AGU CHAPMAN CONFERENCE

Jeju Island, Republic of Korea | 31 August–05 September 2014

Low-Frequency Waves in Space Plasmas

Conference Program

AGU Chapman Conference on Low-Frequency Waves in Space Plasmas

Jeju Island, Republic of Korea
31 August – 5 September 2014

Conveners

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Low-Frequency Waves in Space Plasmas

Meeting At A Glance

Sunday, 31 August

1600h – 1930h	Onsite Registration *(Foyer)*
1800h – 1930h	Welcome Reception *(Regency Ballroom)*

Monday, 1 September

0845h – 0900h	Welcome Remarks
0900h – 1020h	Introductory Lectures I *(Regency Ballroom)*
1020h – 1050h	Morning Break *(Foyer)*
1050h – 1220h	Introductory Lectures II *(Regency Ballroom)*
1220h – 1400h	Lunch – Attendees on their own
1400h – 1600h	Introductory Lectures III *(Regency Ballroom)*
1600h – 1630h	Afternoon Break *(Foyer)*
1630h – 1805h	Planetary Waves *(Regency Ballroom)*

Tuesday, 2 September

0830h – 1010h	Waves in the Solar Atmosphere and Wind I *(Regency Ballroom)*
1010h – 1040h	Morning Break *(Foyer)*
1040h – 1225h	Waves in the Outer Magnetosphere I *(Regency Ballroom)*
1225h – 1400h	Lunch- Attendees on their own
1400h – 1600h	Waves in the Solar Atmosphere and Wind II *(Regency Ballroom)*

1600h – 1900h	Break and Poster Session I *(Terrace Ballroom)*

Wednesday, 3 September

0830h – 1000h	Waves in the Outer Magnetosphere II *(Regency Ballroom)*
1000h – 1030h	Morning Break *(Foyer)*
1030h – 1155h	Waves in the Inner Magnetosphere I *(Regency Ballroom)*
1155h – 1340h	Lunch – Attendees on their own
1340h – 2030h	Field Trip (KSWC, dinner included)

Thursday, 4 September

0830h – 0955h	Waves in the Inner Magnetosphere II *(Regency Ballroom)*
0955h – 1030h	Morning Break *(Foyer)*
1030h – 1230h	EMIC Waves *(Regency Ballroom)*
1230h – 1420h	Lunch – Attendees on their own
1420h – 1540h	MHD Seismology *(Regency Ballroom)*
1540h –1840h	Break and Poster Session II *(Terrace Ballroom)*
1900h – 2100h	Banquet Dinner *(Clilff Garden)*

Friday, 5 September

0830h – 0955h	Waves in the Ionosphere *(Regency Ballroom)*
0955h – 10:30h	Morning Break *(Foyer)*
1030h – 1200h	Wave-Particle Interaction *(Regency Ballroom)*
1200h – 1300h	Wrap-up Session

SCIENTIFIC PROGRAM

SUNDAY, 31AUGUST

1600h – 1930h	**Onsite Registration** Foyer
1800h – 1930h	**Welcome Reception** *Regency Ballroom*

MONDAY, 1 SEPTEMBER

0845h – 0900h	**Welcome Remarks**
0900h – 1020h	**Introductory Lectures I** *Regency Ballroom* Chairs: Dong-Hun Lee and Andreas Keiling
0900h.– 0940h	**Karl-Heinz Glassmeier |** Listening in the Plasma Universe (Invited)
0940h –1020h	**Chio Z Cheng |** Low Frequency Waves in Space Plasmas (Invited)
1020h – 1050h	**Morning Break** *Foyer*
1050h.– 1220h	**Introductory Lectures II** *Regency Ballroom* Chairs: Dragos O Constantinescu and Mark J. Engebretson
1050h –1120h	**Peter A Delamere |** A review of low-frequency waves in the giant magnetospheres (Invited)
1120h –1150h	**Tongjiang Wang |** Longitudinal and transverse waves in solar coronal loops: Overview of recent results (Invited)
1150h –1220h	**Jay Johnson |** EMIC Waves in Space Plasmas (Invited)

1220h – 1400h	**Lunch – Attendees on their own**
1400h – 1600h	**Introductory Lectures III** *Regency Ballroom* Chairs: Jonathan Rae and Robert Rankin
1400h –1430h	**Leon Ofman |** MHD waves in coronal active regions: impacts of mode couplings, flows, and instabilities (Invited)
1430h –1500h	**Kazue Takahashi |** ULF waves in the inner magnetosphere (Invited)
1500h –1530h	**Robert L Lysak |** Global Modeling of ULF Waves in the Inner Magnetosphere: Propagation of Pi1/2 Waves (Invited)
1530 – 1600	**Colin L Waters |** ULF waves and the Ionosphere (Invited)
1600h – 1630h	**Afternoon Break** *Foyer*
1630h – 1650h	**Planetary Waves** *Regency Ballroom* Chairs: Karl-Heinz Glassmeier and Peter A Delamere
1630h –1650h	**Guan Le |** Observations of Upstream Ultra-Low-Frequency Waves in the Mercury's Foreshock (Invited)
1650h –1710h	**Eun-Hwa Kim |** ULF waves at Mercury (Invited)
1710h –1730h	**Joachim Saur |** Non-linear interacting Alfven waves in planetary magnetospheres (Invited)
1730h –1750h	**Tomoko Nakagawa |** ULF/ELF Waves Detected by MAP/LMAG Magnetometer Onboard Kaguya around the Moon and in the Lunar Wake (Invited)
1750h –1805h	**Yu-Qing Lou |** Magneto-Inertial Oscillations of Jupiter's Inner Radiation Belt

TUESDAY, 2 SEPTEMBER

0830h – 1010h	**Waves in the Solar Atmosphere and Wind I** *Regency Ballroom* Chairs: Valeri M Nakariakov and Gary Verth
0830h – 0850h	**Robert Sych |** Wave dynamics in sunspot atmosphere (Invited)
0850h –0910h	**Jongchul Chae |** Chromopheric Jets Powered by Sunspot Oscillations (Invited)
910h – 0930h	**Viktor Fedun |** The numerical simulation of MHD wave modes excited by photospheric motions and their energy fluxes. (Invited)
0930h – 0950h	**James Alexander McLaughlin |** First direct measurements of transverse waves in solar polar plumes using SDO/AIA (Invited)
0950h –1010h	**Gary Verth |** The Generation and Damping of Propagating MHD Kink Waves in the Solar Atmosphere (Invited)
1010h – 1040h	**Morning Break** *Foyer*
1040h – 1225h	**Waves in the Outer Magnetosphere I** *Regency Ballroom* Chairs: Joachim Saur and Shigeru Fujita
1040h –1100h	**Jonathan Rae |** Exploring substorms with ULF waves (Invited)
1100h –1120h	**Anatoly Sergeevich Leonovich |** Features of MHD oscillations in the geomagnetic tail (Invited)
1120h –1140h	**Timothy K Yeoman |** Ionospheric radar measurements of waves with equatorward phase propagation generated by energetic particles (Invited)
1140h –1155h	**Dmitri Yu. Klimushkin |** Generation of the high-m Alfven waves in the magnetosphere by the moving source: theory and experiments
1155h –1210h	**Michael Hartinger |** The effect of magnetopause motion on fast mode resonance

1210h –1225h	**Octav Marghitu |** Magnetosphere-Ionosphere Coupling on Multiple Scales Associated with Magnetotail Flow Bursts: Event Study
1225h – 1400h	**Lunch- Attendees on their own**
1400h – 1600h	**Waves in the Solar Atmosphere and Wind II** *Regency Ballroom* Chairs: Leon Ofman and Larry Kepko
1400h –1420h	**P. F. Chen |** Globally Propagating Waves on the Sun (Invited)
1420h –1440h	**Takeru Ken Suzuki |** Alfven wave-driven solar wind during very active phases (Invited)
1440h –1455h	**Michele D Cash |** The DSCOVR Solar Wind Mission: Algorithm Development to Enhance Space Weather Forecasting
1455h –1515h	**Larry Kepko |** Directly-driven oscillations: Current status, open questions, and how they inform us about magnetic reconnection (Invited)
1515h –1530h	**Kyoung-Joo Hwang |** The role of low-frequency boundary waves in the dynamics of the dayside magnetopause and the inner magnetosphere
1530h –1545h	**Marek Strumik |** Three-dimensional simulations of firehose instability: fluctuating fields and particle acceleration
1545h –1600h	**Igor S. Veselovsky |** Nonlinear coupling between waves and flows in the solar wind sources
1600h – 1900h	**Break and Poster Session I** Terrace Ballroom Chairs: Karl-Heinz Glassmeier and Valeri M Nakariakov
	T-1 **Andreas Keiling |** Magnetosphere-Ionosphere Coupling of Global Pi2 Pulsations
	T-2 **Osuke Saka |** Auroral vortex, poleward surge, and vortical current in the ionosphere associated with Pi2 pulsations: A case for westward propagation of the poleward surge

T-3 **Karl-Heinz Glassmeier |** Low-Frequency Waves in the interaction region of comet Churyumov-Gerasimenko with the solar wind: First Rosetta results

T-4 **Danila V. Kostarev |** Drift-compressional modes generated by inverted plasma distributions in the magnetosphere

T-5 **Dmitri Yu. Klimushkin |** Compressional high-m Pc5 ULF waves in the magnetosphere: theoretical considerations

T-6 **Xiaochen Shen |** Magnetospheric ULF waves with an increasing amplitude induced by solar wind dynamic pressure changes: THEMIS observations

T-7 **Jacob Bortnik |** The curious relationship between chorus and plasmaspheric hiss waves (Invited)

T-8 **Young-Sook Lee |** Periodic strong echoes in summer polar D region correlated with high-speed solar wind streams and ULF Pc5 wave amplitudes

T-9 **Mark J. Engebretson |** Investigating the IMF cone angle control of Pc3-4 pulsations observed on the ground

T-10 **V K Verma |** Low frequency Type II radio bursts from CMEs related solar flares

T-11 **Alexander S Potapov |** Sporadic and Permanent Oscillations in the Magnetosphere: Are They Connected?

T-12 **Shigeru Fujita |** Geoelectric and geomagnetic response to the oscillating magnetospheric current in Japan and Korea

T-13 **Lei Dai |** Cluster observations of fast magnetosonic waves in the heliosphere current sheet

T-14 **Chun-Sun Jao |** Evolution of electrostatic structures in pair plasmas

T-15 **Haoyu Lu |** Numerical study on interchange instability as generation mechanism of dipolarization fronts in the magnetotail

T-16 **Junying Yang |** Solar wind affection on VLF electromagnetic waves in the inner magnetosphere

T-17 **Haoyu Lu |** Evolution of Kelvin-Helmholtz instability at boundary layers on Venus

T-18 **Michael Hartinger |** ULF wave energy transfer from the equatorial plane to the ionosphere: frequency and spatial dependence

T-19 **Yasunori Tsugawa |** Group-standing whistler-mode waves observed as 1 Hz waves in the solar wind

T-22 **Ensang Lee |** Nonlinear Development of ULF waves in the Upstream of Earth's Bow Shock

T-23 **Kyung-Suk F Cho |** Intensity and Doppler Oscillations in Pore Atmosphere

T-24 **Jungjoon Seough |** Generation of superthermal protons via parallel electron fire-hose instability: Particle-in-cell simulations

WEDNESDAY, 3 SEPTEMBER 3

0830h – 1000h

Waves in the Outer Magnetosphere II

Regency Ballroom

Chairs: Robert L Lysak and Timothy K Yeoman

0830h – 0850h **Robert Rankin |** Modelling the interaction of poloidal Pc5 waves with the high-latitude ionosphere (Invited)

0850h – 0910h **Yan Song |** Nonlinear Interaction of ULF Wave Packets, Formation of Non-Propagating EM-Plasma Structures and Plasma Energization (Invited)

0910h –0930h **Fabrice Mottez |** A theory of plasma acceleration by the interaction of parallel propagating Alfven waves with applications to the magnetosphere (Invited)

0930h –0945h **Naiguo Lin |** Ion Temperature Anisotropy Thresholds in the Magnetosheath

0945h –1000h **Alexander S Potapov |** Response of the magnetospheric ULF activity and relativistic electrons to high speed streams of the solar wind

1000h – 1030h **Morning Break**

Foyer

1030h – 1155h	**Waves in the Inner Magnetosphere I** *Regency Ballroom* Chairs: Kazue Takahashi and Dong-Hun Lee
1030h –1050h	**Khan-Hyuk Kim |** Low-latitude Pi2 pulsations during the intervals of quiet geomagnetic conditions (Kp ≤ 1) (Invited)
1050h –1110h	**Shigeru Fujita |** Possible generation mechanisms of the Pi2 pulsations estimated from a global MHD simulation (Invited)
1110h –1125h	**Dae Jung Yu |** Characteristics of compressional eigenmodes in the inner-magnetosphere
1125h –1140h	**Yuki Obana |** Characteristics of quarter wave standing Alfvén waves observed by the New Zealand magnetometer array
1140h –1155h	**Arnaud Masson |** The Cluster Science Archive and its relevance for low frequency waves in space plasma research
1155h – 1340h	**Lunch – Attendees on their own**
1340h – 2030h	**Field Trip (KSWC, dinner included)**

THURSDAY, 4 SEPTEMBER

0830h – 1010h	**Waves in the Inner Magnetosphere II** *Regency Ballroom* Chairs: Qiugang Zong and Yoshiharu Omura
0830h –0850h	**Yoshiharu Omura |** Generation of EMIC rising-tone emissions and associated precipitations of energetic protons and relativistic electrons in the inner magnetosphere (Invited)
0850h –0910h	**Clare Watt |** Localised wave generation in the inner magnetosphere: a new approach (Invited)
0910h –0925h	**Wenlong Liu |** Poloidal ULF wave observed in the plasmasphere boundary layer
0925h –0940h	**Lei Dai |** Van Allen Probe observations: Poloidal ULF waves excited by resonant wave-particle interaction in the inner magnetosphere

0940h –0955h	**Xuzhi Zhou |** Standing Alfven waves transitioned from fast growing, travelling waves: Indications from electron measurements
0955h – 1030h	**Morning Break** *Foyer*
1030h – 1230h	**EMIC Waves** *Regency Ballroom* Chairs: Jay Johnson and Dragos O Constantinescu
1030h –1050h	**Mark J. Engebretson |** EMIC waves in Earth's Magnetosphere (Invited)
1050h –1110h	**Lunjin Chen |** Modeling electromagnetic ion cyclotron waves in the inner magnetosphere (Invited)
1110h –1130h	**Maria Usanova |** Understanding the Role of EMIC Waves in Radiation Belt and Ring Current Dynamics: Recent Advances (Invited)
1130h –1145h	**Dragos O Constantinescu |** Oxygen Ion Cyclotron Waves in the Outer Magnetosphere
1145h –1200h	**Hanying Wei |** Ion cyclotron waves in the solar wind: generation mechanism and source region
1200h –1215h	**Kristoff W Paulson |** Solar cycle dependence of ion cyclotron wave frequencies
1215h –1230h	**Masafumi Shoji |** Spectrum characteristics of electromagnetic ion cyclotron triggered emissions and associated energetic proton dynamics
1230h – 1420h	**Lunch- Attendees on their own**
1420h – 15:40h	**MHD Seismology** *Regency Ballroom* Chairs: Leon Ofman and Peter J Chi
1420h –1440h	**Peter J Chi |** Travel-time Magnetoseismology: Successes, Challenges, and Future Directions (Invited)
1440h –1500h	**Tom Van Doorsselaere |** MHD seismology of the solar corona (Invited)

1500h –1520h **Dipankar Banerjee |** Slow waves and coronal seismology (Invited)

1520h –1540h **Valeri M Nakariakov |** MHD Seismology with fast magnetoacoustic wave trains (Invited)

1540h – 1840h

Break and Poster Session II

Regency Ballroom

Chairs: Khan-Hyuk Kim and Jonathan Rae

R-1 **Busola Olugbon |** Phase Properties of Ulf Waves Observed in the African Sector

R-2 **Guan Le |** Observations of High-m Ultra-Low Frequency Waves at Low Altitudes

R-3 **Dong-Hun Lee |** Time-dependent evolution of externally driven MHD/EMIC waves in the low-latitude magnetosphere

R-4 **Jiwon Choi |** Plasmaspheric virtual resonances in the inner magnetosphere

R-5 **Karl-Heinz Glassmeier |** Enhancement of ultra-low frequency wave amplitudes at the plasmapause

R-6 **Le Minh Tan |** Solar flare induced the parameter changes of lower ionosphere from VLF amplitude observations at a low-latitude site

R-7 **Viacheslav Pilipenko |** ULF wave interaction with the ionosphere: radar and magnetometer observations

R-8 **Khan-Hyuk Kim |** Loss of geosynchronous relativistic electrons by EMIC waves during quiet geomagnetic conditions

R-9 **Satoko Nakamura |** Sub-packet structures in the EMIC triggered emission observed by the THEMIS probes

R-10 **Sneha A Gokani |** Low Latitude Whistlers: Correlation with conjugate region lightning activity and arrival azimuth determination

R-11 **Alexander S Potapov |** IRI-2012 application for IAR frequency scale calculation

R-12 **Kristoff W Paulson |** Statistical Distribution of Observations of Pc1 Pearl Pulsations by the Van Allen Probes and Poynting Flux Analysis from 11th October 2013

R-13 **Eun-Hwa Kim |** Global Modeling of EMIC waves at Earth: Generation and Application of Linearly Polarized EMIC waves

R-14 **Kyung-Chan Kim |** THEMIS onsevations of plasmaspheric hiss: its dependence on solar wind parameters and geomagnetic activity

R-15 **Boris G Gavrilov |** Experimental investigation of ULF/VLF radio waves generation and propagation in the upper atmosphere and ionosphere during EISCAT heating experiment in 2012

R-16 **Mark J. Engebretson |** Purely compressional Pc1 waves observed by the Van Allen Probes

R-17 **Chae Woo Jun |** Statistical study of Pc1 pearl structures observed at multi-point ground-based stations in Canada, Russia and Japan

R-18 **Jaejin Lee |** Expected electron microburst energy dispersion caused by chorus wave interaction

R-19 **Jong-Sun Park |** EMIC waves observed at geosynchronous orbit during quiet geomagnetic conditions

R-20 **Uma Pandey |** Study of Early/slow VLF perturbations observed at Agra, India

R-21 **Peter J Chi |** Narrowband Ion Cyclotron Waves at the Moon in the Terrestrial Magnetotail

R-22 **Kyle R Murphy |** Role of ULF waves in Energetic Particle Transport and Ring Current Dynamics

R-23 **Peter J Chi |** On Improvement in Normal-mode Magnetoseismology with Network Observations by Ground-based Magnetometers

R-24 **Peter Damiano |** Gyrofluid-kinetic electron modeling of dispersive scale Alfven waves associated with broadband aurora

1900h – 2100h **Banquet Dinner**

Cliff Garden

FRIDAY, 5 SEPTEMBER

0830h – 1010h	**Waves in the Ionosphere** *Regency Ballroom* Chairs: Colin L Waters and Akimasa Yoshikawa
0830h –0850h	**Akimasa Yoshikawa |** Theory of Cowling channel formation by reflection of shear Alfven waves from the auroral ionosphere (Invited)
0850h –0910h	**Craig J. Rodger |** Plasma Wave-Driven Energetic Electron Precipitation: Wave-Particle Interactions Affecting the Polar Atmosphere (Invited)
0910h –0925h	**A Surjalal Sharma |** Low Frequency Waves During RF Heating of the Ionosphere: Numerical Simulations
0925h –0940h	**Christopher Watson |** Variations in GPS TEC associated with magnetic field line resonance activity in the early morning auroral ionosphere
0940h –0955h	**Ashutosh K Singh |** Very low frequency (VLF) waves as a probing tool to study the simultaneous effect of Solar Flare and Geomagnetic Storm (occurred on 9 March 2012) on D-region ionosphere
0955h – 1030h	**Morning Break** *Foyer*
1030h – 1200h	**Wave-Particle Interaction** *Regency Ballroom* Chairs: Danny Summers and Qiugang Zong
1030h –1050h	**Reiner H W Friedel |** Direct measurements of chorus wave effects on electrons in the 5-40 KeV range from the Van Allen Probes Mission (Invited)
1050h –1110h	**Danny Summers |** Limiting energy spectrum of an electron radiation belt (Invited)
1110h –1130h	**Qiugang Zong |** Fast acceleration of Ring Current Ions by ULF waves (Invited)
1130h –1145h	**Liuyuan Li |** The growth of whistler-mode waves and the loss of anisotropic distribution electrons inside the bursty bulk flows

1145h –1200h	**Ilan Roth |** Solar-Terrestrial Wave Connection: Solar/Planetary Whistler-excited Relativistic Electron Processes and Coronal Source as Seed for Magnetospheric ULF Energization.
1200h – 1300h	**Wrap-up Session** *Regency Ballroom* Chairs: Dong-Hun Lee, Andreas Keiling and Karl-Heinz Glassmeier

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Banerjee, Dipankar

Slow waves and coronal seismology (Invited)

Dipankar Banerjee, Indian Institute Astrophysics, Bangalore, India

Slow waves are ubiquitously observed in polar regions and active region fan loops. These waves cause periodic disturbances in intensity and are mostly identified from the alternate slanted ridges in the space-time maps. They are observed to have a range of periodicities from 3 to 30 minutes and are found to be rapidly damped. I will focus on their characteristic properties including damping. These characteristics allows us to perform coronal seismology. I will also discuss on the possibility of other wave modes and their role in coronal seismology.

Bortnik, Jacob

The curious relationship between chorus and plasmaspheric hiss waves (Invited)

Jacob Bortnik[1], Lunjin Chen[2], Wen Li[1], Richard M Thorne[1], Vassilis Angelopoulos[3] and Craig Kletzing[4], (1)UCLA, Los Angeles, CA, United States, (2)University of Texas at Dallas, Dallas, TX, United States, (3)UCLA---ESS/IGPP, Los Angeles, CA, United States, (4)Univ. of Iowa, Iowa City, IA, United States

Plasmaspheric hiss is a wideband, incoherent, whistler-mode plasma wave that is found predominantly in inner magnetospheric high-density plasma regions such as the plasmasphere or plasmaspheric drainage plume. The origin of plasmaspheric hiss has been a topic of intense study and controversy ever since its discovery in the late 1960s. A recent set of modeling studies have shown that a different plasma wave, namely whistler-mode chorus, could be responsible for creating plasmaspheric hiss by propagating from its source region in the equatorial plasmatrough, and into the plasmasphere. Early observations made on the THEMIS spacecraft have shown excellent consistency between models and data, but later results concerning the nature of chorus waves and pulsating aurora, the discovery of low-frequency hiss, and coincident observations between high L-shell chorus and hiss have shown that there are facets of the chorus-hiss connection that are still a puzzle. In this talk, we briefly review the chorus-hiss connection mechanism and focus on recent results and open questions.

Cash, Michele

The DSCOVR Solar Wind Mission: Algorithm Development to Enhance Space Weather Forecasting

Michele D Cash[1,2], Douglas Alan Biesecker[1] and Alysha Reinard[1,2], (1)NOAA Boulder, SWPC, Boulder, CO, United States, (2)CIRES, Boulder, CO, United States

We present two space weather algorithms currently under development for use with the upcoming DSCOVR solar wind mission. DSCOVR, which will orbit the L1 Lagrangian point, will provide real-time solar wind thermal plasma and magnetic field measurements to ensure continuous monitoring for space weather forecasting. The DSCOVR spacecraft will include a Faraday cup to measure the proton and alpha particle components of the solar wind and a triaxial fluxgate magnetometer to measure the magnetic field in three dimensions. In preparation for the launch of DSCOVR in January 2015, algorithm development is currently underway for the first two space weather products designed to enhance space weather forecasting.

The first algorithm is an improvement to computing the L1 to Earth delay time. The standard technique for propagating the solar wind from L1 to Earth assumes that all observed solar wind discontinuities, such as interplanetary shocks and ICME boundaries, are in a flat plane perpendicular to the Sun-Earth line traveling in the GSE X direction at the solar wind velocity. In reality, these phase plane fronts can have significantly tilted orientations, and thus relying on a ballistic propagation method often results in delay time errors ranging from 15 minutes to over 30 minutes depending on the distance between the solar wind monitoring spacecraft and the Sun-Earth line. The L1 to Earth delay time product presented here is designed to more accurately predict the delay time from DSCOVR to Earth by taking these tilted phase plane fronts into account.

The second algorithm being developed is an automated solar wind regime identification product, which is designed to autonomously identify the type of solar wind flow in which the monitoring spacecraft is currently situated. This algorithm takes into account the proton speed, density, temperature, and alpha particle abundance and uses a logic-based binary decision tree to determine whether the solar-wind source is most likely a coronal hole, interstream flow, or a coronal mass ejection. An automated shock detection algorithm is included as part of the solar wind regime identification product and recent work to determine the optimal set of shock detection criteria to use with DSCOVR will also be presented.

Chae, Jongchul

Chromopheric Jets Powered by Sunspot Oscillations (Invited)

Jongchul Chae, Seoul National University, Department of Physics and Astronomy, Seoul, South Korea

It still remains mysterious how the solar chromosphere can stand high above the photosphere. The dominant portion of this layer must be dynami- cally supported as evident by the common occurrence of jets such as spicules and mottles in quiet regions, and fibrils and surges in active regions. Hence revealing the driving mechanism of these chromospheric jets is crucial for the understanding how the chromosphere itself exists. Here we report our obser-vational finding that fibrils surrounding a sunspot are powered by the oscil- lations of the sunspot. The fibrils are dynamically connected to the umbra by the shock waves apparently originating from the umbral oscillations. The predominant period of these shock waves increases with distance: from three minutes to ten minutes. This short-to-long period transition is attributed to the selective suppression of shocks by the falling material of their preceding ones. These results suggest that the photospheric or sub-photospheric excitation of a magnetic flux tube is responsible for the maintenance of the chromosphere permeated by the field lines of the flux tube.

Chen, P. F.

Globally Propagating Waves on the Sun (Invited)

P. F. Chen, Nanjing University, School of Astronomy & Space Science, Nanjing, China

There are two wavelike phenomena which were found to propagate across a significant part of the solar disk, namely, Moreton waves and coronal ``EIT waves". While Moreton waves have been successively interpreted as coronal fast-mode MHD wave sweeping the solar surface, coronal ``EIT waves", upon their discovery in 1997 by the EIT telescope on board the SOHO satellite, provoked continuing debates on their nature and their relation with solar flares and coronal mass ejections (CMEs). The wavelike phenomenon was firstly and widely explained in terms of fast-mode MHD waves. However, such a model is contradictory with many observational features. To reconcile the discrepancy, several other models have been proposed, including our magnetic field-line stretching model. With the high spatiotemporal resolution observations from the newly-launched SDO satellite, a clearer and clearer pattern is emerging. In this talk, I will go through the history of the observational and theoretical researches on coronal ``EIT waves".

Chen, Lunjin

Modeling electromagnetic ion cyclotron waves in the inner magnetosphere (Invited)

Lunjin Chen, University of Texas at Dallas, Dallas, TX, United States, Vania Jordanova, Los Alamos National Laboratory, Los Alamos, NM, United States and Richard M Thorne, UCLA, Los Angeles, CA, United States

Electromagnetic ion cyclotron (EMIC) waves play important roles as intermediaries in the interplay between various plasma populations in the magnetosphere, including the plasmasphere, ring current, and radiation belts. We use combined Ring Current-Atmospheric Ring Current Model, Self-Consistent Magnetic Field Model and Ray Tracing Model to model global propagation characteristics and spectral characteristics of EMIC waves. The combined model is applied for the June 2001 geomagnetic storm and the model results are compared and shown to be consistent with the in-situ wave measurement/proxy from multiple geosynchronous satellites. The modeling results are also shown to be consistent with images of proton aurora at subauroral latitudes observed by the IMAGE satellite. We will also present the effect of warm He+ and hot H+, which affect significantly EMIC wave generation near He+ gyrofrequency and might lead to vanishing of "stop band" in the cold plasma, and the effect of fine-density structures, which tend to keep wave vector more field-aligned and thus lead to enhanced amplification of EMIC waves. Finally, the questions on quantifying the contributions of EMIC waves to radiation belt electron loss will be discussed.

Cheng, Chio

Low Frequency Waves in Space Plasmas (Invited)

Chio Z Cheng, National Cheng Kung University, Tainan, Taiwan

Low frequency waves have been widely observed in space plasmas. They have been classified as Pc 1-5 waves for continuous pulsations and Pi 1-2 waves for impulsive pulsations. The theory of low frequency waves have been developed in the last 50 years. Based on the MHD model, the theory of shear Alfven waves and slow and fast magnetosonic waves was developed for uniform magnetized plasma theory. Then, for non-uniform magnetized plasmas the propagation of fast magnetosonic waves and the deposit of the fast wave energy at the field line resonance location into the shear Alfven waves and slow modes were established. Even within the MHD theory, global stable and unstable MHD eigenmodes are possible due to free energy in the plasma pressure and current density gradients, magnetic field curvature, and pressure anisotropy. Even in the MHD theory, the difficulty in the study of the low frequency wave is how to handle the complex magnetic field geometry. By including the ion gyroradius effects, the kinetic Alfven waves were studied. By including wave-particle resonances, unstable low frequency MHD-type modes such as ballooning-mirror instability and kinetic ballooning have also been developed. In this talk I will give an overview of the low frequency wave theories.

Chi, Peter

Narrowband Ion Cyclotron Waves at the Moon in the Terrestrial Magnetotail

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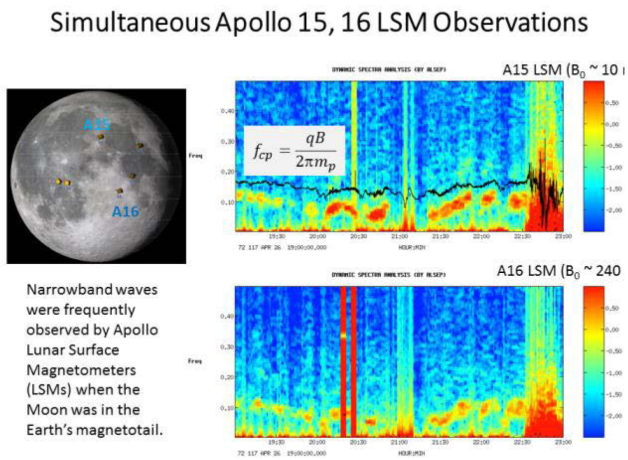
Recent studies of the observations from the Apollo lunar surface magnetometers and the ARTEMIS spacecraft in the lunar orbit have found a class of narrowband ion cyclotron waves at the Moon. With frequencies of the order of 0.1 Hz, these narrowband waves are present only when the Moon is in the terrestrial magnetotail. The peak frequency is at or below the proton gyrofrequency, and the polarization is predominantly left-handed. These waves can propagate at large angles to the background magnetic field, suggesting that they are generated near the Moon and can reach the lunar surface before they are severely damped. We expect that these narrowband ion cyclotron waves result from the anisotropies of ion temperature in the vicinity of the Moon, such as those associated with pickup ions originating from the lunar exosphere or the absorption of ions at the Moon. The particle observations by the ARTEMIS spacecraft during a narrowband wave event indicated that most ions, especially those with lower velocities, that flowed to the Moon were absorbed, providing evidence of temperature anisotropy that could lead to ion cyclotron instability. Simultaneous observations at the Apollo 15 and 16 sites revealed small yet persistent differences in wave amplitude and phase, suggesting that the wave signals could be modified by the mini-

magnetosphere above strong crustal magnetic field.



Chi, Peter

Travel-time Magnetoseismology: Successes, Challenges, and Future Directions (Invited)

Peter J Chi, University of California Los Angeles, Los Angeles, CA, United States

This paper summarizes the research on travel-time magnetoseismology starting from the inception of the method approximately a decade ago. Like terrestrial seismology that infers information about earthquake hypocenters and the Earth's interior by timing seismic arrivals, travel-time magnetoseismology can identify the start of the magnetic impulse and deduce the structure of magnetospheric density by measuring impulse arrivals at different locations simultaneously. Observations of sudden impulses have shown that the arrival time of the preliminary impulse is latitude-dependent in a way consistent with the MHD propagation along the so-called Tamao path. The inverse calculation that incorporates the preliminary impulse arrival times at multiple ground locations has deduced a plasmapause location in good agreement with spacecraft observations. The concept of travel-time magnetoseismology has also been applied to the study of substorm onsets, shedding light not only on the signal propagation from the magnetotail to the ionosphere but also on the start time and location in the magnetotail. An important implication from the travel-time analysis of substorm onsets is that, contrary to the common assumption, the onset location in the ionosphere does not necessarily map along the magnetic field to the onset location in the magnetotail. In most likely scenarios, the impulse signal reaches the ionosphere first at low auroral latitude, explaining why auroral intensification usually starts there. Exercising travel-time magnetoseismology in the magnetotail poses significant challenges to modeling the signal propagation in a complex geometry that can vary substantially from one case to another. The concept of the Tamao path, albeit in good agreement with numerical simulations in a dipole geometry, needs validation or revision for magnetotail problems. The paper concludes by suggesting areas where further research is likely to make clear progress in travel-time magnetoseismology.

Chi, Peter

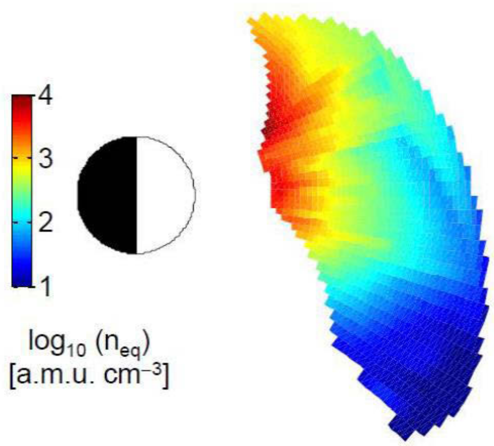
On Improvement in Normal-mode Magnetoseismology with Network Observations by Ground-based Magnetometers

Peter J Chi, University of California Los Angeles, Los Angeles, CA, United States

Estimating magnetospheric density by the measurements of field line resonance (FLR) frequencies, a subject also known as normal-mode magnetoseismology, is one of the most important modern uses of ground-based magnetometer observations. Nowadays, ground detection of FLR frequencies is typically made by using the gradient technique, which compares the wave phase and sometimes amplitude at two stations located on the same meridian but separated by one or a few degrees in latitude. The calculation of the equatorial plasma mass density from the FLR frequency, if only the fundamental mode is observed, requires an assumption on the field-aligned distribution of density.

This paper proposes two improvements over the present practice of normal-mode magnetoseismology. First, if there are multiple pairs of stations on the same meridian, such as those enabled by the Mid-continent MAgnetoseismic Chain (McMAC), it is possible to use the observations to infer not only the dependence of plasma density on L-value but also the field-aligned distribution of density. Second, the gradient technique can still be performed when the two stations have a small separation in longitude. Several event studies using the observations by McMAC and THEMIS ground magnetometers found that the azimuthal wavenumbers associated with the FLR in the plasmasphere were no greater than 2, suggesting a limited effect of the azimuthal phase drift due to the longitudinal separation between stations. These improvements enable a better use of network observations by ground-based magnetometers in normal-mode magnetoseismology, such as monitoring the distribution of plasma density and plasmaspheric dynamics during space weather events.

Image: A two-dimensional snapshot of equatorial plasma density inferred from 10 minutes of the FLR observations by McMAC and other ground magnetometers in North America.



Cho, Kyung-Suk

INTENSITY AND DOPPLER OSCILLATIONS IN PORE ATMOSPHERE

Kyung-Suk F Cho[1,2], Su-Chan Bong[1], Eun-kyung Lim[3], Young-deuk Park[1], Jongchul Chae[4], Heesu Yang[4], Hyungmin Park[4], Valeri M Nakariakov[5] and Vasyl Yurchyshyn[6], (1)Korea Astronomy and Space Science Institute, Daejeon, South Korea, (2)KASI, Daejeon, South Korea, (3)KASI Korea Astronomy and Space Science Institute, Daejeon, South Korea, (4)Seoul National University, Seoul, South Korea, (5)University of Warwick, Physics, Coventry, United Kingdom, (6)Big Bear Solar Observatory, Big Bear City, CA, United States

Due to the vertical structure of magnetic field, pores can be exploited to study the transport of mechanical energy by waves along the magnetic field to the chromosphere and corona. For a better understanding of physics of pores, we have investigated chromospheric traveling features (~ 55 km/s) running across two merged pores from their centers in an active region (AR 11828) that were observed on 2013 August 24 by using high time, spatial, and spectral resolution data from the Fast Imaging Solar Spectrograph (FISS) of the 1.6 meter New Solar Telescope (NST). We infer a LOS velocity by applying the bisector method to the CaII 8542Å band and HI band, and investigate intensity and LOS velocity changes at different wavelengths and different positions of the pores. We find that they have 3 minutes oscillations, and the intensity oscillation from line center is preceded by that from the core (-0.3 Å) of the bands. There is no phase difference between the intensity and the LOS velocity oscillations at a given wavelength, and the amplitude of LOS velocity near center is greater than that far from the center. These results support that the wave is a magnetoacoustic wave propagating along the magnetic fields of the pores. From FISS observation, we conclude that the fast traveling features may be an apparent motion of the magnetoacostic wave and a sudden decrease of their speeds beyond the pores can be explained by the inclination of magnetic field outside of the pores.

Choi, Jiwon

Plasmaspheric virtual resonances in the inner magnetosphere

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Low-latitude Pi2 pulsations have been attributed to the fast mode waves trapped in the Earth's plasmasphere. The conventional idea of this scenario requires somewhat rigid boundaries, the ionosphere and plasmapause, where waves can be reflected off of and get trapped. Sometimes, however, the concept of the plasmapause is inapplicable for this description when the Earth's magnetosphere is devoid of a sharp density drop or if the plasmasphere is too small to confine such a low frequency waves in the Pi2 range. We have conducted 3D MHD simulations in dipole coordinates to understand the generation of Pi2 pulsations at various plasmaspheric conditions. We start from the case at which the plasma density drops rapidly that forms the well-defined plasmapause to where the plasma density decreases monotonically, representing geomagnetically disturbed and quiet time, respectively. Our simulations show the characteristic modes excited in the inner magnetosphere regardless of the shape of the plasmapause. Our results are favorable to the plasmaspheric virtual resonance as a generation mechanism of the low-latitude Pi2 pulsations and able to explain the occurrence of Pi2 pulsations during geomagnetic quiescence when the plasmasphere can reach the saturated state.

Constantinescu, Dragos

Oxygen Ion Cyclotron Waves in the Outer Magnetosphere

Dragos O Constantinescu and Costel Bunescu, Institute for Space Sciences, Bucharest-Magurele, Romania

Due to their strong interaction with the plasma particles, ion cyclotron (IC) waves play a major role in the particle energization and loss, and in the general energy flow throughout the terrestrial magnetosphere. Their excitation requires the presence of a cold ion population combined with an anisotropic energetic population. These conditions are most frequently met in the vicinity of the plasmapause, where both energetic particles from the radiation belts and cold plasma are present. Recent studies showed that IC waves are also common inside and close to plasmaspheric plumes. These plumes can have a significant radial extension, sometimes up to the magnetopause. However, up to date only waves in the H+ and He+ branches have been observed in relation with the plasmaspheric plumes. Here we analyse the presence of O+ IC waves in the outer magnetosphere and their relation with the plasmaspheric plumes.

Dai, Lei

Cluster observations of fast magnetosonic waves in the heliosphere current sheet

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We present Cluster spacecraft observations of large-amplitude fast-mode magnetosonic waves in the heliospheric current sheet (HCS). Multiple current layers are detected using four-point curlometer analysis within the HCS. Current layers are found in correspondence with small-scale magnetic discontinuities. Fast magnetosonic waves are observed at one current layer, accompanying the phase-steeped edge of a large-amplitude transverse Alfven wave. The observed fast-mode waves are in the frequency range 0.01 Hz-0.2 Hz, characterized by a strong correlation between fluctuations of plasma density and magnetic field strength. The observation of fast-mode wave associated with the phase-steepened edge of Alfven wave is consistent with predications of previous numerical simulations, suggesting that the generation of the fast-mode waves may relate to the evolution of large amplitude Alfven wave (rotational discontinuity) in solar wind.

Dai, Lei

Van Allen Probe observations: Poloidal ULF waves excited by resonant wave-particle interaction in the inner magnetosphere

Lei Dai[1], Kazue Takahashi[2], John R Wygant[1], Liu Chen[3,4], John W Bonnell[5], Cynthia A Cattell[1], Scott A Thaller[1], Craig Kletzing[6], Charles William Smith[7], Robert J. MacDowall[8], Daniel N. Baker[9], J Bernard Blake[10], J. F. Fennell[11], Seth G Claudepierre[12], Herbert O Funsten[13], Geoffrey D Reeves[14] and Harlan E. Spence[7], (1)University of Minnesota Twin Cities, Minneapolis, MN, United States, (2)Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, United States, (3)Univ of California - Irvine, Irvine, CA, United States, (4)ZheJiang University,, Institute for Fusion Theory and Simulation, Hangzhou, China, (5)Univ California, Berkeley, CA, United States, (6)Univ. of Iowa, Iowa City, IA, United States, (7)University of New Hampshire, Durham, NH, United States, (8)NASA Goddard SFC, Greenbelt, MD, United States, (9)University of Colorado, Laboratory for Atmospheric and Space Physics, Boulder, CO, United States, (10)The Aerospace Corporation, Los Angeles, CA, United States, (11)The

Aerospace Corp, Los Angeles, CA, United States, (12)The Aerospace Corporation, Santa Monica, CA, United States, (13)Los Alamos Natl Laboratory, Los Alamos, NM, United States, (14)Los Alamos National Laboratory, Los Alamos, NM, United States

Poloidal ULF waves can accelerate (or de-accelerate) particles in the magnetosphere via their azimuthal wave electric field that is aligned with particles' longitudinal drift motion. Using measurements of electric fields (EFW), magnetic fields (EMFISIS) and energetic particles (ECT) from theVan Allen Probes (RBSP) spacecraft, we clearly identify the wave harmonic mode, detect the wave-particle resonance signatures, and determine the free energy source in a event (Oct 23,2012) where a poloidal standing wave is excited by drift-resonance interaction with ring current ions. As the RBSP mission proceeds to the second year and the orbit covers more MLT in the inner magnetosphere, more poloidal wave events have been identified. We will focus on poloidal waves excited by drift and drift-bounce resonance. Multi-events study will be presented on the physical properties, the dependence on geomagnetic activity and the location, and the excitation mechanisms of poloidal ULF waves. In particular, we will present events that excitation of poloidal ULF waves appears to affect ring current in the storm recovery phase.

Peter Damiano

Gyrofluid-kinetic electron modeling of dispersive scale Alfven waves associated with broadband aurora

Peter A Damiano and Jay Johnson, Princeton Plasma Physics Lab, Princeton, NJ, United States

The formation of the broadband aurora (such as seen at substorm onset) is well correlated with Poynting flux associated with dispersive scale Alfven waves. Ion temperature effects are important in this context as the ion gyroradius is a fundamental scale-length for the transfer of global scale substorm energy to particle energization and since these effects modify the phase speed of the wave (which has implications for both substorm onset timing and electron acceleration). With these motivations in mind, we present simulations of dispersive scale Alfven wave pulses using a new gyrofluid ion-kinetic electron model in dipolar coordinates. This model is an extension of an established hybrid MHD-klnetic electron model that has been generalized to include ion gyroradius effects based on a kinetic-fluid model where the ion pressure tensor is computed using a solution of the linear gyrokinetic equation. It is found that consideration of a realistic ion to electron temperature ratio significantly reduces the propagation time of the wave from the plasma sheet to the ionosphere (relative to the case that neglects ion temperature effects) and leads to an increased dispersion of wave energy perpendicular to the ambient magnetic field. Additionally, as the ion gyroradius is increased, we observe a reduction in the parallel current carried by the wave and hence a reduction in the electron energization.

Delamere, Peter

A review of low-frequency waves in the giant magnetospheres (Invited)

Peter A Delamere, University of Alaska Fairbanks, Fairbanks, AK, United States

The giant magnetospheres of Jupiter and Saturn are tremendously rich space-based laboratories for studying low-frequency waves. The plasma parameters in these rapidly-rotating magnetospheres are distinctly different from Earth, the Sun, and the solar wind. Yet the common thread of mass loading, magnetosphere-ionosphere coupling, reconnection, and shear flow instabilities can be found throughout the solar system -- and all involve low frequency (LF) waves operating in different parameter regimes. This review talk will focus on LF waves found in the partially ionized plasmas of Io (Jupiter) and Enceladus (Saturn), LF waves associated with radial transport of plasma, and LF waves associated with the solar wind interaction. The satellite-magnetosphere interactions are perhaps the most fascinating sources of LF waves. Unstable ring beam distributions are created in the mass-loaded plasma flows near Io and Enceladus, generating ion cyclotron waves (e.g. 0.01 to 2 Hz) that carry the fingerprint of satellite atmosphere composition. Dispersive Alfven waves generated by radial transport flows (e.g. centrifugally-driven interchange motion) are thought to generate field-aligned electron beams observed throughout the Io plasma torus. Kelvin-Helmholtz (KH) waves are present along much of the shear flow-unstable

magnetopause boundaries of Jupiter and Saturn. The KH modes combined with magnetic reconnection may account for the large-scale perturbations and ULF waves observed in Saturn's outer magnetosphere. Possible auroral signatures of these waves will also be discussed.

Engebretson, Mark

Investigating the IMF cone angle control of Pc3-4 pulsations observed on the ground

Mark J. Engebretson[1], Elianna A. Bier[1,2], Nana Owusu[1,3], Jennifer L Posch[1], Marc Lessard[4] and Viacheslav Pilipenko[1,5], (1)Augsburg College, Minneapolis, MN, United States, (2)Duke University, Department of Medical Physics, Durham, NC, United States, (3)University of Iowa, Department of Biomedical Engineering, Iowa City, IA, United States, (4)University of New Hampshire, Durham, NH, United States, (5)Space Research Institute, Moscow, Russia

Many studies have shown that Pc3-4 pulsations (~0.014-0.1 Hz) observed in Earth's magnetosphere during daytime hours originate in the ion foreshock region of the solar wind, just upstream from Earth's bow shock. They occur when the interplanetary magnetic field (IMF) is primarily radial – when the IMF cone angle $\theta_{xB} \leq 45°$. However, our knowledge of ion foreshock conditions is often incomplete, because of the finite scale sizes and curvature of magnetic flux tubes in the solar wind. In this study we compared 13 months of wave observations at two widely separated ground stations (Hornsund, Svalbard and Halley, Antarctica) to IMF values in the OMNI database, in order to test this relation. Values of θ_{xB} and the empirically predicted wave frequency (f_{calc}=0.06 B_{IMF}) were compared to daily Fourier spectrograms displaying pulsation power and frequency. Although there was often good temporal agreement between low θ_{xB} and increased Pc3-4 wave power, numerous counterexamples were also evident. A statistical study of wave activity in quarter hour increments showed that Pc3-4 pulsations were associated with low θ_{xB} values 81% of the time at Hornsund, and 83% at Halley. IMF cone angle data from all available upstream monitors were compared to wave observations for a more limited number of days; many of these showed inconsistent IMF orientations. This study indicates some of the limitations of the existing upstream monitors, and provides a quantitative estimate (~80%) of the accuracy of the OMNI data set in characterizing conditions near the nose of Earth's bow shock under predominantly radial IMF conditions.

Engebretson, Mark

EMIC waves in Earth's Magnetosphere (Invited)

Mark J. Engebretson, Augsburg College, Minneapolis, MN, United States, Marc Lessard, University of New Hampshire, Durham, NH, United States and Jay Johnson, Princeton Plasma Physics Lab, Princeton, NJ, United States

Since the intensification of studies of "hydromagnetic emissions" and "pearls" observed in ground records in the late 1950s and early 1960s, continued investigations of waves in the Pc 1-2 frequency band (0.2-5.0 Hz) have provided increasingly detailed characterizations of both the occurrence and properties of these waves and of the plasma processes in Earth's magnetosphere that generate them and control their propagation. Their generation is now attributed, in at least most cases, to the electromagnetic ion cyclotron (EMIC) instability of ion distributions with positive temperature anisotropy. Although many early observations focused on regions near the plasmapause and on the instability of ring current ions, comprehensive ground-satellite studies using elliptically orbiting spacecraft and those in geostationary orbit have extended the range of observed occurrence of these waves from below L = 2 to near the magnetospheric boundary, and even into the polar cap and distant plasma mantle. The role of EMIC waves in thermalizing plasma sheet and ring current ions and also in heating warm He^+ ions is clear, and their possible role in depleting relativistic radiation belt electrons is becoming increasingly circumscribed. Observations of energetic proton precipitation (proton aurora) are also providing new observational means to identify EMIC wave-particle interactions; these observations may supplement ground-based wave observations during disturbed conditions. However, the "pearl" structure of waves observed in ground data remains poorly understood, and most recently, observations of purely compressional and of purely electrostatic Pc1 waves have posed new observational and theoretical challenges.

Engebretson, Mark

Purely compressional Pc1 waves observed by the Van Allen Probes

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Waves in the Pc 1 frequency range (0.2 to 5 Hz) generated in Earth's magnetosphere can serve as diagnostics of instabilities that are understood to thermalize energetic plasma populations, including ions in the ring current and possibly electrons in the radiation belts. We have compared observations of Pc1 waves detected by the EFW double probe electric field experiment and EMFISIS fluxgate magnetometer on the two Van Allen Probes spacecraft during its first 1-1/2 years of operation. In addition to the more common transverse EMIC waves in the Pc1 band, these spacecraft have observed several tens of purely compressional wave events (with no evident transverse magnetic field components). Such purely compressional waves could result as wave energy piles up at the ion-ion hybrid resonance where the wave mode converts from a fast wave to a field-aligned EMIC wave. The wave frequency of the resonant mode is sensitive to the heavy ion density, so mode conversion could explain observations of decreasing frequency with radial distance. These compressional waves exhibited a nearly uniform distribution in local time, occurred at L shells from 2.2 to 5.8 (the spacecraft apogee) and ranged in frequency from 0.6 to over 16 Hz. Wave occurrences had little dependence on the level of geomagnetic activity, and in contrast to transverse EMIC waves, they were observed in association with low, stable fluxes of ring current ions. Almost all of these waves were observed inside the plasmapause, regardless of its radial location, and had Poynting vectors directed radially inward and sunward.

Fedun, Viktor

The numerical simulation of MHD wave modes excited by photospheric motions and their energy fluxes. (Invited)

Viktor Fedun, The University of Sheffield, Sheffield, United Kingdom

The ground- and space-based solar observations reveal the presence of small-scale plasma motion between convection cells in the solar photosphere. These motions in intergranular magnetic field concentrations are responsible for the generation of different types of MHD wave modes, for example, kink, sausage and torsional Alfven waves. In this study we will show the results of a 3D numerical simulation of the excitation and propagation of these MHD modes in the realistic magnetic configurations mimicking the photospheric magnetic flux tubes. Based on a self-similar approach the magnetic flux tube configurations were constructed and implemented in the VALIIIC model of the solar atmosphere. A novel method for decomposing the velocity perturbations into parallel, perpendicular, and azimuthal components in a 3D geometry was developed using field lines to trace a volume of constant energy flux. This method was used to identify the excited wave modes propagating upwards from the photosphere and to compute the percentage of energy contributed by each mode. We have found that for all cases where torsional motion is present the main contribution to the flux (60%) was the Alfven wave. A vertical driver was found to excite mainly the fast- and slow-sausage modes whilst a horizontal driver primarily excited the slow kink mode.

Friedel, Reiner

Direct measurements of chorus wave effects on electrons in the 5-40 KeV range from the Van Allen Probes Mission (Invited)

Reiner H W Friedel[1], Brian Larsen[1], Geoffrey D Reeves[1] and Ruth M Skoug[2], (1)Los Alamos National Laboratory, Los Alamos, NM, United States, (2)Los Alamos Natl Lab, Los Alamos, NM, United States

The Van Allen Probe mission with its dual spacecraft and exquisite particle and wave instrumentation was designed to explore the effects of magnetospheric waves on the in-situ particle populations. Here we use data from the

mission's low energy instrument (HOPE - Helium, Oxygen, Proton and Electron plasma instrument) to investigate the detailed changes in the electron distribution function of electrons that are drifting through a region of chorus waves. To do this we exploit the spacecraft mission constellation where two spacecraft are on the same orbit with changing separation in time. There are many times when spacecraft cross similar radial regions but separated by up to several hours in local time. We focus on the region of most active chorus wave activity, just outside the plasmapause, and focus on the energy range of particles most strongly affected by chorus waves (10's of keV, the top energy range of HOPE). We select time periods where one of the Van Allen Probes is at early local times where no wave activity is observed, while the other Probe is at later local times and in regions where wave activity is observed, and seek out changes in the pitch angle distribution of the electrons that drift from the first probe to the second. We will additionally use a recently developed wave-proxy from the low Earth orbiting NPOES satellites to fill in the local time extend of the chorus wave region, and hope to relate the changes in electron pitch angle shape to the size of the chorus regions they have drifted through. Preliminary results form a few case studies will be presented here.

Fujita, Shigeru

Possible generation mechanisms of the Pi2 pulsations estimated from a global MHD simulation (Invited)

Shigeru Fujita, Meteorological College, Kashiwa, Japan and Takashi Tanaka, Kyushu University, Fukuoka, Japan

The plasmaspheric virtual resonance (PVR) and the transient Alfven wave bouncing between the ionospheres in both hemispheres (the transient response, TR) are regarded as the possible generation mechanisms of the Pi2 pulsations. However, the global MHD simulation of a substorm [Tanaka et al., 2010] did not reproduce such wave modes because of insufficient ionospheric reflection of the Alfven wave, numerical transfer of the Alfven wave across the field lines, and no plasmasphere. Furthermore, it is noted that the substorm current wedge (SCW) which is a driver of the TR is not reproduced in the global MHD simulation. In this study, we search the sources of the Pi2 pulsations in the global MHD simulation, namely, the compressional wave in the inner magnetosphere for the PVR and the Alfven wave injected to the ionosphere for the TR. In conclusion, there appears a compressional signal in the inner magnetosphere when the high-speed Earthward flow at the substorm onset surges in the inner edge of the plasma sheet. This simulation result suggests that this compressional wave would be trapped in the plasmasphere as the PVR if the model has the plasmasphere. As for TR, the global MHD simulation provides suddenly increasing field-aligned current (the Alfven wave) associated with sudden appearance of the shear flow which comes from the high-speed flow in the plasma sheet at the onset of the substorm. If the global MHD simulation correctly lets the Alfven wave be reflected in the ionosphere and transmitted along the field line, the TR would be established. In addition to these, we also present the transient slow mode oscillation in the inner boundary of the plasmasheet. This oscillation appears just after the high-speed plasma flow associated with the depolarization injecting to the inner boundary of the plasmasheet. This oscillation has the frequency slower than the typical Pi2 pulsations.

Fujita, Shigeru

Geoelectric and geomagnetic response to the oscillating magnetospheric current in Japan and Korea

Shigeru Fujita[1], Ikuko Fujii[1,2] and Arata Endoh[3], (1)Meteorological College, Kashiwa, Japan, (2)JMA, Kashiwa, Japan, (3)Japan Meteorological Agency - JMA, Tokyo, Japan

We calculate the electric field induced in the ground with the three-dimensional heterogeneous distribution of the resistivity by the oscillating magnetospheric current. The ground resistivity is given from the specific resistivity values of the sea water layer, the sediment layer, and the rock layer as 0.33Ohm m, 10Ohm m, and 1000Ohm m, respectively, according to the global relief model of land topography and bathymetry as well as from the global sediment map. The oscillation has the period including the ULF range. This calculation is important for evaluation of the extreme value of the geomagnetically induced current for the extreme severe space weather event. The calculation indicates that, in the countries with coastlines like Japan and Korea, the coastline effect plays an essential role in induction of the electric field. As a result, the enhanced electric field intensity will appear when the induced current in the sea water region flows almost perpendicular to the coast line with a steep slope. The eastern coast of Korean Peninsula, the western coast of the northern Honshu Island, and the western part of Niigata Prefecture (central part of the western coast of the Honshu Island) are included in this category. In addition, the bay with deep bathymetry and wide mouth tends to have much enhanced electric field intensity in the throat of the bay when the induced current is parallel to the axis of the bay. This information is important when we prepare the GIC disaster for the extremely severe space weather event. Furthermore, we present the geomagnetic effect due to the current induced in the ground with the three-dimensional heterogeneous resistivity. This information is useful for ground geomagnetic observations.

Gavrilov, Boris

Experimental investigation of ULF/VLF radio waves generation and propagation in the upper atmosphere and ionosphere during EISCAT heating experiment in 2012

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Powerful high frequency radio waves transmitted from high-power ground-based HF heating facilities could strongly modify the ionospheric plasma. The X-mode HF pump wave can generate strong small-scale artificial field aligned irregularities in the F region of the high-latitude ionosphere. One of the tasks of the Russian EISCAT heating campaign on February 2012 was an investigation of the generation and propagation of ULF/VLF signals generated at the result of HF radiation modulation. Despite the numerous attempts of long-range detection of such signals there are only several evidences of successful results. The most reliable and important results were obtained by [Barr et al., 1991] more than 20 years ago. They measured of VLF radio waves in Lindau, Germany at the distance of about 2000 km from EISCAT Heater. We present the results of the ULF/VLF registrations at the same distance during heating campaign on February 2012.

The measurements were conducted at Mikhnevo Geohysical Observatory of IDG RAS located in 80 km to the south from Moscow and at the distance of about 1900 km from Tromso. For measurements were used a sensitive magnetic field receivers with crossed air-coil loop antennas working in the frequency range from 80 Hz to 50 kHz in the femtotesla amplitude range. We recorded the radial and azimuthal magnetic component of the signals and from their ratio obtained the waveguide mode polarization. The amplitude of the signals was in the range of 1-20 femtotesla.

The signals were radiated by EISCAT Heater at 517, 1017, 2017, 3017, 4017 and 6017 Hz. It was shown that at the frequency less than 2 kHz the signals propagates in the QTEM mode, and signals at the frequency range from 2 to 4 kHz were in the QTE mode.

Observed absolute magnetic field strengths and waveguide polarizations are found to be in line with the predictions of simple waveguide models. Qualitative coincidence of the signals polarization character and its dependence on the signals frequency specifies adequacy of numerical models and reliability of the experimental data received in campaign 2012.

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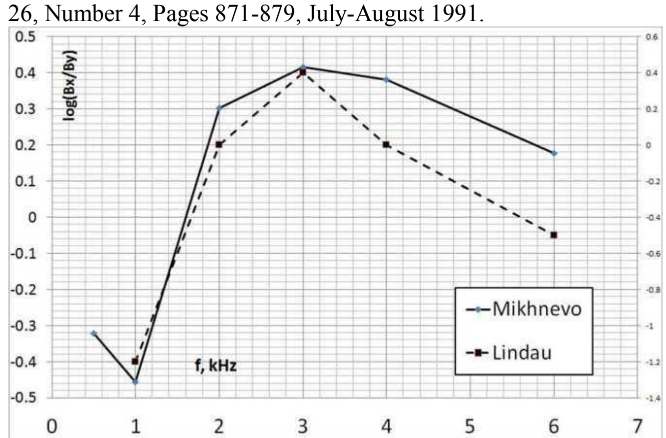

Glassmeier, Karl-Heinz

Enhancement of ultra-low frequency wave amplitudes at the plasmapause

Lasse Clausen, University of Oslo, Oslo, Norway and **Karl-Heinz Glassmeier**, TU Braunschweig, Braunschweig, Germany

We present measurements of ultra-low frequency (ULF) wave amplitudes measured by the THEMIS probes while crossing the plasmapause. During one crossing on 24 June 2007 which we study in detail, all three probes of which data was obtained show an increase in the ULF wave amplitude between 10 and 50 mHz by about 30\%. These results are confirmed by a statistical study that examines the ULF wave amplitude in the same frequency range averaged over 132 plasmapause crossings between June 2007 and December 2007 made by THEMIS C, D, and E. We find that, assuming the plasmapause can be approximated by a tangential MHD discontinuity, a ULF wave amplitude enhancement of 30\% is in agreement with theoretical transmission coefficient calculations if the plasma density increases by a factor of about 130 while simultaneously the plasma temperature decreases by a factor of about 73. While the plasma density estimate is confirmed by observations derived from spacecraft potential measurements, the temperature decrease cannot be confirmed because the cold plasmaspheric particle populations are not detected by the THEMIS particle instruments; however, the value is in reasonable agreement with previous measurements of magnetospheric and plasmaspheric plasma temperatures. These results might have important implications for the detection of global fast modes by satellites as their amplitude is hence expected to by higher inside the plasmasphere than outside.

Glassmeier, Karl-Heinz

Listening in the Plasma Universe (Invited)

Karl-Heinz Glassmeier, TU Braunschweig, Braunschweig, Germany

Through waves we are perceive many phenomena of our immediate and distant environment. Without light waves we would not know about each other, without acoustic waves I could barely communicate with you. Waves as a means to communicate are most important, not only in daily life, but also in our understanding of nature. Geomagnetic pulsations told us and still tell us about dynamic processes in the magnetosphere. Their spatial and temporal characteristics bear information about the generation process as well as the medium permeated. Global occurrence statistics provide a means to map out the magnetosphere. Following the footsteps of astronomers, searching the sky in the infra-red, visible, or ultra-violet range, we are listening in the plasma universe using low-frequency waves. Drivers of these waves are electric currents, caused by a plethora of plasma instabilities, indicating non-thermal phase space distributions, non-uniform plasma conditions, or moving bodies of different kinds. Accumulating knowledge of these processes allows us to disentangle the special wave characters observed. Our beloved pulsations, generated by oscillating currents in the ionosphere, may be stripped like an onion. Deconvolution from the ionosphere through the plasmasphere and outer magnetosphere up into the solar wind now is possible. Ground-based observations become monitors for the conditions in the outer magnetosphere and the solar wind. Waves tell us about their "communication" with charged particles, their acceleration, and other conversions of electro-magnetic into kinetic energy and vice versa. All of these processes we have not yet understood. But travelling in space, to other planetary bodies, or our Sun, offers us adventures in parameter space. Different background plasma conditions, various geometries, rotational effects, the diverse conditions met out there convert us from passive observers into active experimenters. Plasma waves are not just little wiggles, waves matter!

Glassmeier, Karl-Heinz

Low-Frequency Waves in the interaction region of comet Churyumov-Gerasimenko with the solar wind: First Rosetta results

Karl-Heinz Glassmeier[1], Chris Carr[2], Emanuele Cupido[2], Christoph Koenders[1], Ingo Richter[1], Bruce T. Tsurutani[3], Claire Vallat[4] and Martin Volwerk[5], (1)TU Braunschweig, Braunschweig, Germany, (2)Imperial College London, London, United Kingdom, (3)NASA Jet Propulsion Laboratory, Pasadena, CA, United States, (4)ESAC,

Villanueva, Spain, (5)Space Research Institute, Graz, Austria

The interaction of comets with the solar wind is dominated by the ionization and subsequent pick-up of cometary neutrals. Non-thermal particle phase space distributions are caused by this pick-up process, leading to the generation of a plethora of low-frequency plasma waves. Wave properties are strongly dependent on the activity level of the comet as well as the size of the interaction region. Here we present first observations of the Rosetta magnetometer experiment, taken during the approach of the spacecraft to the comet. As cometary activity during this pre-landing phase is still low, low-frequency plasma waves will be of a different nature than compared to those already observed at active comets like 21P/Giacobini-Zinner, 1P/Halley, 26P/Grigg-Sjkellerup, or 19P/Borelly. Detailed comparisons of plasma wave characteristics will be discussed partly based on a newly developed analysis tool, the Rosetta Automatic Wave Analyses (RAWA) tool.

Gokani, Sneha

Low Latitude Whistlers: Correlation with conjugate region lightning activity and arrival azimuth determination

Sneha A Gokani[1], Rajesh Singh[2], Ajeet Kumar Maurya[2], Veenadhari Bhaskara[1], Morris Cohen[3] and Janos Lichtenberger[4], (1)Indian Institute of Geomagnetism, New Mumbai, India, (2)Indian Inst of Geomagnetism, Allahabad, India, (3)Georgia Institute of Technology Main Campus, Atlanta, GA, United States, (4)Eotvos University, Budapest, Hungary

The propagation mechanism of low latitude whistlers has puzzled the scientific community for many years. One of the key to the solution is to find the characteristics of whistler source location. The present study focuses on the correlation of ~ 2000 whistlers recorded for a period of one year (December 2010 to November 2011) using AWD-AWESOME VLF receiver system at Indian low latitude station, Allahabad (Geomag. lat. 16.79° N; L=1.08) with the lightning activity detected by World Wide Lightning Location Network (WWLLN) at and around the conjugate region (9.87° S; 83.59° E). About 63% of whistlers are correlated with the lightning strikes around conjugate region. To confirm the source region of whistlers, arrival azimuths of whistler causative sferics are determined and they are found to point towards the conjugate region. Most of the whistlers are found to be generated from the lightning strikes which are located in the thunderstorm with movement aligned in South-East direction. Moreover, the seasonal variations in spatial and temporal occurrence of whistler and lightning activities have been examined. Winter months, December, January and February are found to be dominant for the whistler activity. An inspection on the energy values of the WWLLN detected lightning strokes and whistler producing WWLLN detected lightning strikes led to a linear relationship between the two. A special focus is also given on the analysis of spectral features of low latitude whistlers by analysing the Power Spectral Density and Amplitude. The results obtained open a new window to look for the propagation mechanism of low latitude whistlers.

Hartinger, Michael

The effect of magnetopause motion on fast mode resonance

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The Earth's magnetosphere supports several types of Ultra Low Frequency (ULF) waves; these include trapped fast mode waves often referred to as cavity modes, waveguide modes, and tunneling modes/virtual resonance. All trapped fast mode waves require a stable outer boundary to sustain wave activity. The magnetopause, usually treated as the outer boundary for cavity/waveguide modes in the dayside magnetosphere, is often not stable, particularly during geomagnetic storms. We examine how magnetopause motion affects the magnetosphere's ability to sustain trapped fast mode waves on the dayside using idealized simulations obtained from the BATSRUS global magnetohydrodynamic (MHD) code. We present the first observations of cavity modes in BATSRUS, replicating results from other global MHD codes. We further show that for most solar wind conditions magnetopause motion negligibly affects fast mode resonance; other mechanisms are responsible for the observed low cavity mode occurrence rates in the outer magnetosphere. However, extreme solar wind conditions with large magnetopause displacements, such as CIR events, may affect cavity mode occurrence. Our simulation results agree with observations from the WIND and GOES spacecraft suggesting that cavity modes are not significantly affected by magnetopause boundary motion.

Hartinger, Michael

ULF wave energy transfer from the equatorial plane to the ionosphere: frequency and spatial dependence

Michael Hartinger[1], Mark Moldwin[1], Shasha Zou[1], John W Bonnell[2] and Vassilis Angelopoulos[3], (1)University of Michigan, Ann Arbor, MI, United States, (2)Univ California, Berkeley, CA, United States, (3)UCLA---ESS/IGPP, Los Angeles, CA, United States

Ultra Low Frequency (ULF) waves transfer energy in the Earth's magnetosphere through a variety of mechanisms that impact the Earth's ionosphere, radiation belts, and other plasma populations. Using THEMIS satellite data, we examine the time averaged electromagnetic energy transfer rate, S(f), as a function of frequency (3-30 mHz) and region of the magnetosphere. We examine radial energy transport near the equatorial plane and compare observations with idealized global simulations of energy transport associated with specific ULF wave modes. From the observations, we find S(f) tends to be field-aligned near the magnetic equatorial plane, suggesting that the ionosphere is an important sink of wave energy. We map S(f) from the equatorial plane to the ionosphere, finding typical energy dissipation rates of 0.001-1 mW/m^2, with most energy transferred at low frequencies and high-latitudes in the dayside post-noon sector. Generally, ULF waves transfer less energy than large scale, static currents (e.g., Region 2), but they can make substantial contributions to Joule heating and aurora in regions far from these current systems.

Hwang, Kyoung-Joo

The role of low-frequency boundary waves in the dynamics of the dayside magnetopause and the inner magnetosphere

Kyoung-Joo Hwang, NASA GSFC, Greenbelt, MD, United States; Goddard Planetary Heliophysics Institute - GPHI, University of Maryland, Baltimore County, Baltimore, MD, United States and David G Sibeck, NASA/GSFC, Greenbelt, MD, United States

Observational studies using data from multipoint spacecraft combined with ground magnetograms are presented to understand the role of the low-frequency waves commonly observed along the Earth's magnetopause and in the low-latitude boundary layer (LLBL) as an intermediary between solar-wind drivers and dayside and/or inner magnetospheric dynamics. Typical physical processes occurring at the magnetopause boundary layer include Kelvin-Helmholtz waves generated by shear flows and newly-identified LLBL velocity fluctuations, which both provide multiple paths to affect inner-magnetospheric particle density and energy fluxes. Ultra-Low-Frequency (ULF) waves detected by inner magnetospheric probes (such as the Van Allen Probes) and/or ground magnetometers are often excited by, or enhanced, during these boundary fluctuations. We present categorized case studies linking boundary fluctuations to variations of inner magnetospheric fields and plasmas and interplanetary drivers. In particular, we present a case study indicating that the magnetopause in the vicinity of a plasmaspheric plume is absolutely unstable to Kelvin-Helmholtz waves, resulting in a dawn-dusk asymmetry in the Earth's dayside magnetosphere.

Jao, Chun-Sun

Evolution of electrostatic structures in pair plasmas

Chun-Sun Jao[1] and Lin-Ni Hau[1,2], (1)Institute of Space Science National Central University, Jhongli City, Taiwan, (2)National Central University, Department of Physics, Jhongli, Taiwan

Electrostatic waves and solitons have been widely observed in solar system plasma environments. While electron-positron plasmas may be present in the early universe and many astrophysical environments. Due to the inertia symmetry between electrons and positrons, the issue of whether solitons can actually form in pair plasmas has been raised and discussed in several papers. Recently we have shown that electrostatic solitons may be generated by streaming and bump-on-tail instabilities in pair plasmas based on particle-in-cell simulations. In this study the generation and evolution of electrostatic waves and solitons in pair plasmas is examined based on two-dimensional

electrostatic particle-in-cell model. The effects of background magnetic field are examined and comparisons between one and two dimensional calculations are made.

Johnson, Jay

EMIC Waves in Space Plasmas (Invited)

Jay Johnson[1], Eun-Hwa Kim[1] and Dong-Hun Lee[2], (1)Princeton Plasma Physics Lab, Princeton, NJ, United States, (2)Kyung Hee Univ, Gyeonggi, South Korea

Electromagnetic Ion Cyclotron (EMIC) waves are found throughout the heliosphere and are thought to control key transport and heating processes. EMIC waves are thought to play an important role in coronal heating and control of anisotropy in the solar wind. At Earth's magnetosphere EMIC waves can heat ionospheric ions, leading to outflows and mass loading of the magnetosphere. EMIC waves, generated in the ring current region, can also facilitate rapid loss of radiation belt electrons. Because they are particularly sensitive to heavy ion dynamics, EMIC waves can also be used as a diagnostic of heavy ion concentrations in planetary magnetospheres. Application of theory, ray tracing, full-wave approaches, and fluid/particle simulation techniques has led to significant advances in understanding of the generation, propagation, mode conversion, and dissipation of EMIC waves as well as associated transport and heating processes. We review successes in modeling EMIC waves, limitations of modeling techniques, and outstanding physics questions that remain.

Jun, Chae Woo

Statistical study of Pc1 pearl structures observed at multi-point ground-based stations in Canada, Russia and Japan

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We investigated Pc1 pulsations observed simultaneously at Athabasca (ATH, 54.7N, 246.7E, L=4.3) in Canada, Magadan (MGD, 60.1N, 150.7E, L=2.6) in Russia, and Moshiri (MOS, 44.4N, 142.3E, L=1.5) in Japan for a 6-year period from 2008 to 2013. We selected a total of 3027 Pc1 events at these three stations. We chose Pc1 pulsations events with high coherence of Pc1 waveforms ($r > 0.5$) simultaneously observed at longitudinally (ATH and MGD) and latitudinally (MGD and MOS) separated ground stations. Then, we verified the similarity of Pc1 pearl structures between two different stations, in order to investigate whether these pearl structures are caused by beating in the ionosphere or not. From these analyses, we investigate the spatial and temporal distributions of Pc1 pearl structures caused by beating processes in the ionosphere. We could also be able to distinguish which mechanism is the dominating process of Pc1 pearl structures in the ionosphere or in the magnetosphere. In addition, we will investigate the relationship between Pc1 pearl structures and the geomagnetospheric activities.

Keiling, Andreas

Magnetosphere-Ionosphere Coupling of Global Pi2 Pulsations

Andreas Keiling[1], Octav Marghitu[2], Joachim Vogt[3], Olaf Amm[4], Costel Bunescu[2], Vlad Constantinescu[2], Harald U Frey[5], Maria Hamrin[6], Tomas Karlsson[7], Rumi Nakamura[8], Hans Nilsson[9], Joshua L Semeter[10] and Eugen Sorbalo[11], (1)Space Sciences Laboratory, Berkeley, CA, United States, (2)Institute for Space Sciences, Bucharest-Magurele, Romania, (3)Jacobs University Bremen gGmbH, Bremen, Germany, (4)Finnish Meteorological Institute, Helsinki, Finland, (5)Univ California Berkeley, Berkeley, CA, United States, (6)Umea Univ, Umea, Sweden, (7)KTH Royal Institute of Technology, Stockholm, Sweden, (8)Austrian Academy of Sciences, Graz, Austria, (9)IRF Swedish Institute of Space Physics Kiruna, Kiruna, Sweden, (10)Boston Univ, Boston, MA, United States, (11)Jacobs University Bremen, Bremen, Germany

Global Pi2 pulsations have mainly been associated with either low/middle latitudes or middle/high latitudes and, as a result, have been treated as two different types of Pi2 pulsations, either the plasmaspheric cavity resonance or the transient response of the substorm current wedge, respectively. However, in some reports global Pi2 pulsations have a single period spanning low/middle/high latitudes. This "super" global type has not yet been satisfactorily explained. In particular, it has been a major

challenge to identify the coupling between the source region and the ground. In this presentation, we report two consecutive super global Pi2 events which were observed over a wide latitudinal and longitudinal range, using the THEMIS and McMAC magnetometer networks. Using in-situ data from THEMIS, GOES and Geotail, it was possible to follow the Pi2 signal along various paths with time delays from the magnetotail to the ground. Furthermore, it was found that the global pulsations were a combination of various modes including the transient Alfven and fast modes, field line resonance, and possibly a forced cavity-type resonance. As for the source of the Pi2 periodicity, oscillatory plasma flow inside the plasma sheet during flow braking is a possible candidate. Such flow modulations, resembling the ground Pi2 pulsations, were recorded for both events.

Kepko, Larry

Directly-driven oscillations: Current status, open questions, and how they inform us about magnetic reconnection (Invited)

Larry Kepko, NASA GSFC, Greenbelt, MD, United States

There exists strong evidence that periodic number density structures in the solar wind drive discrete, global magnetospheric oscillations through a quasi-static 'forced breathing'. These oscillations have periods in Earth's rest frame of 15 minutes up to several hours, and several studies have shown the distribution of frequencies to closely align with the 'magic frequencies' that were originally attributed to global cavity modes. In addition, there is strong evidence that some nightside Pi2 pulsations are directly-driven by periodicities inherent to magnetotail flow bursts. Although seemingly different, both types of pulsations may derive from the same physical process: highly modulated magnetic reconnection. In this talk, I first briefly review the current understanding of both types of directly-driven oscillations, including new multi-point observations of directly-driven Pi2 made by THEMIS, and high-resolution charge-state measurements of solar wind oscillations made by ACE. For both types of directly-driven oscillations, the new observations push the source region closer to the reconnection site. For the forced-breathing oscillations, this links global magnetospheric oscillations to processes occurring near the solar surface. I conclude by discussing how we might use measurements of these directly-driven oscillations in both the solar wind and magnetosphere to probe magnetic reconnection.

Kim, Khan-Hyuk

Low-latitude Pi2 pulsations during the intervals of quiet geomagnetic conditions ($Kp \leq 1$) (Invited)

Khan-Hyuk Kim, Kyung Hee University, Yongin, South Korea, Hyuck-Jin Kwon, Kyung Hee University, Yongin-Si, South Korea, Kazue Takahashi, Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, United States, Dong-Hun Lee, Kyung Hee Univ, Gyeonggi, South Korea and Ensang Lee, Dept. of Astronomy and Space Science, Kyung Hee University, Yongin, Gyeonggi, South Korea

Several case studies reported Pi2 pulsations during the interval of extremely quiet geomagnetic condition (Kp = 0). Until now, however, no statistical study has been reported for Pi2 activity during quiet geomagnetic interval. In our study we statistically examine the properties of Pi2 pulsations observed at low-latitude Bohyun (BOH, L = 1.35) station in South Korea. 989 Pi2 events were identified for the intervals of Kp=0-1 in 2008 when BOH was on the nightside from 1800 to 0600 local times. Comparing Pi2 parameters and solar wind conditions, it was found that Pi2 frequencies decrease with decreasing solar wind speed. We also found that Pi2 pulsations quasi-periodically occur with about 30-min recurrence time. We will discuss why the Pi2 frequency depends on solar wind speed and what determines the 30-min recurrence time of Pi2 pulsations under quiet geomagnetic conditions (Kp=0-1).

Kim, Khan-Hyuk

Loss of geosynchronous relativistic electrons by EMIC waves during quiet geomagnetic conditions

Khan-Hyuk Kim, Kyung Hee University, Yongin, South Korea, Kiho Hyun, Kyung Hee Univ, Yongin-si, Gyeonggi-do, South Korea, Ensang Lee, Dept. of Astronomy and Space Science, Kyung Hee University, Yongin, Gyeonggi, South Korea and Dong-Hun Lee, Kyung Hee Univ, Gyeonggi, South Korea

We have examined relativistic electron flux losses at geosynchronous orbit under quiet geomagnetic conditions. Two 3-day periods, from 11 to 13 October and from 29 November to 1 December, in 2007 were chosen for analysis because geomagnetic conditions were very quiet (3-day average of Kp < 1) and significant losses of geosynchronous relativistic electrons were observed. During both intervals, there were no geomagnetic storm activities. Thus, the loss processes associated with geomagnetic field modulations caused by ring current buildup can be excluded. The flux of geosynchronous relativistic electrons with energy > 2 Mev shows typical diurnal variations with a maximum near noon and a minimum near midnight for each day. The flux level of the daily variation gradually decreased from first day to third day for each 3-day period. The total magnetic field strength (Bt), however, is relatively constant for each day. Unlike electron flux decreases, the flux of protons with energy between 0.8 and 4 MeV adiabatically responses to the daily variation of Bt. That is, there is no significant decrease of the proton flux when the electron flux decreases. During both 3-day periods, well-defined electromagnetic ion cyclotron (EMIC) waves were detected at geosynchronous spacecraft. Low-altitude polar orbiting spacecraft observed the precipitation of energetic electrons and protons in the interval of EMIC waves enhancement. From these observations, we suggest that the EMIC waves are a major factor to control the electron flux decrease under quiet geomagnetic conditions.

Kim, Eun-Hwa

ULF waves at Mercury (Invited)

Eun-Hwa Kim[1], Scott A Boardsen[2], Jay Johnson[1] and James A Slavin[3], (1)Princeton Plasma Physics Lab, Princeton, NJ, United States, (2)NASA Goddard SFC, Greenbelt, MD, United States, (3)University of Michigan Ann Arbor, Ann Arbor, MI, United States

Ion cyclotron frequency range waves (or electromagnetic ion cyclotron wave, EMIC) have been often observed at Mercury's magnetospheres. The previous statistical study showed the magnetic compressional component is dominant near the magnetic equator and the transition from compressional to transverse dominance occurs roughly at magnetic latitudes of ±20˚. Because the observed waves also often show linearly polarization, the field-line resonance in the single or multiple ion plasmas have been suggested to discuss such waves. On the other hand, electromagnetic ion Bernstein wave (IBW) is also suggested because of strong power of compressional component. In this talk, we will address both field-line resonance and electromagnetic IBWs in order to discuss the ULF waves at Mercury. We adopted 2D full-wave code that recently developed at Princeton Plasma Physics Laboratory. When compressional fast waves launched in the outer magnetosphere, the waves propagate to inner magnetosphere and strong field-aligned waves are mode-converted from the incoming compressional waves. Such mode-converted waves globally oscillate and have strong transverse components. Near the magnetic equator, due to mixture of incoming compressional waves and mode-converted field-line resonance, magnetic compressional component is dominant while transverse component is dominant off the equator, which is consistent with statistical study. We also used warm plasma ray-tracing to explore the propagation of the IBW mode in a dipole magnetic field and found that the electromagnetic IBWs are highly unstable to the proton loss cone distribution function and the wave's group velocity is highly field aligned. The wavelength of this mode is on the order of 100 km. We also discovered that as the waves propagate they can become highly compressional even in a moderate proton beta ~0.05 to 0.54 plasma, which is also consistent with observations.

Kim, Eun-Hwa

Global Modeling of EMIC waves at Earth: Generation and Application of Linearly Polarized EMIC waves

Eun-Hwa Kim[1], Jay Johnson[1], Dong-Hun Lee[2], Hyomin Kim[3], Ernest J Valeo[4] and Cynthia Phillips[1], (1)Princeton Plasma Physics Lab, Princeton, NJ, United States, (2)Kyung Hee University, Yongin, South Korea, (3)Virginia Polytechnic Institute and State University, Blacksburg, VA, United States, (4)Princeton University, Princeton, NJ, United States

We develop a two-dimensional, finite element code that solves the full wave equations in global magnetospheric geometry. The code describes a three-dimensional wave structure including mode conversion when plasma waves are launched in a two-dimensional axisymmetric background plasma with general magnetic field topology. Using this code, we examine how EMIC waves are generated and propagated along the magnetic field line. While left-handed polarized EMIC waves are known to be excited by the cyclotron instability associated with hot and anisotropic ion distributions in the equatorial region of the magnetosphere, the generation mechanism of linear and right-handed polarized EMIC waves, which are often observed near the magnetic equator, is remained as one of the unsolved scientific questions. In this presentation, we show the linear polarization of the EMIC waves can be explained by mode conversion at the ion-ion hybrid (IIH) resonance (an analogue of the field-line resonance when the resonance frequency is on the order of the heavy ion cyclotron frequency) when externally driven compressional waves propagate into an increasing/decreasing heavy ion concentration or inhomogeneous magnetic field. Since these mode-converted waves depend sensitively on the heavy ion concentration, this dependence makes it possible to estimate the heavy ion concentration ratio. We also evaluate the absorption coefficients at the IIH resonance at Earth's geosynchronous orbit for variable concentrations of He+ and wave frequencies and found that the resonance only occurs for a limited range of wave frequency such that the IIH resonance frequency is close to, but not exactly the same as the crossover frequency. Using the wave absorption and observed EMIC waves from the GOES-12 satellite, we demonstrate how this technique can be used to estimate that the He+ concentration is around 4% near L = 6.6.

Kim, Kyung-Chan

THEMIS observations of plasmaspheric hiss: its dependence on solar wind parameters and geomagnetic activity

Kyung-Chan Kim, KASI Korea Astronomy and Space Science Institute, Daejeon, South Korea

Accurate knowledge of the global distribution of plasmaspheric hiss is essential for radiation belt modeling because it provides a direct link to understanding radiation belt losses in the slot and the inner region of the outer belt. In this study, we show its dependence on solar wind parameters and geomagnetic activity using THEMIS hiss measurements made from 1 July 2008 to 30 June 2012 for all five probes, and develop models of the global distribution of hiss amplitudes based on in-situ measurements of IMF and solar wind parameters as well as geomagnetic indices using an artificial neural network technique. We find that solar wind speed and IMF BZ employed as inputs are the most influential parameters that affect the evolution of the magnetospheric hiss. The solar wind parameter-based hiss model generally results in a higher correlation between measured and modeled hiss amplitudes than any other models including geomagnetic indices AE, Kp, and Dst.

Klimushkin, Dmitri

Compressional high-m Pc5 ULF waves in the magnetosphere: theoretical considerations

Dmitri Yu. Klimushkin and Pavel N. Mager, Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia

The compressional Pc5 waves with hight azimuthal wave numbers (m>>1) are often observed in the magnetosphere at high level of the geomagnetic activity. The four ULF modes were suggested as a possible explanation of these waves: Alfven ballooning mode, slow magnetosonic mode, drift compressional mode, and drift mirror mode. These modes are considered for the following issues: field aligned structure, transverse structure, generation mechanism, instabilities. Both MHD and kinetic approaches are used. It is concluded that the most probable modes are Alfven ballooning and drift compressional modes coupled with each other. In a gyrokinetic framework, these modes are described by a system of two integro-differential equations. This system takes into account drift-bounce wave-particle interaction, finite plasma pressure, plasma and magnetic field inhomogeneity along field lines and transverse to magnetic shells, and mode coupling due to field line curvature. The conditions of the stablity of these modes and their spatial structure are studied.

Klimushkin, Dmitri

Generation of the high-m Alfven waves in the magnetosphere by the moving source: theory and experiments

Pavel N. Mager[1], **Dmitri Yu. Klimushkin**[1] and Oleksiy V Agapitov[2], (1)Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia, (2)LPC2E/CNRS, Orelans, France

The theory of generation of the high-m Alfven wave by substorm injected energetic particles in the magnetosphere is suggested. The wave is supposed to be emitted by an alternating current created by the substorm injected drifting particle cloud. Under the reasonable assumption about the density of the energetic particles, the amplitude of the generated wave is close to the observed amplitudes of poloidal ULF pulsations. The spatio-temporal structure of the generated waves was calculated. The azimuthal phase speed of the wave coincides with the gradient-curvature drift velocity of the injected particles. This equality holds for the substorm-related waves statistically studied with SuperDARN radars by James et al. (2013). Experimental indication of this mechanism is a double change of the wave polarization: from mixed to poloidal to toroidal. This change was observed for several events observed with geostationary and THEMIS satellites. Moreover, the theory allows one to give interpretation of the equatorward phase motion of the high-m Alfven waves as observed with radars.

Kostarev, Danila

Drift-compressional modes generated by inverted plasma distributions in the magnetosphere

Danila V. Kostarev, Pavel N. Mager and Dmitri Yu. Klimushkin, Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia

The polarization and field-aligned structure of drift-compressional modes and the corresponding plasma instability are studied in a gyrokinetic framework in the axisymmetric model of the magnetosphere with isotropic plasma. The plasma is assumed to be composed of core cold particles and an admixture of hot protons, with an inverted distribution of hot protons. Such plasma experiences a compressional resonance when the wave frequency is equal to an eigenfrequency of the drift-compressional mode. In this resonance, the wave is dominated by the field-aligned and azimuthal magnetic field components and is narrowly localized along the field line at the equator, the same as the plasma to magnetic pressure ratio β. The plasma instability occurs when the temperature diamagnetic drift velocity is less than the magnetic drift velocity or opposite in direction. Furthermore, the narrower the inverted distribution, the higher the instability growth rate and the smaller the value of b required for the instability to occur. The growth rate reaches its highest values when a positive radial temperature gradient and a negative radial density gradient occur simultaneously.

Le, Guan

Observations of High-m Ultra-Low Frequency Waves at Low Altitudes

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With short azimuthal scale lengths and high azimuthal wavenumbers (m), the high-m ultra-low-frequency (ULF) waves in the magnetosphere occur due to drift and drift bounce resonances of energetic particles. Measuring high-m ULF waves can be challenging in observations because it requires multiple satellites that meet stringent separation requirements to confirm the short azimuthal wavelengths. The vast number of ground-based magnetometers cannot detect high-m waves because the variations in short horizontal scales are screened by the ionosphere. Recently, we discovered many events of high-m ULF waves in the magnetic field data from the Space Technology 5 (ST-5) mission at altitudes ranging from several hundred km to over 1000 km. ST-5 is a three micro-satellite constellation in a 300 x 4500 km, dawn-dusk, and sun synchronous polar orbit with 105.6 degree inclination angle. Due to the Earth's rotation and the dipole tilt effect, the spacecraft's dawn-dusk orbit track can reach as low as subauroral latitudes during the course of a day. Whenever the spacecraft traverse across the dayside closed field line region at subauroral latitudes, they frequently observe strong transverse oscillations at 30-200 mHz, or in the Pc 2-3 frequency range. As the maximum separations of the ST-5 spacecraft are in the order of 10 minutes, the three

ST-5 satellites often observe very similar wave packets, implying these wave oscillations occur in a localized region. The coordinated ground-based magnetic observations at the spacecraft footprints, however, do not see waves in the Pc 2-3 band; instead, the waves appear to be the common Pc 4-5 waves associated with field line resonances. We concluded that these unique Pc 2-3 waves seen by ST-5 are in fact the Doppler-shifted Pc 4-5 waves as a result of rapid traverse of the spacecraft across the resonant field lines azimuthally at low altitudes. The observations with the unique spacecraft dawn-disk orbits at proper altitudes and magnetic latitudes reveal the azimuthal characteristics of field-aligned resonances. These observations suggest a new opportunity for using low-altitude satellites to monitor the occurrence of the high-m waves and infer the state of energetic ions in the magnetosphere.

Le, Guan

Observations of Upstream Ultra-Low-Frequency Waves in the Mercury's Foreshock (Invited)

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We report the observational results of upstream ULF waves in the Mercury's foreshock using high-time resolution magnetic field data, 20 samples per second, from the MESSENGER spacecraft. The Mercury's bow shock is unique in our solar system as it is produced by low Mach number solar wind blowing over a small magnetized body with a predominately radial interplanetary magnetic field. Our study has showed the existence of at least three types of upstream waves: 1) whistler waves at frequencies near 2 Hz, similar to the 1-Hz waves at the Earth; 2) waves with frequencies ~ 0.3 Hz, similar to the large-amplitude 30-s waves at the Earth; 3) fluctuations with spectral peaks centered at ~ 0.8 Hz. Unlike the Earth's foreshock where the most prominent upstream wave phenomenon is locally generated large-amplitude 30-s magnetosonic waves, the most common foreshock waves are whistler waves generated at the bow shock, with properties similar to the 1-Hz waves in the Earth's foreshock. Their occurrence characteristics show that the 1-Hz• wave generation is generic to the bow shock and not affected by the strength and size of the shock at Mercury. On the other hand, the 30-s• magnetosonic waves at Mercury occur only sporadically and with small amplitudes. The general lack of strong 30-s• magnetosonic waves at Mercury can be attributed to the lack of strong backstreaming ions due to a weak bow shock and not enough time for wave growth due to the small foreshock size. Superposed on the 1-Hz• whistler waves, there are short bursts of spectral peaks at ~ 0.8 Hz that are new and have not been reported previously in Mariner 10 data. The source of the ~ 0.8 Hz waves remains to be identified.

Lee, Dong-Hun

Time-dependent evolution of externally driven MHD/EMIC waves in the low-latitude magnetosphere

Dong-Hun Lee[1], Dae Jung Yu[1], Eun-Hwa Kim[2], Jay Johnson[2], Kihong Kim[3], SungHwan Lee[1], Khan-Hyuk Kim[1] and Ensang Lee[1], (1)Kyung Hee Univ, Gyeonggi, South Korea, (2)Princeton Plasma Physics Lab, Princeton, NJ, United States, (3)Ajou University, Suwon, South Korea

The magnetosphere is often perturbed by external sources, which may excite various low frequency waves. The excitation of such waves inside the magnetosphere should depend on the characteristics of sources as well as the profile of an inhomogeneous magnetosphere. Since many observations are limited to the local measurements in space, it becomes important to understand how the magnetosphere responds to a certain external source at the different locations in space. In this study, we investigate how MHD and EMIC waves are excited preferentially by the different external sources and they appear at the different positions, and how their E and B time histories are affected by either impulsive sources or long lasting sources, respectively. We adopt the theoretical technique called the IIM (invariant imbedding method) in a simplified model that allows arbitrary inhomogeneity, but exact calculations on the wave coupling problem, and also the numerical dipole models for MHD/EMIC wave simulation studies, respectively. It is found that the initial time-dependent responses at the various locations become sensitive to the time-scale of the impulsive sources. In addition, we present how MHD waves are affected by the continuous movement of the magnetosphere and how EMIC waves are affected by the co-existing MHD waves. Each case is accompanied by numerical simulation studies, which are found to be consistent with the theoretical results.

Lee, Jaejin

Expected electron microburst energy dispersion caused by chorus wave interaction

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Electron microbursts in space physics are defined by strong electron precipitation having duration less than 1 sec. Since the first observations with X-ray detectors onboard balloon in 1960s, many experiments have revealed the detail characteristics of the microbursts. The microbursts have minimum duration of 250 msec and the coincidence of chorus and microburst occurrence supports the origin of wave-particle interaction. In addition, recent measurements revealed the microburst does not fill the loss cone and shows less e-folding energy in parallel component than perpendicular one. However, several characteristics are remained unsolved. For example, the relationship between ~100 keV and MeV microburst is still unknown. If the energy dispersion of microbursts could be measured, we might understand how the microbursts are produced by wave-particle interaction. Because the microburst duration is less than the electron bouncing period, the energy dispersion should be identified if the detectors have enough fast time resolution. During chorus waves propagate along magnetic field, the resonance condition should be satisfied at different magnetic latitude for different energy electrons because chorus have narrow frequency band. If we observed electron microbursts at low altitude, the arrival time of different energy electrons should make unique energy dispersion structures. In this study, we tried to show the expected microburst energy dispersion with simple test particle simulation. These results may provide useful information in designing electron detectors for the future mission.

Lee, Ensang

Nonlinear Development of ULF waves in the Upstream of Earth's Bow Shock

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In the upstream region of Earth's bow shock ULF waves are frequently observed. These waves are usually observed in association with backstreaming ions from the bow shock. In this study we report observations of nonlinear development of the ULF waves using the multi-point measurements from the Cluster spacecraft when the spacecraft were separated as large as ~1.5 RE. The small amplitude waves observed by the spacecraft (C3) at farther upstream rapidly grew and became nonlinear as they were observed by the spacecraft (C1) downstream from C3. Intense ion beams backstreaming from the bow shock were observed with the small amplitude waves at C3, but the beams were dissipated into diffuse distributions at C1, where the waves became nonlinear. We will discuss detailed characteristics of the wave-particle interactions resulting in the nonlinear development of the waves.

Lee, Youngsook

Periodic strong echoes in summer polar D region correlated with high-speed solar wind streams and ULF Pc5 wave amplitudes

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We report long-periodic oscillations of polar mesospheric summer echoes (PMSE) correlated with high-speed solar wind streams (HSS) as observed between June 1-August 8 in a solar minimum year of 2006. PMSE (80-90 km altitude) were observed by 52 MHz VHF radar measurements at Esrange (67.8°N, 20.4°E), Sweden. The correlation between PMSE volume reflectivity/counts, HSS and AE index is primarily found at 7- , 9- and 13-day for 2006. The observation shows that the effects of HSS appear in PMSE. During corotating interaction region (CIR)-induced HSS, the long-duration enhancements of PMSE, ULF Pc5 wave amplitude and geomagnetic disturbance support that a favorable condition in generating PMSE can be facilitated by the precipitating energetic electrons (> 30 keV), which are frequently multiplied in the magnetosphere during the HSS.

Leonovich, Anatoly

Features of MHD oscillations in the geomagnetic tail (Invited)

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The features of the structures and spectra of MHD oscillations in the geotail are studied. Large-scale fast magnetosonic (FMS) waves can form the spectrum of the lowest-frequency magnetospheric resonator in the near-Earth part of the current sheet. A new concept is proposed for the emergence of ULF geomagnetic oscillations with a discrete spectrum of frequencies (0.8, 1.3, 1.9, 2.6 ... mHz) registered in the magnetosphere's midnight-morning sector. The wave confinement is a result of the velocity values of fast magnetosonic waves in the near-Earth plasma sheet differing greatly from those in the magnetotail lobes, leading to turning points forming in the tailward direction. The fundamental harmonics of this resonator's eigen-frequencies are shown to be capable of being clustered into groups with average frequencies matching, with good accuracy, the frequencies of the observed oscillations. A possible explanation for the stability of the observed oscillation frequencies is that such a resonator might only form when the magnetosphere is in a certain unperturbed state.

Coupled modes can be formed by azimuthally small-scale Alfven and slow magnetosonic (SMS) waves at the geomagnetic field lines crossing the plasma layer. It is shown that the linear transformation of these waves occurs in the current sheet on geomagnetic field lines stretched into the magnetotail. In most of the field lines their structure is determined by the large-scale Alfven wave structure. Near the ionosphere and in the current sheet, a small-scale SMS wave field starts to dominate. Such modes are neutrally stable on the field lines that do not cross the current sheet, but switch to the ballooning instability regime on field lines crossing the current sheet. In the direction across magnetic shells the coupled modes are waves running away from the magnetic shell on which they were generated. At the field lines crossing the current sheet the structure of the field components of coupled modes has four singularities at the inflection points of a field line, that look like as resonance peaks.

Li, Liuyuan

The growth of whistler-mode waves and the loss of anisotropic distribution electrons inside the bursty bulk flows

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During the interval ~07:45:36-07:54:24 UT on 24 August 2005, Cluster satellites (C1 and C3) observed the growth of whistler-mode waves and the loss of anisotropic distribution electrons (~3-95keV) inside some bursty bulk flows (BBFs) in the midtail plasma sheet (X_{GSM} ~ -17.25R_E). However, the fluxes of the higher-energy electrons (>120 keV) and energetic ions (10-160 keV) were relatively stable in the BBF-impacted regions. The energy-dependent electron loss inside the BBFs is mainly due to the energy-selective pitch angle scatterings by whistler-mode waves within the time scales from several seconds to one minute, and the electron scatterings in different pitch angle distributions are different in the wave growth regions. The energetic electrons have mainly a quasi-perpendicular pitch angle distribution during the expansion-to-recovery

development of a substorm (AE index decreases from 1677 nT to 1271 nT), and their loss can occur at almost all pitch angles in the wave growth regions inside the BBFs. Unlike the energetic electrons, the low-energy electrons (~0.073-2.1 keV) have initially a field-aligned pitch angle distribution in the absence of whistler-mode waves, and their loss in field-aligned directions is accompanied by their increase in quasi-perpendicular directions in the wave growth regions. By modeling the electron pitch angle scattering process, we find that the loss of the initial field-aligned distribution electrons is obviously rapider than that of the initial quasi-perpendicular distribution electrons.

Lin, Naiguo

Ion Temperature Anisotropy Thresholds in the Magnetosheath

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Observations of ion temperature anisotropy boundaries in the magnetosheath are studied and compared with the theoretical stability thresholds. Distributions of wave parameters including $|dB_{\|}/B_0|$, $|dBperp/B_0|$, and the magnetic compressibility, $dB_{\|}^2/(dB_{\|}^2+ dBperp^2)$, on the $Tperp/T_{\|}$ vs $beta_{\|}$ plane are examined. It is found that for compressional waves, $dB_{\|}$, there exist enhancements at temperature anisotropy larger than expected mirror mode threshold, which may indicate evolving process of the unstable plasma, i.e. fluctuations of mirror mode instability before it reaches saturation. The transverse variations are bounded by the threshold curve of the electromagnetic ion cyclotron (EMIC) wave mode for $Tperp>T_{\|}$ plasma. These EMIC fluctuations seem to have compressional component, which is likely to happen when the waves propagate obliquely. There also exist plasma regions in the magnetosheath where $T_{\|} > Tperp$ and $beta_{\|}$>>1, with intense fluctuations. These fluctuations are mostly transverse. They seem to be restricted by firehose instability thresholds, which is largely unstudied in magnetosheath plasma study. Simulation of the temperature anisotropy-driven instabilities with time-varying local magnetic field shows that evolving mirror mode fluctuations occur at $Tperp>T_{\|}$ above the mirror mode curve, while in the $T_{\|} > Tperp$ and $beta_{\|}$>>1 region the fluctuations are confined by the firehose instabilities thresholds. These simulation results are consistent with the observations and justify our interpretation.

Liu, Wenlong

Poloidal ULF wave observed in the plasmasphere boundary layer

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We report on a rare ultra-low-frequency (ULF) wave generation event associated with the formation of a plasmasphere boundary layer (PBL), which was well observed by one of the THEMIS satellites, TH-D, during subsequent outbound passes. On 13 September 2011, TH-D observed a sharp plasmapause at L = 3.4. The plasmasphere started to expand and continued to be refilled on 14 September. On 15 September, a PBL was formed with two density gradients at L = 4.4 and 6.5, respectively. Within the two density gradients, strong radial magnetic field and azimuthal electric field oscillations were observed, suggesting poloidal ULF waves. Based on the phase delay between magnetic and electric field signals, as well as the comparison between the observed wave frequency and predicted harmonic eigenfrequency, we find that the observed oscillations are second harmonic poloidal waves. Further investigation shows that the observed waves are likely generated by drift-bounce resonance with "bump-on-

tail" plasma distributions at ~10 keV. We demonstrate that the waves are excited within the PBL where the eigenfrequency is close to the bounce frequency of these hot protons, but not outside the PBL where the eigenfrequency deviates from the bounce frequency. Finally, we suggest that cold plasma density seems to be a controlling factor for ULF wave generation as well, in addition to the bump-on-tail energy source, by altering eigenfrequency of the local field lines.

Lou, Yu-Qing

Magneto-Inertial Oscillations of Jupiter's Inner Radiation Belt

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In 1992, Ulysses spacecraft discovered quasi-periodic 40 minute

(QP-40) bursts of relativistic electrons and of low-frequency radio emissions from the south polar direction of Jupiter. These radio bursts are right-hand circularly polarized and strongly correlate with the arrival of fast-speed solar winds at Jupiter. We proposed (Lou 2001) that these relativistic electron bursts originate from the circumpolar leakage of the inner radiation belt (IRB) where intense synchrotron emissions reveal the presence of trapped relativistic electrons therein. The QP-40 variabilities are associated with QP-40 magneto-inertial global IRB oscillations which are excited and sustained by intermittent high-speed solar winds. We present 6cm observations of Jupiter's IRB flux variations using the Urumqi 25m radio telescope. In reference to extensive observations of different diagnostics, we discuss various aspects of our model scenario and predictions more specifically. The recent joint space (X-ray, EUV) and ground (radio and optical) observational campaigns to monitor global activities of Jupiter are also mentioned.

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Bursty synchrotron intensity variations of Jovian 6-cm radio

emissions and Jupiter's quasi-periodic polar activities

Yu-Qing Lou, Huagang Song, Yinyu Liu and Meng Yang

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On the importance of searching for oscillations of the Jovian

inner radiation belt with a quasi-period of 40 minutes

Yu-Qing Lou and Chen Zheng

(3) THE ASTROPHYSICAL JOURNAL, 548: 460-465, 2001 February 10,

2001. MAGNETOINERTIAL OSCILLATIONS OF JUPITERÏS INNER RADIATION

BELT, YU-QING LOU

Lu, Haoyu

Numerical study on interchange instability as generation mechanism of dipolarization fronts in the magnetotail

Haoyu Lu, Beihang University, Beijing, China

Energy and magnetic flux transports associated with flow bursts and bursty bulk flows (BBFs) are considered to be important during substorm activity in the magnetotail. Dipolarization fronts (DFs) play important roles in transporting energy fluxes and accelerating particles. Although Hall effect and electron pressure gradient effect on the mesoscale of ion inertial length was considered in our previous study, observations indicated that the key features on DFs are on the scale of ion gyro-radius, which means that the ion finite Larmor radius (FLR) effect might have influence on the mesoscale of DF. Resent investigations demonstrate that the gyro-viscous cancellation arising due to the FLR effect would cause the drifts of the structure of interchange instability in the direction of ion diamagnetic drift. Therefore, it is reasonable to speculate that the FLR effect would be the cause for the dawnward drifting movement of DFs. Two dimensional Hall MHD simulation argumented by FLR effects was performed to reproduce the key mesoscale feature of interchange instability as generation mechanism of DFs. Numerical results indicated that the interchange instability is a solid candicate of generation mechanism of DFs. On DFs, Hall effects make the plasma density and magnetic field asymmetric in the dawn-dusk direction, the electric field is mainly produced by Hall term, and the contributions from the convectional and EPG electric fields are very small. The FLR effect becomes important in the regime $L \gg \rho_i$, where L is the characteristic scale length. FLR effect arises due to the gyro-viscous component of the ion stress tensor that appears in the moment equations. The simplified expressions of the gyro-viscous stress can be frequently approximated in the dimensionless form by $\nabla \cdot \boldsymbol{\pi}_i \approx -d_i \rho \boldsymbol{V}_* \cdot \nabla \boldsymbol{V}$, where $\boldsymbol{V}_*$ is ion velocity associated with the so-called gyroviscous cancellation via subtracting a significant part from the advective acceleration. Despite the fact that the gyro-motion velocity is composed by ion diamagnetic velocity and the magnetic drift velocity, the gyro-motion velocity is mainly contributed by ion diamagnetic velocity. Therefore, the ion diamagnetic velocity determines the drifting motion of the whole structure of the interchange instability.

Lu, Haoyu

Evolution of Kelvin-Helmholtz instability at boundary layers on Venus

Haoyu Lu, Beihang University, Beijing, China

Two-dimensional MHD simulation was performed to study the evolution of Kelvin-Helmholtz (KH) instability on Venusian ionopause in response to the strong sheared velocity flow in presence of the in-plane magnetic field parallel to the direction of the flow. The physical behavior as well as the trigger condition and occurrence condition for highly rolled-up vortex are characterized through several principle parameters, including Alfven Mach number on the upper side of the layer, the ratio of density and increase and the ratio of in-plane magnetic field between the two sides of the layer, et al. The Key result from our simulations is that both of the density increase and in-plane magnetic component on the boundary layer play a role of stabilizing the instability. In the high density increase cases, the value of final total magnetic energy in the quasi-steady status is much more than that of the initial status and dependent on the ratio of density increase, which is quite distinct from that with low density increase. The nonlinear development of case with high density increase and uniform magnetic field is of interest that a single magnetic island forms before the instability saturation. In the non-linear development phase, a new magnetic island arises associated with magnetic reconnection occurring inside the narrow high rolled up density region, combining the pre-existing magnetic island together to form a quasi-steady two island pattern. This pattern subsequently persists for a long period until the two magnetic islands die away because of the strong magnetic tension, instead of a steady pattern with almost uniform magnetic field.

Lysak, Robert

Global Modeling of ULF Waves in the Inner Magnetosphere: Propagation of Pi1/2 Waves (Invited)

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A new three-dimensional model of ULF waves using non-orthogonal dipolar coordinates has been developed that simulates the propagation of fast mode and shear Alfvén waves in the inner magnetosphere. This model includes distributed conductivities in a height-resolved ionosphere and directly calculates the ground magnetic fields produced by these currents. This model will be applied to the propagation of Pi1/2 waves that are produced during magnetospheric substorms. Possible mechanisms for the generation of these waves will be considered. Using the new model, the magnetic and electric fields observed on the ground, in the ionosphere, and by spacecraft in the magnetosphere can be modeled and compared with observations. It will be shown that ULF wave propagation can transmit energy and carry field-aligned currents throughout the inner magnetosphere on time scales of less than a minute. The implications of this fast propagation during the onset of storms and substorms will be considered.

Marghitu, Octav

Magnetosphere-Ionosphere Coupling on Multiple Scales Associated with Magnetotail Flow Bursts: Event Study

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Magnetosphere-ionosphere (M-I) coupling in the auroral region is achieved, essentially, by field-aligned currents (FAC) and ultra-low frequency (ULF) waves, covering a broad range of spatial and temporal scales. Current systems of various sizes and intensities, often embedded in each other, connect the auroral ionosphere to the equatorial magnetosphere, while changes in these current systems, like their setup or intensification, are naturally associated with ULF waves. Even if addressed by somewhat different communities, field-aligned currents and ULF waves complement each other in providing M-I coupling paths, whose most spectacular effect is the aurora. The present investigation addresses an M-I coupling event during a relatively quiet time interval, when conjugate data from THEMIS and Cluster spacecraft, ground based observations, as well as data from GOES spacecraft, show dynamic features on multiple scales, associated with magnetotail flow bursts. Thus, on small scale, the flow bursts in the tail, probed by THEMIS D and E, are related to episodes of Alfvenic acceleration, probed by conjugate Cluster 1 observations near the auroral acceleration region. On meso-scale, the THEMIS plasma flow data show evidence for vortical motion (known to be associated with field-aligned current), whose low altitude end is explored by ground magnetic field and optical data. Finally, on large to global scale, the flow bursts in the tail are associated with Pi2 geomagnetic pulsations, examined closely in a companion presentation by THEMIS, GOES, and ground data.

Masson, Arnaud

The Cluster Science Archive and its relevance for low frequency waves in space plasma research

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The science data archive of the Cluster mission is a major contribution of the European Space Agency (ESA) to the International Living With a Star program. Known as the Cluster Active Archive (CAA), its availability since 2006 has resulted in a significant increase of the scientific return of this on-going mission. The Cluster science archive (CSA) has been developed in parallel to CAA over the last few years at the European Space Astronomy Center of ESA in Madrid, Spain. It is the long-term science archive of the Cluster mission developed and managed along with all the other ESA science missions data archives. CSA design and data services are based on the CAA interface and its user-friendly services. Publicly opened in November 2013, CSA was available in parallel to CAA during a transition period until CAA public closing in early summer 2014. It is the purpose of this presentation to first provide an overview of the various services offered by the Cluster Science Archive, including: data visualisation, data streaming, particle distribution plot visualisation, command line capabilities (e.g. data access via Matlab or IDL softwares)... Support data related to EU FP7 projects such as ECLAT and MAARBLE are also available on the CSA which includes rarely available datasets such wave propagation parameters. These data are clearly an outstanding data ressource that might be of great interest for low frequency waves researchers.

McLaughlin, James

First direct measurements of transverse waves in solar polar plumes using SDO/AIA (Invited)

James Alexander McLaughlin, Richard J. Morton and Jonathan O. Thurgood, Northumbria University, Department of Mathematics and Information Sciences, Newcastle-Upon-Tyne, United Kingdom

Currently, there is intense interest in determining the precise contribution of Alfven waves propagating along solar structures to the problems of coronal heating and solar wind acceleration. Since the launch of SDO/AIA, it has been possible to resolve transverse oscillations in off-limb solar polar plumes and recently McIntosh et al. (2011, *Nature*, **475**, 477) concluded that such waves are energetic enough to play a role in heating the corona and accelerating the fast solar wind. However, this result is based on comparisons to Monte Carlo simulations and confirmation via direct measurements is still outstanding. Here we report on the first direct measurements of transverse wave motions in solar polar plumes. Over a 4 hour period, we measure the transverse displacements, periods and velocity amplitudes of 596 distinct oscillations observed in the 171 Angstrom channel and find a broad range of parameter values (64 - 2558 km, 61 - 2097 s and 1 - 88 km/s respectively). The parameters are non-uniformly distributed with a significant positive skew and are well described by log-normal distributions with peaks at 234 km, 121 s and 8 km/s, and mean and standard deviations of the parameters are 407±297 km, 173±±118 s and 14±10 km/s. Within standard deviations, our direct measurements are broadly consistent with previous results. However, accounting for the whole of our observed non-uniform parameter distribution we calculate a time averaged energy flux of 9 - 24 W/m^2, indicating that transverse MHD waves carry a much less significant energy flux in the open-field corona than previously thought.

Mottez, Fabrice

A theory of plasma acceleration by the interaction of parallel propagating Alfven waves with applications to the magnetosphere (Invited)

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It is shown that two circularly polarised Alfven waves that propagate along the ambient magnetic field in an uniform plasma trigger non oscillating electromagnetic field components when they cross each other. The non-oscilliating field components can accelerate ions and electrons with great efficiency. This work is based on particle in cells (PIC) numerical simulations and on analytical non-linear computations. The analytical computations are done for two counter-propagating monochromatic waves. The simulations are done with monochromatic waves and with wave packets. The simulations show parallel electromagnetic fields consistent with the theory. They show that the particle acceleration causes plasma cavities and, if the waves amplitudes are high enough, in ion beams. These acceleration processes could be relevant in space plasmas. For instance, they could be at work in the auroral zone and in the radiation belts of the Earth magnetosphere. In particular, they may explain the origin of the deep plasma cavities observed in the Earth auroral zone.

Murphy, Kyle

Role of ULF waves in Energetic Particle Transport and Ring Current Dynamics

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ULF waves are recognised as playing an important role in the transport of energetic electrons into the outer radiation belt through ULF wave driven radial diffusion. Since the drift frequency of energetic particles is controlled by particle energy and is independent of mass (neglecting any relativistic correction) a similar diffusive transport via ULF wave energisation is also possible for energetic ions. Although the energies of ions and specifically those in the ring current are typically less than those characteristic of electrons in the outer radiation belt, whenever the ULF wave-energetic particle drift resonance condition is

satisfied for ring current ions, ULF wave diffusive transport of ions should be expected to be important. Here we examine the correlation between ULF wave power observed inside of the magnetosphere and the response of the ring current as characterised by Dst. We use both standard rank order correlations as well as analyses of the probability distributions for ULF waves and Dst. Our observations show that there is a clear and definitive correlation between ULF wave power and Dst. Significantly, the correlation peaks on the day prior to the Dst response such that the ULF waves precede the response of the ring current. We suggest that this correlation and the enhancements in Dst are the a result of enhanced radial transport and energisation of ring current ions through drift resonance and ULF wave radial diffusion during periods of increased ULF wave activity.

Nakagawa, Tomoko

ULF/ELF Waves Detected by MAP/LMAG Magnetometer Onboard Kaguya around the Moon and in the Lunar Wake (Invited)

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The moon stands in the solar wind flow as an insulating obstacle. Absorption of the most of the solar wind particles by the lunar surface leads to the formation of the lunar wake, a plasma cavity in the solar wind left on the anti-solar side of the moon. A few percentage of the solar wind particles were found to be reflected by the lunar surface or the lunar crustal field[1], generating magnetic fluctuations in the ultra low frequency (ULF) range and in the extremely low frequency (ELF) range.

The waves repeatedly observed on the dayside of the moon were the ULF waves at 0.01 Hz [2] and the ELF waves of 0.03-10 Hz [3]. Predominance of the two frequency bands is analogous to the low-frequency waves in the upstream of the Earth's bow shock where the solar wind protons are reflected. The two frequency bands detected by Kaguya were also generated by the solar wind protons reflected by the moon. The monochromatic, circularly polarized low frequency waves of 0.01 Hz were generated through the cyclotron resonance of the magnetohydrodynamic waves with the solar wind protons reflected by the moon. The non-monochromatic fluctuations in the range from 0.03 to 10 Hz were whistler waves, and the generator is supposed to be the reflected particles, too, because the detection was concentrated above the magnetic anomaly.

Although the nightside of the moon was essentially quiet because of the absence of access of the solar wind particles, magnetic fluctuations in ELF range of 0.1-10 Hz were occasionally observed in association with the "type-II entry" solar wind protons which were once reflected by the dayside surface and entered the central wake region due to their large Larmour radius [4]. The magnetic fluctuations were detected on the magnetic field lines along which the solar wind electrons were injected into the wake, so it is expected that some cross-field current driven instability such as the lower-hybrid two-stream instability is responsible for the generation of the waves.

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Nakamura, Satoko

Sub-packet structures in the EMIC triggered emission observed by the THEMIS probes

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Environment Laboratory, Nagoya, Japan; ISAS/JAXA, Sagamihara, Japan, Danny Summers, Memorial University of Newfoundland, Dept of Math and Stats, St John's, Canada and Masahito Nose, Kyoto Univ, Graduate School of Science, Kyoto, Japan

We report observations of electromagnetic ion cyclotron (EMIC) triggered emissions observed by the Time History of Events and Macroscale Interactions during Substorms (THEMIS) probes. These phenomena have recently attracted much attention because of their strong nonlinear interaction with energetic particles in the inner magnetosphere[1,2]. For 1400-1445 UT on 9 September 2010, THEMIS A, D, and E observed strong EMIC waves with rising tone emissions. The probes were located near the dayside magnetopause at a radial distance 8 R_E from the Earth 13 MLT, and a few degrees of the geomagnetic latitude. During this time interval, the geomagnetic field was very distorted by a variation in the solar wind. We assume these emissions were excited in an extended region near the equator where the field-aligned Bgradient was much reduced because of compression of the magnetosphere by the solar wind. It is found that the rising tone emissions comprise some smaller rising tones, which are called sub-packet structures[3]. We try to interpret each of the observed sub-packets with the nonlinear wave growth theory developed by Omura et al. [4]. The observed relationship between the amplitudes and frequencies of the sub-packets are well explained by the theory, and it is also found that the observed dynamic spectra of the emissions agree well with the threshold and optimum amplitudes for the nonlinear growth.

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Nakariakov, Valeri

MHD Seismology with fast magnetoacoustic wave trains (Invited)

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Fast magnetoacoustic waves are readily guided by field-aligned plasma non-uniformities, such as plasma loops is solar coronal active regions, polar plumes in coronal holes, and fibrils in coronal prominences. Guided fast waves are subject to geometrical dispersion. The dispersion causes dispersive evolution of fast wave trains. In particular, impulsively generated fast wave trains have a characteristic “crazy tadpole” wavelet spectra, detected in the white-light and radio emission of the corona. Recently, rapidly-propagating wave trains of the EUV emission disturbances were discovered in the corona, and were shown to form distinct wave trains. Numerical simulations of the development of impulsive energy releases in the lower solar atmosphere showed that the initial perturbation develops into similar longitudinally-propagating wave trains in 2D plasma non-uniformities, such as dense funnels and expanding loops. It is found that together with the guided wave trains propagating along the magnetic field, there are appear freely propagating fast wave trains outside the waveguide. Due to refraction caused by the stratification and the magnetic field, the side wave trains tend to propagate upwards. Similar side fast wave trains are found in coronal anti-waveguides, such as coronal holes. Fast wave trains reveal solar atmospheric magnetic geometry and connectivity, and allow us to determine the transverse plasma gradient and the absolute value of the magnetic field.

Obana, Yuki

Characteristics of quarter wave standing Alfvén waves observed by the New Zealand magnetometer array

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Magnetometer data from the New Zealand array (L=2.2-2.8 Re) were analyzed to investigate quarter-wave mode standing Alfven waves in mid latitudes. We used cross-phase and related methods to determine the field line resonance frequency and width of resonance region. Three typical events were observed in July 2012 which showed extraordinarily low eigenfrequencies and wide resonance width when the ionosphere above New Zealand was in darkness while its conjugate was sunlit. Later in the morning the eigenfrequency and width of resonance gradually came to the normal daytime value. The frequency change started when the terminator passed over New Zealand and finished on hour later. These observations indicate strong evidence of presence of quarter wave and mode conversion from quarter wave to more usual half wave. We also investigated the distribution of ULF wave field using a 2.5D magnetospheric model. Comparing these results, the quarter wave formation will be discussed.

Ofman, Leon

MHD waves in coronal active regions: impacts of mode couplings, flows, and instabilities (Invited)

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Low frequency (MHD) waves in coronal active regions were recently observed in unprecedented detail in EUV thanks to the high cadence, high-resolution observations by SDO/AIA instrument, and spectroscopic observations by Hinode/EIS instrument. Multi-dimensional MHD modeling revealed the complexity of wave propagation, linear and nonlinear model coupling in the structured solar corona. Observations show the details of the interactions between the CME driven global EUV waves and active region magnetic structures, and the generation of secondary waves. Very fast quasi-periodic pulsations were detected and interpreted as fast magnetosonic waves associated with flares and CMEs in cool active regions. The generation of magnetosonic waves by quasi-periodic flows at the chromospheric footpoints of active region loops was observed and modeled using 3D MHD. Flow related instabilities, such as Kelvin-Helmholtz, and the associated nonlinear waves were detected in the corona and modeled at large and small scales. I will review recent observations and 3D MHD modeling results of these phenomena. I will discuss the impact of the results on the understanding of MHD wave couplings, the diagnostics of solar activity, and on the energy transport in coronal active regions.

Olugbon, Busola

Phase Properties of Ulf Waves Observed in the African Sector

Busola Olugbon, University of Lagos, Lagos, Nigeria

ULF waves have been investigated in Lagos, Nigeria. Events were recorded with a ground magnetometer in Abuja (Geographic: 7.39°E, 8.99°N; Dip latitude -1.53). To understand the propagation mode and propose source mechanisms for the observed ULF wave events, we analyzed data from four other spatially distributed magnetometer stations in the African region namely Medea (Algeria), Adigrat (Ethiopia), Yaounde (Cameroun), and Tsumeb (Namibia). Five days when a ULF wave event was registered simultaneously in the HF-Doppler receiver and magnetometer in Abuja, Nigeria were analyzed. These events were also registered in at least two other magnetometer stations in Africa (subject to data availability from the stations). Results from phase analyses showed two distinct patterns. We propose the effects of solar heating as the source mechanism for the first set of events while for the second set of events we propose any or all of: enhanced solar activity, disturbed magnetic conditions, or a strong downward acting component of the interplanetary magnetic field (IMF Bz). Observed events are not likely to be Field Line Resonances (FLRs) because the geometry of magnetic

field lines at the equator and the sampling rate of data do not support observation of FLRs at the low L – shell locations. Also, the same events have been registered on different L-shell values or across field lines and these are unlikely features of FLRs.

Omura, Yoshiharu

Generation of EMIC rising-tone emissions and associated precipitations of energetic protons and relativistic electrons in the inner magnetosphere (Invited)

Yoshiharu Omura, RISH Research Institute for Sustainable Humanosphere, Kyoto, Japan

Coherent electromagnetic ion cyclotron (EMIC) emissions with rising frequencies are generated by energetic protons in the equatorial region of the Earth's inner magnetosphere as observed by spacecraft such as Akebono, Cluster, and THEMIS [1,2,3,4]. Hybrid code simulations successfully reproduce EMIC emissions and show that a substantial amount of protons is scattered into the loss cone through the nonlinear growth of EMIC waves with rising frequencies [5]. The emissions can also interact with relativistic electrons, inducing effective pitch angle scattering of them through nonlinear wave trapping [6]. Recent progress of observations, theory, and simulations of the nonlinear wave-particle interactions will be reviewed.

[1] J. S. Pickett et al., Cluster observations of EMIC triggered emissions in association with Pc1 waves near Earth's plasmapause, Geophysical Research Letters, 37, L09104, doi:10.1029/2010GL042648, 2010.
[2] Y. Omura et al., Theory and observation of electromagnetic ion cyclotron triggered emissions in the magnetosphere, J. Geophys. Res., 115, A07234, doi:10.1029/2010JA015300, 2010.
[3] K. Sakaguchi et al., Akebono observations of EMIC waves in the slot region of the radiation belts, Geophys. Res. Lett., 40, doi: 10.1002/2013GL058258, 2013.
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Pandey, Uma

Study of Early/slow VLF perturbations observed at Agra, India

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Initial results of sub-ionospheric VLF perturbations observed on NWC (19.8 kHz) transmitter signal propagating in the Earth-ionosphere waveguide, monitored at our low latitude station Agra (Geomag. Lat 27°E, long.78°N). During the period of observation (June, 2011 to December, 2011), we found 74 cases of abrupt amplitude/phase perturbations showing early character. The onset duration of these early VLF perturbations is up to ~ 5 sec, showing early/slow character. Most of the observed early events show amplitude change lying between ±3.0 dB, and phase change ±12 degree respectively and found to occur mainly during nighttime. One of the interesting result we found that the events with larger recovery time lies far away from the VLF propagation path, while events with smaller duration of recovery are within the ±50-100 km of signal path. The World Wide Lightning Location Network (WWLLN) data is analysed to find the location of causative lightning and temporal variation. The lightning discharge and associated processes that leads to early VLF events are discussed.

Park, Jong-Sun

EMIC waves observed at geosynchronous orbit during quiet geomagnetic conditions

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It is generally accepted that electromagnetic ion cyclotron (EMIC) waves can be generated under the conditions of anisotropic and energetic ion population. Such conditions are expected when the magnetospheric convection is enhanced or when the magnetosphere is compressed by strong solar wind dynamic pressure enhancement. Even in the absence of strong magnetospheric convection or strong solar wind dynamic pressure enhancements, we have observed EMIC waves at geosynchronous orbit. In this study we focus on the geosynchronous EMIC waves excited during very quiet geomagnetic conditions ($Kp \leq 1$). We examine the relationship between EMIC wave enhancements and solar wind conditions.

Paulson, Kristoff

Statistical Distribution of Observations of Pc1 Pearl Pulsations by the Van Allen Probes and Poynting Flux Analysis from 11th October 2013

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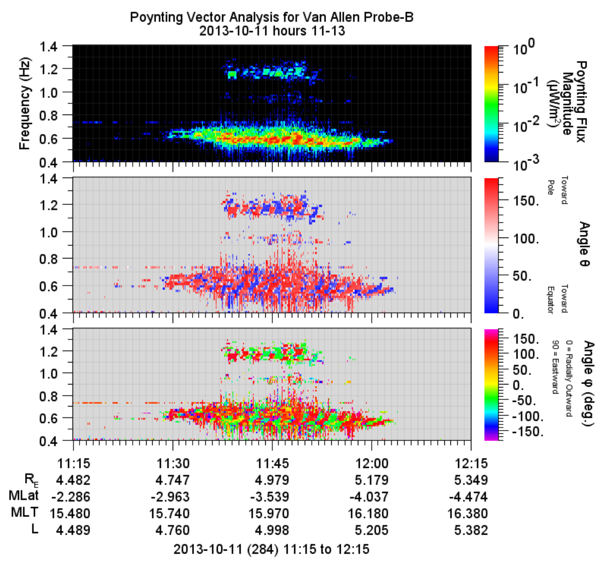
Pc1 pearl pulsations are a time-modulated electromagnetic wave in the Pc1 band of the ULF spectrum. They are believed to be a subclass of electromagnetic ion cyclotron (EMIC) waves, and so are generated through the ion cyclotron instability. However, the exact cause of their modulated structure is still a topic of debate. The previously held idea of ionospheric reflection between conjugate hemispheres has been discredited due to several observations of a similar modulation period on the ground as in the magnetosphere as well as numerous in situ observations of unidirectional poynting flux. However, there still exist examples of events exhibiting bidirectional poynting flux which would suggest a reflecting wave packet. We will show analysis from one such event observed in October of 2013 using both in situ and ground-based data. The Van Allen Probes spacecraft, launched in August of 2012, have offered us an unprecedented view into the equatorial magnetosphere where the generation region of EMIC waves is thought to reside. As of August of 2014, the spacecraft will have undergone one full precession around Earth, allowing for observations spanning the full range in MLT. We therefore present here a statistical analysis of EMIC waves, both pearl pulsations and unstructured, observed within the first two years of the Van Allen Probes mission.



Paulson, Kristoff

Solar cycle dependence of ion cyclotron wave frequencies

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Electromagnetic ion cyclotron (EMIC) waves have been studied for decades, though remain a fundamentally important topic in heliospheric physics. The connection of EMIC waves to the scattering of energetic particles from

Earth's radiation belts is one of many topics that motivate the need for a deeper understanding of characteristics and occurrence distributions of the waves. In this study, we show that EMIC wave frequencies, as observed at Halley Station in Antarctica from 2008 through 2012, increase by approximately 50% from 2009 to 2012. Assuming that these waves may be excited in the vicinity of the plasmapause, the change in Kp in going from solar minimum to near solar maximum would drive increased plasmapause erosion, thereby shifting the generation region of the EMIC to lower L and resulting in the higher frequencies. Numerical results from a Kp-driven empirical model over this period show an inward shift of the plasmapause of ~0.6 RE in the region (which is near dawn for these events), suggesting that plasmapause erosion may play a role in this effect.

Pilipenko, Viacheslav

ULF wave interaction with the ionosphere: radar and magnetometer observations

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Combined usage of radars and magnetometers, supported by an adequate theory of ULF wave interaction with the multi-layer magnetosphere - ionosphere - atmosphere ground system, is an effective way to reveal the physical mechanism of ULF disturbances. we analyze the data from such combined observations:

- EISCAT radar (the Tromso-Kiruna-Sodankyla system) and IMAGE magnetometers;

- SuperDARN Hokkaido radar and NIICT magnetometers at Kamchatka;

- recently installed SuperDARN radar at Ekaterinburg (Russia) and AANI magnetometers at Arctic shore;

To determine relative contributions of different MHD modes into their structure, the method of apparent impedance can be applied. An approximate analytical relationship derived from the theory of ULF wave transmission through the thin ionosphere has been compared with the measured ratio between the simultaneous ionospheric electric and ground magnetic fields. The impedances of Alfven and compressional modes are predicted to be essentially distinct. This technique has been applied to the interpretation of the following ULF wave events:

- global Pc5 waves at the recovery phase of strong magnetic storm;

- mid-latitude Pi2 pulsations;

- poloidally-polarized Pc5 waves.

From these observations we conclude that global Pc5 pulsations above the ionosphere are predominantly composed from Alfven waves with a small contribution of the fast compressional mode. Observations of mid-latitude Pi2 pulsations showed that the concept of a pure cavity mode is not sufficient to explain these observations, and that a contribution of Alfvén waves must be taken into account. Coordinated high-sampling radar and magnetometer observations are very promising for the examination of the ULF wave structure in the upper ionosphere.

Potapov, Alexander

IRI-2012 application for IAR frequency scale calculation

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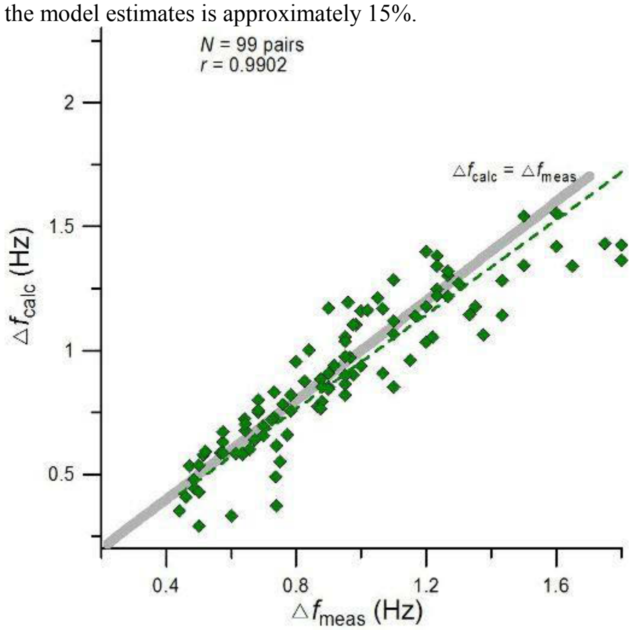
The paper addresses a problem of ionosphere-magnetosphere interaction through Alfven wave propagation. A new approach to analysis of emission of ionospheric Alfven resonator (IAR) is proposed. We apply the IRI-2012 version of International Reference Ionosphere model to calculate difference between frequencies of adjacent harmonics (frequency scale) of IAR emission. The calculated values are compared with the frequency scale

data obtained from search-coil magnetometer measurements. It appears that to reach satisfactory results it is necessary to modify IRI-2012 model replacing the vertical profile of ionospheric parameters adopted in the standard model with the profile elongated along the magnetic field lines. Subsequent improvement was obtained by the model correction with using local f_0F_2 measurements. Finally, our results showed strong correlation between the estimated and measured values of the frequency scale. Calculated f_{calc} versus measured f_{meas} values of the IAR frequency scale are shown in Figure as a result of computation based on the modified and corrected IRI-2012 model. Dashed line is the regression line running through the origin of coordinates; gray line is the line of perfect match $f_{calc} = f_{meas}$. The relative mean-square error of the model estimates is approximately 15%.



Potapov, Alexander

SPORADIC AND PERMANENT OSCILLATIONS IN THE MAGNETOSPHERE: ARE THEY CONNECTED?

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We study the impact of the Pc3 permanent oscillations on the excitation of Pi2 sporadic fluctuations (periods are 10-45 and 40-150 s respectively). The hypothesis is formulated that Pc3 oscillations which are originated in front of the magnetosphere penetrate into the geomagnetic tail, cause local depression of the current in the neutral sheet, and under favorable conditions stimulate the tearing instability. This leads to the reconnection of magnetic field lines and an explosive release of magnetic energy stored in the tail. As a result, the substorm breaks up, with sporadic pulsations Pi2 as an important element of this process. It is expected from theoretical estimates and kinematic considerations that the higher Pc3 frequency, the faster Pi2 train starts. We test this prediction using observational data from satellite measurements of the interplanetary magnetic field and on-ground magnetic measurements. The results confirm the theoretical expectation. Additional ways for the theoretical and experimental testing of the hypothesis are proposed.

Potapov, Alexander

Response of the magnetospheric ULF activity and relativistic electrons to high speed streams of the solar wind

Alexander S Potapov, Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia

The impact of wave patterns associated with high-speed solar wind streams on the variable geomagnetic field and the trapped radiation is studied. A superposed epoch analysis of the ULF oscillations associated with two main types of the solar wind high speed streams has been performed. Data from magnetic and plasma measurements onboard ACE spacecraft along with on-ground magnetic data were used for the analysis. The zero epoch of each event was set to the time of ACE observation of the current sheet coinciding with the stream front. The results demonstrate that CIR events produce a more intense and more continuous ULF activity both in the solar wind and in the magnetosphere. Data from GOES measurements of energetic electrons at geostationary orbit were also included in our superposed epoch study. Higher effectiveness of CIR events in enhancement of electron population in outer radiation belt is confirmed. A new feature is that higher amplitude of ULF on-ground oscillations gives more intense flux of 2 MeV electrons but it does not influence flux of less energetic electrons (600 keV).

Rae, Jonathan

Exploring substorms with ULF waves (Invited)

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The temporal sequence of events at substorm onset requires the generation and propagation of electromagnetic waves as the system evolves from its pre- to post-onset state. Such waves offer a unique diagnostic for the dynamics of this system, and the important coupling between the equatorial magnetosphere and auroral onset dynamics in the ionosphere. ULF waves have been shown to be a pivotal aspect of the substorm onset process, their arrival denoting the epicentre of the magnetic and auroral displays in the ionosphere. However the magnetotail region to which this ULF wave epicentre maps is unknown. Equally, what hinders progress in finding the ionospheric counterpart to magnetospheric features is the uncertainty in mapping high-precision but sparse magnetotail measurements of substorm-related phenomena into the ionosphere.

We review the properties of ULF waves before and during expansion phase onset, from ground-based magnetometry, auroral cameras and in-situ spacecraft. We use ULF waves to provide new mapping capabilities in the magnetotail, as well as a means to remote sense the plasma physics of substorm onset itself.

Rankin, Robert

Modelling the interaction of poloidal Pc5 waves with the high-latitude ionosphere (Invited)

Robert Rankin and Dmytro Sydorenko, Univ Alberta, Edmonton, AB, Canada

A 2D multi-fluid wave model is used to interpret EISCAT observations of poloidal Pc5 waves as they interact with the ionosphere. The wave model describes the full interaction of waves with a dynamic ionosphere that is prescribed using the IRI2007 model. Neutral species are incorporated using the MSIS86 model. The event of interest is described by Lester, Davis, and Yeoman [Annalles Geophysicae, vol 18, p.257-261 (2000)], which shows variations of plasma density, electron and ion temperature, and meridional and azimuthal flows in the ionosphere due to Pc5 ULF waves. The observations suggest the wave has a compressional component indicative of a moderate to high azimuthal wavenumber. In order to reproduce the observations, two populations of precipitating electrons with different energies and time variations are introduced into the model. Constant high-energy precipitation is introduced to enhance the ionospheric conductivity to levels observed, while a pulsating low-energy population is introduced to explain the modulations in ionospheric plasma density and electron temperature that are observed. To obtain agreement with the observations, it was also necessary to adjust the phase shift between the Alfven wave and precipitating electrons. With these assumptions, the temporal evolution of the electron and ion temperatures, as well as the azimuthal flow velocity obtained in the simulation are similar to the observations. The simulation also reproduces the observed timing between electron density and electron temperature peaks. Without adjustments to the ionospheric model, it is found that the rate of decay of electron density spikes after the precipitation pulse is over is insufficient to return the electron density to its initial value. The major role in the decay of electron density ehancements is found to be recombination, with the contribution from the convective term in the continuity equation playing only a minor role. It is found that by increasing the N2 density sufficiently in the ionosphere, the recombination rate can be enhanced to a point where the electron density decays in agreement with the observations. The conclusion from our wave modelling is that in conjunction with ground observations such models can shed light on Pc5 wave generation and precipitation processes in the magnetosphere.

Rodger, Craig

Plasma Wave-Driven Energetic Electron Precipitation: Wave-Particle Interactions Affecting the Polar Atmosphere (Invited)

Craig J. Rodger[1], Mark A. Clilverd[2], Monika E. Andersson[3], Pekka T Verronen[3] and Annika Seppälä[3],

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(2)British Antarctic Survey, Cambridge, United Kingdom,
(3)Finnish Meteorological Inst., Helsinki, Finland

Wave particle interactions are a fundamental physical mechanism driving change in the radiation belts. Growing evidence indicates that cyclotron resonance between plasma waves and energetic electrons play crucial roles for the acceleration of electrons to relativistic energies. It has long been recognised that the same resonances also pitch-angle scatter electrons, moving them towards the loss cone and loss into the atmosphere through precipitation. ULF, ELF and VLF plasma waves have all been shown to have an important role to play in precipitation of energetic electrons into the mesosphere. VLF Whistler-mode waves precipitate energetic electrons through "normal" cyclotron resonance, while ULF EMIC waves can precipitate relativistic electrons through "anomalous"• cyclotron resonance.

We combine observations from multiple sources to show how wave activity controls the loss of radiation belt particles, determining both the loss rate and the atmospheric location for which this loss occurs. In particular we will use VLF wave observations made in LEO by the DEMETER spacecraft to contextualise electron precipitation observations provided by the POES spacecraft in LEO as well as the AARDDVARK network of ground-based sensors. These results provide evidence that strong diffusion due to high wave intensities dominates during storm-times, producing rapid pitch angle scattering and hence immediate precipitation. Our suggestion is confirmed by the completely independent observations of atmospheric HOx distributions, produced in the polar atmosphere by electron precipitation. This presentation combines observations made in space with ground-based measurements, emphasising their importance in this research.

This work demonstrates how the changing intensity of plasma waves can decrease polar ozone concentrations in the mesosphere. Such decreases have also recently been experimentally observed during particle precipitation events. There is growing evidence that this is important route by which plasma waves can alter the chemistry of the polar atmosphere and lead to polar surface climate variability.

Roth, Ilan

Solar-Terrestrial Wave Connection: Solar/Planetary Whistler-excited Relativistic Electron Processes and Coronal Source as Seed for Magnetospheric ULF Energization.

Ilan Roth, University of California, Space Sciences, Berkeley, CA, United States

The formation mechanisms of relativistic electrons in space due to electromagnetic waves are crucial to discern the most relevant observations, since most of the emissions in the Universe are due to energetic electrons. Direct observations of the ULF/VLF waves, together with magnetospheric and solar energetic populations indicate clearly that generation of intense fluxes of relativistic electrons occurs during the evolution of active magnetized plasma systems. Examples of relativistic electron energization include the (a) recovery phase of a planetary magnetic storm, (b) post solar coronal mass ejection activity and (c) various astrophysical electromagnetic bursts. It is suggested that there exists a universal mechanism, which may explain electron energization at the vastly different magnetized plasma environments. The favorite configuration consists of an inhomogeneous, marginally stable magnetic field anchored at a given large scale structure (1) with a local-field excitation of whistler waves due to external magnetic reconfiguration or (2) adiabatic cross-field diffusion due to global eigen-oscillations. The relevant magnetic reconfigurations include planetary magnetic storm and solar CME, respectively. An additional prospect of coupling between solar and terrestrial (planetary) processes may emerge when the solar, whistler-accelerated electrons reach the planetary magnetosphere, serving as a pre-accelerated seed population for the ULF process. The validity for the processes in the experimental contex will be scrutinized. Recent observations may pinpoint to the missing link for the whistler pre-accelerated mechanism.

Saka, Osuke

Auroral vortex, poleward surge, and vortical current in the ionosphere associated with Pi2 pulsations: A case for westward propagation of the poleward surge

Osuke Saka, Office Geophysik, Ogoori, Japan and Kanji Hayashi, University of Tokyo, Tokyo, Japan

An auroral breakup event accompanying a westward propagating auroral surge at the poleward boundary of the auroral zone was observed during the interval 0500 - 0510 UT 27 January 1986 by all-sky imagers installed at GWR (65.7N, 358.6) and SHM (66.3N, 336.0), and by magnetometers at four ground stations in the auroral and sub-auroral zone. Results obtained are as follows:

1. Poleward expansion of the aurora accompanied the magnetic pulse on the order of ~400nT.

2. The ionospheric current loop propagating westward explained the wave polarizations of the magnetic pulse.

3. The vortex was also observed in auroras. The rotations were opposite to those of the current loop.

4. The auroral surge propagating poleward separated from the auroral vortex in lower latitudes.

The occurrence of a ground Pi2 signal in the auroral zone during the auroral breakup was consistent with the propagating loop current hypothesis [Pashin et al., 1982].

The loop current appeared in association with the violent motion of auroras breaking out of the onset latitudes.

References;Pashin et al., 1982, J.Geophys., 51, 223-233.

Saur, Joachim

Non-linear interacting Alfven waves in planetary magnetospheres (Invited)

Joachim Saur, University of Cologne, Cologne, Germany

Alfven waves play an important role in planetary magnetospheres as they communicate energy and momentum between the parent planets, the magnetospheres, and the moons within the magnetospheres. At the outer planets the interaction of the planetary moons with the magnetospheric plasma is generally sub-Alfvenic, which results in standing Alfven waves in the rest frame of the moon. The Alfven wave electromagnetically couple the moon to the ionosphere of the parent planet. If the amplitudes of the standing waves are very large, the reflections at the planetary ionosphere are non-linear and the reflected waves interact with the incident waves. This results in filamentation of the waves to smaller spatial and temporal scales. Similar processes occur also in the outer planets magnetospheres, where Alfven waves transport angular momentum from the planets' ionospheres into their magnetospheres. Counter-propagating Alfven waves along the magnetospheric field lines interact non-linearly and establish a turbulent cascade of waves with large spatial and temporal scales to smaller scales. In this presentation, we will review relevant observations, theoretical concepts, and numerical simulations of these phenomenae.

Seough, Jungjoon

Generation of superthermal protons via parallel electron fire-hose instability: Particle-in-cell simulations

Jungjoon Seough[1], Peter Haesung Yoon[2,3], Junga Hwang[1] and Khan-Hyuk Kim[4], (1)KASI Korea Astronomy and Space Science Institute - KASI, Solar and Space Weather Group, Daejeon, South Korea, (2)Univ Maryland, College Park, MD, United States, (3)Kyung Hee University, Yongin-Si, South Korea, (4)Kyung Hee University, Yongin, South Korea

In situ observations have shown that the measured electron temperature anisotropy in the expanding solar wind is regulated by the electron fire-hose instabilities (EFI), which could be excited by excessive parallel temperature anisotropy. It is known that for parallel propagation mode the enhanced transverse fluctuations driven by the parallel EFI are resonant with the ions. In the present study, nonlinear properties of the parallel EFI are investigated using one-dimensional particle-in-cell simulations with various initial proton plasma betas. It is found that the protons in resonance with the left-hand polarized EFI modes are anisotropically heated and subsequently their resonant interactions give rise to the excitation of the ion-acoustic waves (IAW). The intensity of IAW is proportional to the values of the electron to proton temperature ratio. In addition, the presence of the unexpected electrostatic waves driven by nonlinear behavior of the protons, especially for the lower proton beta simulations, leads to the formation of the suprathermal component in the proton parallel velocity distribution, although the parallel proton temperature does not practically change throughout the simulation period.

Sharma, A Surjalal

Low Frequency Waves During RF Heating of the Ionosphere: Numerical Simulations

A Surjalal Sharma[1], Xi Shao[2], Bengt Erik Eliasson[3] and Dennis Papadopoulos[2], (1)Univ Maryland, College Park, MD, United States, (2)University of Maryland, College Park, MD, United States, (3)University of Strathclyde, Glasgow, United Kingdom

Radio frequency heating of the ionosphere produces local plasma heating and the resulting pressure gradient leads to plasma currents. When the heating is modulated the time varying current can excite waves of frequency close to the modulation frequency and propagate away from the heating region. The generation of the waves by a modulated heating of the F-region ionosphere is modeled using numerical codes of wave propagation in the ionosphere with the conducting ground as the lower boundary and the magnetosphere as the top boundary. The diamagnetic current due to the pressure gradient resulting from the localized RF heating oscillates at the modulation frequency and excites hydromagnetic waves, mostly the magnetosonic mode. As these waves propagate away from the heated region in the F-region it encounters regions of different conductivity, driving an oscillating Hall current in the E-region where Hall conductivity is dominant. These currents produce shear Alfven waves which propagate along the field lines. Simulations of RF heating with modulation frequencies in the range 2 - 10 Hz in the high- and mid-latitude ionosphere provide the wave propagation characteristics which depend on the ionospheric conductivity, modulation frequency and size of the heated region. In the high-latitude case the wave propagation is simulated using an essentially vertical magnetic field and the parameters corresponding to the HAARP heater experiments are used. The measurements on the ground during these experiments agree well with the simulation results. The mid-latitude case is simulated using a code that uses a dipole magnetic field in polar coordinates. With a source located at L = 1.6 and altitude of 300 km the EMIC and whistler waves are generated and the field-aligned waves propagate to the conjugate region. The characteristics of these waves depend on the modulation frequency, and in the case of modulation at 10 Hz the EMIC waves encounter the resonance layer. The whistler waves on the other hand propagate along the field lines to the conjugate region. These simulations correspond to the ionospheric heating by the Arecibo facility.

Shen, Xiaochen

Magnetospheric ULF waves with an increasing amplitude induced by solar wind dynamic pressure changes: THEMIS observations

Xiaochen Shen[1,2], Qiugang Zong[2], Quanqi Shi[1], Anmin Tian[1,3], WeiJie Sun[2], Yongfu Wang[2] and Suiyan Fu[4], (1)Shandong University at Weihai, Weihai, China, (2)Peking University, Beijing, China, (3)Shandong university at Weihai, Weihai, China, (4)Peking Univ, Beijing, China

We report the in situ observation of the magnetospheric ultra-low frequency (ULF) waves with an increasing amplitude induced by solar wind dynamic pressure changes. We check the magnetospheric responses to solar wind dynamic pressure enhancements from April 1, 2007 to December 31, 2012, and find six events of ULF wave with slow clear wave amplitude increase. The ion velocities of these waves continuously increase to 2.1 - 4.4 times during three to six wave cycles. We choose two cases for further investigating the cause of this wave amplitude increase. We find that the wave amplitude growth is mainly contributed by the toroidal mode wave. Interestingly, the wave are standing in the azimuthal direction, but propagating in the radial direction. Thus, we suspect that the wave amplitude increase may be the caused by the superposition of two wave sources. And the simple model calculation of superposing the standing wave excited by the

solar wind dynamic impulse and the magnetic field perturbation in the azimuthal direction, induced by the compressional wave via passing the the magnetic field and shaking it continuously, match the observations pretty well.

Shoji, Masafumi

Spectrum characteristics of electromagnetic ion cyclotron triggered emissions and associated energetic proton dynamics

Masafumi Shoji, Nagoya University, Solar-Terrestrial Environment Laboratory, Nagoya, Japan; ISAS/JAXA, Sagamihara, Japan

We perform parametric analyses of electromagnetic ion cyclotron (EMIC) triggered emissions with a gradient of the non-uniform ambient magnetic field using a hybrid simulation. According to nonlinear wave growth theory, as the gradient of the ambient magnetic field becomes larger, the theoretical threshold of the wave amplitude becomes larger although the optimum wave amplitude for nonlinear wave growth does not change. With a larger magnetic field gradient, we obtain coherent rising tone spectra because the triggering process of the EMIC triggered emission takes place only under a limited condition on the wave amplitude. On the other hand, with a smaller magnetic field gradient, triggering of the emissions can be caused with various wave amplitudes, and then the sub-packets are generated at various locations at the same time. The concurrent triggering of emissions results in incoherent waves, observed as ``broadband'' EMIC bursts. Broadband emissions induce rapid precipitation of energetic protons into the loss cone since the scattering by the concurrent triggering takes place faster than that of the coherent emissions. The coherent triggered emission causes efficient proton acceleration around the equator because of the stable particle trapping by the coherent rising tone emission.

Singh, Ashutosh

Very low frequency (VLF) waves as a probing tool to study the simultaneous effect of Solar Flare and Geomagnetic Storm (occurred on 9 March 2012) on D-region ionosphere

Ashutosh K Singh[1,2], Uma Pandey[3,4], O.P. P. Singh[1], Birbal Singh[4], Abhay Singh[5] and V K Saraswat[3], (1)Raja Balwant Singh Engineering Tech. Campus, Bichpuri Agra, Physics, Agra, India, (2)Banaras Hindu University, Physics, Varanasi, India, (3)Bansthali University, Physics, Bansthali, India, (4)Raja Balwant Singh Engineering Tech. Campus, Bichpuri Agra, Electronics and Communication Engineering, Agra, India, (5)Banaras Hindu Univ, Varanasi, India

We examine the effects on the low-latitude D-region ionosphere of two peculiar events occurred on 9 March 2012, the solar flare and the geomagnetic storm, by means of the associated perturbations of several subionospheric VLF/LF signals. We use VLF/LF daytime data recorded at our low latitude station Varanasi (L = 1.07). On 09 March 2012, a ~ 2.5 dB enhancement in VLF amplitudes was recorded at the peak of the solar flare event. Strong fluctuations in the amplitude of the VLF signals were again observed in the recovery phase of the flare event, which is due to geomagnetic storm and persisted through the end of the data-recording period. We suggest that both the signal enhancement and subsequent fluctuations were associated with variations in the precipitation flux of energetic electrons onto the upper atmosphere. Farther down, in the lower ionosphere, a strong increase of the electron density is observed as a consequence of a very strong enhancement of particle precipitation**.** Quantitative modeling of subionospheric VLF wave propagation incorporating energetic electron flux measurements (and the associated altitude profiles of secondary ionization produced) yield results consistent with the variations in the VLF signal amplitude observed.

Song, Yan

Nonlinear Interaction of ULF Wave Packets, Formation of Non-Propagating EM-Plasma Structures and Plasma Energization (Invited)

Yan Song and Robert L Lysak, University of Minnesota Twin Cities, School of Physics and Astronomy, Minneapolis, MN, United States

The nonlinear interaction of ULF wave packets in strongly inhomogeneous plasma regions can produce non-propagating electromagnetic-plasma structures. The quasi-steady dynamical structures are often characterized by localized strong electrostatic electric fields, density cavities and enhanced magnetic and mechanical stresses. The free

energy stored in locally enhanced magnetic and velocity fields can support the irreversible generation of electrostatic electric fields during a meaningful time interval. The generated electrostatic electric fields supported by the local dynamo can cause effective acceleration and energization of charged particles, deepening the low density cavity.

In auroral acceleration regions, transverse Alfvenic Double Layers (TA-DL) and charge holes (TA-CH) are such EM-plasma structures. These structures are responsible for auroral particle acceleration and the formation of quasi-static and Alfvenic discrete auroras. The TA-DL not only can accelerate electrons to high energy, but also may cause ion outflows, perpendicular ion heating and create proper conditions for generating Auroral Kilometric Radiation.

ULF waves play a crucial role in plasma energization and acceleration. By propagation and reflection, ULF waves provide a main energy supply for charged particle acceleration and energization. ULF waves also can redistribute the magnetic and kinetic stresses and generate a local stress concentration in regions of strong gradients in the plasma and fields. In such regions, the non-propagating EM-plasma structures are created by nonlinear interaction of ULF wave packets. These structures act as powerful high energy particle accelerators and important plasma EM wave radiators in cosmic plasmas.

Strumik, Marek

Three-dimensional simulations of firehose instability: fluctuating fields and particle acceleration

Marek Strumik and Kristof Stasiewicz, Space Research Centre PAS, Warsaw, Poland

Observations of waves in plasmas with anisotropic pressure close to firehose marginal stability level are often associated with the presence of energetic ion populations. Possible role of electric field fluctuations produced by firehose instability in particle acceleration is not well understood [1]. We investigate properties of structures produced by the firehose instability and its role in particle heating. Results of three-dimensional numerical simulations in Hall-MHD approximation are compared with properties of one-dimensional analytical solutions and results of two-dimensional simulations. Processes of particle scattering and acceleration in the generated structures are studied in detail by using test particle method.

[1] Stasiewicz K. et al., Acceleration of solar wind ions to 1 MeV by electromagnetic structures upstream of the Earth's bow shock, Europhysics Letters, Vol. 102, 49001, 2013.

Summers, Danny

Limiting energy spectrum of an electron radiation belt (Invited)

Danny Summers, Memorial University of Newfoundland, Dept of Math and Stats, St John's, Canada and Run Shi, Memorial University of Newfoundland, Dept of Math and Stats, St John's, NL, Canada

In the last decade there has been a resurgence of radiation belt science. The NASA Van Allen Probes mission has further intensified the need to re-examine old theories and develop new theories to explain the wealth of new radiation belt particle and wave data that accumulates daily. Here we carry out a fresh examination of the Kennel-Petschek concept of self-limiting particle flux in a planetary magnetosphere. In a marginally stable state when diffusion is weak,whistler-mode waves can act to limit the trapped electron flux. Similarly,electromagnetic ion cyclotron waves can limit the stably-trapped flux of ions. In a fully relativistic regime,and without assuming in advance a particular form for the particle energy distribution,we derive an integral equation that determines the self-limiting particle flux. We obtain numerical solutions for the limiting particle spectra and compare our results with Cassini data at Jupiter and Van Allen Probes data at Earth.

Suzuki, Takeru

Alfven wave-driven solar wind during very active phases (Invited)

Takeru Ken Suzuki, Nagoya University, Physics, Nagoya, Japan

We investigate the solar wind driven by Alfven waves, particularly focusing on the solar wind during very active phases. We perform forward-type magnetohydrodynamical numerical experiments for Alfven wave-driven winds with a wide range of the input Poynting flux from the photosphere. Increasing the magnetic field strength and the turbulent velocity at the photosphere from the current averages, the mass loss rate rapidly increases at first owing to the suppression of the reflection of the Alfven waves. The surface materials are lifted up by the magnetic pressure associated with the Alfven waves, and the cool dense chromosphere is intermittently extended to 10 - 20 % of the solar radius. The dense atmospheres enhance the radiative losses and eventually most of the input Poynting energy from the solar surface escapes by the radiation. As a result, there is no more sufficient energy remained for the kinetic energy of the wind; the solar wind saturates in very active cases, as observed in solar-type stars by Wood et al. The saturation level is positively correlated with the average magnetic field strength contributed from open flux tubes. If the field strength is a few times larger than the present level, the mass loss rate could be as high as 1000 times. Some cases with large injection of Alfvenic Poynting flux show temporal inflows triggered via reflected Alfven waves at large density fluctuations. We also discuss such extreme phenomena which could occur in active phases of the Sun.

Sych, Robert

Wave dynamics in sunspot atmosphere (Invited)

Robert Sych, Institute of Solar-Terrestrial Physics SB RAS, Irkutsk, Russia

The temporal, spatial and frequency dynamics of 3-min slow magnetoacoustic wave propagating in sunspot active region NOAA 11131 on December 8, 2010 is analyzed. We used the Pixelised Wavelet Filtering (PWF) method to compute narrowband power maps of SDO/AIA imaging datasets in the 1700A, 1600A, 304A, 171A, 211A, 193A, 131A and 335A bandpasses, that correspond to different heights. For the 1D data preparation we used the method of time-distance plots. It is shown that there are time intervals where the changes of 1D shape of wave fronts was observed. There is correlation between power of 3-min oscillations and shape of waves. In maxima power we observed symmetrical propagation. Oscillation minima connect with the asymmetrical propagation and collapse of the wave fronts. Two-dimensional spectral analysis shows the spatial structure of wave fronts as a spiral with two arms, connected with pulsed source in umbra center. We observed counterclockwise rotation of spiral during the 3-min oscillation cycle with extend arms up to umbra border. Decreasing of power oscillation connect with waves transform from spiral to quasi-spherical shape. We found that helicity is exist on all heights of atmosphere above the sunspot. At different wavelengths there are time delays between upward wave propagation. We use the spatial cross-correlation method between narrowband details in umbra for obtain value of delays. The calculated values for baseline 1700A showed delays: 4.5 sec. for 1600A, 16.8 sec for 304A, 17.9 sec for 45 sec and 193A for 167A. The propagating speed of the waves about 90-100 km/s. The spatial-frequency structure of spiral shown a set of narrowband details in 3-min waveband, spatially distributed in different parts of sunspot umbra. There is a central, high frequency component (~ 9.3mHz) as a pulsing source and low- frequency component (~ 6.4mHz - 4.9mHz) as a expending wave fronts. On coronal level we observed a radial motion along coronal loops. We suppose that observed helicity have projection nature and based on spatial distribution of magnetic waveguides in the sunspot and height of emission generation. We can conclude that the cut-off frequency is a main factor of appearance a narrowband details in a 3-min oscillations waveband and observed helicity in wave propagation.

Takahashi, Kazue

ULF waves in the inner magnetosphere (Invited)

Kazue Takahashi, Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, United States

Earth's magnetosphere is constantly subjected to disturbances in the solar wind and it also sustains plasma instabilities associated with geomagnetic storms and magnetospheric substorms. All these processes lead to excitation of ULF MHD waves in the inner magnetosphere, which includes the plasmasphere, the radiation belts, and the ring current. In this presentation, we review recent observations with both spacecraft and ground-based experiments to highlight several distinct types of waves that exist in the inner magnetosphere. Examples will include fast and shear Alfven waves driven by disturbances in the solar wind and Alfven waves driven by unstable particle populations in the ring current. We will also discuss interaction of the waves with energetic particles.

Tan, Le

Solar flare induced the parameter changes of lower ionosphere from VLF amplitude observations at a low-latitude site

Le Minh Tan, TayNguyen University, Department of Physics, Faculty of Natural Science and Technology, Buon Ma Thuot, Vietnam, Nguyen Ngoc Thu, South Vietnam Geological Mapping Division, Geophysical Center, Ho Chi Minh, Vietnam and Tran Quoc Ha, University of Education, Ho Chi Minh, Vietnam

We recorded and analyzed 43 solar flare events from C2.56 to X3.2 classes at Tay Nguyen University, Vietnam (12.56^o N, 108.02^o E) during May, 2013 - February, 2014 using the well known VLF technique to understand the behaviour of low-latitude D-region ionosphere during solar flares. The VLF amplitude perturbations of NWC/19.8 kHz signal and time delay between the VLF amplitude peaks and the X-ray flux peaks recorded by GOES satellites were computed. We found that almost peaks of VLF amplitude occurred about 1 - 4 minutes after the peak of X-ray flux. However, some solar flare events, the peaks of VLF amplitudes appearred about 1 - 5 minutes before the peaks of flare flux. The observed VLF amplitude perturbations are used as the input parameters for the simulated LWPC code, using Wait's model, to calculate two Wait's parameters of the Earth - ionosphere waveguide: the reflection height, and the exponential sharpness factor. Results reveal that when the X-ray irradiance increased, the exponential sharpness factor increased from 0.301 km^{-1} to 0.506 km^{-1}, while the reflection height decreased from 73.6 km to 60 km. The variation of electron density is a logarithmic function of amplitude perturbation. The 3D representation of the electron density changes with altitude and time supports us to sufficiently understand the rules of the electron density changes during solar flares. The shape variation of electron density is roughly followed to the variation of the amplitude perturbation and keeps this rule for the different altitude. During solar flares, the ionization due to X-ray irradiance becomes greater than that due to cosmic rays and Lyman-alpha radiation, which increases the electron density profile. Using amplitude perturbations and time delay, we also calculate the effective electron recombination coefficient at solar flare peak region. The effective electron recombination coefficient versus X-ray flux varies from ~ 10^{-14}m^3/s to ~ 10^{-12} m^3/s for C1.0 to M9.0 classes. The changes rules of the Wait's parameters and electron density of lower ionosphere of our results are in accordance with the studied results shown by other authors. We also found that the electron density versus the height in lower latitude D-region ionosphere increases more rapidly during solar flares.

Tsugawa, Yasunori

Group-standing whistler-mode waves observed as 1 Hz waves in the solar wind

Yasunori Tsugawa[1], Yuto Katoh[1], Naoki Terada[1], Hideo Tsunakawa[2], Futoshi Takahashi[3], Hidetoshi Shibuya[4], Hisayoshi Shimizu[5] and Masaki Matsushima[6], (1)Tohoku University, Sendai, Japan, (2)Tokyo Inst. Tech., Tokyo, Japan, (3)Kyushu University, Fukuoka, Japan, (4)Kumamoto Univ, Kumamoto, Japan, (5)Univ Tokyo, Tokyo, Japan, (6)Tokyo Tech, Tokyo, Japan

"1 Hz waves" have been generally observed in the solar wind around many solar system bodies: Mercury [*Le et al*., 2013], Venus [*Orlowski et al*., 1990], Earth [e.g., *Heppner et al*., 1967; *Russell et al*., 1971], the Moon [*Nakagawa et al*., 2003; *Halekas et al*., 2006], Mars [*Brain et al*., 2002], Saturn [*Orlowski et al*., 1992], and comets [*Tsurutani et al*., 1987]. The waves mostly exhibit narrowband spectra with the frequency around 1 Hz and left-hand polarizations. They are whistler mode waves Doppler shifted significantly to be reversed the polarization in the spacecraft frame [*Fairfield*, 1974]. A variety of energy sources of the waves have been proposed including reflected ions and electrons from the bow shock, temperature anisotropies in the foreshock, cross-field drift in the foot region, and shock front perturbations. In the present study, in order to clarify the generation process of the waves, we suggest that it is necessary to understand effects on the observed wave spectra in the propagation process.

We propose the group-standing effects [*Tsugawa et al*., 2014] which can explain the observed frequency, wave spectra and wave vector direction of 1 Hz waves observed by Kaguya around the Moon and by Geotail around the terrestrial bow shock. The results suggest that 1 Hz waves are nearly stagnating in the spacecraft frame. Since most of the properties of 1 Hz waves are determined by the group-standing effects, it is difficult to clarify the generation process merely from the observed properties. Based on the group-standing effects, we reveal the essential differences of the waves around the Moon and the terrestrial bow shock, which should reflect their different generation processes.

Usanova, Maria

Understanding the Role of EMIC Waves in Radiation Belt and Ring Current Dynamics: Recent Advances (Invited)

Maria Usanova[1] and Ian Robert Mann[1,2], (1)University of Alberta, Edmonton, AB, Canada, (2)Univ Alberta, Edmonton, AB, Canada

Electromagnetic ion cyclotron (EMIC) waves are believed to be important for influencing the dynamics of energetic particles in the inner magnetosphere, especially in relation to ring current dynamics (cf. ring current models, such as Khazanov et al. [2007], Jordanova et al. [2012], and other models). EMIC waves also postulated to influence the higher energy electrons in the Van Allen belts, through a Doppler shifted cyclotron resonance. We will present latest results on EMIC wave characterizations and studies of their impact on energetic particles in the inner magnetosphere. We will draw on results from recent satellite missions including THEMIS and Cluster, as well as the very latest results from the Van Allen Probes launched on 31st August 2012. We will also highlight the value of data from networks of modern ground-based magnetometers in providing continuous monitoring over local, continental, and even global scales, especially in conjunction with in-situ measurements from satellites.

Van Doorsselaere, Tom

MHD seismology of the solar corona (Invited)

Tom Van Doorsselaere, KULeuven, Leuven, Belgium

MHD seismology is the technique where one uses observed wave properties to infer information on the medium that carries the waves. In plasmas, three wave modes are available to the observer to analyse the background.

In this talk, I will focus on the application of MHD seismology to the waves in the solar corona. I will give an overview of the recent developments in the field. In particular, I will present the development of models for waves in coronal loops, how these waves are observed in the solar corona, and how they are used for seismology. Moreover, I will highlight some recent results on the heating of the solar corona by the use of low frequency MHD waves.

Verma, V

Low frequency Type II radio bursts from CMEs related solar flares

V K Verma, Uttarakhand Space Application Center, Department of Science & Technology, Dehradun, Uttarakhand, India and Nishant Mittal, Meerut Universty, Astrophysics Research Group, Meerut College, Meerut, India

We present a study of 11 type II radio bursts observed at starting frequency of 1MHz and solar flares related coronal mass ejections (CMEs) phenomena. The time durations of these type II radio bursts are ranges between 5 min to 2020 min. On investigation of 11 type II radio bursts and associated CMEs, solar flares and coronal holes (CHs) data we have found that 4 type II radio bursts were observed when there were CHs and solar flares within 10 degree and 5 type II radio bursts were observed when there were CHs and solar flares within 20 degree, respectively. Earlier Verma and Pande (1989) and Verma (1998, 2002) presented a view that the CMEs may have been produced by some mechm, in which the mass ejected by solar flares or active prominences, gets connected with the open magnetic lines of CHs (source of high speed solar wind streams) and moves along them to appear as a halo CMEs. The each low frequency type II radio bursts and other solar events observed are analyzed separately to understand the origin of low frequency type II radio bursts from the Sun in view in view of recent scenario of solar Heliophysics.

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Verth, Gary

The Generation and Damping of Propagating MHD Kink Waves in the Solar Atmosphere (Invited)

Gary Verth, University of Sheffield, School of Mathematics and Statistics, Sheffield, United Kingdom

The source of the non-thermal energy required for the heating of the upper solar atmosphere to temperatures in excess of a million degrees and the acceleration of the solar wind to hundreds of kilometers per second is still unclear. One such mechanism for providing the required energy flux is incompressible torsional Alfvén and kink magnetohydrodynamic (MHD) waves, which are magnetically dominated waves supported by the Sun's pervasive and complex magnetic field. In particular, propagating MHD kink waves have recently been observed to be ubiquitous throughout the solar atmosphere, but, until now, critical details of the transport of the kink wave energy throughout the Sun's atmosphere were lacking. Here, the ubiquity of the waves is exploited for statistical studies in the highly dynamic solar chromosphere. This large-scale investigation allows for the determination of the chromospheric kink wave velocity power spectra, a missing link necessary for determining the energy transport between the photosphere and corona. Crucially, the power spectra contain evidence for horizontal photospheric motions being an important mechanism for kink wave generation in the quiescent Sun. In addition, a comparison with measured coronal power spectra is provided for the first time, revealing frequency-dependent transmission profiles, suggesting that there is enhanced damping of kink waves in the lower corona.

Veselovsky, Igor

Nonlinear coupling between waves and flows in the solar wind sources

Igor S. Veselovsky, Space Research Institute (IKI) RAS, Moscow, Russia; Skobeltsyn Institute of Nuclear Physics, Moscow State University, Moscow, Russia

Plasma wave energy in the solar wind sources is comparable or even greater than other shapes of the free energy (magnetic, thermal, gravity, radiation) here. The weakly nonlinear formalism is presented for the description of the interaction between the waves and flows in the solar corona. Dimensionless scaling approach is developed with the aim of the classification of physically similar and different types of the energy, momentum and mass transports of the plasma and fields in the solar atmosphere beneath and above the turbopause. Dissipative MHD and plasma kinetic theory examples are considered for the construction of the independent and orthogonal parametric representation in the generalized space of independent physical variables. The results show that one should clearly distinguish between mass and energy sources and their transport trajectories when considering local and non-local problems of the corona heating and solar wind generation. Both problems are unsolved and tightly related in this sense. The general theory principles are understood, but their quantitative side in practical applications is not completely known because of the scarce observational input information about the dimensionless Trieste number sets and other parameters characterizing the openness degree of structures under consideration (coronal holes, active regions, quiete Sun etc.). Geometry factors are very different in this multi parametric phase space and show no standard situations and evolution with many possible and competing mechanisms because of the large free energy reservoirs available for the generation of flows and waves. We enumerate different regimes. Wind driven waves and wave driven flows are envisaged in the solar wind sources. Any universal scenario is problematic and could serve only as illustration of conceptual models with some initial and boundary conditions determining the solution.

Wang, Tongjiang

Longitudinal and transverse waves in solar coronal loops: Overview of recent results (Invited)

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Recent observations have revealed the ubiquitous presence of magnetohydrodynamic (MHD) waves and oscillations in the solar corona (mainly in active region loops). The study of MHD waves is motivated by two major goals in solar physics, namely coronal seismology and the role of MHD waves in coronal heating. The SDO/AIA with a large field of view (full Sun) and high spatio-temporal resolutions not only provides us more opportunities to captue the flare-excited oscillation events that were ever seldom observed but also allows us to explore their details for better understanding the wave excitation, propagation and damping mechanisms. Spectroscopic observations by the Hinode/EIS reinforce the capability of imaging instruments in identification of various wave modes. In this talk I will briefly review recent results in observational studies of longitudinal and transverse waves. The talk focuses on four kinds of wave phenomena in coronal loops: (i) Flare-excited standing slow-mode waves in hot loops, (ii) Persistently propagating slow magnetosonic waves and outflows in fan-like loops, (iii) Impulsively-excited standing kink loop oscillations, (iv) Persistently propagating transverse Alfvenic (kink) waves. I will discuss the relevant debates in their interpretations, and the possible impacts of new results on the current wave theories concerning applications of coronal seismology.

Waters, Colin

ULF waves and the Ionosphere (Invited)

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ULF waves in the Pc3-5 (1-100 mHz) band respond to conditions in the magnetosphere, prompting the investigation and development of remote sensing techniques using these signals. An important factor in these endeavours is the near-Earth boundary of space, the ionosphere, where ULF plasma waves transition to electromagnetic perturbations that are routinely detected by ground-based magnetometers. Several effects on ULF wave amplitude and phase properties caused by transition through the ionosphere have been known for some time, while others are more recent developments. In this paper, the important ionospheric effects on ULF properties detected at the ground and in the ionosphere through radar and Doppler sounder data are discussed. In addition, results from recent ULF wave simulations that include altitude varying ionosphere parameters are discussed and compared with experimental observations.

Watson, Christopher

Variations in GPS TEC associated with magnetic field line resonance activity in the early morning auroral ionosphere

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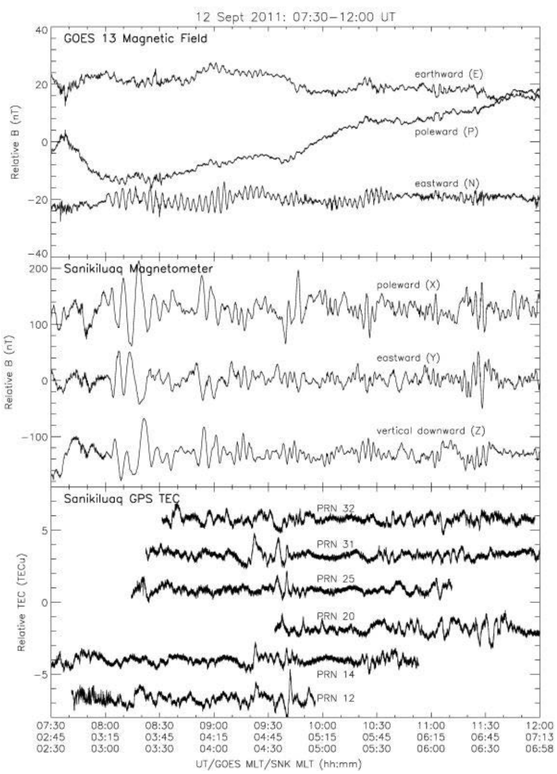
Observations of ionospheric total electron content (TEC) variations associated with magnetic field line resonance activity (FLR) in the Pc5 (1.7 to 6.7 mHz) frequency band are presented. TEC measurements are from the Sanikiluaq, Nunavut (56.54ºN, 280.77ºE) Global Positioning System (GPS) receiver of the Canadian High Arctic Ionospheric Network (CHAIN), which is located in the auroral region. Over a period of 3.5 hours in the early morning, continuous TEC variations at Pc5 frequencies are concurrently observed with Pc5 band FLR activity observed by the geosynchronous GOES 13 satellite magnetometer and the ground magnetometer in Sanikiluaq. Spectral analysis indicates a narrow band of dominant Pc5 frequencies in the GOES magnetic field variations, with a broadening of the spectral distribution in ground magnetic field and TEC

variations. The dominant frequencies observed on the ground and at GOES agree with the calculated fundamental mode FLR eigenfrequency. Amplitudes of TEC variations range from 0.1 - 2 TECU, and are most likely a result of energetic particle precipitation modulated by the Pc5 FLR. Further, GOES 13 particle measurements show flux variations for >30 keV electrons located in the atmospheric loss cone during the largest amplitude TEC variations. These flux variations are of similar frequency to the TEC variations. In addition, measurements from multiple GPS satellites are used to examine the phase delay of FLR-associated TEC variations in the longitudinal and latitudinal directions. Due to the high temporal and spatial resolution of GPS TEC measurements, detection of ULF waves by GPS TEC is a potentially useful tool in the study of ULF properties and the associated ionospheric response.



Watt, Clare

Localised wave generation in the inner magnetosphere: a new approach (Invited)

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I will present results from a new model of electromagnetic wave generation in inhomogeneous plasma and relate our findings to wave-particle interactions in the Outer Radiation Belt. Theory has predicted, and observations have confirmed, that locally-generated electromagnetic waves are important for the acceleration and loss of high energy plasma in the magnetosphere. Locally-generated in this context means that large-scale magnetospheric convection creates regions of free energy in the inner magnetosphere that are unstable to electromagnetic wave generation. An important example of this process is the generation of whistler-mode waves in the dawn/dayside sector of the magnetosphere due to temperature anisotropy. In this talk, I will discuss different approaches that can be used to model wave generation and describe the new method we have created. I will present results from our new model that predict the latitudinal variation of wave spectra, and show comparisons with in-situ observations.

Wei, Hanying

Ion cyclotron waves in the solar wind: generation mechanism and source region

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Ion cyclotron waves have been observed in the solar wind at several heliocentric distances. The STEREO magnetic field observations are examined to understand the wave properties and the possible formation mechanisms. Statistical studies show that the waves are probably generated in the solar corona and carried outward by the solar wind. Among these ion cyclotron wave observations, there is a special group of events in which waves last for over half an hour (i.e. so-called storm events) and have co-existing right-handed and left-handed waves. We study such events and find that these waves have the properties expected for left-handed in the solar wind frame but are Doppler-shifted in the spacecraft frame, with Sunward-propagating waves shifted to higher frequency, and anti-Sunward-propagating waves shifted to lower frequency or even reversed in polarity. Assuming both left-handed and right-handed waves are generated by pickup ion at the same source location, we estimate the pickup ion's initial velocity at the source region is typically one third of the solar wind velocity and three times the Alfven velocity. We also use the frequencies of these waves to estimate the field strength and heliocentric distances of the source region.

Yang, Junying

Solar wind affection on VLF electromagnetic waves in the inner magnetosphere

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The morphology of VLF electromagnetic wave activity in the inner magnetosphere can be affected by local time, L shell, and geomagnetic disturbance level. A statistical satellite survey showed that there is also a longitudinal dependence. Whatever this work reveals how the solar wind affects the VLF electromagnetic waves in the inner magnetosphere indeed.

Yeoman, Timothy

Ionospheric radar measurements of waves with equatorward phase propagation generated by energetic particles (Invited)

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Energetic particles injected from the magnetotail into the Earth's inner magnetosphere will experience gradient-curvature drift and thus move around the Earth, constituting part of the global ring current. Such drifting particles can drive MHD wave modes through wave-particle interactions, leading to perturbations in the electric and magnetic fields in the magnetosphere and ionosphere.

Such particle-driven waves generally have a small azimuthal scale length, and this results in a strong attenuation of the wave between the ionosphere and the ground, making ionospheric radars particularly useful instruments for their study. In addition, a subset of such waves have a strong equatorward phase propagation (a small scale length in latitude), which results in further attenuation. Such events have been observed by a variety of radar systems over the last 20 years at L-shells ranging from 5 - 15. The latitude of the observations has previously been determined to have a strong influence on the driving particle energies, and hence the wave characteristics. Here we report on recent progress in our understanding of such waves, made possible through the combination of the SuperDARN radar array and substorm morphology provided through IMAGE observations of the global UV aurora. It is revealed that the proximity of the wave observations and the substorm also has a strong influence on particle energy and wave characteristics. In-situ particle data from the van Allen probes has provided an opportunity to directly measure the driving particles for the lower latitude wave observations.

Yoshikawa, Akimasa

Theory of Cowling channel formation by reflection of shear Alfven waves from the auroral ionosphere (Invited)

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We present the first complete formulation of the coupling between the ionospheric horizontal currents (including Hall currents) and the field-aligned currents (FAC) via shear Alfven waves, which can describe the formation of a Cowling channel without any a priori parameterization of the secondary (Hall-polarization) electric field strength. Our theory reorganizes the Cowling channel by "primary" and "secondary" fields. Until now there are no theoretical frameworks, which can derive these separated components from observed or given total conductance, electric field and

FAC distributions alone. But when a given incident Alfven wave is considered as the driver, the reflected wave can be uniquely decomposed into the primary and secondary components. We show that the reflected wave can, depending on actual conditions, indeed carry FAC that connect to divergent Hall currents. With this new method we can identify how large the secondary electric field becomes, how efficiently the divergent Hall current is closed within the ionosphere, and how much of the Hall current continues out to the magnetosphere as FAC. In typical ionospheric situations only a small fraction of FAC is connected to Hall currents at conductance gradients, i.e. the secondary field is relatively strong. But when conductances are relatively low compared with Alfven conductance and/or horizontal scales smaller than ~10 [km], the Hall FAC may become significant.

Yu, Dae Jung

Characteristics of compressional eigenmodes in the inner-magnetosphere

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We study the transport characteristics of MHD compressional waves incident on the plasmasphere from the outer magnetopshere with accompanying resonant absorption into transverse mode via mode conversion and the excitation behavior of the eigenmodes where the Alfven speed has a typical nonmonotonic profile in radial direction. By using invariant imbedding method (IIM) that allows numerically exact calculations, we present numerically the exact eigenmode structures excited in the magnetosphere and show that the virtual resonant modes are mainly excited ones whose eigenfrequencies and band widths have a sensitive dependence on the Alfven speed profile. The behavior of eigenmode structures related to the deformation of the profile is clearly shown, which can be used for obtaining the time series of the trapped modes in a certain radial location by the inverse Fourier transform and can be compared with the observations. We show how the time histories at each location appear for some different Alfven speed profiles. We also present a new feature of the mode excited in a certain frequency regime, which is similar to discrete Alfven eigenmode or global Alfven eigenmode.

Zhou, Xuzhi

Standing Alfven waves transitioned from fast growing, travelling waves: Indications from electron measurements

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Ultra-Low Frequency (ULF) electromagnetic oscillations, usually interpreted as standing Alfven waves, are one of the major candidates to explain the electron acceleration to relativistic energies in the Earth's radiation belt. Prompt acceleration can be achieved when electrons resonantly gain energy from the ULF waves (via a process named drift resonance), which is observationally characterized by an energy dependence of the phase differences between electron flux and electromagnetic field oscillations. Such dependence, recently observed by the Van Allen Probes, has been presented as a most unambiguous evidence for the drift-resonance acceleration (Claudepierre et al., 2013). In this paper, we revisit the same event to find that in the early stage of the waves, the observed phase relationship appeared to be not fully consistent with the drift resonance theory. We further examine these apparent inconsistencies, to suggest that they arose from the fast growth of travelling Alfven waves before being transitioned into the more typical standing waves. These observations, therefore, provide a rare opportunity to understand the generation and evolution of ULF oscillations in the Earth's magnetosphere.

Zong, Qiugang

Fast acceleration of Ring Current Ions by ULF waves (Invited)

Qiugang Zong, Peking University, Beijing, China

We have investigated the response of the Earth's ring current ions including oxygen ions to ULF waves induced by interplanetary shocks. Both Earth's ring current ions -- hydrogen and oxygen ions are found to be accelerated significantly with their temperature enhanced by a factor of two and three immediately after the shock arrival respectively. Multiple energy dispersion signatures of ring current ions were found in the parallel and anti-parallel direction to the magnetic field immediately after the interplanetary shock impact. The energy dispersions in the anti-parallel direction preceded those in the parallel direction. Multiple dispersion signatures can be explained by the flux modulations of local plasmaspheric ions (rather than the ions from the Earth's ionosphere) by ULF waves. It is found that both cold plasmaspheric plasma and hot thermal ions (10 eV to 40 keV) are accelerated and decelerated with the various phases of ULF wave electric field. We then demonstrate that ion acceleration due to the interplanetary shock compression on the

Earth's magnetic field is rather limited, whereas the major contribution to acceleration comes from the electric field carried by ULF waves via drift-bounce resonance for both the hydrogen and oxygen ions. The integrated hydrogen and oxygen ion flux with the poloidal

mode ULF waves are highly coherent (>0.9) whereas the coherence with the toroidal mode ULF waves is negligible, implying that the poloidal mode ULF waves are much more efficient in accelerating hydrogen and oxygen ions in the inner magnetosphere than the toroidal mode ULF waves.