the launch of SDO, these observations are now routinely available thanks to the EUV Variability Experiment (EVE) instrument. Here we present unambiguous, spectrally and temporally resolved detections of enhanced free-free and free-bound continua during the first X-class solar flare of Solar Cycle 24. While we find that the flare energy in the EVE spectral range amounts to at most a few percent of the total flare energy, these findings highlight the capability of EVE in giving us the first comprehensive look at these diagnostically important continuum components.

Hard X-ray Observations of Solar Loops and Wandering Magnetic Field Lines

Author: Eduard Kontar

University of Glasgow

Co-Authors: I.G. Hannah (U. of Glasgow) and N.H. Bian (U. Glasgow)

Session: SP6: Solar Physics General session

Presentation type: Talk *15:15 Friday 30th 14:15-15:30*

Summary:

Using RHESSI observations and the X-ray visibility analysis, we determine the spatial and spectral distributions of energetic electrons for a well observed flare. Because of the high density plasma in the loop, electrons have to be continuously accelerated about the loop apex of length ~2 × 109 cm and width ~7 × 108 cm. Energy-dependent transport of tens of keV electrons is observed to occur both along and across the guiding magnetic field of the loop. We show that the cross-field transport of energetic electrons is consistent with the presence of wandering magnetic field lines in the loop, where electrons are accelerated, and estimate the magnitude of the field line diffusivity.

Stellar Variability in the Kepler Q1 Data

Author: Amy McQuillan

University of Oxford

Co-Authors: S. Aigrain (Department of Astrophysics, University of Oxford); S. Roberts (Department of Engineering Science, University of Oxford)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

We investigate the variability properties of main sequence stars in Kepler Q1 data, using a new astrophysically robust correction for systematics (ARC), and find that 60% of stars appear more active than the Sun. We define low and high variability samples and compare the properties of the stars belonging to each sample, showing tentative evidence that more active stars have lower proper motions. We also investigate the frequency content of the variability, finding clear evidence for periodic or quasi-periodic behaviour in 16% of stars, and showing that there exist significant differences in the nature of variability between spectral types. Of the periodic objects, most A and F stars have short periods (<2 days) and highly sinusoidal variability, suggestive of pulsations, whilst G, K and M stars tend to have longer periods (>5 days, with a trend towards longer periods at later spectral types) and show a mixture of periodic and stochastic variability, indicative of activity. Finally, we use auto-regressive models to characterise the stochastic component of the variability, and show that its typical amplitude and time-scale both increase towards later spectral types, which we interpret as a corresponding increase in the characteristic size and life-time of active regions.

Influence of a variation of the fine structure constant on the sun and the habitability of earth

Author: Bjoern Soergel

University Observatory Munich (USM), LMU Munich

Co-Authors: D. Boneberg (USM,LMU), H. Lesch (USM,LMU)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

We develop a model of a one solar mass star with variable fine structure constant. For this purpose, we calculate the reaction rate and energy generation of the pp-chain depending on α. Based on the analytic model of stellar structure by D.D.Clayton (1986), we obtain a fine structure constant dependent solar model with one fudge factor. By equating the predicted luminosity for not varied α with the one of the sun, the fudge factor can be calculated. Thus a solar radius of R=6.95·10^10 cm is determined from the model, which is in good agreement with the actual value. We are also able to estimate the change in the solar luminosity when varying α. This is used to obtain an expression for the inner and outer border of the habitable zone, where the change of the melting and boiling point of water depending on α are as well taken into account. The model only allows an increase of α by 0.2% to prevent the earth from freezing. Assuming a linear change over the past 4.5 Gyrs, this gives an upper limit for the rate of change of 4·10^(-13) per year. Finally, the question is addressed whether the obtained results indicate a fine tuning of α. (Comment: This has been written as a bachelor thesis by B.Soergel and D.Boneberg under supervision of Prof. Dr. H.Lesch at USM/LMU in 2011)

A method for analysing the temperature structure of the solar corona

Author: Andrew Leonard

Aberystwyth University

Co-Authors: H. Morgan (Aberystwyth University)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

Many studies which look at the temperature of the solar corona fail to account for the various multi-thermal structures along the line of sight (LOS). The high-quality multi-channel observations of AIA/SDO are used to estimate temperature across large off-limb regions. Preliminary results are shown which are broadly consistent with other published results. Coronal hole temperatures are at a maximum near the Sun, at 0.25MK at a height of 1.06Rs, dropping gradually to 0.15MK at a height of 1.24Rs. Quiet Sun temperatures are higher, starting at 1.5MK at 1.06Rs and dropping to 0.2MK at 1.24Rs. Estimating the temperature of active regions forces the introduction of multiple temperatures into our fitting routines which distinguishes the contribution of other structures along the LOS. This preliminary work lays the foundation for a more comprehensive tomographical approach which will accurately resolve the LOS in the next few years.

Treasures at RAS: Analysis of Schwabe

Author: R.Arlt

Leibniz Institute for Asstrophysics Potsdam

Co-Authors: R.Leussu (Univ. Oulu), K.Mursula (Univ. Oulu)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

Samuel Heinrich Schwabe made about 8500 detailed drawings of sunspots on the solar disk from 1825 to 1867. The original observations are stored in the library of the Royal Astronomical Society, London, and are perfectly preserved. The drawings were digitized and are now being measured. We compiled a preliminary database of 128,000 heliographic positions and sizes of individual sunspots. The measurements are about 90 per cent complete. We show a solar butterfly diagram of the period of 1825-1867 which adds details about four more cycles to our knowledge of the solar cycle.

Observations of Low Frequency Solar Radio Bursts from the Rosse Solar-Terrestrial Observatory.

Author: Pietro Zucca

Trinity College Dublin

Co-Authors: E. P. Carley (School of Physics, Trinity College Dublin, Dublin 2,Ireland) J. McCauley (School of Physics, Trinity College Dublin, Dublin 2,Ireland) P.T. Gallagher (School of Physics, Trinity College Dublin, Dublin 2,Ireland) C. Monstein (ETH-Zentrum, Zurich,Switzerland) R. T. J. McAteer (Department of Astronomy, New Mexico State University)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

The Rosse Solar-Terrestrial Observatory (RSTO) was established at Birr Castle, Co. Offaly, Ireland (53°05'38.9", 7°55'12.7") in September 2010, to study solar radio bursts and the response of the Earth's ionosphere and geomag- netic field. To date, three Compound Astronomical Low-Cost Low Frequency (Callisto) spectrometers have been installed with the capability of observing in the frequency range 10-870 MHz. The receivers are fed simultaneously by a bicone and a log-periodic antenna. Nominally, frequency spectra in the range 10-400 MHz are obtained with 4 sweeps per second over 600 channels. Here, we describe the RSTO solar radio spectrometer setup, and present first-light spectra of a sample of Type II, III and IV radio bursts. In particular, we describe fine-scale structure observed in Type II bursts, including band splitting and rapidly varying herringbone features. RSTO was established under the auspices of International Heliophysical Year 2007 and the International Space Weather Initiative, supported by the United Nations Basic Space Science Initiative.

Downward-moving Thick Target Flare Emission Driven by Hardening in Nonthermal Electron Spectrum

Author: Aidan O'Flannagain

Trinity College, Dublin

Co-Authors: P.G. Gallagher (Trinity College, Dublin) R.O. Milligan (Queens University, Belfast) J.C. Brown (University of Glasgow) G.D. Holman (Goddard Space Flight Centre)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

The thick-target model has made several accurate predictions of the behaviour and evolution of nonthermal x-ray emission produced during solar flares. The emergence of new theories however brings into question a key part of the flare process - the transport of energy from the corona into the chromosphere prior to the major production of X-rays. In order to investigate this portion of the mechanism, we must study a unique subset of solar flares which show nonthermal emission prior to the peak in X-rays, called 'early impulsive' events. This work details the rigorous investigation of one such event, and by interpreting the X-ray images and spectra produced by RHESSI, sheds light on some of the remaining questions of the theory behind solar flare initiation.

CME-related changes in line-of-sight magnetic field strength in dimming regions observed by Hinode

Author: Ehsan Pedram

MSSL

Co-Authors: Sarah A. Matthews (MSSL) Lidia van Driel-Gesztelyi (MSSL, Observatoire de Paris)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

Following many coronal mass ejections (CMEs), dark areas referred to as coronal dimming regions have been observed to form within and around the erupting active region. We probe the nature of coronal dimmings in relation to the expanding CME through the analysis of the associated photospheric magnetic field in the flare and CME event of 14 December 2006, using data from Hinode's SOT. We have systematically analysed the variation of the line-of-sight magnetic field strength in a large region surrounding AR 10930 using Hinode SOT Stokes V data. Our analysis, for the first time, shows that at the site of the dimmings there is a decrease in the magnetic field strength at the onset of the dimming in the dominant polarity of the plage regions surrounding the Active Region (AR), persisting during the dimming and recovering at the onset of the intensity recovery reported in Attrill et al. (2010). Using simple geometric arguments we show that the decrease in the dominant polarity flux is consistent with an ≈35 degrees change in the inclination angle of the photospheric magnetic fields in the plage regions, from horizontal to vertical. We further observe a close correlation between the site of plasma outflow with velocities of ≈30 km/s and one of the plage regions showing change in magnetic field strength. Our findings indicate a reconfiguration and opening of the magnetic field lines resulting in a change in their inclination angle in the dominant polarity of the plage regions surrounding the erupting active region. This then leads to a decrease in the plasma density observed as coronal dimming.

Invisible Active Region emergences in line-of-sight magnetogram data

Author: Silvia Dalla

University of Central Lancashire

Co-Authors: L. Fletcher (University of Glasgow), D.H. Mackay (University of St. Andrews), F. Watson (University of Glasgow)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

The emergence of a new solar Active Region (AR) is typically detected using full-disk continuum images or line-of-sight magnetograms. It produces modifications in the structure and connections of the coronal magnetic field, and can trigger activity such as flares and Coronal Mass Ejections. It is generally assumed that current instrumentation allows good visibility of the emergence process. We present the results of a statistical analysis of AR emergences and disappearances in line-of-sight magnetogram data over a 20-year time range. We developed an automated detection technique identifying AR emergence by means of morphological methods applied to difference images. The technique is used on the NSO Kitt Peak 512-channel magnetograph dataset, spanning the time range between 1974 and 1993. We obtain the distribution of locations of new emergences on the solar disk, and show that it has a strong asymmetry in longitude. There is an 11:1 ratio between the number of new regions seen to emerge in the [-60,-40] longitude bin and in the [+40,+60] longitude bin. As a result, a very large fraction of new ARs emerging in the West of the Sun go undetected in line-of-sight magnetograms. We discuss the causes of this phenomenon and its implications.

Impulsive Phase Footpoint DEMs

Author: David Graham

University of Glasgow

Co-Authors: I.G. Hannah (University of Glasgow), L. Fletcher (University of Glasgow), R.O. Milligan (Queen's University Belfast)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

The differential emission measure is an important tool in understanding the properties of flaring plasma. However, determining the DEM of impulsive phase footpoints has been difficult in the past without sufficient spatial resolution to resolve footpoints from loop structures, and a lack of spectral and temporal coverage. We use the capabilities of Hinode/EIS to present the first DEMs from the impulsive phase of a number of flare footpoints. Observations were chosen from a period when EIS telemetry was at its best and analysed using a new regularised inversion method (Hannah & Kontar 2012). We find a peak temperature in the DEM of around 7 MK with emission measures peaking between 10^28 and 10^29 cm-5, indicating a substantial presence of plasma at 'coronal' temperatures within the footpoint.

The influence of coronal emission lines on prominence plasma.

Author: Gerrard Brown

University of Glasgow

Co-Authors: N.Labrosse (University of Glasgow); L.Fletcher (University of Glasgow)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

Prominences are cool, high density structures located in the corona; the surrounding corona can influence the processes which go on inside the prominence via the effect of coronal radiation illuminating the prominence. This can affect the ionisation degree of the plasma inside the prominence. Several strong emission lines are found in the coronal spectrum, and the impact that these lines in the coronal spectrum has on the radiative transfer processes of the prominence is examined. A one dimensional model is used to model the radiative transfer processes of the prominence. Previous modelling did not include the coronal lines. In this study coronal lines are added to the code's incident radiation; we present the influence of this additional coronal radiation on the state of the prominence plasma.

Flare ribbons in the early phase of an SDO flare: emission measure and energetics

Author: Lyndsay Fletcher

University of Glasgow

Co-Authors: Iain G. Hannah (University of Glasgow); Hugh S. Hudson (U. C. Berkeley & University of Glasgow); D. E. Innes (Max Planck Institute fuer Sonnensystemforschung)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

We report on the M1.0 flare of 7th August 2010, which displayed extended early phase chromospheric ribbons well observed by SDO/AIA and RHESSI. Most large flares saturate rapidly in the high-temperature AIA channels, however this event could be followed in unsaturated AIA images for ten minutes in the build-up to and first few minutes of the impulsive phase. Analysis of GOES, RHESSI and SDO/AIA demonstrates the presence of high temperature (~10MK), compact plasma volumes in the chromospheric flare ribbons, with a column emission measure of on average 3-7 x 10^28 cm^-5. We construct a time-resolved energy budget for the ribbon plasma, including also SDO/EVE data, and discuss the implications of the observed ribbon properties for flare energisation and electron acceleration.

SDO observations and modeling of flaring loops.

Author: Dr Panagiota Petkaki

University of Cambridge

Co-Authors: G. Del Zanna (Univ. Cambridge), H.E. Mason (Univ. Cambridge), S.J. Bradshaw(Rice University)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

We present multi-wavelength observations of a C1 class Solar flare using the AIA and EVE instruments onboard the Solar Dynamic Observatory. We obtained temperatures and densities of the flaring loops using both instruments. We found good agreement, which confirms the AIA calibration and opens up the possibility to use AIA for flare diagnostics. We used the self-consistent 1-d hydrodynamic code HYDRAD to perform various time-dependent simulations of the thermal evolution of a flaring loop, by varying the location and amount of heating to match the observations. We find good overall agreement for the gradual phase.

Predicting space climate change.

Author: Luke Barnard

Department of Meteorology, University of Reading

Co-Authors: M. Lockwood (University of Reading) M.A. Hapgood (RAL Space, Rutherford Appleton Laboratory) M.J. Owens (University of Reading)

Co-Authors: M. Lockwood (University of Reading) M.A. Hapgood (RAL Space, Rutherford Appleton Laboratory) M.J. Owens (University of Reading) C.J. Davis (University of Reading) F. Steinhilber (EAWAG, Swiss Federal Institute of Aquatic Science and Technology)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

The recent decline in the open magnetic flux of the Sun heralds the end of the Grand Solar Maximum (GSM) that has persisted throughout the space age, during which the largest−fluence Solar Energetic Particle (SEP) events have been rare and Galactic Cosmic Ray (GCR) fluxes have been relatively low. In the absence of a predictive model of the solar dynamo, we here make analogue forecasts by studying past variations of solar activity in order to evaluate how long−term change in space climate may influence the hazardous energetic particle environment of the Earth in the future. We predict the probable future variations in GCR flux, near−Earth interplanetary magnetic field (IMF), sunspot number, and the probability of large SEP events, all deduced from cosmogenic isotope abundance changes following 24 GSMs in a 9300−year record.

Mass estimates of rapidly-moving prominence material from high-cadence EUV images

Author: David Williams

UCL Mullard Space Science Laboratory

Co-Authors: D. Baker (UCL MSSL), L. van Driel-Gesztelyi (UCL MSSL, Observatoire de Paris (Meudon), Konkoly Observatory)

Session: SP6: Solar Physics General session

Presentation type: Poster *Poster Session B*

Summary:

Much of the work on filament/prominence structure can be divided between studies that use a polychromatic approach with targeted campaign observations, and those that use synoptic observations, frequently in only one or two wavelengths. The superior time resolution, sensitivity and near-synchronicity of data from the Solar Dynamics Observatory's Advanced Imaging Assembly allow us to combine these two techniques using photo-ionisation continuum opacity to determine the spatial distribution of hydrogen in filament material. We apply the combined techniques to SDO AIA observations of a filament which erupted during the spectacular coronal mass ejection on 2011 June 07. The resulting "polychromatic opacity imaging" method offers a powerful way to track partially ionised gas as it erupts through the solar atmosphere on a regular basis, without the need for co-ordinated observations, thereby readily offering regular, realistic mass distribution estimates for models of these erupting structures.

Probing nearby galaxies with the brightest stars in the Universe [Invited]

Author: Miguel Urbaneja

Institute for Astronomy, University of Hawaii

Co-Authors:

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *10:00 Tuesday 27th 10:00-11:15*

Summary:

Measuring distances to galaxies and determining their chemical compositions are two fundamental activities in modern extragalactic astronomy, in that they help characterizing the physical properties of their constituents and their evolutionary status. Ultimately, these measurements lead to stronger constraints on the cosmological parameters of an expanding universe and the history of cosmic chemical enrichment. Both these questions can be tackled afresh with the quantitative analysis of the absorption line spectra of individual massive and luminous, young B- and A-type supergiant stars. A spectroscopic distance determination method, the FGLR, can yield accurate distances up to several Mpc, extending to a local volume where the results can be compared with those obtained from Cepheids and other distance indicators. Moreover, and this being a unique advantage of the FGLR, reddening values and metallicities are simultaneously determined for each individual stellar target. These stellar metallicities are very accurate and can be used to constrain the formation and evolution of galaxies and to assess and overcome the systematic uncertainties of H II region strong-line abundances through a galaxy-by-galaxy comparison. Moreover, stellar spectroscopy provides fundamental complementary abundance information for star forming galaxies on additional atomic species such as iron-group elements. I will present recent results of our on-going efforts to study individual blue supergiant stars in galaxies within and beyond the Local Group based on medium and low resolution optical spectra collected with ESO VLT and the Keck telescopes. The promising perspectives of future work, based on the giant ground-based telescopes of the next generation (E-ELT, TMT) are also discussed.

Early-type stars in the Wing of the Small Magellanic Cloud

Author: Rainer Hainich

University of Potsdam

Co-Authors:

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *10:30 Tuesday 27th 10:00-11:15*

Summary:

We [illegible] the optical spectra taken with FLAMES of a sample of 10 O and B stars in NGC602 [illegible] in the Small

We have analyzed the optical spectra, taken with FLAMES, of a sample of 10 O- and B-type stars in NGC602, a young star cluster in the Small Magellanic Cloud (SMC). Our analysis is based on non-LTE iron-blanketed model atmospheres calculated with the Potsdam Wolf-Rayet (PoWR) code which treats the photosphere as well as the wind. The most prominent star in NGC602a is Sk183 which is one of the most massive stars in the SMC. Classified as an O3-type dwarf on the basis of its nitrogen spectrum, the star also displays broadened HeI absorptions. Therefore we suggest that Sk183 is a binary showing a composite spectrum. This brings the number of rare O2- and O3-type stars known in the whole of the SMC to a mere three. Sk183 is the earliest-type star known in NGC602a, and hence the dominant source of hydrogen-ionizing photons in this cluster. Therefore it is expected to have a primary influence driving the star formation along the inner edge of the N90 nebula associated with NGC602a.

Red Supergiants as Cosmic Abundance Probes

Author: Ben Davies

University of Cambridge

Co-Authors: Rolf-Peter Kudritzki (Hawaii), Bertrand Plez (Montpellier), Maria Bergemann (MPIA), Zach Gazak (Hawaii), Chris Evans (ATC)

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *10:45 Tuesday 27th 10:00-11:15*

Summary:

The chemical abundances of galaxies can provide provide powerful diagnostic information on their formation and evolution within the framework of cosmological models. Unfortunately, many abundance measurements in the literature use the HII-region 'strong-line' method, which has been shown to have large systematic errors and calibration problems. Here I describe a novel method to derive the chemical abundances of galaxies using Red Supergiants - the galaxies' brightest stars in the infrared. I will show that this technique can potentially map the abundances of galaxies out to 4Mpc with current facilities, and 70Mpc with the E-ELT.

Models for the circumstellar medium of runaway young red supergiants: application to Betelgeuse?

Author: Jonathan Mackey

Argelander-Insitute for Astronomy, University of Bonn

Co-Authors: Shazrene Mohamed (AIfA, Bonn and SAAO, Cape Town), Hilding R. Neilson (AIfA, Bonn), Norbert Langer (AIfA, Bonn), Dominique M.-A. Meyer (AIfA, Bonn)

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *11:00 Tuesday 27th 10:00-11:15*

Summary:

A significant fraction of massive stars are moving supersonically through the interstellar medium (ISM), with their stellar winds generating bow shocks. In post-main sequence evolution these stars may evolve rapidly from red to blue and vice versa on the Hertzsprung-Russell diagram, with accompanying rapid changes to their stellar winds and bow shocks. Our constant wind 3D simulations of the bow shock produced by the nearby runaway red supergiant (RSG) Betelgeuse indicate that the bow shock is very young (<20,000 years old), hence Betelgeuse may have only recently become a RSG. To test this possibility we calculated stellar evolution models for single stars with properties consistent with Betelgeuse. We incorporated the resulting evolving stellar wind into 2D hydrodynamic simulations to model a runaway blue supergiant (BSG) undergoing the transition to a RSG near the end of its life. The collapsing BSG wind bubble induces a bow shock-shaped inner shell which at least superficially resembles Betelgeuse's bow shock. Surrounding this is the larger-scale retreating bow shock generated by the now defunct BSG wind's interaction with the ISM. We investigate whether this outer shell could explain the bar feature located (at least in projection) just in front of Betelgeuse's bow shock.

Weak magnetic fields in early-type stars

Author: Jon Braithwaite

Bonn University

Co-Authors: M.Cantiello (KITP, Santa Barbara)

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *11:45 Tuesday 27th 11:45-13:00*

Summary:

Recently weak magnetic fields have been detected in the main-sequence A stars Vega and Sirius. I shall present two hypotheses concerning their origin: (a) a dynamo operating in a thin convective layer just below the photosphere and (b) a dynamically evolving field leftover from the stars' formation. I shall then describe theoretical arguments as well as indirect observational evidence that one or both of these mechanisms should produce weak magnetic fields in essentially *all* main-sequence A, B and O stars in which large-scale fossil fields are absent.

The mass loss and nature of B supergiants

Author: Blagovest Petrov

Armagh Observatory

Co-Authors:

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *12:00 Tuesday 27th 11:45-13:00*

Summary:

The nature of B supergiants (BSGs) is a long-standing problem in stellar evolution theory. Lamers et al (1995) reported the existence of a jump in the terminal wind velocities of B supergiants, which may produce a jump in the mass-loss rate (Vink et al., 1999) . Understanding the H alpha behavior with temperature as a main mass-loss indicator will produce new aspects on the evolutionary properties of BSGs. I will present my results from a comprehensive study of the H alpha with CMFGEN for supergiant models in the temperature range of the bistability jump.

The VLT-FLAMES Tarantula Survey

Author: Chris Evans

STFC - UKATC

Co-Authors:

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *12:15 Tuesday 27th 11:45-13:00*

Summary:

Massive stars play a key role in the dynamical and chemical evolution of star-forming galaxies, via their intense stellar winds, UV radiation fields, and explosive deaths. To develop realistic tools to analyse integrated-light observations of distant galaxies, we first need to calibrate the models via study of stars closer to home. To this end, I will present an overview of the VLT-FLAMES Tarantula Survey, which has obtained multi-epoch spectroscopy of the massive-star population of 30 Doradus, the richest stellar nursery in the Local Group.

The most massive stars in the Universe: the Of/WN transition

Author: Joachim M. Bestenlehner

Armagh Observatory

Co-Authors: J. S. Vink (Armagh Observatory) G. Graefener (Armagh Observatory)

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *12:25 Tuesday 27th 11:45-13:00*

Summary:

To date, the evolution of the most massive stars is still poorly understood. In particular, the initial, present-day, and final masses are considerably different as a result of mass loss. Theoretical predictions form Graefener et al. and Vink et al. postulate a strong dependency of the mass-loss rate on the Eddington-factor Gamma, and the latter predict a notable change of the mass-loss behaviour with Gamma at a certain Eddington-factor. I will present the first spectral synthesis results of the Of/WN stars in the context of the VLT-Flames Tarantula Survey (Bestenlehner et al. in prep.).

The evolution of rotating very massive stars in the LMC

Author: Karen Koehler

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Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *12:37 Tuesday 27th 11:45-13:00*

Summary:

The formation and evolution of very massive stars, with initial masses above 100 solar mass, are currently interesting fields of research, as are rotational mixing and mass loss from stars during their main sequence evolution. We present data from stellar evolution models for the LMC metallicity with a dense spacing in mass from 70 to 500 solar mass and initial rotation rates up to 550 km/s, which take into account rotation, transport of angular momentum by magnetic fields and mass loss. We focus on the evolution of very massive stars during the main sequence near the Eddington limit and chemically homogeneous evolution. We find that the main sequence evolution of very massive stars is affected significantly by rotational mixing and mass loss, which is reflected by nitrogen and helium surface enhancements. Additionally, we predict a region in the Hertzsprung-Russell diagram where no stars are expected similar to the Humphreys-Davidson limit. Rapidly rotating stellar models show partial- and complete-chemically homogeneous evolution. In the investigated mass range of 70 to 500 solar mass, complete-chemically homogeneous evolution occurs only in rapidly rotating stars in the mass range 125 to 230 solar mass.

Peculiar objects from the VLT-FLAMES Tarantula Survey

Author: Paul Dunstall

Queen

Co-Authors:

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *12:49 Tuesday 27th 11:45-13:00*

Summary:

A series of large scale investigations were performed to detect radial velocity variations and measure the projected rotational velocities for a sample of over 500 early-type objects in the 30 Doradus region of the LMC. The results of these investigations detected the existence of a number of objects of particular interest, namely VFTS102, VFTS450, VFTS652 and VFTS698. Dufton et al. (2011) investigated the VFTS102 and found it to be a runaway star with a projected rotational velocity close to 600 km/s. The close proximity of VFTS102 to the X-ray pulsar PSR J0537-691 suggests that both objects originate from a binary system which gave rise to the unusual properties of VFTS102. VFTS450 and VFTS652 appear to be two short period binary supergiant systems with radial velocity amplitudes of ~200 km/s. From photometric and spectroscopic observations the presence of a 6.89 and 8.59 day period has been found for VFTS450 and VFTS652 respectively. An analysis of the VFTS698 system was performed by Dunstall et al. (2012) which

suggested it to be an interacting binary comprising an early B-type secondary, with features associated with the B[e] phenomenon, orbiting a veiled, more massive companion.

The young massive cluster R136: in virial equilibrium and rotating

Author: Vincent Henault-Brunet

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Co-Authors: the VLT-FLAMES Tarantula Survey consortium

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Poster *Poster Session A*

Summary:

Detailed studies of resolved young star clusters are necessary to determine their dynamical state and evaluate the importance of gas expulsion in early cluster evolution. In an effort to gain insight into the dynamical state of the young massive cluster R136 and obtain the first measurement of its velocity dispersion, we analyse multi-epoch spectroscopic data of the inner regions of 30 Doradus in the Large Magellanic Cloud obtained as part of the VLT-FLAMES Tarantula Survey. After accounting for the contributions of undetected binaries and measurement errors, we estimate the true velocity dispersion of the cluster and find a low value consistent with what is expected if the cluster is in virial equilibrium. This suggests that violent gas expulsion has not altered the its dynamics. We find that the velocity dispersion would be at least four times larger if binaries were not identified and rejected, confirming the importance of the multi-epoch strategy and the danger of interpreting velocity dispersion measurements of unresolved extragalactic young massive clusters. We also uncover the first evidence of significant rotation of a young massive cluster.

LBV nebulae in the Local Group

Author: Kerstin Weis

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Co-Authors:

Session: STA1: Massive stars: From the Milky Way to beyond the Local Group

Presentation type: Talk *00:00 Poster Session A*

Summary:

The LBV phase marks an active evolved phase in which massive stars undergo photometric and spectroscopic variations. Enhanced mass loss by stellar winds and possibly giant eruptions indicate the stars proximity to an instable state. As a consequence of both winds and eruption a fraction of LBVs form LBV nebulae. Analysis of the properties of the nebulae provide further insight about the underlying mechanism of the instability. With typical sizes below 5 pc these circumstellar LBV nebulae can be studied in detail in the Galaxy and close members of the Local Group. An overview of morphologies and kinematics of LBV nebulae will be presented, as well as a outlook about the connection of LBV nebulae and the closely related WR nebulae.

Natal kicks of stellar-mass black holes

Author: Melvyn Davies

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Co-Authors: S.Repetto (Nijmegen) Steinn Sigurdsson (Penn State)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *10:00 Thursday 29th 10:00-11:15*

Summary:

We investigate whether stellar-mass black holes have to receive natal kicks in order to explain the observed distribution of low-mass X-ray binaries containing black holes within our Galaxy. We combine population synthesis calculations with integrations of binary systems within the Galactic potential. We find that in a number of cases, natal kicks are in fact necessary. Further, we find that the distribution of natal kicks would seem to be similar to that of

neutron stars. This result is somewhat surprising; in many pictures of stellar-mass black-hole formation, one might have expected black holes to receive kicks having the same momentum (rather than the same speed) as those given to neutron stars.

The Tidal Excitation of Oscillations and Heartbeat Stars

Author: Kelly Hambleton

UCLan

Co-Authors: Don Kurtz (UCLan), Andrej Prsa (Villanova University), Steven Bloemen (Katholeke Universiteit Leuven), Jonh Southworth (Keele University)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *10:15 Thursday 29th 10:00-11:15*

Summary:

The tidal excitation of stellar oscillations occurs in eccentric binary systems due to the varying tidal forces on the stellar components. The signature of tidally excited modes is a frequency (or set of frequencies) that are precise multiples of the binary orbital frequency. Heartbeat stars are an entirely new class of object, first observed by Kepler, that demonstrate tidally excited modes and an increase in flux at periastron, similar in nature to the those seen in ellipsoidal variables. As the shape and size of the periastron brightening is highly dependent on quantities such as the eccentricity and argument of periastron, through binary modelling and the theory of tidally induced pulsations we are able to determine information about the orbital evolution of these fascinating systems. Moreover, through the asteroseismology of the non-resonant modes present in a selection of these objects we are able to determine information about the internal structure of the stellar components. We present an array of binary stars demonstrating tidal excitation including a selection of of Heartbeat stars. We demonstrate how the rate of apsidal advance can be measured in Heartbeat stars and thus how we can obtain a measure of the density distribution of the stellar components.

Binaries among debris disc A-stars.

Author: Nathalie D Thureau

University of St Andrews

Co-Authors: DEBRIS team

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *10:30 Thursday 29th 10:00-11:15*

Summary:

We have observed a sample of 89 main-sequence A-stars with Herschel-PACS (Photodetector Array Camera and Spectrometer) at 100 and 160 um. The data are from the Herschel Open Time Key Programme DEBRIS: “Disc Emission via a Bias-free Reconnaissance in the Infrared/Sub-millimetre”. We studied the disk population in order to determine if these debris discs are associated with binary or multiple stars. We found that 32% of our debris discs systems are binary or triple systems. The discs we detect fall into two groups: widely separated binaries with disc surrounding a single star or close binaries with circumbinary discs. We investigate the properties of the observed discs and draw a comparison between evolution scenarios in single versus multiple systems.

MIDIs Interferometric View of Circumstellar Discs in Binary and Multiple Systems

Author: Thorsten Ratzka

Universitäts-Sternwarte München

Co-Authors:

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *10:45 Thursday 29th 10:00-11:15*

Summary:

Young low-mass stars are very often formed as part of binary or multiple systems. In such systems circumstellar discs do not only transport angular momentum and serve as reservoir from which the central stars accrete gas and dust. The discs are also probes of the dynamical evolution of the systems. With the unprecedented spatial resolution offered by the MID-infrared Interferometric instrument (MIDI) at the Very Large Telescope Interferometer (VLTI) detailed investigations of the geometry, structure, and dust composition of circumstellar discs became possible. Among the studied objects are the binary system GV Tau and the triple system T Tau. Both systems harbour a so-called 'infrared companion', a star not detectable in the visual, but dominating the flux at longer wavelengths. All components of GV Tau and T Tau are surrounded by discs and were clearly resolved. The discs in these two prominent systems are misaligned and suggest a highly dynamic formation process of the objects.

Exposed red giant cores in eclipsing binary stars from the WASP archive

Author: Pierre Maxted

Keele University

Co-Authors: S. Geier (Bamberg); U. Heber (Bamberg); T.R. Marsh (Warwick); B. Smalley (Keele); R. Ostensen (Leuven); S. Bloemen (Leuven)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *11:00 Thursday 29th 10:00-11:15*

Summary:

We have identified 16 eclipsing binary stars in the WASP archive in which an apparently normal A-/F-type star eclipses a very unusual star with a typical mass of about 0.2 solar masses, effective temperature Teff = 9,000-14,000K and luminosity of a few solar luminosities. These are shell-hydrogen burning stars which have lost >80% of their mass by Roche-lobe overflow onto the companion star, i.e., progenitors of the eclipsing hot white dwarf binaries discovered using Kepler photometry. The new systems can be studied in great detail because they are bright (V=10-13), there is no on-going mass transfer, the eclipses are total and features from both stars can be seen in the observed spectrum. This makes it possible to measure the masses and radii of both stars to +-2% and to measure the effective temperature and composition of both stars. These are the only stars for which models for the formation of low mass white dwarfs (such as companions to milli-second pulsars) can be tested at this level of detail. We will present first results from a detailed study of J0247-25, the first such binary discovered, and follow-up spectroscopy for some of the 15 newly discovered binaries.

Duplicity in stellar populations

Author: Dr John Eldridge

University of Auckland

Co-Authors:

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *11:45 Thursday 29th 11:45-13:00*

Summary:

There is growing consensus that the binary fraction of massive stars is close to 100%. Therefore we cannot ignore the effect that binaries have on stellar systems. The evolution of binaries is strange and varied compared to single star evolution where only the initial mass determines a star's fate. Instead a binary star's fate also depends on the relative mass of its companion and the initial orbital separation. These two facts essentially determine whether the stars will interact, or "get in each other's way", and importantly during which phase of evolution. I will outline the common evolutionary pathways for binary stars and discuss how this will effect observations of stellar populations in our own Galaxy to those at the edge of the observable Universe. Showing examples of synthetic stellar populations, calculated using the Binary Population and Spectral Synthesis (BPASS; www.bpass.org.uk) code, providing closer agreement to observations when stellar duplicity is accounted for.

The VLT-FLAMES Tarantula Survey: Binary fraction of B type stars in the Tarantula Nebula

Author: Paul Dunstall

Queen

Co-Authors: P.L.Dufton (Queen's University Belfast); C.J.Evans (Royal Observatory Edinburgh); H.Sana (University of Amsterdam); W.D.Taylor (Royal Observatory Edinburgh)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *12:00 Thursday 29th 11:45-13:00*

Summary:

From spectroscopy of over 500 B-type stars in the 30 Doradus region of the LMC, we have used a cross correlation method to search for radial velocity variations for the estimation of the binary fraction. Spectral cross correlation has been performed for a series of metal and helium absorption lines within the wavelength region 3960 - 4560 A, yielding the velocity space shifts between different exposures. Spectra were obtained at different epochs and covered time cadences from less than one night to approximately one year. By determining the significance of the velocity shifts, it was possible to infer the binary status of each object. A criteria has been created in order to determine the binary status of our sample of B-type stars. From this criteria we find a binary fraction of close to 0.40, which appears consistent when compared with a secondary model for binary detection.

A Binary and Single star population synthesis model of the Kepler Field

Author: Robert Farmer

The Open University

Co-Authors: U.Kolb (The Open University)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *12:15 Thursday 29th 11:45-13:00*

Summary:

We present population synthesis calculations for the Kepler field, using a comprehensive stellar and binary evolution code based on that of Hurley, Pols, Tout (2000,2002) and Willems et al (2006). We modified the code to take into account magnitudes of star systems in multiple filters, including Kepler's; transits depths of eclipsing binaries, taking into account limb and gravity darkening; and 3D spatial information, including the Kepler CCD structure. We show how our Galactic model compares with that of the Kepler Input Catalogue and how we have calibrated the model to fit the observations. We also present our initial results for creating a synthetic catalogue of eclipsing binaries for comparison with the catalogues of Prsa et al (2011) and Slawson et al (2011).

Orbital decay of binary stars in gas

Author: Christina Hövel

Forschungszentrum Jülich GmbH

Co-Authors: T. Kaczmarek (MPIfR Bonn); S. Pfalzner (MPIfR Bonn)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *12:30 Thursday 29th 11:45-13:00*

Summary:

In the early, embedded phases, clusters consist of already formed stars and a large gas component from which further stars may form. The formed stars remain inside their natal gas cloud until it is removed by strong winds of massive stars or supernova explosions. During this embedded phase, stars and

binary systems experience dynamical friction due to the surrounding gas. For binary systems, this dynamical friction leads to energy and angular momentum loss, which results in the reduction of the binary orbit and in some cases even in merging. The aim of the presented work is to investigate the effect of the ambient gas and the dynamical cluster evolution on a primordial binary population. Analytical results by Stahler (2010) show that circular low-mass binaries with separations less than 100 AU in infrared dark clouds of peak densities up to 10^7 cm^-3 will merge within about one Myr, due to dynamical friction. In the presented work, self consistent hydrodynamic simulations were used to validate the approach and extend the application area from circular to eccentric orbits.Additionally, the dynamical cluster evolution was investigated using n-body simulations. The combined effect of dynamical friction and dynamical evolution shows the conversion from a log-uniform to a log-normal period distribution for binary systems with G-star primaries. These results are consistent with those observed by Duquennoy and Mayor (1991) and Raghavan et al. (2010).

Tidal Disruption of binaries: Hypervelocity Stars and Triton

Author: Shiho Kobayashi

Liverpool John Moores University

Co-Authors: Y. Hainick (Tel-Aviv Univ); Re'em Sari(Hebrew Univ/Caltech); E.M. Rossi (Leiden Obs)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *12:45 Thursday 29th 11:45-13:00*

Summary:

We study the tidal disruption of binaries by a massive point mass (e.g. the black hole at the Galactic centre), and we discuss how the ejection and capture preference between unequal-mass binary members depends on which orbit they approach the massive object. We show that the restricted three-body approximation provides a simple and clear description of the dynamics. The orbit of a binary with mass m around a massive object M should be almost parabolic with an eccentricity |1-e| < (m/M)^ << 1 for a member to be captured, while the other is ejected. Indeed, the energy change of the members obtained for a parabolic orbit can be used to describe non-parabolic cases. In principle, for any hyperbolic (elliptic) orbit, the heavier member has more chance to be ejected (captured), because it carries a larger fraction of the orbital energy. However, if the orbital energy is close to zero, the difference between the two members becomes small, and there is practically no ejection and capture preference. The preference becomes significant when the orbital energy is comparable to the typical energy change at the encounter. We discuss its implications to irregular satellites around giant planets, especially Triton - Neptune's largest moon. We also predict the velocity distribution of hypervelocity stars from the Galactic centre. The presentation is based on Kobayashi et al. 2012 ApJ in press (arXiv:1201.4794) and Rossi et al. 2012 in preparation.

Planetary nebulae after common-envelope phases initiated by low-mass red giants

Author: Philip D. Hall

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Co-Authors: C.A. Tout (Institute of Astronomy, Cambridge, UK); R.G. Izzard (Argelander-Institut für Astronomie, Bonn, Germany)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *10:00 Friday 30th 10:00-11:15*

Summary:

Planetary nebulae are commonly thought to be formed from the envelopes lost from asymptotic giant branch stars in strong stellar winds. However, the observation of planetary nebulae with short-period, binary central stars suggests that some were formed after common-envelope phases, in which a star's envelope is ejected by its inspiralling companion. The ejected envelope becomes a planetary nebula if the remnant core is able to photoionize it before it disperses. We considered the question of which post-common envelope remnants of low-mass red giants are able to do this. Iben & Tutukov (1993) found that such remnants must have core masses greater than 0.4 solar masses and end the common-envelope phase with radii less than 1 solar radii for this to happen. However their conclusions were based on only a few computed models. We present the results of a more systematic theoretical investigation into this question.

On the Progenitors of Classical and Recurrent Novae

Author: Matt Darnley

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Co-Authors: Valerio Ribeiro (University of Cape Town); Mike Bode (Liverpool John Moores University); Rebekah Hounsell (Liverpool John Moores

Co-Authors: Valerio Ribeiro (University of Cape Town); Mike Bode (Liverpool John Moores University); Rebekah Hounsell (Liverpool John Moores University); Farung Surina (Liverpool John Moores University); Steve Williams (Liverpool John Moores University)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *10:15 Friday 30th 10:00-11:15*

Summary:

Of the approximately 400 known Galactic classical novae, only ten of them, the recurrent novae, have been seen to erupt more than once. Eight of these recurrents are known to harbour evolved secondary stars, rather than the main-sequence secondaries typical in classical novae. We recently proposed a new nova classification system, based solely on the evolutionary state of the secondary and not (like the current schemes) based on the properties of the outbursts. Using archival optical and near-infrared photometric observations of a sample of 38 quiescent Galactic novae we have shown that the evolutionary state of the secondary star in a quiescent system can be predicted. We have already applied this technique to a number of Galactic novae. Here we also present the implications of this new approach to extragalactic systems including the viability of identifying potential SN Ia progenitors of the single-degenerate class.

Modelling the spectrum of the recurrent nova U Scorpii in quiescence

Author: Michael Maxwell

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Co-Authors: S.P.S. Eyres (UCLan) M.T. Rushton (UCLan)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *10:30 Friday 30th 10:00-11:15*

Summary:

U Scorpii is a recurrent nova which underwent its 10th observed outburst in January 2010. In May 2011, by which time the system was expected to have returned to quiescence, we obtained NUV, optical, and NIR spectra of the system with VLT/XShooter across a range of orbital phases. The continuum and spectral features were found to be dominated by the accretion disc. We have modelled the disc emission in order to investigate the effect of varying the mass transfer rate on these spectra and, by comparing these to our observed spectra, we estimate the mass transfer rate in U Sco during quiescence. Since U Sco has a very short recurrence timescale, approximately 10 years, understanding the mass transfer rate is essential if the behaviour of this system and other recurrent novae are to be understood; this is crucial if the question regarding a potential link between recurrent novae and type Ia supernovae is to be definitively answered.

Classical Novae : solving the J star puzzle

Author: Sutirtha Sengupta

Argelander-Institut für Astronomie

Co-Authors: R.G.Izzard(Argelander-Institut für Astronomie);H.B.Lau(Argelander-Institut für Astronomie)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *10:45 Friday 30th 10:00-11:15*

Summary:

I describe a binary scenario for the origin of a peculiar class of carbon stars - the J-stars - which remain an elusive mystery for standard stellar evolutionary models. J-stars are rich in C13 such that 12C/13C<10 and constitute 10-15% of the observed carbon stars in our Galaxy and the LMC. Using the stellar population synthesis code binary_c/nucsyn, I investigate the effect of back-accretion of novae ejecta from explosions of CO WDs on the binary companion which evolves into a J-star with its peculiar chemical features. The binary model yields two distinct classes of such J-star candidates - for a wide enough separation, the WD companion evolves as a dimmer sub-giant for hundreds of Myrs whereas, for closer binaries, the system undergoes a second post-nova common-envelope phase resulting in a bright AGB star, enriched in C13 owing to previous chemical pollution during the nova phase. I present a population synthesis study which estimates the number of such systems and compare this with existing J-star observations such as luminosity functions and chemical abundances of 13C, 18O & Li.

Morphological changes in the circumstellar environment of V Hya

Author: Foteini Lykou

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Co-Authors: A.A. Zijlstra (Jodrell Bank Centre for Astrophysics); P.G. Tuthill (University of Sydney)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *11:00 Friday 30th 10:00-11:15*

Summary:

The process of stellar mass loss and the shaping of ejecta in AGB stars is a key point in understanding stellar evolution. The transformation of the stellar ejecta during/after the end of the AGB from spherically symmetric shells into asymmetric structures has been attributed to magnetic fields and binarity. These mechanisms can shape the ejecta into asymmetric nebulae, accretion disks, circumbinary disks/torii, dense spirals and jets. Here we present the influence of binarity on the peculiar variable V Hya, a C-rich giant currently transiting from AGB to post-AGB with an unknown companion, a molecular

bipolar jet and a torus. We have resolved the circumbinary dusty structure of V Hya in the near-infrared with the means of aperture masking interferometry, a novel technique that transforms a single-dish optical telescope into an interferometer that allows the acquisition of diffraction-limited images. Our findings provide further constraints on the binary's orbit and mass ratio from the morphological changes of the circumstellar environment (possible detection of an orbiting, dusty "clump" associated with the companion) and the variability of the central component over several epochs.

Aspherical Planetary Nebulae: Binaries Blowing Bubbles

Author: David Jones

European Southern Observatory

Co-Authors: B. Miszalski (South African Astronomical Observatory), H.M.J. Boffin (European Southern Observatory), A.A. Tyndall (University of Manchester)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *11:45 Friday 30th 11:45-13:00*

Summary:

Central star binarity has long been thought to offer a solution to the vexing problem of how Planetary Nebulae (PNe) form such a wide variety of morphologies. Only now, thanks to recent surveys and improved observing strategies, is it clear that a binary channel is indeed responsible for a large fraction of PNe. Furthermore, our studies have started to identify strong links between binarity and morphology, including bipolarity, jet-like structures and rings of low ionisation material resembling those of SN 1987A. Here, I will review the currently known sample of binary central stars, focusing on our own recent discoveries including intermediate period central stars whose chemical compositions have been altered by a phase of mass transfer traced by the ejected nebula. I will also discuss the importance of the growing sample of "fresh out of the oven" post-common-envelope central stars, and their importance in constraining theories of the poorly understood common-envelope phase of evolution.

Deep optical surveys in search for accreting compact binaries

Author: Sandra Greiss

The University of Warwick

Co-Authors:

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *12:00 Friday 30th 11:45-13:00*

Summary:

White dwarfs, either accreting from non-degenerate companions, or coalescing with a second white dwarf, are thought to be the progenitors of Type Ia supernovae. Our knowledge of the galactic white dwarf population has increased substantially thanks to large sky surveys such as SDSS. However, the understanding of their formation and evolution remains incomplete. It is therefore crucial to expand the known sample of white dwarf binaries, as well as that of related types of compact binaries. Here we focus on The European Galactic Plane Surveys collaboration (EGAPS), a deep optical survey of the entire galactic plane in Ugri and H-alpha. It is an ideal location to detect compact binaries, whether CVs, double-degenerates, or LMXBs, as the density of these systems is highest in the plane, and confusion with background quasars and hot OB stars is suppressed by extinction. In addition, most if not all, accreting binaries are H-alpha emitters, therefore they stand out clearly in colour-space. Slightly away from the Galactic Plane, at lower extinction, lies the Kepler field. It is the target of the most intensive search for transiting planets to date. Despite the fact that the Kepler mission provides the best ever time series photometry, with an enormous impact on all areas of stellar variability, its field lacks deep optical photometry necessary for selecting various classes of targets such as hot, young, or active stars, white dwarfs or subdwarfs, and accreting objects. For this reason, we make use of the available EGAPS observing strategy and pipeline to produce a deep optical survey of the Kepler field in Ugri and H-alpha, down to 21st mag. Here, we present the initial data release of the catalogue and the type of interesting objects which are expected to be discovered in this region.

The hidden population of AM CVn binaries in the SDSS

Author: Philip Carter

University of Warwick

Co-Authors: T.R.Marsh (University of Warwick); D.Steeghs (University of Warwick); P.J.Groot(Radboud University Nijmegen); G.Nelemans (Radboud University Nijmegen); A.Rau (MPE Garching); C.M.Copperwheat (University of Warwick); G.Roelofs (Harvard-Smithsonian CfA)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *12:15 Friday 30th 11:45-13:00*

Summary:

The ultracompact AM CVn binaries are a small, but growing, rare class of objects that have binary periods below the minimum for normal hydrogen-rich Cataclysmic Variables (<1 hour). They are of particular interest for the study of common envelope binary evolution, are key sources of low-frequency gravitational waves, and are related to the double-degenerate pathway towards Type Ia supernovae. The Sloan Digital Sky Survey has almost doubled the number of AM CVn systems known; initially through discoveries from amongst the serendipitous spectroscopic targets and, more recently, via our dedicated spectroscopic survey designed to uncover the 'hidden' population in the photometric database. This survey is now approximately 70% complete, and has uncovered significantly fewer new systems than expected, indicating a lower space density than predictions suggest. With the knowledge gained so far, and the addition of GALEX UV data for much of the sample, we can adjust our selection criteria to optimise the follow-up. This will provide us with the larger, homogeneous sample required to more reliably estimate the AM CVn space density. Establishing this is important for testing our

understanding of common envelope evolution, but also to determine the stability of mass transfer in these double degenerates that will dictate the merger rate for related objects such as their double white dwarf progenitors.

The effects of stellar and close binary evolution on the present day mass function

Author: Fabian Schneider

Argelander Institut für Astronomie, Universität Bonn

Co-Authors: Robert G. Izzard (Argelander Institut für Astronomie, Universität Bonn) Norbert Langer (Argelander Institut für Astronomie, Universität Bonn)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *12:30 Friday 30th 11:45-13:00*

Summary:
The initial mass function (IMF) governs observable properties of stellar systems, the chemical enrichment of the interstellar medium, supernova rates and predicts the outcome of star formation. It is impossible to measure the IMF directly because we can only observe the current mass distribution of stars. We therefore need to understand which systematic effects cause variations in the observed present day mass function (PDMF). We explore the influence of single and binary stellar evolution on the PDMF with a rapid binary evolution code. Stellar wind mass loss, mass transfer because of Roche lobe overflow, stellar mergers and rejuvenation shape the PDMF at the high mass end. The PDMF and the inferred IMF are flattened if binaries cannot be resolved. The most massive stars in a star cluster originate --- in a statistical sense --- from binary interactions if binary stars have enough time to interact efficiently, i.e. if the star cluster has an age of the order of the MS lifetime of its initially most massive stars. The determination of stellar upper-mass limits and ages of star clusters based on the most massive stars are thus biased by binary interactions. We conclude that single and binary stellar evolution must be taken into account to determine the IMF and interpret observations of the stellar content of star clusters correctly.

Evidence for neutron star formation without a core-collapse supernova in the double pulsar system

Author: Robert Ferdman

University of Manchester

Co-Authors:

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *12:45 Friday 30th 11:45-13:00*

Summary:

The double pulsar system PSR J0737-3039A/B is a highly relativistic double neutron star (DNS) binary, with a 2.4-hour orbital period. The low mass of the second-formed NS, as well the low system eccentricity and proper motion, point to an alternative evolution compared to other DNS systems. We describe analysis of the pulse profile shape over 6 years of observations, and present the resulting constraints on the system geometry. We find the spin axis of the recycled pulsar in this system, PSR J0737-3039A, to be nearly aligned with the orbital angular momentum axis. Our tight constraint supports the idea that the supernova that formed the second neutron star was relatively symmetric, possibly involving electron-capture onto an O-Ne-Mg core.

Dual Chemistry of GB PNe from HST, VLT and Spitzer

Author: Lizette Guzman-Ramirez

JBCA, University of Manchester

Co-Authors: Albert Zijlstra

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Poster *Poster Session B*

Summary:

Galactic Bulge Planetary Nebulae show evidence of mixed chemistry with emission from both silicate dust and PAHs. We analysed a sample of 40 nebulae using Sptizer, a sub-sample of these were observed with HST and VLT (UVEX and VISIR). A strong correlation is found between strength of the PAH bands and morphology, in particular, the presence of a dense torus. A chemical model is presented which shows that hydrocarbon chains can form within oxygen-rich gas through gas-phase chemical reactions. We conclude that the mixed chemistry phenomenon occurring in the Galactic Bulge Planetary Nebulae is best explained through hydrocarbon chemistry in an UV-irradiated, dense torus.

Period decrease in three SuperWASP eclipsing binary candidates near the short-period limit

Author: Marcus Lohr

Open University

Co-Authors: A.J.Norton (Open University)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Poster *Poster Session B*

Summary:

Summary:

W UMa-type variables are contact binaries with low-mass main sequence components. Their light curves exhibit continuous variation associated with the ellipsoidal Roche-lobe-filling components, and eclipses of similar depth due to a shared atmospheric envelope, concealing low mass ratios. Their orbital periods, typically of several hours, exhibit a lower limit around 0.22d. The reason for this is uncertain, but may be associated with a lower limit of primary mass and/or mass ratio, below which the stars rapidly inspiral and merge. Our research follows up the identification of 53 W UMa candidates near the short-period limit, by Norton et al. (2011), in SuperWASP archival data. Here, a three-part period search program confirmed the periods of all but nine objects as <20000s. Additionally, O-C diagrams were automatically constructed, indicating period decrease significant at more than 5σ in three objects. One system with a period of only 0.21d appears to be losing orbital period at a rate of about 0.3s/yr, suggesting a possible merger on a rapid timescale. Such objects can help understand W UMa evolution and the reason for the short-period limit. We are currently trying to model these systems to determine their parameters, and to identify further SuperWASP short-period eclipsing binaries.

Photometric and spectroscopic study of the recurrent nova T Pyx in its 2011 outburst

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Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Poster *Poster Session B*

Summary:

T Pyx is a short orbital period recurrent nova with previous outbursts in 1890, 1902, 1920, 1944, 1966, and now 2011. The outburst in 2011 was discovered and reported to have a visual magnitude of 13.0 on 2011 April 14.29. White light observations of T Pyx, using The Solar Mass Ejection Imager (SMEI) were made from 2011 April 15.70 UT (t = 1.4 days) to 2011 May 20.90 UT (t = 36.6 days). These photometric observations provide unprecedented detail regarding the behavior of the light curves and are compared to the spectra of T Pyx obtained by FRODOSpec on the Liverpool Telescope plus those obtained by the SMARTS telescopes. The investigations of how spectra change together with brightness are presented in order to determine the origin of light curve variability in the early stage of the nova outburst.

A substellar cuckoo

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Co-Authors: M.R. Burleigh (University of Leicester), G. Wynn (University of Leicester), R.D. Alexander (University of Leicester), R. Napiwotzki (University of Hertfordshire), K.A. Lawrie (University of Leicester), P.D. Dobbie (Australian Astronomical Observatory), S.T. Hodgkin (University of Cambridge)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

Stars with masses >1Msun with close (< 3AU), substellar companions are extremely rare, despite the fact that numerous stellar and planetary companions are discovered at such separations. White dwarf-substellar binaries are the rare descendants of these unusual systems, and in extreme cases these galactic fossils offer unique insights into both the birth and death of these stars and their companions. We have discovered a close substellar companion to a massive white dwarf member of the Praesepe open star cluster. Using the known age of the cluster and the cooling time of the white dwarf we have determined the mass of the progenitor star (3.5-3.7MSun; B9). The high mass of the white dwarf means that the substellar companion must have been engulfed by the B star's envelope while it was on the late asymptotic giant branch, locating the original orbit of the substellar companion at ~ 2AU. We are also able to establish the conditions under which the system formed, and conclude that the substellar object was probably captured by the white dwarf progenitor early in the life of the cluster.

A proper motion study of wide binary companions to Hipparcos stars with Pan-STARRS1

Author: Niall R. Deacon

MPIA

Co-Authors: M.C. Liu (IfA, Hawai`i); E.A. Magnier (IfA, Hawai`i); B. Goldman (MPIA)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

We present initial results from a survey to identify wide common proper motion companions to Hipparcos stars. Using a proper motion catalogue created for our Pan-STARRS1-2MASS search for brown dwarfs we have identified plausible candidate companions out to a projected separation of 10,000 AU. This has already yielded the discovery of a mid-T companion to the Hipparcos star HIP38939. As well as constraining the fraction of wide, low-mass companions to intermediate mass stars, such systems can be used to test evolutionary models of brown dwarfs and exoplanets using the determined properties of the companion and an age inferred from the primary. Additionally wide M dwarf companions can be used to build up a catalogue of red

dwarfs with metallicities determined from their primaries. Such a catalogue can be used to create improved M dwarf metallicity measurements, greatly improving the selection criteria for targets for exoplanet searches. We present results from our initial survey containing over 800 candidate companions and discuss methods to better characterise objects and filter out chance associations.

The formation and fragmentation of discs around primordial (Pop III) protostars

Author: Paul Clark

ITA/ZAH Universität Heidelberg

Co-Authors: Simon Glover (ITA, Universität Heidelberg); Rowan Smith (ITA); Thomas Greif (MPE, Garching); Ralf Klessen (ITA); Volker Bromm (University of Texas).

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

The very first stars to form in the universe heralded an end to the cosmic dark ages and introduced new physical processes that shaped early cosmic evolution. Until now, it was thought that these stars lived short, solitary lives, with only one extremely massive star, or possibly a very wide binary system, forming in each dark matter minihalo. Here we describe numerical simulations that show that these stars were, to the contrary, often members of tight multiple systems. Our results show that the discs that formed around the first young stars were unstable to gravitational fragmentation, producing small binary and higher-order systems that had separations as small as the distance between the Earth and the Sun. The first stars could thus have given rise to high redshift gamma-ray bursts and X-ray binaries, which may be detectable with ongoing and planned facilities on the ground and in space.

Planets around the cataclysmic variable UZ Fornacis?

Author: Madelon Bours

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Co-Authors: T.R. Marsh (University of Warwick)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Poster *Poster Session B*

Summary:

UZ Fornacis is an eclipsing binary of the cataclysmic variable type. Accurate observations show that the time from one mid-eclipse to the next is not constant. A possible cause for deviations from strict orbital periodicity is the presence of small bodies in wide orbits around the close binary. These have a gravitational influence on the binary which is strictly periodic. Recovering this from the mid-eclipse time data provides limits on the planets' orbits and minimum masses. Here we investigate data of UZ Fornacis which spans roughly 27 years. Using Markov Chain Monte Carlo fitting suggests their may be two or three planets in orbit around UZ Fornacis. Subsequent analysis of the dynamical stability of such a planetary system shows if it is stable on timescales exceeding 10^6 years. If unstable, it is unlikely for us to find and observe such a system. Other possible causes for the mid-eclipse timing variations that can be considered are variations in existing magnetic fields and apsidal motion.

Probing the Substellar Graveyard

Author: Paul Steele

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Co-Authors:

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

We present the results of a near-infrared survey using UKIDSS to identify brown dwarf companions to white dwarfs. The sensitivity of UKIDSS in such a survey is addressed leading to an estimate of the white dwarf + brown dwarf binary fraction.

Multiplicity of B type stars by direct imaging

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Co-Authors: R. Neuhäuser (AIU Jena)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

It is still not clear, whether intermediate mass stars form preferentially by accretion of material through a circumstellar disk or by coagulation of many

lower mass stars in a multiple system. Maybe, both ways of formation are possible, then it is still unknown, how often each of the two channels is chosen by nature. Intermediate mass stars very often are multiple (Zinnecker & Yorke, 2007, ARA&A) with a binary fraction of 70 to 90 % (Pfalzner & Olczak, 2007, A&A; Ostrov, 2002, MNRAS). For many high and intermediate mass stars, no deep and sensitive multiplicity survey has been done. In particular, only few of these stars have been observed so far by AO imagers, which can find very faint companions also at a separation range (roughly 0.1 to few arc sec, i.e. long orbital periods), which is not reachable for spectroscopic surveys (short periods). In this presentation we present some preliminary results of our search for multiplicity among B-type stars and introduce a new method for calibration of archival data, if no extra calibration images are taken (for pixel scale and/or detector orientation). In particular we will show a new, possible sub-stellar companion to the young B-type star HR 3672.

The Dependence of Dust Formation Timescale on the Speed Class of Novae

Author: Steven Williams

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Co-Authors: M. F. Bode (Liverpool John Moores University), M. J. Darnley (Liverpool John Moores University), A. W. Shafter (San Diego State University), V. Zubko (U.S. Naval Observatory)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

Dust formation in novae appears to depend strongly on how fast the nova optical light curve declines (their speed class). Using simple relationships of e.g. speed class with luminosity and ejection velocity, it can be shown that the dependencies effectively cancel, leaving dust formation essentially independent of speed class. After a nova outburst the spectrum of the central hot source evolves, with an increasing proportion of the radiation being more energetic than the Lyman limit. The rate at which the spectra evolve depend on the speed class. We have refined the models by assuming radiation at higher energies than the Lyman limit is absorbed by neutral hydrogen gas internal to the dust formation sites. Here we present the effect our theoretical refinement has on the relationship between dust formation timescale and speed class, where we now find a much more sensitive relation between these two quantities.

Kepler

Author: Rene Breton

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Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

Thanks to Kepler’s staggering photometric capabilities, we can now obtain stellar light curves with accuracies of a few parts in 10,000. Such high level of precision allowed for the first measurement of Doppler boosting in a binary system in 2010, a feat that opened the door to the photometric measurement of orbital radial velocities! When Doppler boosting is observed in conjunction with transits/eclipses, one gains great leverage at inferring physical parameters of a binary system. In this talk, I will discuss developments in this area in the light of the recent discovery in Kepler data of several thermally bloated, hot white dwarfs in close orbit with more or less normal stars of spectral class A/F. These systems, which are likely the long-sought direct descendants of Algol-type binaries, pose certain challenges in terms of binary evolution.

OH Maser Flaring Event in o Ceti

Author: Sandra Etoka

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Co-Authors: Eric Gerard (Observatoire de Paris - Meudon - Fr); Anita Richards (JBCA - The University of Manchester - UK); Dieter Engels (Hamburger Sternwarte - Germany); Jan Brand (INAF, Istituto di Radioastronomia - Italy); Thibaut Le Bertre (Observatoire de Paris - Meudon - Fr)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

o Ceti (a.k.a Mira A) is known as the prototype of Miras and Mira-type long-period variable stars. o Ceti has a typical optical period of 332 days; nevertheless, it is quite a remarkable Mira. It belongs to a detached binary system (Mira AB) in which mass transfer by wind interaction is taking place. The hot companion of o Ceti, Mira B (either a main-sequence star or a white dwarf), is orbiting ~75 AU. OH masers - originating in the outer part of the circumstellar shell (CSE) - are commonly found towards isolated Miras, they are fairly unusual around binary systems close enough to be in interaction as is the case for the Mira AB system. Flares in OH are a fairly rare event. They have been detected only towards Miras (i.e., not observed so far in any OH/IR objects). All the 6 previous other documented flares emanated from isolated stars. And, the spectral characteristics seem to indicate that OH flaring features occur in the inner CSE. But this has never been confirmed by actual mapping yet. O Ceti experienced a flaring event in the 1990's. After 10 years of non-emissivity, in November 2009, it showed a new outburst in the 1665 MHz OH maser line. It has been active since and is continuously monitored at the Nancay Radiotelescope (NRT) and we also mapped it with the EVN+MERLIN. We present here the preliminary results of this exceptional event.

Observation of the Planetary Nebula surrounding V458 Vulpeculae via its Light-Echo

Author: Rebkah Hounsell

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Co-Authors: D.J. Harman (Liverpool John Moores University), M. J. Darnley (Liverpool John Moores University), and M. F. Bode (Liverpool John Moores University)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

Nova V458 Vulpeculae was discovered in outburst on 2007 August 8th at a magnitude of 9.5, reaching its peak visual magnitude a few days later at V = 8.1. The nova was seen to occur within a planetary nebula (PN) making it one of only two novae observed to have occurred in such an environment and as such very rare event. Due to fash ionization by the nova outburst, light is being re-emitted by the PN gas creating a light-echo effect. Since 2007, V458 Vul has been imaged multiple times by the Liverpool telescope in addition to several other telescopes worldwide producing 20 epochs of H-alpha data between 2008 and 2011. Each epoch of data provides a one-off map of the PN material for a given light-echo paraboloid. Using these data the illumination of the PN with time has been examined and a 3D reconstruction of its morphology obtained using C. Comparison to PN models created in the morphokinetic modelling tool XS5 has enabled measurements of the PN size, inclination, position angle, and distance. Here we present the results of a detailed reconstruction of the PN geometry based on a study of the light-echo propagation over a four year period.

Infrared-Interferometry of the septuple system nu Scorpii

Author: Rebekka Grellmann

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Co-Authors: Thorsten Ratzka (USM) Thomas Preibisch (USM) Rainer Koehler (LSW) Paola Mucciarell (USM)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

Using infrared interferometry for the search of companions around stars efficently fills the gap between spectroscopic and visual (adaptive optics etc.) studies in terms of angular resolution. Only in this way, a complete picture of the mulitplicity of stars can be obtained. In this talk I will focus on interferometric observations of the septuple hierarchical B star nu Scorpii perfomed with the AMBER instrument at the Very Large Telescope Interferometer. Using published speckle interferometry observations we can constrain the orbit of one of the close companions (~80 mas). We furthermore combine this observation with ROSAT X-ray data of the system and can thus make even more conclusions about the mass distribution between the companions.

Evolution towards the field binary population in dense star clusters

Author: Thomas Kaczmarek

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Co-Authors: C. Hövel (Forschungszentrum Jülich), S. Pfalzner (Max-Planck Institut für Radioastronomie)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Poster *Poster Session B*

Summary:

Surveys of the binary populations in the solar neighbourhood have show, that the periods of G- and M-type stars are \textit distributed in the range from 0.1 days to $10^$ days. However, observations of young binary populations in various star forming regions suggest a \textit period distribution rather than a log-normal distribution. In the here presented study, we investigate, if the early evolution of the binary populations in there natal environments can change a initially log-uniform period distribution to a log-normal one. Most stars, including binaries, form in star clusters of thousands of stars which are embedded in the gas, they are forming from. In these dense systems two important processes take place: i) the orbital decay of embedded binary systems and ii) the destruction of soft binaries in three body interactions. To investigate the effect of these two processes on the period distribution, we performed Monte-Carlo simulations of binary populations to model the former process, while the latter was simulated using Nbody simulations of a binary population embedded in a ONC-like star cluster. Neither of the two processes is capable to change a log-uniform to a log-normal period distribution. While the orbital decay significantly reduces the number of short-period binaries and does not effect wide binaries, the cluster dynamics do not alter short period binaries but reduce the number of wide binaries. However, after we combined the two processes, the log-uniform distribution was successfully converted to the a log-normal period distribution. To prove this we performed a χ^2-test of our evolved period distribution and the observed period distribution of Duquennoy \& Mayor 1991 and obtained a probability of 89% that both distributions have been sampled from the same parent distribution. To further generalize the results obtained for the ONC, we additionally reperformed the above mentioned simulations for clusters of varying initial stellar and gas densities. For them, we investigate, if the dynamical evolution of the binary population is self-similar as described by Kaczmarek (2011) for ONC-like systems and how the shape of the period distribution differs when varying the stellar and gas-densities in the cluster.

PG1544+488: First of its kind -- A binary containing twin hot helium-rich subdwarfs

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Armagh Observatory

Co-Authors: Prof.Dr.C.Simon Jeffery - Armagh Observatory

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Poster *Poster Session B*

Summary:

Our research aims to study binary systems containing at least one unusual hot subdwarf. Such systems demonstrate the extreme range of possible outcomes of common-envelope ejection in a close binary. The first object to be studied is PG1544+488, a binary containing two extremely helium-rich subdwarfs in a 12 hour orbit. Spectroscopic observations obtained with the William Herschel Telescope provide improved orbital parameters and much tighter constraints on possible progenitors.

Searching for companions in CRIRES spectra and slit-viewer images of telluric standards

Author: Jonathan Smoker

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Co-Authors: M. Rodriguez, ESO Chile H. Boffin, ESO Chile S. Guieu, ESO Chile A. Smette, ESO Chile F. P. Keenan, Queen's University Belfast C. Hill, Queen's University Belfast

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Poster *Poster Session B*

Summary:

This project aims at producing an atlas of the 500+ mainly early-type telluric standards observed to date with CRIRES, which is the near to- mid-infrared high-resolution spectrometer on the VLT. The project comprises two parts: (1) To produce spectra of all of the telluric standards taken to date that can be used for a variety of scientific and technical purposes (looking for the presence of companions in the stellar spectra, searching for warm CO in the disks of early-type stars, spectral analysis of B type stars to act as templates for stars with high extinction in the optical, avoiding tellurics in the future that show emission-line features etc) and (2) To use the slit viewer images of CRIRES in order to search for previously unresolved stellar companions. These slit-viewer images (typically in J, H or K bands) have a plate scale of around 0.05 arcseconds and, due to the adaptive optics system in CRIRES, have a spatial resolution of typically <0.2 arcseconds. Although they are shallow (integration times generally a few seconds), the high-resolution infrared nature of the observations makes them useful for detecting new companions. Due to the properties of speckle, the putative faint companions will have to be followed up at a future date to determine (1) If they are really stellar objects and (2) If the proper motions are the same in order to confirm if they are companions or just background objects. Initial results are presented including a sub-sample of the reduced spectra and a number of cases that show putative companions.

The sky has still got the blues for us to explore! The blue objects catalogue from The RATS project

Author: Onur SATIR

Armagh Observatory

Co-Authors: G.Ramsay (Armagh Observatory)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Poster *Poster Session B*

Summary:

We present the first catalogue of "blue" objects selected from The RATS (the RApid Temporal Survey) project, which explores the faint, variable sky. The RATS project covered approximately 40 square degrees of the sky close to the Galactic plane via observations taken between 2003-2010. The observational strategy was to take exposures approximately every minute with wide-field CCD cameras for two hours in each field. To select “blue” objects, we have developed an automated colour-selection method on a field-by-field basis. Our targets, include white dwarfs, white dwarf binaries (such as AM CVn binaries and other CV's, non-interacting WD-WD binaries etc.), sdB's, stellar pulsators for example. We anticipate that this work will allow us to place constraints on the space density of these objects.

Suppression of X-rays during an optical outburst of the helium dwarf nova KL Dra

Author: Gavin Ramsay

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Co-Authors: Tom Barclay (NASA Ames), Danny Steeghs (Warwick), Simon Rosen (Leicester), Peter Wheatley (Warwick)

Session: STA2: Binary Stars: Duplicity is Everywhere

Presentation type: Talk *00:00 Poster Session B*

Summary:

KL Dra is a helium accreting AM CVn binary system with an orbital period of 25 mins. Approximately evey 60 days there is an optical outburst which has a duration of 10 days where its brightens by 4 mag. We present the most sensitive X-ray observations made of an AM CVn over the course of an outburst cycle. A series of eight observations were made using XMM-Newton which started shortly after an optical outburst. We find that the X-rays are suppressed during the optical outburst: there appears to be a delay in the re-appearance of the X-rays compared to the decay of the UV emission. There is some evidence for a spectral variation of the X-ray spectrumduring the course of the outburst (especially at the softest energies) and that its temperature is

cooler during optical outburst compared to quiescence.We compare these results with outburst from the hydrogen accreting dwarf novae.