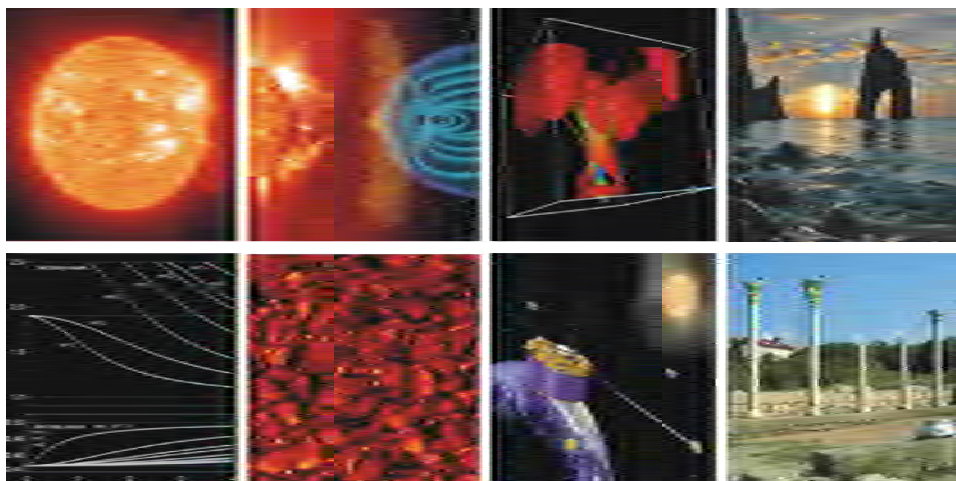


UK-Ukraine Meeting on Solar Physics and Space Science
joint with Topical Advanced Summer School
UKU SPSS/TASS

PROGRAMME and ABSTRACTS



August 29 - September 2, 2011

Alushta, Crimea, Ukraine
2011

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PROGRAMME and ABSTRACTS

August 29 - September 2, 2011
Alushta, Crimea, Ukraine

Organised by

Solar Wave Theory Group (SWAT), The University of Sheffield, UK
Space Plasma Department, Institute of Space Research, Ukraine

The Topical Advanced Summer School is supported by STFC (UK)

UK-Ukraine Meeting on Solar Physics and Space Science
joint with Topical Advanced Summer School (Ukraine, Crimea, Alushta)
Programme and abstracts / UKU SPSS/TASS 2011,
August 29 - September 2, 2011, Alushta, Ukraine

Scientific Programme Committee

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Programme Overview

		Theatre	Classroom
Sunday	19:00 – 21:00	Arrival and Registration	
Monday	09:00 – 09:25	Registration	
	09:25 – 09:30	Welcome and Introduction	
	09:30 – 11:00	Solar observations: From the interior to heliosphere	
	11:00 – 11:30	Coffee break and poster session	
	11:30 – 13:00	Solar observations: From the interior to heliosphere	
	13:00 – 14:30	Lunch	
	14:30 – 16:30	Summer School	
	16:30 – 17:00	Coffee break	
	17:00 – 19:00	Summer School	
	19:00	Joint Icebreaker UKU SPSS/TASS	
Tuesday	09:00 – 11:00	Numerical simulations in the solar and astrophysical plasmas	
	11:00 – 11:30	Coffee break and poster session	
	11:30 – 13:00	Space Science	
	13:00 – 14:30	Lunch	
	14:30 – 16:30	Summer School	
	16:30 – 17:00	Coffee break	
	17:00 – 19:00	Summer School	
Wednesday	09:00 – 10:30	Analytical theory of waves in magnetised plasma	
	10:30 – 18:00	Excursion	
Thursday	09:00 – 11:00	Space Science	
	11:00 – 11:30	Coffee break and poster session	
	11:30 – 13:00	Solar observations: From the interior to heliosphere	
	13:00 – 14:30	Lunch	
	14:30 – 16:30	Summer School	
	16:30 – 17:00	Coffee break	
	17:00 – 19:00	Summer School	
	19:00	Joint Dinner UKU SPSS/TASS	
Friday	09:00 – 11:00	Space Science	
	11:00 – 11:30	Coffee break and poster session	
	11:30 – 12:00	Space Science/Solar observations	
	12:00 – 12:10	Meeting/Summer School Closing	

SUNDAY, August 28, 2011

19:00–21:00 Arrival and Registration

09:00–09:25 Registration

09:25–09:30 Welcome and Introduction (Theatre)

09:30–11:00 Solar observations: From the interior to heliosphere (Theatre) Chair: Erdélyi R.

09:30–10:10 **Marcel Goossens**, Inigo Arregui, Roberto Soler and Jaume Terradas Coronal seismology using standing and propagating MHD waves (Invited)

10:10–10:30 **Sven Wedemeyer-Böhm** Swirl events in the solar chromosphere

10:30–10:50 **Maria Jesus Martinez Gonzalez** and Elena Khomenko Puzzling magnetic field oscillations found in the quiet Sun

10:50–11:00 **Discussion**

11:00–11:30 Coffe break and poster session

Nina Kondrashova and Elena Khomenko Temporal Variations in Photospheric Parameters During a Small Solar X-Ray Burst

Margarita Pasechnik, Nina Kondrashova and Svetlana Chornogor Lower Atmosphere Dynamics Of The New-Cycle Active Region NOAA 11024

Roman Kostik Convective and wave motions in thermal plume

Dilyara Baklanova, Sergei Plachinda, D Mkrtychian, I Han and K.-M. Kim General Magnetic Field on weakly-active yellow giant β Geminorum

Yuriy Tsap and E Isaeva Type II Radio Bursts and the solar proton acceleration by the interplanetary shock waves

11:30–13:00 Solar observations: From the interior to heliosphere (Theatre) Chair: Kostik R.

11:30–11:50 **Nataliya Shchukina** and Javier Trujillo Bueno Magnetization of the quiet sun photosphere from the Hanle effect and surface dynamo simulations

11:50–12:10 **Andrés Asensio Ramos** Which model is suited for my spectro-polarimetric observations?

12:10–12:30 **Alexander Kryshtal**, Svitlana Gerasimenko and Anna Voytsekhovska Small-scale kinetic instabilities of low-frequency waves in preflare plasma of the chromosphere of solar active region.

12:30–12:50 **Yuriy Tsap**, Alexander Stepanov and Yulia Kopylova Hinode Observations and MHD Waves in the Solar Photosphere

12:50–13:00 **Discussion**

13:00–14:30 Lunch

14:30–16:30 Summer School (Classroom)

MONDAY, August 29, 2011

14:30–15:30 **Robertus Erdélyi** MHD waves and oscillations in the solar atmosphere

15:30–16:30 **Eduard Kontar** Wave and particle interaction in heliophysics

16:30–17:00 Coffee break

17:00–19:00 Summer School (Classroom)

17:00–18:00 **Michael Balikhin** How can advanced data analysis methods teach us about physics?

18:00–19:00 **Tutorial** for All TASS Lecturers of the day

19:00 Joint Icebreaker UKU SPSS/TASS

09:00–11:00 Numerical simulations in the solar and astrophysical plasmas (Theatre) *Chair: Hood A.*

09:00–09:40 **Eamon Scullion**, L Rouppe van der Voort, J de la Cruz Rodriguez, Viktor Fedun and Robertus Erdélyi Chromospheric Swirls: What is the response of the solar corona? (Invited)

09:40–10:00 **Elena Khomenko** and Manuel Collados Partial Ionization Effects in the Solar Photosphere and Chromosphere

10:00–10:20 **Sergiy Shelyag** Multiwavelength radiative diagnostics of high-resolution MHD simulations of solar photosphere

10:20–10:40 **Viktor Fedun** and Robertus Erdélyi 3D Numerical Simulation of Torsional Alfvén Waves

10:40–11:00 **Discussion**

11:00–11:30 Coffee break and poster session

Varvara Butkovskaya On mystery of solar and stellar magnetic fields measured in different lines
Shervin Ziaei Identification Methods of Magnetic Bright Points

Igor Kremenetsky, Oleksiy Agapitov and Nikolai Salnikov Quasi-periodic motion of the Earth dayside magnetopause

Chris Nelson, Robertus Erdélyi and A Hague Relationship of P1/P2 for a string with non-uniform density

Nikolai Salnikov and Igor Kremenetsky Dst-index forecasting using an adaptive two-level model adjustment

11:30–13:00 Space Science (Theatre)

Chair: Balikhin M.

11:30–11:50 **Danny Summers** Rapid acceleration of charged particles by nonlinear wave trapping in the magnetosphere and cosmic plasmas

11:50–12:10 **Natalia Beloff**, Alexander Karpachev and Pavel Denisenko Characteristic of the Traveling Ionospheric Disturbances from the Multi-Satellite and Ground-Based Observations

12:10–12:30 **Oleg Cheremnykh** and Aleksei Parnowski ULF MHD Perturbations in the Inner Magnetosphere of the Earth: Theoretical Study

12:30–12:50 **Vladimir S. Mikhailenko**, Vladimir V. Mikhailenko, Nikolay A. Azarenkov, Dmitry V. Chibisov and Konstantin N. Stepanov Ion cyclotron turbulence of plasma shear flows and related anomalous transport

12:50–13:00 **Discussion**

13:00–14:30 Lunch

14:30–16:30 Summer School (Classroom)

TUESDAY, August 30, 2011

14:30–15:30 **Alan Hood** MHD waves and instabilities: Numerical modelling

15:30–16:30 **Michael Kenneth Griffiths** Implementation of Magnetohydrodynamic codes for gravitationally stratified media on hybrid and highly parallel graphical processing units

16:30–17:00 Coffee break

17:00–19:00 Summer School (Classroom)

17:00–18:00 **Yuriy Voitenko** From MHD waves via kinetic waves toward plasma energization.

18:00–19:00 **Tutorial** for **All** TASS Lecturers of the day

09:00–10:30 Analytical theory of waves in magnetised plasma (Theatre) *Chair: Fedun V.*

09:00–09:40 **Gary Verth** Solar Magnetoseismology (Invited)

09:40–10:00 **Yevgen Kravets**, Alan Cairns, Bernhard Ersfeld, Adam Noble and Jaroszynski Dino
High energy laser pulse propagation in plasma: photon acceleration and self focusing effects.

10:00–10:20 **Amy Scott** and Michael S. Ruderman Kink Oscillations of Non-Planar Coronal Loops

10:20 **Discussion**

10:30–18:00 Excursion

THURSDAY, September 1, 2011

09:00–11:00 Space Science (Theatre)

Chair: Mathioudakis M.

09:00–09:40 **Johan De Keyser**, Yuriy Voitenko, Marius Echim and Romain Maggiolo Electrostatic Aurora and Waves (Invited)

09:40–10:00 **Yuriy Voitenko**, Johan De Keyser and Padma Shukla Inertial Alfven waves and turbulence in solar and space plasmas

10:00–10:20 **Galina Korotova** and David Sibeck THEMIS observations of a transient event at the magnetopause

10:20–10:40 **Oleksiy Agapitov** and Oleg Cheremnykh MHD modes coupling in the Earth magnetosphere

10:40–11:00 **Discussion**

11:00–11:30 Coffee break and poster session

Valentyn Bovchaliuk and Oleksiy Agapitov Source of the periodic perturbation in the Solar wind plasma

Aleksei Parnowski Regression modelling of space weather

Oleh Semeniv Learning and evolutionary algorithms for space weather predicting and modelling

Sergei Syusyuckalov, Viacheslav Pilipenko and S Klimanov Wavelet localization of the substorm onset using the ground magnetometer array

Andriy Woschepynets and Oleksiy Agapitov The chorus source structure in the inner magnetosphere

11:30–13:00 Solar observations: From the interior to heliosphere (Theatre) *Chair: Voitenko Yu.*

11:30–11:50 **Manuel Collados** Observational capabilities of the European Solar Telescope

11:50–12:10 **Eduard Kontar**, Iain Hannah and Nicolas Bian Electron acceleration and magnetic fluctuations in solar flares

12:10–12:30 **Istvan Ballai** P1/P2 seismology of coronal loops (Invited)

12:30–12:40 **Adam Stanier**, Philippa Browning and S Dalla Particle acceleration at null points in self-consistent spine and fan reconnection models

12:40–12:50 **Michael Bareford**, Philippa Browning and Ronald Van der Linden The Energy Liberated, via Ideal Kink Instability, from an Ensemble of Isolated and Current-neutralised Coronal Loops

12:50–13:00 **Discussion**

13:00–14:30 Lunch

14:30–16:30 Summer School (Classroom)

14:30–15:30 **Michael Ruderman** Nonlinear waves in the solar atmosphere

15:30–16:30 **Michail Mathioudakis** Ground-based instrumentation and techniques of detecting MHD waves and instabilities

16:30–17:00 Coffee break

17:00–19:00 Summer School (Classroom)

17:00–18:00 **James McLaughlin** Oscillatory Reconnection : Unification of Magnetic Reconnection and MHD Waves

18:00–19:00 **Tutorial** for **All TASS** Lecturers of the day

19:00 Joint Dinner UKU SPSS/TASS

09:00–11:00 Space Science (Theatre)

Chair: Kontar. E.

09:00–09:40 **Vladimir Krasnoselskikh**, D Sundkvist, S Schwartz, Michael Balikhin and V Lobzin
High Mach Number Collisionless Shocks : Cluster Discoveries (Invited)

09:40–10:00 **Hugo Breuillard**, Y Zaliznyak, Oleksiy Agapitov, Vladimir Krasnoselskikh and G Rolland
Reconstruction of Chorus Type Whistler Wave Statistics in the Radiation Belts and Inner Magnetosphere Using Ray Tracing

10:00–10:20 **Alexander Volokitin** and C Krafft
Interaction of suprathermal particle fluxes with waves in magnetized plasma

10:20–10:40 **Yuri Khotyaintsev**, Vladimir Krasnoselskikh, Oleksiy Agapitov and G Rolland
Remote sensing of plasma fluctuations structure by means of VLF waves spacecraft interferometry

10:40–10:50 **Oleksandr Goncharov**, Jana Safrankova and Zdenek Nemecek
The Role of the Interplanetary Shock Orientation on Interaction with the Bow Shock and Magnetopause

10:50–11:00 **Discussion**

11:00–11:30 Coffee break and poster session

Yuriy Rapoport, Yu Selivanov, Vasyl Ivchenko, V Grimalsky, Viktor Fedun and G Milinevsky
Oscillations of neutral and charged components of near-Earth plasma and effects of active media

Sergey Cheremnykh and Vitaliy Yatsenko
Geomagnetic Dst Index Forecast Based on Bilinear Models and Nonlinear Filtering Techniques

Kristina Melikyan, Viacheslav Pilipenko and Olga Kozyreva
Spatial structure of ULF waves in the near-Earth space according to Themis observations

Nikolay Pankov, Sergei Plachinda and Dilyara Baklanova
General Magnetic Field of the Sun as a Star: variability of the frequency spectrum from cycle to cycle

S Fedulova
Effect of weak electromagnetic fields of magnitude of order of geomagnetic pulsations on the formation of GABA-ergic inhibitory synapses in cultured hippocampal neurons.

11:30–12:00 Space Science/Solar observations (Theatre)

Chair: Cheremnykh O.

11:30–11:50 **Vitaliy Yatsenko**
Nonlinear Dynamics of Space Weather: Predictability, Lyapunov Exponents and Applications

11:50–12:00 **Stuart Hardwick**, A Breen, M Bisi, R Fallows, J Davies, R Harrison and C Davis
IPS Observations of Rapid Velocity Variations In the Slow Solar Wind

12:00–12:10 Meeting/Summer School Closing (Theatre)

ABSTRACTS

Solar observations: From the interior to heliosphere

Coronal seismology using standing and propagating MHD waves (Invited)

Marcel Goossens¹, Inigo Arregui², Roberto Soler³ and Jaume Terradas⁴

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I shall review recent results on the resonant absorption of standing and propagating MHD waves in the solar atmosphere and the possible use of these results as seismological tools.

Swirl events in the solar chromosphere

Sven Wedemeyer-Böhm

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So-called swirl events were first detected by observing the chromosphere in a coronal hole region in the line core of the Ca II line at 854.2 nm. Swirls appear as rotating Doppler-shifted thin ring fragments with diameters on the order of 2 arcsec above close groups of photospheric bright points. The magnetic footpoints are buffeted by the convective flows in the low photosphere, which most likely induces twisting and braiding of the magnetic field in the chromosphere above. New three-dimensional radiation magnetohydrodynamic simulations exhibit events resembling the observed swirls. The simulated swirls develop abundantly from an initially weak magnetic field. First results of these computationally involved simulations will be presented and analyzed with respect to their implications for the heating of the upper solar atmosphere. These small-scale events are potentially important building blocks of the solar atmosphere that could provide an efficient way to channel energy from the photosphere into the upper atmosphere.

Puzzling magnetic field oscillations found in the quiet Sun

Maria Jesus Martinez Gonzalez¹ and Elena Khomenko²

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I report on the discovery of a new type of oscillatory behaviour of weak magnetic patches all over the quiet Sun. These oscillations are not associated to isolated, monolithic magnetic structures, but rather to a continuous distribution of magnetic fields whose evolution is largely determined by the turbulent plasma motions. I will show that the area of patches kept at constant magnetic flux in a magnetogram oscillates with time, which implies that the magnetic field oscillates too. The periods of these oscillations are 3-11 minutes, but they may change abruptly in the course of the time series, which suggests that they might not correspond to characteristic oscillatory modes of magnetic structures, but to the forcing by granular motions. In one particular instance, three patches around the same granule oscillating in phase, which means that the spatial coherence of these oscillations can reach 1600 km. Interestingly, the same kind of oscillatory phenomenon is found also in the upper photosphere, suggesting wave propagation.

Coffe break and poster session

Temporal Variations in Photospheric Parameters During a Small Solar X-Ray Burst

Nina Kondrashova¹ and Elena Khomenko²

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²Instituto de Astrofísica de Canarias, La Laguna (Tenerife), Spain; khomenko@iac.es

We present the results of the study of the thermodynamical parameters and the magnetic field in the solar photosphere during a weak soft X-ray burst on 4 July 2009. The analysis is based on the observations with the French-Italian THEMIS telescope, operated on the island of Tenerife in the Spani Observatorio del Teide of the Instituto de Astrofísica de Canarias, in the MRT multi-line spectropolarimetric mode. The high-resolution Stokes I, Q, U, and V profiles of ten photospheric lines are used for the modeling. Semiempirical models are derived from the inversion with SIR (Stokes Inversion based on Response functions) code, described by Ruiz Cobo and del Toro Iniesta (Astrophys. J. 398, 975, 1992). The models include two components: a thin magnetic flux tube and nonmagnetic surroundings. The filling factor obtained from the inversion is about 10%. The temporal variations in all photospheric parameters are revealed during the burst. The magnetic field strength increased from 800 to 1200 G during the onset phase of the burst. The inferred flux-tube models show the temperature enhancement in the photospheric layers relative to the quiet-Sun model atmosphere at the onset of the burst. The temperature inhomogeneities are found in the inferred atmosphere at the end of the burst.

Lower Atmosphere Dynamics Of The New-Cycle Active Region NOAA 11024

Margarita Pasechnik¹, Nina Kondrashova² and Svetlana Chornogor³

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We analyze the variations of the line-of-sight velocity field in the chromosphere and the photosphere of the active region NOAA 11024, at the new solar activity cycle onset phase. The simultaneous multi-wavelength observations were carried out by E. V. Khomenko with the French-Italian THEMIS telescope of the Instituto de Astrofísica de Canarias, on 4 July 2009. We use one of the time series of the high resolution spectra over 20 minutes under good seeing conditions, obtained in the H alpha line and the FeI 6301.5Å, 6302.5Å, 6303.7Å lines, and the TiI 6303.4Å line. The spectrograph slit intersected two sunspots 9472; large and small, and two plages 9472; active and quiet. We revealed strong velocity temporal variations in the chromosphere and in a wide interval of photospheric heights for different active objects. The physical state and the velocity field structure of the active region in the lower atmosphere layers were very unstable during the observations. The chromospheric matter motions with the velocity $-8 \div 11$ km/s are observed in the large spot, $1 \div 9$ km/s in the small spot, $-19 \div 18$ km/s in the active plage, $-5 \div 5$ km/s in the quiet plage. The large negative velocities are associated with the surges. At all the photospheric levels the upward motions are found with the velocities up to -0.8 km/s, -3 km/s, -2 km/s, and -1 km/s, respectively. We analyzed the space telescopes GOES, SOHO, STEREO data as well. During our observations the B1 class soft X-ray burst was recorded by GOES. The EUV-images and the H alpha-spectra show the expansion of the heated plasma along the loops. All the data indicate the close relationship of the detected velocity variations with the physical processes in the corona.

Convective and wave motions in thermal plume

Roman Kostik

Main Astronomical Observatory, NASU, Kyiv, Ukraine; kostik@mao.kiev.ua

We analyze wave and flow motions, thermal structure and other properties of a so-called "thermal plume" which we observed with the VTT (Tenerife) in August 2001. The time series of spectral images with a total duration of about 158 minutes were acquired in the two FeI and FeII iron lines simultaneously. The observations revealed a rather stable feature which has been detected during the whole period of observations. The size of this feature along the slit was 2000-2500 km. The plume shows a compact brightening in comparison with the nearby granulation. At heights around 200 km, its intensity contrast is a factor of two larger than that of the surrounding area while reaching a factor of 4 at heights near 500 km. The following properties characterize the feature during the whole period of the observations:

1. The high-speed downflow of 1 km/s had been seen at the continuum level. At higher photospheric layers upward flows had been observed with the modulus of the velocity increasing with height. The sign change of the velocity occurs at about 170 km.
2. The velocity-intensity correlation does not exceed 0.25 at all observed heights from 0 km up to 500 km.
3. The amplitudes of the five-minute oscillations of the intensity and velocity are twice lower than outside the plume.
4. There is a large difference between spectral line asymmetry observed in the plume and quiet regions.

We conclude that the observed phenomenon has a non-convective origin. The thermodynamic properties of the atmosphere where the plume occurred have been recovered from the observed profiles using the SIR inversion code. We used the spatially averaged profiles of granules, intergranular lanes and the plume in the inversion. The plume is found to be hotter and more dense than the quiet Sun at almost all heights in the photosphere. The average magnetic field is non-zero in the plume. It can be around 400 G. The decrease of the amplitudes of oscillations can be attributed to the larger density and the stronger magnetic field in comparison with the surrounding atmosphere.

General Magnetic Field on weakly-active yellow giant β Geminorum

Dilyara Baklanova¹, Sergei Plachinda², D Mkrtychian³, I Han⁴ and K.-M. Kim⁵

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Pollux is a neighbor of the Sun with known regular surface magnetic field about 1 Gauss. Together with the spectropolarimetric observations of β Gem, which were carried out during 10 nights 2010 at the Crimean Astrophysical Observatory using coude spectrograph of 2.6-meter Shajn telescope and Stokesmeter, we also used spectropolarimetric observations, which were obtained at Bohyunsan Optical Astronomy Observatory with 1.8-meter telescope and high-resolution échelle spectrograph BOES during 4 nights 2007. In addition we used precise radial velocity literature data. Analysis of the periodic behavior of magnetic field and radial velocities was performed. The radial velocity measurements of Pollux show variations with period 592.9 days due to the planetary companion. Using magnetic field data we estimated the axial rotation period of the Pollux of 491.5 days. The centered dipole gives the angle between spin axis and line of sight $i = 31^\circ$ and the angle between both the spin and dipole axes $\beta = 133^\circ$.

Type II Radio Bursts and the solar proton acceleration by the interplanetary shock waves

*Yuriy Tsap*¹ and *E Isaeva*²

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The correlation between the meter and the decameter-hectometer type II bursts with the solar energetic particle events based on observations with the Radio Solar Telescope Network and the Wind satellite in 1989-2005 has been considered. Analysis of the 87 solar energetic particle events showed that the correlation coefficient between the proton flux intensity and the frequency drift velocity for the type II radio bursts does not exceed 0.40. The proton flux intensity increases with an increase of the frequency drift velocity for the meter bursts while it decreases for decameter-hectometer bursts. The efficiency both the diffusive shock acceleration and the shock-drift mechanism increases with an increase of the Mach number, which is proportional to the frequency drift velocity of the type II radio bursts. Comparison of experimental and theoretical results suggests that the interplanetary shock waves as distinguished from the coronal ones do not effectively accelerate solar energetic protons.

Solar observations: From the interior to heliosphere

Magnetization of the quiet sun photosphere from the Hanle effect and surface dynamo simulations

Nataliya Shchukina¹ and Javier Trujillo Bueno²

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²Instituto de Astrofísica de Canarias, La Laguna (Tenerife), Spain; jtb@iac.es

We have solved the radiative transfer problem of resonance polarization and the Hanle effect of the Sr I 4607Å line in a 3D model of the quiet solar photosphere resulting from the magneto-convection simulations with surface dynamo action of Vögler & Schüssler (2007). We find that the level of magnetic activity in their surface dynamo model is too low for explaining the scattering polarization observations of the Sr I 4607Å line. The observed linear polarization amplitudes can be explained after multiplying each grid-point magnetic strength by a scaling factor $F \approx 12$ which implies ≈ 130 G in the upper photosphere. We also argue that in order to explain both the Hanle depolarization of the Sr I 4607Å line and the Zeeman signals observed in Fe I lines, we need to introduce a height-dependent scaling factor, such that the ensuing ≈ 160 G in the low photosphere and ≈ 130 G in the upper photosphere.

Which model is suited for my spectro-polarimetric observations?

Andrés Asensio Ramos

Instituto de Astrofísica de Canarias, La Laguna (Tenerife), Spain; aasensio@iac.es

The selection of a model for the inversion of Stokes profiles is typically done based on subjective reasons. In this talk I present the application of Bayesian model comparison techniques for deciding which is the model best suited to the observations. The Bayesian approach correctly balances the complexity of the model with the amount of information present on the observations.

Small-scale kinetic instabilities of low-frequency waves in preflare plasma of the chromosphere of solar active region.

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The process of the small-scale kinetic instabilities rise and development for the low-frequency plasma waves has been studied for the preflare chromospheric plasma near the foot-point of flare loop, - in the area of relatively weak "mixed" magnetic fields. Subreicer electric field in a loop as well as spatial inhomogeneity of plasma temperature and density have been considered as the main drivers of these instabilities. It has been shown that development of these instabilities is the main reason of generation of kinetic Alfvén waves and kinetic ion-acoustic waves well before the beginning of the "preheating phase" of the flare process in the atmosphere of solar active region.

Hinode Observations and MHD Waves in the Solar Photosphere

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The origin of the quasi-periodical photospheric pulsations of the line-of-sight magnetic field, the line-of-sight velocity, and the intensity with periods of 3-6 and 4-9 min revealed with the SOT/Hinode space telescope in the pores and in the intergranular magnetic elements, respectively, is considered. Following Fujimura and Tsuneta (ApJ, 2009, 702, 1443) these pulsations are connected with the excitation of the magnetohydrodynamic oscillations in the magnetic flux tubes by convective motions. The phase relations between disturbed variables in the case of the excitation of the slow magnetoacoustic waves with regard to the gravitational force are analyzed. As distinguished from Fujimura and Tsuneta (2009) it has been shown that observed pulsations can be caused by the generation of the resonance evanescent waves rather than the formation of the standing ones. Consequences of obtained results are discussed.

Summer School

MHD waves and oscillations in the solar atmosphere

Robertus Erdélyi

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Recent solar and space satellite missions (e.g. SOHO, Trace, STEREO, Hinode, SDO) and high-resolution ground-based observations (e.g. COMP at the Swedish Solar Telescope, Dutch Open Telescope, ROSA & IBIS at Dunn Solar Telescope) have opened new avenues for 21st century plasma astro-physics. With unprecedented details a very rich and abundant structure of the solar atmosphere is now unveiled from tiny magnetic bright points to large cross-equatorial loops. Revolutionary observations clearly confirmed the existence and ubiquitous abundance of MHD waves and oscillations in a wide range of solar atmospheric magnetic structures. The first objectives of this review is to give an up-to-date account of the observational findings of MHD waves and oscillations in the solar atmosphere.

Parallel to the impressive observational developments the theory of MHD waves and oscillations in solar and astrophysical magnetic waveguides has also taken a leap in recent years. Since magnetic structuring acts as excellent waveguide, plasma waves and oscillations are able to propagate and form in these structures. The second objective of my lecture will be to introduce the students to the theory of MHD waves and oscillations. We will briefly introduce the linear theory of MHD waves and oscillations in a range of geometries, including magnetic surfaces, slabs and cylinders. The complexity introduced by the waveguide stratification, inhomogeneity, geometry, non-ideal effects and the dynamic nature of the waveguide will be addressed.

Observations and theoretical modelling of waves can provide excellent diagnostic tools about the state of the magnetised solar plasma. Key examples of the various types of MHD waves and oscillations will be discussed in details both from observational and theoretical perspectives and the novel concept of solar magneto-seismology will be covered. The lecture will also contain a few short exercises in order to highlight the important and subtle points of the applications of solar MHD wave and oscillation theory.

Wave and particle interaction in heliophysics

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All solar transient phenomena is accompanied by a large number of dramatic phenomena often related to wave-particle phenomena. The theoretical basics of high frequency plasma oscillations and their role in the remote sensing of various heliosphere phenomena including shocks, energetic particles, etc will be overviewed. The interactions between waves and energetic particles will be briefly summarized. The basic physics discussion will be complemented by recent observational results and methods using data from various space and ground based instruments.

Summer School

How can advanced data analysis methods teach us about physics?

Michael Balikhin

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There are many examples of complex dynamical systems for which our present level of knowledge lacks the details required to describe the system using an analytical model derived from first principles. The fields of biology and medicine provide many obvious cases of complex nonlinear systems, for example the functioning of the brain of any living creature. Although the terrestrial magnetosphere is not quite as complex as many biological systems, we are still far from the situation in which we can derive the ultimate mathematical relation that governs its evolution under the influence of the solar wind.

Data based identification of nonlinear processes that occur in these complex dynamical systems can help to develop analytical models. Identification of nonlinear processes based on Volterra decomposition and its application to experimental studies of space plasma turbulence and magnetospheric dynamic will be reviewed.

Numerical simulations in the solar and astrophysical plasmas

Chromospheric Swirls: What is the response of the solar corona? (Invited)

Eamon Scullion¹, L Rouppe van der Voort², J de la Cruz Rodriguez³, Viktor Fedun⁴ and Robertus Erdélyi⁵

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Recently discovered, and highly abundant, chromospheric swirls may play an important role in channelling magnetic energy and plasma from the solar surface/interior towards the hot outer solar corona. Spatially confined swirl events were first detected (2009) in the chromospheric Ca-II 854.2nm spectral line with the 1-m Swedish Solar telescope (SST). Their characteristic vortex motions are thought to be driven by the build up of magnetic tension in the intergranular magnetic flux concentrations. But we still do not understand (both observationally and numerically) what is the response of the corona to these chromospheric swirls? Is there sufficient energy flux in the swirls to heat the outer atmosphere and contribute to the coronal heating? Here we present follow up observations (Ca-II 854.2nm and H_α (656.3nm) spectral line scans) of chromospheric swirls, as observed with SST / CRISP (Crisp Imaging Spectro-polarimeter: 0.06 arcsec spatial resolution in H_α , 15 s cadence) in May 2011. We successfully co-align these observations with the SDO/AIA (Solar Dynamics Observatory: 0.6 arcsec spatial resolution) field-of-view revealing the corona counterpart of swirls. Furthermore, we present supporting 3D numerical simulations of swirl formation using a fully non-linear MHD code (SAC: Sheffield Advanced Code), in order to investigate wave propagation (driven by photospheric granulation) and transmission through the chromosphere and into the corona. As a result, we address an important piece of the puzzle regarding solar swirls and, hence, further our understanding of how small-scale processes couple into the magnetized corona.

Partial Ionization Effects in the Solar Photosphere and Chromosphere

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The particular temperature and density conditions in the magnetized photosphere and chromosphere of the Sun can lead to a very small degree of atomic ionization. In addition, the magnetic field may be strong enough to give rise to a cyclotron frequency larger than the collisional frequency for some species, while for others the opposite may happen. Under these circumstances, the collective behavior of the particles may be influenced and some of the hypotheses of magnetohydrodynamics may be relaxed, giving rise to additional terms in the classical MHD equations. In this contribution, the results of numerical simulations using the modified equations applied to magnetic structures of diverse field strength will be shown. Some consequences derived from the new terms of the equations on the solar photosphere and chromosphere will be discussed.

Multiwavelength radiative diagnostics of high-resolution MHD simulations of solar photosphere

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Using radiative MHD modelling of the solar magnetised photosphere and multiwavelength radiative diagnostics of the simulated photospheric models, we compute artificial images of the solar photosphere as observed in various spectral bands used in solar observations. We analyse the simulated observations in terms of properties of the radiation, such as intensity contrast, statistical distribution of photospheric magnetic bright points on their characteristics, thus providing the link between the solar plasma parameters and the parameters of radiation originating from it.

3D Numerical Simulation of Torsional Alfven Waves

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High-resolution ground-based observations provide clear evidence for the existence of oscillations driven by magnetic twist in solar flux tubes. These torsional oscillations are associated with Alfven waves. It is of particular interest to study the excitation and propagation of torsional Alfven waves into the upper, magnetised atmosphere because they can channel photospheric energy into the corona. Here we examine numerically the direct propagation of such torsional waves, driven at the foot-point of a solar magnetic flux tube, into a three-dimensional magnetised atmosphere representing the gravitationally stratified solar atmosphere between the photosphere and low corona. The simulations are based on fully compressible ideal magneto-hydrodynamical modelling. The model solar atmosphere is constructed based on realistic temperature and density stratification derived from VAL IIIIF, and is most suitable perhaps for a bright magnetic network element or magnetic pore. We discuss how torsional photospheric motion can excite Alfven and other types of MHD waves that reach the upper parts of the solar atmosphere. Finally, we briefly discuss the observational signatures of these waves.

Coffee break and poster session

On mystery of solar and stellar magnetic fields measured in different lines

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An unexplained effect one can see on the Sun and some chemically peculiar magnetic stars is that the effective magnetic field values measured in different spectral lines are significantly differed from each other. The short review of the problem for Sun and chemically peculiar stars beta CrB and theta Aur and normal star alpha Lyr are presented. It is shown that the problem is common for Sun and other stars with magnetic fields.

Identification Methods of Magnetic Bright Points

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Magnetic Bright Points are small scale magnetic structures in the solar photosphere which can be seen better at G-band images of Hinode/SOT. Hinode was launched in autumn 2006 and delivers multi-wavelength data from the photosphere to the upper corona of sun. In this poster we present our research on identification methods of Magnetic Bright Points and we set our algorithm based on "developed MLT-4 algorithm".

Quasi-periodic motion of the Earth dayside magnetopause

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Terrestrial magnetopause (MP) is a current sheet between two plasmas which are frozen in the solar and the Earth's magnetic fields. Different perturbations of the solar wind and magnetosphere make MP to be a highly dynamic object and subject to various hydrodynamic and plasma instabilities. Multi-spacecraft observations in the framework of THEMIS mission provides an opportunity to reconstruct the shape and dynamics of MP.

We focus our study on the properties of the quasi-periodic MP motion and magnetosphere waves with the same frequencies (ULF range) on the base of magnetic field measurements by Fluxgate Magnetometer (FGM) and plasma parameters measurements by Electrostatic Analyzer (ESA) aboard the five THEMIS spacecraft. We present the following results: (a) the MP motion characteristics for different solar wind regimes; (b) the statistical relationship between the amplitude-frequency characteristics of MP surface traveling disturbances and solar wind parameters; (c) the comparison of MP motion with MHD waves inside the magnetosphere; (d) the model of the dayside MP shape taking into account its dynamic properties during 2007-2011 years. Two different types of MP motion directly connected to magnetosphere wave activity can be distinguished: surface waves and one dimensional displacement of surface. Dayside one dimensional periodic displacements are caused by cavity modes - standing fast MHD wave between the magnetopause and reflection point near the plasmapause. Traveling surface waves are generated mainly by the cavity modes and can be sufficiently increased later by the Kelvin-Helmholtz instability.

Relationship of P1/P2 for a string with non-uniform density

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The transversal oscillations of coronal loops within the solar atmosphere have been studied widely since they were observed by TRACE in 1999. It is only relatively recently that the first harmonic of this oscillation behaviour has been reported. The transversal oscillations of coronal loops often can be modelled surprisingly accurately by investigating the transversal oscillations of a one-dimensional string. By analysing the relation of the properties of the fundamental harmonic to the first harmonic of a transversally oscillating finite string with a non-uniform density, and by considering both two-fixed end and one open end models, here we attempt to expand the solar spatio-seismology work of Verth et al., who studied the anti-node shift of the first harmonic with relation to the density stratification. Applying this advanced solar magneto-seismology method to real solar data, it could well be possible to observationally infer the density structure of the oscillating coronal loop within the solar atmosphere, a wonderful tool for continuing the structured mapping of the upper solar atmosphere.

Dst-index forecasting using an adaptive two-level model adjustment

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The dynamic relationship between the geomagnetic activity index and solar wind parameters can be adequately described by the nonlinear dynamic regressive model. However, the parameters of that model depend also on the slowly varying factors caused by season and solar cycle phase. The impact of these factors can be accounted in the model with a large memory depth. But this leads to increase of the model dimension and parameters as a cosequence. As a result, the accuracy of model parameters determination decreases [1].

We proposed the alternative approach in which the simple model of small dimension is used for description of the magnetic storms development and the model parameters are adjusted functions of the slowly varying factors. Dimension and the model parameters are determined using a new approach [2]. Actually, two stages process of the model adjustment is used: the local current model parameters are determined for each separate storm which values are then used for approximation of their dependence on slow-changing factors that affect the dynamics of the storm. Developed approach as much as possible accounts for the specific tasks of short-term prediction of magnetic storms, its effectiveness is demonstrated on a number of examples.

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Space Science

Rapid acceleration of charged particles by nonlinear wave trapping in the magnetosphere and cosmic plasmas

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We present a particle acceleration mechanism called ultra-relativistic acceleration (URA). URA comprises electron energization due to a special form of nonlinear phase trapping by a coherent whistler-mode wave for electrons exceeding a certain critical energy. The critical energy depends on the wave frequency and the electron gyrofrequency at the equator of an assumed dipole magnetic field. Radiation belt electrons that encounter a combination of relativistic turning acceleration (RTA) followed by multiple URA interactions can undergo significant energy increase. Under ideal conditions, at Earth ($L=4$) several-hundred-keV electrons can be energized to several MeV within a few seconds, while at Jupiter ($L=8$), several-hundred-keV electrons can be energized by tens of MeV in a few tens of seconds. URA can play a prominent role in generating the several-MeV electrons observed in Earth's outer zone and the tens-of-MeV electrons observed in Jupiter's magnetosphere. More generally, we expect URA to be an effective electron energization mechanism in cosmic plasma environments that contain a magnetic mirror geometry and electromagnetic whistler-mode emissions.

Characteristic of the Traveling Ionospheric Disturbances from the Multi-Satellite and Ground-Based Observations

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The characteristics of the large-scale and media-scale Traveling Ionospheric Disturbances (TIDs) connected with the Internal Gravity Waves (IGWs) are studied from the multi-satellite and ground-based observation. The data of the Intercosmos-19, Cosmos-900, Cosmos 1809 and DMSP satellites, SuperDARN radars and ground-based magnetometers and ionospheric stations are used. Several disturbances with the different intensity were investigated and the following main results were obtained. During the intense disturbance (magnetic storm) the wave front of the TID covers all local times, i.e., all longitudes. During the media disturbance (substorm) the area where the TID is observed looks like a wedge since it covers the night time hours at the sub-auroral latitudes and contracts to 02 LT local sector at the low-latitudes. The ionospheric response is strongly asymmetric because the wedge area and the TID amplitude are larger in the winter hemisphere than in the summer one. The clear evidence was obtained that in the midnight hours the more powerful TID from the winter hemisphere passes across the equator to the low latitudes of the summer hemisphere. Intercosmos-19 data show that the disturbance covers all the thickness of the topside ionosphere, from hmF2 up to at least the satellite height (of 1000 km). The relationship between the TID parameters and the source characteristics from the global network of the magnetometers are studied. The role of the day-side cusp in the generation of the TID in the day time ionosphere is discussed. It is shown that the use of SuperDARN radars is a more powerful technique than a routine ground-based sounding for studies of weak quasi-periodic variations in the dayside sub-auroral ionosphere related to IGW. The propagation of the IGWs was also detected from the quasi-periodic variations in the skip distance of the ground backscatter measured by SuperDARN radars. The method was also devised to extract the weak TIDs from the topside sounding data. The IGW effects were clearly separated from the magnetospheric electric field effects.

ULF MHD Perturbations in the Inner Magnetosphere of the Earth: Theoretical Study

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We analyze coupled Alfvén and slow magnetosonic eigenmodes in the dipolar geomagnetic field model with different ionospheric conductivities in the framework of ideal single-fluid magnetic hydrodynamics (MHD) with finite pressure. We derived a set of equations describing arbitrary perturbations with small transversal scale of a static MHD equilibrium, which generalizes the results of Cheng and Chance (1986) on one hand and of Dewar and Glasser (1987) on another. We use analytical and numerical methods to determine eigenmode frequencies, growth rates and waveforms. The spectrum of Alfvén and slow modes is discrete and equidistant. The eigenmode frequencies of the first Alfvén and slow eigenmodes are estimated as 1 Hz and 1 mHz respectively. In the case of finite conductivity, periodic and aperiodic modes are separated and their interaction is analyzed. Their mutual conversion was demonstrated. A flute stability criterion, which is stricter than Gold criterion, is derived. For quasiflute eigenmodes, the deviations of transversal displacement from a constant value are calculated. An approximation for longitudinal displacement near the ionosphere is derived.

Ion cyclotron turbulence of plasma shear flows and related anomalous transport

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The sounding rocket and satellite data have demonstrated [1] that often observed in the ionospheric plasma environment magnetic field-aligned shear flows correlated with broadband low-frequency electrostatic oscillations and with anisotropic heating of ions predominantly across the magnetic field. These oscillations were detected under conditions at which the parallel current density was above as well as below the threshold for the ion cyclotron current driven (ICCD) instability, which has the lowest threshold in the ionosphere plasma without shear flow. It was shown [2-4] that shear flow along the magnetic field does not only modify the frequencies, growth rates and the thresholds of the known ICCD instability, but it is a source of the development of shear-flow-driven ion cyclotron instabilities at the levels of field-aligned current which are subcritical for the development of the ICCD instability. In this report, we present new results of the comprehensive analytical investigations of the linear and nonlinear evolution of the shear flow modified and shear flow driven ion cyclotron instabilities in one and two ion species plasma. It is shown that the shear-flow-driven electrostatic ion cyclotron instabilities can be considered as a combination of different instabilities determined by their own mechanism of excitation: ion-kinetic, ion-hydrodynamic and electron-kinetic. Each of these instabilities are dominant in different ranges of the wavelength along the magnetic field. The renormalized strong turbulence theory [3], which accounts for the combined effect of shear flow and turbulent scattering of ions, is used for the comparative analysis of different mechanisms of the nonlinear evolution instabilities and determining the ultimate levels of the energy density of the turbulence in the saturation states in different ranges of the wavelength. The turbulent heating rates of plasma species resulted from the interaction of ions and electrons with turbulence in plasma shear flow are determined. The results obtained give the assessment of the ion cyclotron turbulence as a possible sources of the anomalous anisotropic collisionless heating of ions and electrons in ionosphere shear flows.

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Summer School

MHD waves and instabilities: Numerical modelling

Alan Hood

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Some basic ideas in the numerical modelling of MHD waves and instabilities will be presented. For the linear MHD equations, schemes like Lax-Wendroff are simple to code but care must be taken to ensure that code remains numerically stable and that the waves in the numerical solutions propagate at the correct speeds. Identifying numerical dissipation from real dissipation is extremely important and examples will be presented. Numerical modelling of MHD instabilities is tricky and can must be taken when using a linear code. Some examples of linear MHD instabilities will be presented. Other schemes for studying linear and nonlinear waves will be discussed.

Implementation of Magnetohydrodynamic codes for gravitationally stratified media on hybrid and highly parallel graphical processing units

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We describe the implementation of Magnetohydrodynamic codes for gravitationally stratified media on graphical processing units and highly parallel compute architectures. The aim of the paper is to present the numerical methods used and the techniques for porting the code to this novel and highly parallel compute architecture. The methods employed are justified by the presentation of validation results and performance benchmarks.

Summer School

From MHD waves via kinetic waves toward plasma energization.

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In this lecture I will introduce a basic physical description of magnetohydrodynamic (MHD) waves and their kinetic counterparts. The particular emphasis will be on Alfvén waves (AWs) - energetically dominant wave mode in space plasmas immersed in the background magnetic field. Kinetic Alfvén waves (KAWs) is a generic name for AWs modified by various effects arising with decreasing cross-field wavelengths. A genuine signature of KAWs has been found in many phenomena observed in space and in laboratory. We will start describing KAWs by means of a "2-fluid foot-bridge" from large (MHD) to small (kinetic) length scales. Next, in order to explain how KAWs interact with particles, we will add basic notions from kinetic plasma theory and from nonlinear theory. This will allow us to understand how KAWs are generated and dissipated, and what effects they produce in plasma. In the last part I will present several new results concerning KAWs and their applications to recent satellite observations of the solar corona, solar wind and terrestrial magnetosphere.

Analytical theory of waves in magnetised plasma

Solar Magnetoseismology (Invited)

Gary Verth

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In this talk I will review the most promising and exciting area of solar physics known as magnetoseismology. This technique, analogous to seismology here on Earth, analyses observations of waves in the Sun's atmosphere and compares them to the detailed results of mathematical models. From that comparison, crucial information about the Sun's local plasma environment can be obtained, e.g., magnetic field strength, which cannot be easily measured by other means. In the last decade, magnetoseismology of the Sun has made great leaps forward due to the advances of space borne and ground based telescopes. After initial success, a new generation of improved instruments primarily dedicated to detecting waves in the solar atmosphere were developed, e.g., Hinode (Japan), Solar Dynamics Observatory (USA) and Rapid Oscillations in the Solar Atmosphere (UK). In this talk I will discuss recent advances in magnetoseismological techniques that exploit the wealth of data from this "new generation" of instruments to probe the structure of Sun's atmosphere with unprecedented accuracy.

High energy laser pulse propagation in plasma: photon acceleration and self focusing effects.

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The interaction of intense electromagnetic fields with matter is currently an important area of research. In many cases the propagation of an intense laser pulse in plasma plays an important role. We present an analysis of pulse propagation using the ray-tracing approach and compare it with a fluid description using set of partial differential equations for the electric and magnetic fields. This work is relevant to the evolution of the laser pulse in laser plasma wakefield accelerators operating in the bubble regime.

Kink Oscillations of Non-Planar Coronal Loops

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Many types of oscillations have been observed on the Sun, including kink oscillations of coronal loops. The simplest model used to investigate these oscillations is a circular magnetic cylinder. Recently more sophisticated models have been used. However, all of them concerned oscillations of planar loops. We have considered a simple three dimensional model of a curved, non-planar loop, with helical geometry. Using the thin tube approximation we have examined the kink oscillations of this loop. In particular, we have found that, depending on the direction from which we observe the loop oscillation, it is possible for the fundamental mode of a helical loop to look like the second harmonic of a planar loop. We have also gone on to investigate the effect that a non-planar loop has on the ratio of the periods of its fundamental mode and second harmonic.

Space Science

Electrostatic Aurora and Waves (Invited)

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Auroras are the manifestation of a specific form of coupling between magnetosphere and ionosphere. Understanding the underlying electric current circuit remains a major challenge. In particular, there are two groups of models for explaining the origin of parallel auroral electric fields: the electrostatic models and the wave models. Since auroral acceleration is known to occur as the result of the action of such parallel electric fields, a proper understanding is very much needed.

We will focus here primarily on the electrostatic model of auroral systems in which the generator is located in the magnetosphere, and where the ionosphere represents a load. The behaviour of the current system is controlled by current continuity. The generator is described in terms of magnetospheric electric fields. The ionospheric load is modelled in a very simple way. The crucial role of the current-voltage relation is highlighted. We illustrate various types of auroral and subauroral signatures that are found in the Earth's magnetosphere-ionosphere system. The model results are compared to in situ observations.

Nevertheless, the observations clearly indicate that both electrostatic and wave features are important. The present contribution aims at bridging the gap between both types of models, by studying the problem for sufficiently low frequencies. Electrostatic acceleration then remains the dominant phenomenon. The waves nevertheless do modify the configuration. It is suggested how and where higher-frequency waves would lead to further modifications of the electrostatic picture.

Inertial Alfven waves and turbulence in solar and space plasmas

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Kinetic Alfven waves (KAWs) are known to be important for energy transport and release in space plasmas. Recent FAST measurements have revealed a turbulent character of inertial KAWs and their spectra in auroral zones at 1.5-2 Earth's radii. Radio scintillations measurements suggest the presence of the KAW turbulence in the high solar corona as well. We address the problem of how the turbulent state can be achieved and maintained by the nonlinear interactions among inertial KAWs. We derived new analytical expressions for nonlinear KAW interactions and found new turbulent spectra. The wave-particle interactions and their consequences in the context of energy release in the auroral zones and solar corona are also discussed.

THEMIS observations of a transient event at the magnetopause

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This study focuses on THEMIS observations of a long-duration transient event in the vicinity of the dayside magnetopause at 1534 UT on July 18, 2008 that was characterized by features typical of a magnetospheric flux transfer event (FTE): a bipolar (-,+) 5-7 nT signature in the B_n component, a positive monopolar variation in the B_l and B_m components, a 5-7 nT enhancement in the total magnetic field strength, and a transient density and flow enhancement. The interplanetary magnetic field (IMF) was mostly radial and disturbed during the intervals studied, i.e., it was favorable for the repeated formation, disappearance and reformation of the foreshock just upstream from the subsolar bow shock. We show that varying IMF directions and solar wind pressures created significant effects that caused the compressions of the magnetosphere and the bow shock and magnetopause motions and triggered the transient event. Global signatures of magnetic impulse events (MIEs) in ground magnetograms during the period suggest a wide-spread pressure pulse instead of a localized FTE as the cause of the event in the magnetosphere. The directions of propagation and the flow patterns associated with the event also suggest an interpretation in terms of pressure pulses.

MHD modes coupling in the Earth magnetosphere

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The eigenmode spectrum of the MHD waves in the plasma system with the dipole magnetic field configuration is discrete and consists of Alfvén and slow magnetosonic modes. Their interaction depends on boundary conditions and the magnetic field curvature. We present the physical conditions of resonant MHD waves realization obtained for different wave polarization type. The poloidal waves strongly couple with slow MHD waves. The critical influence of the magnetic shear for the poloidal modes is shown. The toroidal resonant ULF waves have not the magnetic pressure and plasma pressure perturbation component. The verification of obtained conditions with parameters of waves collected in the inner Earth magnetosphere by spacecraft is carried out. The magnetic field pressure and plasma pressure anticorrelation oscillation with partial pressure compensation is obtained for coupled slow MHD and Alfvén waves. The obtained polarization properties of magnetosphere ULF waves are in a good agreement with the theoretical prediction.

Coffee break and poster session

Source of the periodic perturbation in the Solar wind plasma

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The poster is devoted to analysis of the periodic MHD perturbation detected in the interstellar plasma on the Earth orbit by the THEMIS spacecraft. We use the magnetic field and plasma parameters measurements aboard THEMIS B spacecraft (the apogee is 30 RE). Periods of observed perturbations are close to the periods of the field line resonance modes of the Earth magnetosphere so the detected periodic perturbation can effectively couple with the magnetosphere Alfvén resonance system. We determine the wave vector direction, the ellipticity, and the polarization properties by use of the singular value decomposition, the imaginary part of the spectral matrix analysis and the minimum variance analysis. We find the wave vector direction and the wave phase velocity by use the minimization of the Faraday rescue technique. We find that the observed oscillation of the plasma parameters can be explained in terms of the Alfvén wave Sun-ward propagation in the moving system of the solar wind. The Alfvén wave is observed in the vicinity of the interplanetary shock wave surface and in the region with electron and proton beams accelerated by the shock. We speculate that exactly the observed particle beams generate the periodic MHD perturbations due to beam instability.

Regression modelling of space weather

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We developed a new approach to the problem of real-time space weather indices forecasting using readily available data from ACE and a number of ground stations. It is based on the regression modelling method [1-3], which combines the benefits of empirical and statistical approaches. Mathematically it is based upon the partial regression analysis and Monte Carlo simulations to deduce the empirical relationships in the system. The typical elapsed time per forecast is a few seconds on an average PC. The proposed system can also be useful for investigating physical phenomena related to interactions between the solar wind and the magnetosphere.

1. Parnowski A.S. Regression modeling method of space weather prediction // *Astrophysics Space Science*, 2009, **323**, 169
2. Parnowski A.S. Regression Modeling and its Application to the Problem of Prediction of Space Weather // *Journal of Automation and Information Sciences*, 2009, **41**, 61
3. Parnowski A.S. Statistically predicting Dst without satellite data // *Earth, Planets and Space*, 2009, **61**, 621

Learning and evolutionary algorithms for space weather predicting and modelling

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The solar energy provides a great impact on technical systems in the Space and in the Earth surface. Such an influence happens due to the mass ejections from the Sun. The solar wind causes storms which impact the stable work of electronic and electrical systems. The space weather abnormal perturbations occurring during solar cycles can bring to the electricity systems overload breakages. The problem of space weather modelling & predicting is considered on the example of Dst-index and Ap-index forecasting. The method is suggested for the model identification for predicting the dynamics of geomagnetic indexes using satellite and ground experimental data. The method is based on reconstruction of a nonlinear discrete dynamic input-output system with several input variables. The model structure, as well as its parameters is chosen by solving the mathematic programming problem with constraints. The learning and evolutionary methods have been used to developing heuristic algorithm of the mix mathematic programming problem solving. An advantage of this approach is that the algorithm is able to automatically select the appropriate input variables as well as to simultaneous search of the optimal model structure and its parameters using genetic methods. This research was supplied by the National Academy of Sciences of Ukraine under the Scientific Program "GEOKOSMOS".

1. Semeniv O.V., Sidorenko V.I., Shatokhina Iu.V., Cheremnykh O.K., Yatsenko V.A. Optimization Approach to Space Weather Prediction // Journal of Automation and Information Sciences, 2008, **40**, 41
2. Yatsenko V.A., Cheremnykh O.K., Kuntsevich V.M., Semeniv O.V. Identification of Models of Geomagnetic Activity and Space Weather Prediction // Journal of Automation and Information Sciences, 2009, **41**, 58
3. Cheremnykh O., Yatsenko V., Semeniv O., Shatokhina Iu. Nonlinear dynamical model for space weather prediction // Ukr. Physician Journal, 2008, **53**, 502
4. Semeniv O.V., Yatsenko V.A. Identification of dynamic models for Dst-index forecasting // Space science and technology, 2010, **16**, 51

Wavelet localization of the substorm onset using the ground magnetometer array

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We have implemented the method to restore the amplitude and phase fronts of ULF wave disturbances in the range of Pi1-2 geomagnetic pulsations using the data from the ground array of magnetometers. The algorithm is based on complex wavelet analysis and subsequent 2D interpolation of the wavelet coefficients. The fronts are presented as 2D contour surfaces of wavelet coefficients at any selected frequency with a short cadence. This technique was validated for various modeling disturbances. The method was applied for the determination of an apparent ionospheric source of Pi1-2 burst during the explosive substorm phase using the combined data from available magnetometer arrays in Canada. The developed method enables one to estimate the source localization, to monitor the disturbance propagation pattern in various frequency bands, and even to reveal a ULF "precursor" of the substorm onset.

The chorus source structure in the inner magnetosphere

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Discrete ELF/ULF chorus emissions are the most intense electromagnetic plasma waves of the whistler diapason observed in the Earth's radiation belts and in the outer magnetosphere. They are suggested to be generated due to the cyclotron instability in the plasma with the velocity anisotropy. Thus the wave generation region is assumed to be located at the magnetic field minimum which is situated in the vicinity of the magnetic equator in the inner magnetosphere. Previous studies showed that the source position can deviate from the geomagnetic equator by a several degrees. The main aim of our work is to investigate the source position and structure during high geomagnetic activity time intervals. To achieve our aim we use Spatio Temporal Analysis of Field Fluctuation (STAFF) spectral matrices measurements for 27 frequencies (Spectrum Analyzer measurements from 8 Hz to 4 kHz) and magnetic field measurements by flux gate magnetometer (FGM) aboard the four Cluster spacecrafts. We estimate the Poynting flux direction for the whistler wave frequencies range. Changes of Poynting flux direction (relatively the magnetic field direction) indicate the position of the generation region. We confirm that the chorus source is situated at the minimum of magnetic field on the given geomagnetic field line. On the base of Cluster measurements (2001-2009) we show that the local minimum can be displaced from the geomagnetic equator more then $\pm 5^\circ$ during periods of high geomagnetic activity. Two characteristic scales of disturbances are found. First (characteristic time scale is about an hour) refers to global current system rebuilding and can be determined from N. Tsyganenko magnetic field models. Second (the characteristic time scale is about minutes) - magnetic field minimum has the fine structure with several minimum along the magnetic field line. On the base of multi-points magnetic field measurements we have found that during the high geomagnetic activity periods the location and the structure of the generation region can be additionally disturbed and controlled by MHD perturbation.

Solar observations: From the interior to heliosphere

Observational capabilities of the European Solar Telescope

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One of the most important aims of Solar Physics studies is to understand the coupling of the different layers of the solar atmosphere, where the magnetic field represents the key ingredient. While in the photosphere, and below it, the plasma determines the behaviour of the magnetic field, the properties of the layers above are fully governed by the magnetic topology. In addition, the best images taken from the ground and from space show that its fine structure plays a crucial role in the mechanisms that help to store energy in it and transport it to the higher layers where it can be released. This is one of the reasons why new generation ground-based telescopes must have a large aperture, considerably larger than the presently 1 m-class telescopes, to be able to resolve the smallest features on the solar atmosphere. To that aim, multi-conjugate adaptive optics is crucial to overcome the difficulties arisen from the terrestrial atmospheric turbulence. In addition, a large number of simultaneous instruments must be operated to make possible the study of the photosphere and chromosphere to get their magnetic properties with the best accuracy. This is the aim of the 4-meter European Solar Telescope (EST), which will be the most important ground-based facility to observe the Sun, together with the American Advanced Technology Solar Telescope (ATST). In this contribution, the novel design of EST, which minimises the instrumental polarisation, and its expectatives for instrumental development will be presented.

Electron acceleration and magnetic fluctuations in solar flares

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Plasma turbulence is thought to be associated with various physical processes involved in solar flares, however there is virtually no observational knowledge of magnetic fluctuation in solar flares. Using RHESSI observations and the X-ray visibility analysis, we analyze a well observed flare, which was previously found to be consistent with a reconnection scenario. Energy-dependent transport of tens of keV electrons is observed to occur both along and across the guiding magnetic field of the loop. We show that the cross-field transport is consistent with the presence of magnetic turbulence in the loop, where electrons are accelerated, and estimate the magnitude of the field line diffusion coefficient for different phases of the flare. The energy density of magnetic fluctuations is calculated for given magnetic field correlation lengths and is larger than the energy density of the non-thermal electrons providing the first observational evidence that magnetic turbulence governs the evolution of energetic electrons in a dense flaring loop.

P1/P2 seismology of coronal loops (Invited)

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The P1/P2 period ratio of transversal loop oscillations is currently used for the diagnostics of longitudinal structuring of coronal loops as its deviation from 2 is intrinsically connected to the density scale-height along coronal loops and/or the sub-resolution structure of the magnetic field. The same technique can be applied not only to coronal structures, but also to other oscillating magnetic structures. In this talk I will review the progress in diagnosing the internal structure of coronal loops via the observed oscillations period, with special emphasis on the effect of the environment on the period ratio and further possible seismological tools.

Particle acceleration at null points in self-consistent spine and fan reconnection models

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RHESSI observations of hard X-rays indicate a significant fraction of the flare energy budget is transferred to non-thermal accelerated charged particles. A plausible explanation for the origin of these particles is acceleration by super-Dreicer electric fields associated with reconnection or convective plasma motion, which process is particularly efficient near magnetic null points where particles become unmagnetised.

We use a test particle code to study proton and electron trajectories in fields that are self-consistent solutions to the steady-state resistive MHD equations near 3D null points (eg. Craig & Fabling 1996). We compare these 'Spine' and 'Fan' flux-pileup solutions with the results of Dalla & Browning (2005), which considered only the outer ideal regions.

In the spine regime we find particles that intersect the spine become unmagnetised and are accelerated briefly in a spine-localised current sheet. In the outflow they have large pitch angles making them likely to undergo magnetic mirror reversals within the acceleration site.

For the fan model we find that particles entering the current sheet get accelerated very efficiently as they become magnetised by a component of the background magnetic field parallel to the reconnection electric field. This increasing guide field helps to stabilise particles in the current sheet, stopping them from being ejected.

Craig, I.J.D & Fabling, R.B., ApJ, 1996, **462**, 969

Dalla, S., & Browning, P. K., A&A., 2005, **436**, 1103

The Energy Liberated, via Ideal Kink Instability, from an Ensemble of Isolated and Current-neutralised Coronal Loops

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The million degree temperature of the corona might be due to the combined effect of barely-distinguishable energy releases, so-called nanoflares, that occur throughout the solar atmosphere. Alas, the nanoflare density and brightness implied by this hypothesis means that conclusive verification is beyond present observational capabilities. Nevertheless, we investigate the plausibility of the nanoflare hypothesis by constructing a magnetohydrodynamic (MHD) model that can derive the energy of nanoflares, based on the assumption that the ideal kink instability of a twisted loop triggers a relaxation to a minimum energy state. The energy release depends on the current profile when the ideal kink instability threshold is crossed. Subsequent to instability onset, fast magnetic reconnection ensues in the nonlinear phase. As the flare erupts and declines, the field transitions to a lower energy level, which can be modelled as a helicity-conserving relaxation to a linear force-free state.

In contrast to our earlier work (Bareford et al. 2010), we now consider current-neutralised loops. The photospheric motions that twist the loop and thereby create azimuthal field are spatially localised; outside the loop boundary the field is purely axial.

Results of 3D numerical MHD simulations of unstable loops are presented, showing the dynamics of the relaxation process. A new localised relaxation model is developed which fits the simulation results. We apply our revised model to an ensemble of loops driven by random photospheric twisting motions, producing a nanoflare energy distribution. Furthermore, we vary the loop aspect ratio, the spatial correlation of the twisting motions and the level of radial expansion that may accompany loop relaxation. The range of active-region heat fluxes extracted from all the different scenarios is 10^6 to 10^7 erg cm⁻² s⁻¹. The flux approaches the latter limit, which is sufficient for coronal heating, when the relaxation radius is increased, regardless of the aspect ratio and of the randomness of the path to instability. The distribution of energies has a Gaussian shape when the twisting motions are correlated across the loop radius. Uncorrelated motions yield power-law distributions with gradients approximately equal to -2.

Bareford, M. R., Browning, P. K., Van der Linden, R. A. M., A&A, 2010, **521**, A70

Summer School

Nonlinear waves in the solar atmosphere

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An attempt to give a brief review of the contemporary theory of nonlinear waves in the solar atmosphere is made. The choice of topics reflects personal interests of the author. Historically the theory of nonlinear waves was first applied to the solar atmosphere to explain the chromospheric and coronal heating. It was assumed that the turbulent motion in the solar convective zone excites sound waves that propagate upwards. Due to nonlinearity these waves steepen and form shocks. The wave energy dissipates in these shocks thus heating the corona. We give a brief description of propagation and damping of nonlinear sound waves in the stratified solar atmosphere, and point out that, at present, the acoustic heating remains the most popular theory of heating of the lower chromosphere. Then we extend the analysis to consider propagation of nonlinear sound waves in coronal plums and loops. The next topic of interest is the propagation of nonlinear waves in a magnetically structured atmosphere. Here we restrict our analysis to slow sausage waves in magnetic slabs and tubes, and discuss properties of solitary waves described by the Benjamin-Ono and Leibowich-Roberts equation.

Ground-based instrumentation and techniques of detecting MHD waves and instabilities

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TBA

Summer School

Oscillatory Reconnection : Unification of Magnetic Reconnection and MHD Waves

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Traditionally, magnetic reconnection and MHD wave theory have been viewed as separate areas of solar physics. However, this is a misnomer: we know that (steady-state) reconnection models not only generate outflows/waves, but also require inflows/waves. Several authors (including Craig & McClymont 1991; Longcope & Priest 2007; McLaughlin et al. 2009) have challenged this point-of-view, and their investigations contribute to our understanding of dynamic or time-dependent models of magnetic reconnection. In particular, the work of McLaughlin et al. (2009) provides a link between these two traditionally separate areas of solar physics, and is one of the first demonstrations of reconnection naturally driven by MHD wave propagation, via a process entitled oscillatory reconnection. This lecture will give a generous introduction to the topic, discuss both previous and recent results on oscillatory reconnection, and set the work in the larger context of wave-driven reconnection and reconnection-generated oscillations. We will also look at how this relates to solar phenomena.

Space Science

High Mach Number Collisionless Shocks : Cluster Discoveries (Invited)

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Collisionless shocks play a fundamental role in space plasmas from plasma astrophysics to solar and planetary physics. They are intensively studied in the near-Earth environment and in the vicinity of other planets, as well as in the interplanetary space, in the solar atmosphere and in astrophysical objects (supernova remnants, jets etc.). A fundamental topic of collisionless shock physics is to determine the shock front structure and its dynamics, as well as to identify the main physical processes affecting both the structure and dynamics. This topic is of crucial importance both from fundamental and practical point of view. From the very beginning of the collisionless shock studies it was found that there exists a set of critical Mach numbers corresponding to qualitative changes of shock front structure and of the main dissipative and dispersive effects that form this structure. Most of the shocks in the solar wind as well as planetary bow shocks are supercritical or ion-reflection shocks. This means that shock Mach number exceeds the so-called 2nd critical Much number and ion reflection with subsequent energyzation make a significant contribution into slowing down of the incoming flow and dissipation of its kinetic energy. However, in the very beginning of the collisionless shock physics Paul et al. [1967] hypothesized that high-Mach-number shocks can be nonstationary, and the first unambiguous evidence of the nonstationarity was obtained by Morse et al. [1972] in the laboratory experiments. Krasnoselskikh [1985] and Galeev et al. [1988a,b] proposed models describing the shock front instability due to domination of nonlinearity over dispersion and dissipation. This macroscopic instability results in a gradient catastrophe within a finite time interval. For purely perpendicular shocks the overturning process results in dynamic behavior of the shock front in the close vicinity of the ramp. It consists of steepening, overturning and the relaxation. Most interesting phenomena are associated with the ramp dynamics when spatial scales are as small as electron inertial length. In quasiperpendicular case the model takes into account the presence of the precursor wave train. Several aspects of it, including the role of nonlinear whistler oscillations and existence of a critical Mach number above which a nonstationarity appears, were developed in further detail and more rigorously by Krasnoselskikh et al. [2002] and complemented by numerical simulations with the use of the 1-D full particle electromagnetic code with a small ratio of electron and ion masses, $m_e/m_i = 0.005$.

It was shown that the transition to nonstationarity is always accompanied by disappearance of the phase-standing whistler wave train within the shock front. Moreover, for large Mach numbers the nonstationarity manifests itself as a periodic ramp reformation, which influences considerably the ion reflection, in particular, the reflection becomes bursty and sometimes the ions are reflected from both old and new ramps simultaneously. We also present here a set of experimental data a high-Mach-number ($M_f = 5$) quasiperpendicular ($Bn = 81^\circ$) bow shock layer crossed by Cluster spacecraft on 24 January 2001 at 07:05-07:09 UT. The measurements of magnetic field, spectra of electric field fluctuations, and ion distributions reveal that the shock is highly nonstationary. In particular, the magnetic field profiles measured aboard different spacecraft differ considerably from each other. The mean frequency of downshifted waves observed upstream of the shock ramp oscillates with a characteristic time comparable with the proton gyroperiod. In addition, the reflection of ions from the shock is bursty and a characteristic time for this process is also comparable with the ion gyroperiod. All these features in conjunction are the first convincing experimental evidence in favour of the shock front reformation.

Reconstruction of Chorus Type Whistler Wave Statistics in the Radiation Belts and Inner Magnetosphere Using Ray Tracing

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The quasi-monochromatic whistler wave packets are widely assumed to be formed in the vicinity of the magnetic equator and are frequently observed for example by Cluster spacecraft. The objective of our study is a reconstruction of realistic chorus emissions in radiation belts and in inner magnetosphere. To achieve this aim the data from the electric and magnetic field measurements onboard Cluster satellite is used to determine the major characteristics of the chorus signal around the equator region, namely, its averaged wave vector, wave vector distribution, Poynting flux and polarization. Then the propagation of such a wave packet is modeled in the framework of so-called ray tracing technique using the original code which employs K. Ršnnmark's WHAMP to obtain hot plasma dispersion function values along the wave packet trajectory. The observed (real) rays at the equator are first fitted to the observed waveform using Cluster observations (initial conditions) and then these rays are propagated numerically through the inner magnetosphere in the frame of the WKB approximation. The density distributions of the magnetospheric particles is taken from the Gallagher et al. package that is provided by the authors and distributed as free software. Ray tracing allows one to reconstruct the properties of waves such as electric and magnetic fields, and the width of the wave packet in k-space along the ray propagation path. The calculations take into account realistic effects of the spreading of the signal due to propagation in the inhomogeneous and anisotropic magnetized plasma, the dependence of signal propagation characteristics upon initial conditions, etc. Our calculations make possible to follow the wave packets and calculate their properties in the desired regions, e.g. the regions where an efficient wave-particle interaction is expected to occur. We plan to compare the distributions obtained with the statistical data sets of wave intensity based also on Cluster observations during several years.

Interaction of suprathermal particle fluxes with waves in magnetized plasma

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Results of theoretical research of excitation of lower hybrid waves and whistlers in magnetized plasma are presented in the presence of nonequilibrium fluxes of energetic particles. In particular, nonlinear saturation of fan instability and loss-cone instability in magnetized and collisionless plasma is studied. Research is based on numerical simulation by means of a mathematical model in which nonlinear dynamics of resonant particles with a three dimensional package of waves is completely considered. At the same time a motion of the particles which are not getting in a resonance with waves is described in linear approach. The analysis of an initial stage of instability development at which some waves dominate in the spectrum of waves is carried out and formation of almost continuous spectrum of waves in the course of saturation of instability and a relaxation of unstable distribution of particles is considered. The dependence of wave's energy in a steady state from the parameters describing degree of nonequilibrium of initial distribution of particles, such as a density of energy of particles belong to an anisotropic tail of distribution in case of fan instability or a loss-cone angle in case of loss-cone instability, is investigated. The carried out calculations allow to conclude that though for development of the considered instabilities the main is interaction of particles with waves under conditions of a cyclotron resonance, influence of interaction of the same particles with waves at Landau resonance cannot be neglected, as it leads to smoothing of features of particles arising in velocity distribution during transition to a quasistationary spectrum of waves. Nevertheless it is shown that the role of the Landau resonances in an exchange of energy of particles with waves for the given instabilities is insignificant. The conducted detailed research of motion of a great number of particles in a stage of saturation of instability shows that they make a complex oscillation which despite its casual character, not always is possible to describe in terms of a quasilinear diffusion in velocity space.

Remote sensing of plasma fluctuations structure by means of VLF waves spacecraft interferometry

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Random inhomogeneities of plasma density are known to effect the propagation of whistler mode waves resulting in fluctuations of the refractive index of the waves. Irregularities of the refractive index along the ray path lead to the loss of the phase coherence of the wave packet. Such irregularities are often present around the plasmopause and in the radiation belts; they occur at scales ranging from a few meters up to several hundred kilometers and can be highly anisotropic. The statistical characteristics of these irregularities can be probed by means of inter-satellite correlations of their phases and amplitudes. From such cross-correlation analysis we reconstruct the statistical properties of the density fluctuations along the wave propagation path. This allows us to distinguish the wave source properties from the effects of the wave propagation through the media. The proposed technique is applied to the discrete ELF/VLF chorus emissions observed onboard Cluster and Themis. Chorus type whistler waves are the most intense electromagnetic plasma waves that are observed in the radiation belts. They are assumed to be generated in source regions in the vicinity of the magnetic equator and in minimum B pockets in the dayside outer zone of the magnetosphere. The parallel and perpendicular to the background magnetic field correlation scales of the plasma density fluctuations are determined by analyzing the wave phase difference dependence upon the duration of the signal recording time. The results obtained can be summarized as follows:

1. The characteristic spatial scales of plasma density irregularities transverse to the local magnetic field are found to be in a range from 60 to 110 km in the inner magnetosphere and about 300-350 km for L-shell about 8-9, which is of the order of the local ion gyroradius. We find that the chorus wave phase coherence scale near the generation region is defined by the density fluctuation scale but not by size of the source. The correlation scale along the magnetic field is found to be 5-10 times greater than transverse.
2. The location of the wave sources is found to be in a good agreement with its determination from the multi-point Poynting flux measurements. The distance from the spacecraft to the wave source (from 300 to 1000 km) is found to be sufficiently smaller than the characteristic thickness of the source region, which is known from previous studies to be of the order of 3000-5000 km. From this we come to the conclusion that the estimated parallel scale of the fluctuations corresponds to the characteristic scale of the inhomogeneity of the source.

The Role of the Interplanetary Shock Orientation on Interaction with the Bow Shock and Magnetopause

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Propagation of interplanetary (IP) discontinuities through the interplanetary space, their modification in the foreshock and interaction with the bow shock and magnetopause is a key problem of the Space Weather program because these discontinuities are often associated with strong geomagnetic disturbances. Many studies often suppose the shock plane perpendicular to the Sun-Earth line but our analysis revealed that a large portion of the discontinuities is oblique, i.e., the shock normal is declined from the solar wind direction. The situation with several solar wind monitors and a number of the spacecraft orbiting in the magnetosheath and in the vicinity of magnetospheric boundaries allows us to trace the path of an original shock and induced discontinuities through them. We present several case studies of such discontinuities and discuss the changes of their parameters in the foreshock and due to their interactions with the bow shock and magnetopause.

Coffee break and poster session

Oscillations of neutral and charged components of near-Earth plasma and effects of active media

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The waves involving linear and nonlinear oscillations of charge and neutral components in the system "Lithosphere-Atmosphere-Ionosphere-Magnetosphere" (LAIM) are considered as a sensitive indicator of the energy flows coming into the ionosphere both, "from below" (lithosphere and lower atmosphere) and "from above" (magnetosphere). Examples of nonlinear processes in this active system, such as 1) heating instability of Atmospheric Gravity Wave (AGW) in lower atmosphere; 2) interaction of spatial packet of AGW with ionospheric equatorial plasma in the presence of Rayleigh-Taylor instability; 3) electric-heating instability in the D region are discussed.

The new system of 2D nonlinear equations is derived for Planetary Electromagnetic Waves (PEMW) moving in the horizontal layer of ionosphere and in the approximation of "beta-plane" and incompressibility. For the first time, to our best knowledge, Ampere force term, which determines losses of PEMW, is written in the form valid for any ionospheric altitude.

The vertical component of neutral's velocity and neutral winds in the longitudinal and meridional directions are taking into account. Influence of the losses in the region of equatorial anomaly on possible "waveguide propagation" of PEMW is considered.

Our theoretical results are applied to observational data of magnetic oscillations in the region of equatorial anomaly (1). Present approaches to the wave coupling in the different layers can be further extended to the applications for Solar atmosphere and atmospheres of Solar system planets.

1. Kotsarenko A., Molchanov O., Pérez Enríquez R., López Cruz-Abeyro J. A., Koshevaya S., Grimalsky V., and Kremenetsky I., Natural Hazards and Earth System Sciences (NHESS), 2005, **5**, 711

Geomagnetic Dst Index Forecast Based on Bilinear Models and Nonlinear Filtering Techniques

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This presentation describes new algorithms for forecasting the geomagnetic activity of the Dst-index using nonlinear prediction filtering and bilinear models (BM). In this report, the process of the Dst-index is treated to be a structure-known bilinear system, where the solar wind parameter (VBz) is the system input, and the Dst-index is the system output. Forecasting is formulated in terms of bilinear systems and optimization techniques. We present new algorithms to identify continuous-time and discrete-time bilinear systems from input-output measurements. This report is also concerned with the blind identification of bilinear models excited by solar wind parameters. We present an analysis and modeling of the Dst time series over the period 1983-2004. The numerical results indicate that the method is useful in predicting storm events 5-7 hours ahead.

Spatial structure of ULF waves in the near-Earth space according to Themis observations

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ULF waves in the Pc5 frequency range recorded on 5 THEMIS satellites during the first stage of the mission ("pearl-on-string" configuration) were analyzed. In essence, these observations can be considered as gradient installation in space. Analysis of these gradient measurements allows to determine the local spatial-temporal structure of the waves and to identify their physical nature. The relationship between Pc5 waves in the Earth's magnetosphere and their ground response observed at worldwide magnetometer network was also examined.

General Magnetic Field of the Sun as a Star: variability of the frequency spectrum from cycle to cycle

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During 40 years of observations General Magnetic Field of the Sun as a star (GMF) demonstrates stable picture of variability of amplitude of oscillations with the activity cycle: in maximum activity GMF reaches ≈ 2 Gs, and in a minimum reaches ≈ 0.2 Gs. The values of frequencies of prominent peaks of power spectrum of GMF significantly vary from cycle to cycle of activity. After all data averaging with period ≈ 26.9 d (more prominent peak in the power spectrum) resulting magnetic field is not equal to zero and has a specific phase curve similar to the dipole, with amplitude of oscillation ≈ 0.2 Gs. The ratio of absolute value of the positive to negative magnetic flux is equal approximately 1. Because the balance of positive to negative magnetic flux one can suppose the presence additional very weak large-scale magnetic field on the Sun - there is a global dipole magnetic field whose axis lies near the equatorial plane of solar rotation. One of the assumptions is that this field reflects properties of the stationary global magnetic field of the Sun's radiative interior on the surface, and there appears to be a third large-scale component of the magnetic field along with toroidal and poloidal fields, which are produced by dynamo.

Effect of weak electromagnetic fields of magnitude of order of geomagnetic pulsations on the formation of GABA-ergic inhibitory synapses in cultured hippocampal neurons.

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Effect of electro-magnetic field on synaptogenesis in cultured hippocampal neurons was studied by recording as spontaneous activity as evoked inhibitory currents in pair-recording scheme of stimulation. It was shown, functional inhibitory GABA-ergic synapses formed later after plating, than in control group.

Space Science/Solar observations

Nonlinear Dynamics of Space Weather: Predictability, Lyapunov Exponents and Applications

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This report concentrates on the following problems: (a) empirical time series prediction with non-linear autoregressive moving-average models; (b) dynamical-information approach to prediction of space weather; (c) estimation of Lyapunov exponents of time series from geomagnetic indexes; (d) dynamic probabilistic risk analysis of satellite devices with complex characterizations for damages using a physical model of elements and a predictable level of ionizing radiation and space weather; (e) spatio-temporal nonlinear and bilinear modeling the amplitude and location of the disturbance as a function of space, as well as its time evolution; (f) optimization techniques to identification of dynamical models using geomagnetic indexes. The local and global Lyapunov exponents based on infinitesimal uncertainty dynamics are considered to reflect an optimal predictability. An error analysis in bilinear dynamics is also used to develop criteria necessary for progress evaluation in space weather. Numerical results of Dst-index prediction are shown.

IPS Observations of Rapid Velocity Variations In the Slow Solar Wind

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⁷Space Science and Technology Department, Rutherford Appleton Laboratory, United Kingdom;

Interplanetary Scintillation (IPS) observes the rapid fluctuations of an astronomical radio signal as the signal passes through the changing density of a solar wind stream. Cross-correlation of received IPS radio signals at two radio antenna, observing a common radio source, is used to determine the velocity of the solar wind material passing through the line of sight of the antenna. Two-site, long-baseline, observations performed using the European Incoherent Scatter Radar (EISCAT) network have revealed the slow solar wind to contain rapid velocity variations when viewed using a three minute time resolution. STEREO Heliographic Imager (HI) observations of white light intensity have been combined with the IPS observations to display common density structures which may cause the rapid variations in the slow solar wind.

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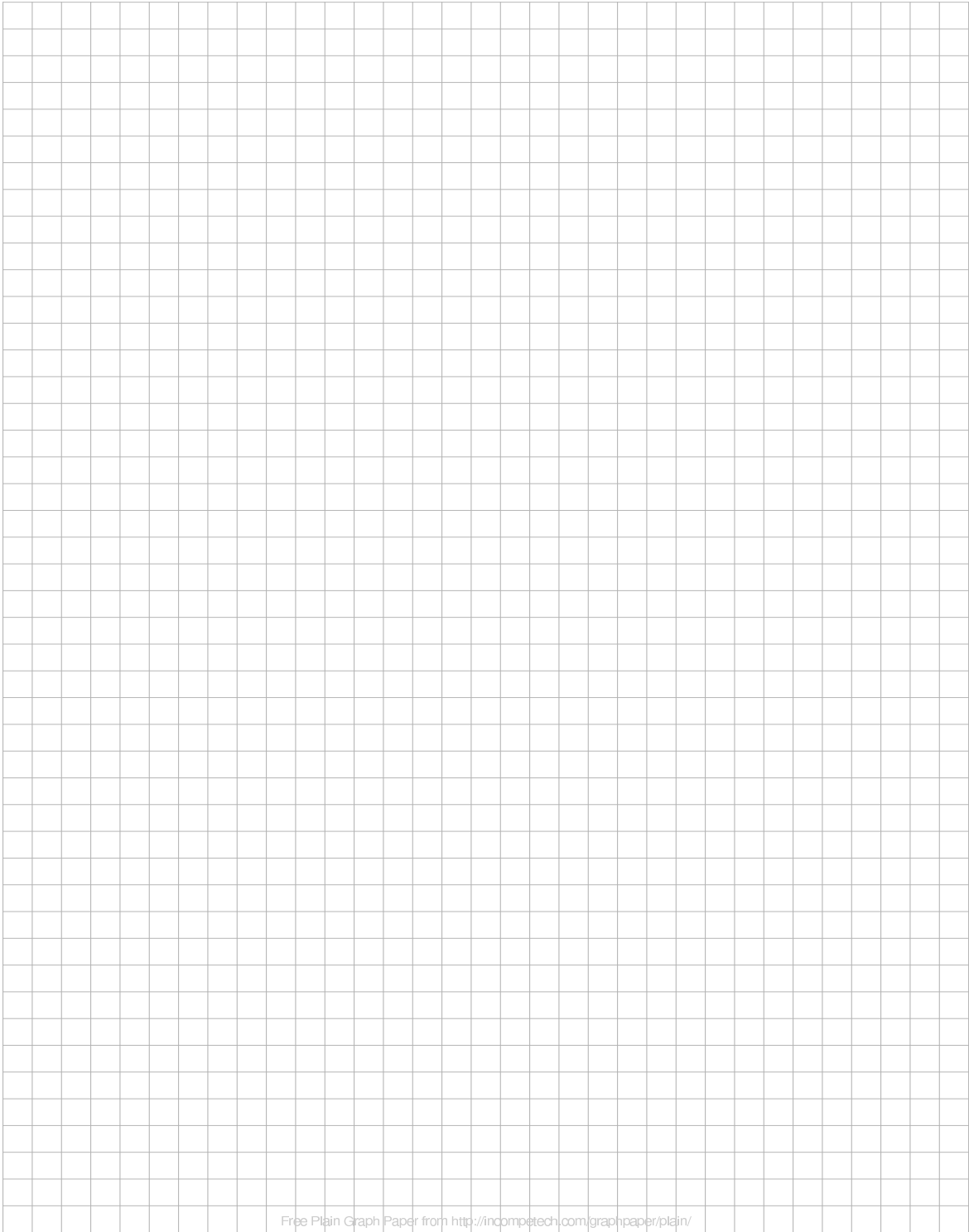
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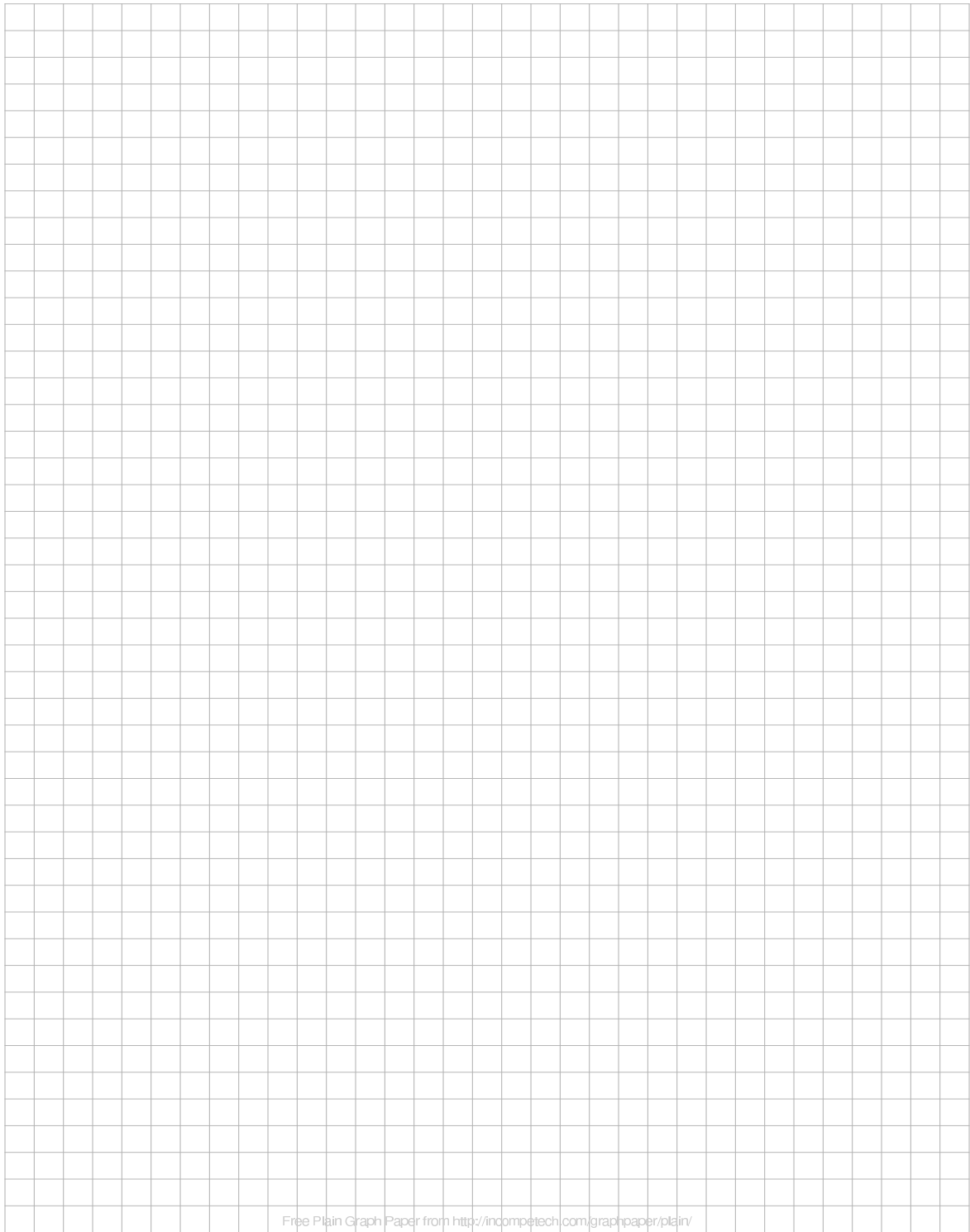
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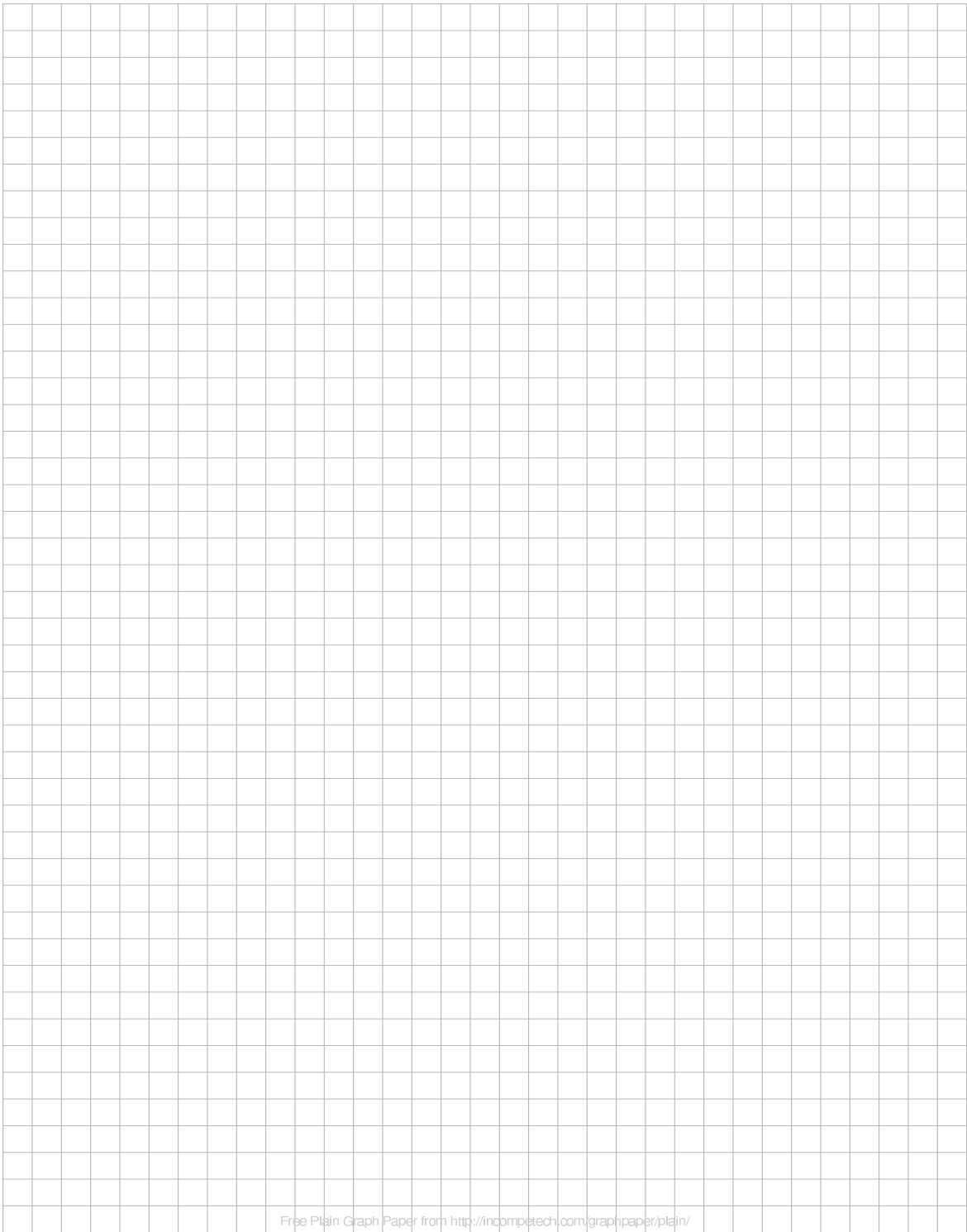
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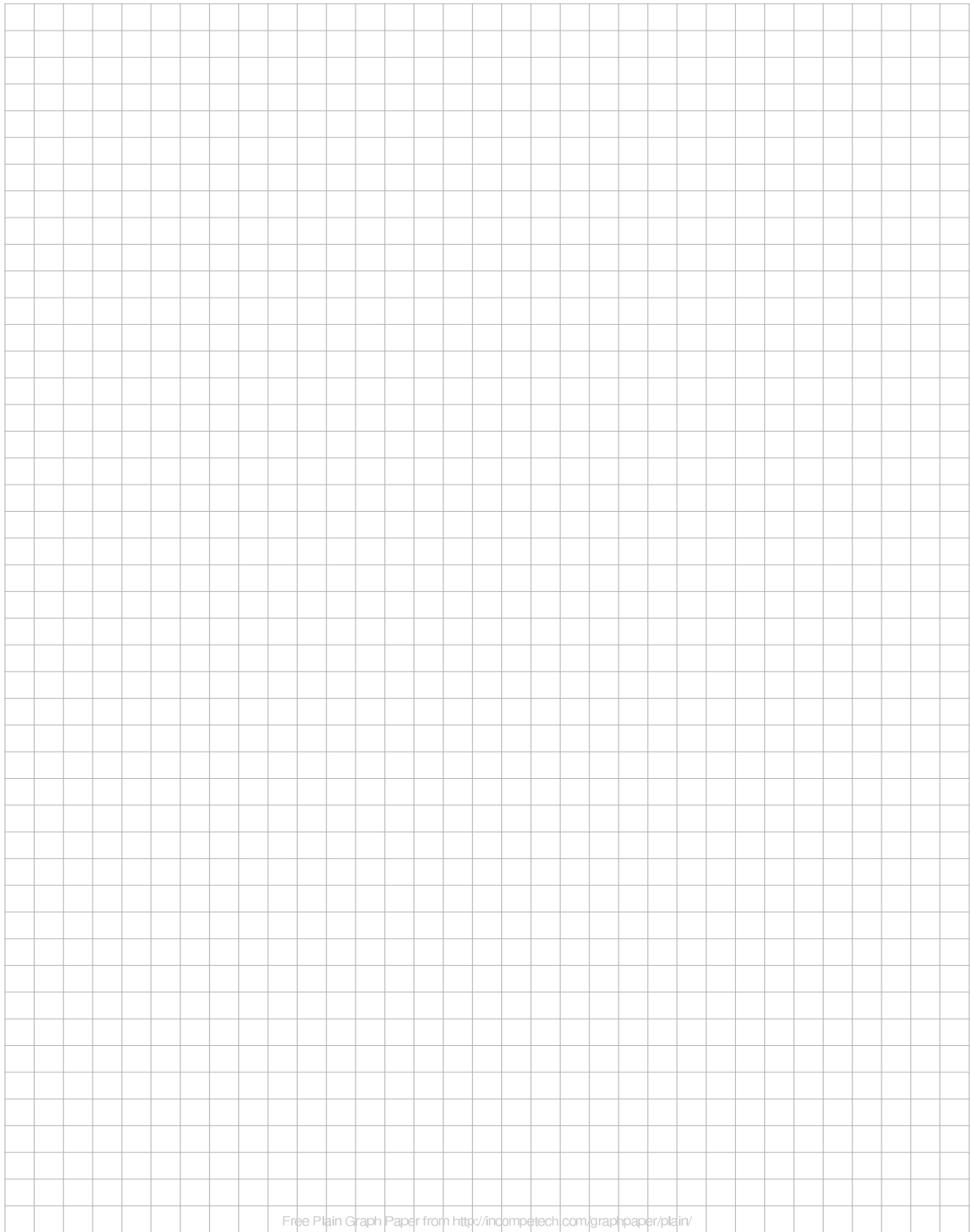
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