Indian Institute Of Astrophysics, Bangalore

January 21 – 23, 2013

PROGAMME & ABSTRACT BOOK

Scientific Programme

21 January 2013 (Monday)

Waves in Active regions

Session I Chair: Arnab Rai Choudhuri

09:00-09:30	Registration
09:30-09:40	Opening Remarks
09:40-10:30	D. Nandi - *Solar Active Regions Magnetic Fields and Waves: It takes two to Tango*
10:30-11:00	**Tea**
11:00-12:00	S. P. Rajaguru - *Active region seismology and magnetohydrodynamic (MHD) waves*
12:00-13:00	B. Ravindra - *Oscillations in Large Scale Magnetic Structures*
13:00-14:00	**Lunch**

Waves within smaller magnetic structures

Session II Chair: P. Venkatakrishnan

14:00-15:00	Mihalis Mathioudakis - *The Structure and Dynamics of Magnetic Bright Points*
15:00-15:30	**Tea**
15:30-16:15	R. Erdelyi
16:15-17:00	Viktor Fedun - *3D Simulations of Magnetohydrodynamic Waves driven by Photospheric Motions*
17:00-17:45	Richard Morton - *Waves in the chromosphere: From excitation to dissipation*

22 January 2013 (Tuesday)

Seismology and Diagnostics

Session III Chair: Dipankar Banerjee

09:30-10:30 B. Dwivedi - *Solar Plasma Line Diagnostics and Coronal Seismology*

10:30-11:00 **Tea**

11:00-12:00 Durgesh Tripathi - *Emission measure distribution and flows in active regions*

12:00-13:00 Abhishek Srivastava - *MHD Seismology of Solar Corona Through The Observation of MHD Waves : Current and Future Aspects*

13:00-14:00 **Lunch**

Waves in the extended corona

Session IV Chair: R. Erdelyi

14:00-15:00 P. Subramanian - *Waves in the extended solar corona/solar wind*

15:00-15:30 **Tea**

15:30-16:15 D. Banerjee - *On the nature of propagating disturbances in the extended corona*

16:15-17:00 K. Kontar - *Particle acceleration and solar flares*

17:00-17:45 P. Venkatakrishnan – *The Multi-Application Solar Telescope (MAST)*

19:00 **Conference Dinner**

23 January 2013 (Wednesday)

Forthcoming and future ground based solar facilities

Session V Chair:

09:30-10:30 S. S. Hasan - *National Large Solar Telescope (NLST) of India*

10:30-11:00 **Tea**

11:00-12:00 R. Ramesh - *Ground based low frequency radio observations of the Sun*

12:00-13:00 Group Discussion

13:00-14:00 **Lunch**

Forthcoming space based programme from India and UK

Session VI Chair: S. S. Hasan

14:00-15:00 J. Singh - *The Status of Visible Emission Line Coronagraph for ADITYA-1 Mission*

15:00-15:30 **Tea**

15:30-16:30 K. Subramanian - *Solar Coronal Studies with Aditya-1 Mission*

16:30-17:30 D. Williams - *An overview of future UK involvement in solar missions*

Solar Active Regions Magnetic Fields and Waves: It takes two to Tango

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Active region magnetic fields bridge the solar interior to its outer atmosphere and are responsible for most of the dynamic phenomena observed on the Sun. They also act as conduits of waves that transport energy. On the one hand, diagnostics of magnetic fields and waves in solar active regions can constrain coronal heating and the processes associated with eruptive phenomena. On the other hand, observations of oscillations and waves are a diagnostic of the magnetic fields themselves. In this talk, I will first provide a basic introduction to solar active region magnetic fields and waves and subsequently discuss some of the outstanding issues in this field from the theoreticians' perspective.

Active region seismology and magnetohydrodynamic (MHD) waves

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A consistent implementation of the seismology of sunspots and active regions requires including explicitly the acoustic wave (p modes) - magnetic field interactions, i.e. the attendant MHD waves, so that the thermal and magnetic perturbations are separated out in the seismic inversions. However, such consistency is so far unattainable for a variety of reasons. On the other hand forward modeling of p mode - magnetic field interactions at varied levels of complexities, ranging from idealised analyical framework to full 3D simulations, exist. We will look at the basic difficulties in the disconnect between theory and practice (or observations), and identify questions/problems that need to be addressed. We will also discuss the effects of atmospheric magnetic field and MHD wave modes driven by the p modes (via mode conversions) in the seismic inferences. Finally, we will cover the roles of 3-D MHD simulations in addressing the above problems.

Oscillations in Large Scale Magnetic Structures

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Since Galileo Galili's first observation of the sunspots through the telescope, sunspots have always been fascinating structures on the Sun. It is also a subject of great interest because of variates of dynamics occurring in sunspots. From large scale solar energetic events to small scale surges they exhibit a variety of dynamic phenomena on the sun. From 1970's to till date many periodic phenomenon have been observed in sunspot umbra and penumbral regions. In the photosphere a 5-minute oscillations have been reported in the sunspot umbra and penumbral regions. In the chromosphere 3-minute oscillations have been reported in the sunspot umbra. The running waves have been observed in the sunspot penumbra. In this talk, I will present the observational aspects of 5-min and 3-min oscillations in sunspot umbra. The theoretical discussion will focus on how the 3-minute power observed at chromospheric heights originates directly by means of linear wave propagation from the photosphere. In the end, I would also discuss some of the quasi periodic phenomena such as Evershed effect in sunspot penumbra with current theoretical model.

The Structure and Dynamics of Magnetic Bright Points

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Photospheric Magnetic Bright Points (MBPs), also known as G-band bright points, are formed in the dark intergranular lanes by the interaction between the magnetic field and the convectively unstable photospheric plasma. Recent state-of-the-art instrumentation and techniques have allowed us to resolve the smallest of these structures and study their size and dynamics. MBPs are ubiquitous in the photosphere and appear to be associated with many of the structures of the quiescent chromosphere. I will attempt to provoke some discussion on the properties of these structures and how they may be associated with wave generation in the lower solar atmosphere.

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3D Simulations of Magnetohydrodynamic Waves driven by Photospheric Motions

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Recent simulation, ground- and space-based observational results reveal the presence of small-scale motion between convection cells in the solar photosphere. In these regions small-scale magnetic flux tubes are generated due to the interaction of granulation motion and background magnetic field. The torsional/vertical/horizontal motions of the plasma at the base of these magnetic structures could excite various MHD wave modes which propagate upwards though the solar atmosphere into the solar corona. Here we examine numerically the generation and direct propagation of such mhd wave modes in such magnetic structures. Simulations are run as the motions propagate through a gravitationally strongly stratified atmosphere towards the solar corona. We analyse the excited MHD wave modes and determine the energy flux they carry along the magnetic field lines.

Waves in the chromosphere: From excitation to dissipation

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It has been suggested that the chromosphere and its observed dynamics play a key role in the heating of the solar atmosphere and the acceleration of the solar wind. Periodic phenomena in the chromosphere has been reported for a number of years, however it is only within the last few years that improved spatial, temporal and spectral resolutions have allowed for the observation and identification of individual wave modes. This has meant there has been a reignition of interest in the chromosphere and the part waves can play in the energy balance of the atmosphere. I will talk about some past and present observations of chromospheric waves, focusing on attempts to explain how the waves are excited, how energetic they are and what happens to the waves after they have been observed in the chromosphere. This will hopefully highlight the future direction needed for chromospheric (and atmospheric) wave studies.

Solar Plasma Line Diagnostics and Coronal Seismology

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Line diagnostics of solar plasma has played a crucial role in understanding the dynamical processes and physics of the solar corona in pre- and post-SoHO era. The spectroscopic observations from SUMER onboard SoHO has provided several new results to help understand the plasma structuring, its dynamics and heating as well as the formation of the solar wind: outstanding issues in the SoHO and TRACE era and now with Hinode and SDO. The spectral window of SUMER in UV/EUV with its high spectral and spatial resolution enabled us to measure density, temperature, as well as flow structures in various coronal structures, providing further new results and constraints in understanding several aspects, e.g., formation of the wind and jets, coronal loop dynamics and heating, as well as signature of MHD waves. In addition, the principle of MHD seismology has been widely utilized which is a unique tool to measure plasma properties, especially the coronal magnetic field, using data from SoHO and TRACE, and now progressing with observations from Hinode and SDO. Various MHD modes have been detected from space-borne instruments in the solar coronal structures and are potentially used in diagnosing their physical conditions. However, coronal diagnostics through waves also depends upon precise measurements of plasma properties from spectroscopic observations. In the present paper, we review the plasma diagnostics in understanding the physics of the solar corona as well as its important role in deriving the crucial physical parameters through the observations of waves and their interpretations in light of MHD seismology.

Emission measure distribution and flows in active regions

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Considering that structures in the active regions are not fully resolved, we will have to rely on techniques which do not require the fundamental structures to be resolved. Such techniques are emission measure distribution and bulk flow of the plasma.

MHD Seismology of Solar Corona Through The Observation of MHD Waves : Current and Future Aspects

Abhishek Srivastava

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Theory of various pure magnetohydrodynamic (MHD) modes (fast and slow) are well established since last three decades and progressively being refined keeping the view of realistic solar atmosphere. However, the principal of MHD seismology has been significantly grown in the era of Solar and Heliospheric Observatory (SoHO) as well as Transition Region and Coronal Explorer (TRACE), and progressed tremendously with the advent of Hinode, STEREO, and SDO. Various tubular waves (kink, sausage, torsional, and slow) are ubiquitous now in the various types of the coronal flux-tubes (e.g., loops), and are significantly used in diagnosing the physical conditions (e.g., magnetic field, density scale height and contrast, field divergence etc) in the localized solar atmosphere. However, our current understanding about the detection of the pure magnetohydrodynamic modes and their capacity of coronal diagnostics depends upon the limit of resolution (spatial and spectral) of various instruments in space. The recent reports of the existence of mixed MHD modes in the very dynamical coronal flux-tubes in which the plasma conditions are varying in and around, are now providing new insight on our current knowledge of the MHD seismology of dynamic (non-static) corona. In the present paper, I will review the past, present, and future aspects of coronal seismology under the light of various findings as well as under our new result about the detection of transverse waves in large-scale and dynamic magneto-plasma structure.

Waves in the extended solar corona/solar wind

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Much of the attention devoted to waves in the extended solar corona has focused on the momentum flux carried by these waves. This is because the prime objective has been the pursuit of mechanisms that can "power" the solar wind, especially the fast solar wind. In particular, (relatively) recent research has concentrated on wave-particle interactions that can couple wave motions with the particles that constitute the solar wind. On the other hand, there is a considerable body of literature that deals with turbulence in the solar wind, which of course, is a structured ensemble of waves. It is interesting to examine the synergy between these related (and yet somewhat distinct) pictures.

Despite the impressive advances made in these areas, there still are basic questions that remain very relevant: we start with the most challenging one first:

1. Our understanding of solar wind turbulence is mostly in the framework of incompressible turbulence, which concentrates on correlations in velocity and magnetic field fluctuations. However, a parallel stream of research in solar wind turbulence concentrates on density fluctuations, which clearly need to invoke compressibility. A comprehensive understanding of the nature of turbulent solar wind fluctuations is awaited.
2. The wave-particle interactions that govern the inner scale of the turbulent spectrum, where it turns over from a power law, are related to the rate of viscous dissipation. Since the extended solar corona is collisionless, the nature of this viscous dissipation is not clear, and is only starting to be understood. Not only does it determine the amount of energy that can be transferred from the waves to the solar wind particles, but it also governs the viscous drag experienced by CMEs as they travel from the Sun to the Earth.
3. Another important issue is the amplitude (or normalization) of the turbulent spectrum; it determines the amount of power available for transfer to the solar wind at the dissipation scale. While the slope of the turbulent spectrum has received considerable attention in the literature, its normalization is only starting to be addressed.

On the nature of propagating disturbances in the extended corona

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I will discuss on the properties of waves which actually are able to travel to extended corona and may help in the heating and acceleration of the solar wind. Different wave properties and their detection possibilities in terms of observables will be discussed. A combination of spectroscopic and imaging methods allows the diagnosis of the nature of these waves. The ambiguity in terms of detection and its interpretation will be addressed.

Particle acceleration and solar flares

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In the talk I will overview the recent work in the area of high energy solar flare physics. The new knowledge gained via Hard X-ray observations with RHESSI, the particle simulations, and advances in theory will be presented and discussed. The talk will identify the challenges in physics of solar flares and potential Indo-UK collaborative work to address these questions.

The Multi-Application Solar Telescope (MAST)

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National Large Solar Telescope (NLST) of India

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India's 2-m National Large Solar Telescope (NLST) primary objective is to study the solar atmosphere with high spatial and spectral resolution. With an innovative optical design, NLST is an on-axis Gregorian telescope with a low number of optical elements to reduce the number of reflections and yield a high throughput with low polarization. In addition, it is equipped with a high order adaptive optics that works with a modest Fried's parameter of 7-cm to produce close to diffraction limited performance. To control atmospheric and thermal perturbations of the observations, the telescope will function with a fully open dome, taking advantage of the natural air flush to achieve its full potential atop a 25 m tower. Given its design, NLST can also operate at night, without compromising its solar performance. The post-focus instruments include broad band and tunable Fabry-Perot narrow band imaging instruments; a high resolution spectropolarimeter and an echelle spectrograph for night time astronomy. The main science goals of NLST include: a) Magnetic field generation and the solar cycle; b) Dynamics of magnetized regions; c) Helioseismology; d) Long term variability; e) Energetic phenomena and Activity; and f) Night time astronomy.

Ground based low frequency radio observations of the Sun

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The Gauribidanur radioheliograph (GRH), located about 100 km north of Bangalore at the Gauribidanur radio observatory, has been the only obser- vational facility for dedicated two-dimensional imaging observations of the solar corona in the frequency range 120 − 30 MHz since its commissioning in 1997. The situation continues even today. In addition to the GRH, the institute also operates a radio spectrograph (GLOSS, Gauribidanur LO fre- quency Solar Spectrograph) and a radio polarimeter (GRIP, Gauribidanur Radio Interference Polarimeter), both in the same frequency range as the heliograph and at the same observatory, for the last few years. Radio emis- sion in the 120 − 30 MHz frequency limit originates typically in the radial distance range of $\approx 1.2 - 2\ R_\odot$ in the solar atmosphere. The practical dif- ficulties in observing the solar corona, particularly in white light, over the above distance range are well known. The various interesting solar activities observed in the above height range with the aforementioned unique suite of instruments, the ongoing Gauribidanur radioheliograph expansion (GRHx) and its potential, will be presented in the talk.

The Status of Visible Emission Line Coronagraph for ADITYA-1 Mission

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A coronagraph with the facility to take images of the solar corona in two emission lines at high frequency about 3-4 Hz, in space above the earth's atmosphere will provide ideal conditions to study the existence of waves and predicting space weather. Keeping in view the scientific objectives and other requirements we are developing a 20 cm coronagraph to be launched in space by ISRO and take the images of the solar corona in the green at 530.3 nm [Fe xiv], the red at 637.4nm [Fe x] emission lines and continuum with the view to understand the heating of solar plasma, formation of coronal loops, acceleration of CME's etc.. Also, a provision is being made to generate Doppler-grams by taking the images of the solar corona through narrow band filters in the blue and red side wavelength of the 637.4 nm emission line. Here I shall discuss the status of the Visible Emission Line Coronagraph.

Solar Coronal Studies with Aditya-1 Mission

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Aditya-1 is India's first dedicated mission to study the Sun. This is a low-earth dawn-dusk orbit mission providing un-interrupted observation throughout the year apart from few minutes of eclipses during few months. The main payload on this mission is the visible emission line solar coronagraph which observes the solar corona simultaneously in the Green (Fe XIV) and Red (Fe X) emission lines over the 3 solar radii (~ 1.5 degree) field-of-view (FOV). A large FOV (~ 6 solar Radii; 3.0 degree) continuum channel is also added for the study of Coronal Mass Ejections. The major thrusts of this mission are: (i) to obtain high cadence and high spatial resolution coronal images, (ii) to obtain observations as close to the disk (targeted for 1.05 solar radii) as possible, and (iii) to obtain simultaneous intensity or polarization images in the Green, Red, and continuum channels. The main scientific objectives are: (1) Understanding of the wave heating mechanisms of the corona, (2) Physical (like temperature, density, and plasma motion) diagnostics of the coronal plasma as well as the dynamics of coronal structures, (3) Understanding the physical mechanisms behind the origin of CMEs, and (4) Mapping the coronal magnetic topology. In this presentation, we will briefly go through each of the scientific objectives and the methodology adopted to derive the physical parameters from observations.

There are few areas - listed below - can be the focal point of discussion for potential collaboration (of course depend on the expertise available from UK):

1. Feasibility studies of coronal seismology using the high cadence emission line observations - especially its limitation due to the plane-of-the-sky observations. How does combined observations, with say EUV, help to address this issue?
   Possibly initiate discussions on combining existing eclipse data along with EUV data to understand the multi-thermal environment of corona and hence study the advantages and limitations with the Green and Red emission line data over the EUV observations. At the end of the study, bring out a comprehensive report on the complementarity nature of these two different wavelength regions. This can then be used for future missions like Aditya-II.
2. 3D CME reconstruction using polarization data.
3. Implications on fast cadence imaging - extracting features and signals out of noise. Required methodology and implementation. Experience on this by ROSA team will be useful for the Aditya-1 mission as well as NLST. Can this methodology be implemented in hardware, like ASIC designs which can be potential for future missions like Aditya-II?

An overview of future UK involvement in solar missions

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The UK continues to take the space sector very seriously, where it has experienced substantial year-on-year growth in commercial space. Civilian solar system research, too, has a rosy future, with involvement in a large number of instruments on the forthcoming Solar Orbiter mission, Co-Investigators in the NASA small explorer IRIS, and future possibilities -- and continuing involvement in highly successful missions such as Hinode and Solar Orbiter, which we will also cover. Pathways for new collaborations and scientific discussions are greatly welcomed.

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