SECOND UK-UKRAINE MEETING ON SOLAR PHYSICS AND SPACE SCIENCE

PROGRAMME, ABSTRACTS, INFORMATION

16th - 20th September 2013, Kiev, Ukraine

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The University Of Sheffield.

ІКД

SSL space systems laboratory

SWAT Solar WAve Theory Group

Supported by The European Office of Aerospace Research & Development (EOARD)

Second UK-Ukraine Meeting on Solar Physics and Space Science

2013

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INFORMATION

16 - 20 September, 2013

Kyiv, Ukraine

Organised by

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

Second UK-Ukraine Meeting on Solar Physics and Space Science
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Programme, abstracts, information
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09:00–09:25 Registration

09:25–09:30 Welcome and Introduction (Section Hall)

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09:30–10:10 **Nataliia Shchukina** *Magnetograph-like analysis using surface dynamo simulations: Si I 1082.7 nm line (Invited)*

10:10–10:30 **Gary Verth**, Richard Morton, Andrew Hillier and Robertus Erdélyi *The generation and energy transport of propagating MHD kink waves in the Sun's atmosphere*

10:30–11:10 Coffee break and poster session

11:10–12:10 Advanced solar observations (Section Hall)

11:10–11:30 **Manuel Collados**, Christoph Kuckein, Andres Asensio Ramos and Rafael Manso Sainz *Observation of a Two-Ribbon Flare as Seen From the Ground and From Space*

11:30–11:50 **Olena Andriiets** and Nina Kondrashova *Semiempirical Models of the Photosphere at the Main Phase of a Solar Flare*

11:50–11:55 **Roman Zhygalkin** *TST spectra view - online service for solar images and spectra management (Poster)*

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12:00–12:05 **Margarita Pasechnik** and Svetlana Chornogor *Spectroscopic investigation of three Ellerman bombs (Poster)*

12:05–12:10 **Liudmyla Kozak**, Roman Kostik and Oleg Cheremnykh *Characteristics of Turbulent Process in the Solar Photosphere (Poster)*

12:10–14:00 Lunch

14:00–15:30 Structure and dynamics of solar magnetic fields (Section Hall) *Chair: Valery Nakariakov*

14:00–14:40 **Paul Cally** *Seismology of the Wounded Sun (Invited)*

14:40–15:00 **David Long**, David Williams, Stephane Regnier and Louise Harra *Measuring the Magnetic Field Strength of the Quiet Solar Corona Using EIT Waves*

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16:00–16:55 Non-linear phenomena in space plasmas (Section Hall)

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16:45–16:50 **Oleh Semeniv** *Statistical learning approach for geomagnetic storms prediction (Poster)*

16:50–16:55 **Yurij Kyzyurov** *Dependence of plasma irregularities in the lower ionosphere on kinetic energy of neutral air turbulence (Poster)*

16:55–17:25 Discussion of the day (Section Hall)

09:00–10:25 **Particle acceleration in the Sun and heliosphere** (Section Hall) *Chair: Paul Cally*

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10:00–10:20 **Olga Verkhoglyadova**, Bruce T. Tsurutani, Gary P. Zank, Anthony J. Mannucci and Martin G. Mlynczak *Solar driving of the Earth environment during the declining and solar minimum phases of a solar cycle*

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14:00 **Excursion**

09:00–10:20 Waves and flows in the Solar atmosphere (Section Hall) *Chair: Leon Ofman*

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09:40–10:20 **Yuriy Voitenko** *MHD-kinetic transition in Alfvenic turbulence (Invited)*

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11:00–11:50 Waves and flows in the Solar atmosphere (Section Hall)

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11:20–11:40 **Irantzu Calvo Santamaria**, Elena Khomenko and Manuel Collados Vera *MHD Wave Propagation Through an Arcade-Shaped Magnetic Field with a Null Point*

11:40–11:45 **Badma Mikhalyaev** and Dzhirgal Bembitov *The structure of fast sausage waves in the current-carrying coronal loops (Poster)*

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14:00–15:20 New physics in numerical modelling (Section Hall) *Chair: Tom Van Doorsselaere*

14:00–14:40 **Leon Ofman** *The sources of the slow solar wind: observations and models (Invited)*

14:40–15:00 **Pedro A. Gonzalez-Morales**, Lena Khomenko and Tobias Felipe *Multi-Source Modelling of Helioseismic Waves in the Sunspots and Quiet Sun Regions.*

15:00–15:20 **Sergiy Shelyag** *Spectropolarimetric signatures of photospheric intergranular vortices*

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16:00–16:40 New physics in numerical modelling (Section Hall)

16:00–16:20 **Nikola Vitas**, Elena Khomenko, Manuel Collados Vera and Angel de Vicente *Solar convection simulated with the Mancha code: A progress report*

16:20–16:40 **Viktor Fedun** *3D Simulations of Magnetohydrodynamic Waves Driven by Photospheric Motions*

16:40–17:10 Discussion of the day (Section Hall)

18:30 Conference Dinner (restaurant 'Opanas')

09:00–10:05 Physics of magnetosphere and ionosphere (Section Hall) *Chair: Oleksiy Agapitov*

09:00–09:20 **Oleg Cheremnykh**, Aleksei Parnowski and Vitaliy Yatsenko *AFFECTS: Space Weather for the European Community*

09:20–09:40 **Yuriy Rapoport**, Yuriy Selivanov, Vasiliy Ivchenko and Vladimir Grimalsky *Modeling electromagnetic and hydromagnetic wave coupling in LAIM/MIAL system and possible application to Space Weather studying*

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10:00–10:05 **Yuriy Rapoport**, Vladimir Grimalsky, C. Price and E. Tkachenko *Quasistatic-photochemistry channel of the coupling in the system Lithosphere-Atmosphere-Ionosphere-Magnetosphere (LAIM/MIAL) system and possible application to the Space weather and seismoionospheric phenomena. (Poster)*

10:05–10:45 Coffee break

10:45–11:25 Physics of magnetosphere and ionosphere (Section Hall)

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11:25–11:30 Meeting Closing (Section Hall)

ABSTRACTS

Advanced solar observations

Magnetograph-like analysis using surface dynamo simulations: Si I 1082.7 nm line

Nataliia Shchukina

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The spectral region around 1083.0 nm is a powerful diagnostic window: it contains information coming simultaneously from the chromosphere (He I 1083.0 nm triplet) and from the photosphere (Si I at 1082.7 nm). It is this region is one of science objectives of the next Japan Solar-C Mission. Here we present three-dimensional radiative transfer investigations of the Zeeman effect in Si I 1082.7 nm line using a 3D solar photospheric model resulting from the solar surface dynamo simulations by Vögler and Schüssler (2007). We apply the magnetograph-like analysis in order to investigate the sensitivity of this line to the circular and linear polarization. We show that the longitudinal & transversal components correlate remarkably well with spatial variations of the vertical and horizontal components of the magnetic field strength taken at the surface where the optical depth equals unity.

The generation and energy transport of propagating MHD kink waves in the Sun's atmosphere

Gary Verth[1], *Richard Morton*[2], *Andrew Hillier*[3] *and Robertus Erdélyi*[4]

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Magnetohydrodynamic (MHD) waves are thought to play a decisive role in the transport of energy between the photosphere and corona in the Sun's quiescent atmosphere. To investigate the transport of Alfvénic wave energy provided by the MHD kink mode we exploit multi-instrument observations, finding that the chromospheric kink wave velocity power spectra contains the signature of the horizontal photospheric motions. This provides strong evidence that these motions are the main driving mechanism for the observed incompressible modes. Crucially, the first comparison between chromospheric and coronal power spectra is provided, revealing transmission profiles that imply both enhanced and frequency-dependent damping of Alfvénic waves in the lower corona.

Advanced solar observations

Observation of a Two-Ribbon Flare as Seen From the Ground and From Space

Manuel Collados[1], *Christoph Kuckein*[2], *Andres Asensio Ramos*[3] *and Rafael Manso Sainz*[4]

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On 2013, 17th May, a two-ribbon M3.2 flare took place in the solar atmosphere at the active region AR 11748. The flare evolution was observed at the German VTT of the Observatorio del Teide using the instrument TIP-II, with spectropolarimetric measurements of the photosphere (Si I at 1082.7 nm) and the chromosphere (Helium triplet at 1083 nm). Simultaneous spectroscopic data of the chromospheric spectral line of Ca II at 854.2 nm and filtergrams at Halpha were also obtained. The temporal interval of the observations covered several hours, including the pre-flare, impulsive, gradual and post-flare phases. The flare evolution as observed from the ground will be compared with the changes observed by AIA@SDO at different ultraviolet wavelengths.

Semiempirical Models of the Photosphere at the Main Phase of a Solar Flare

Olena Andriiets[1] *and Nina Kondrashova*[2]

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[2]Main Astronomical Observatory, NASU, Kyiv, Ukraine; kondr@mao.kiev.ua

We present the results of the study of the thermodynamical parameters and the magnetic field in the solar photosphere at the main phase of a solar flare on 2012 May 28 in active region NOAA 11490. The analysis is based on the spectropolarimetric observations with the French Italian telescope THEMIS, operated on the island of Tenerife in the Spanish Observatorio del Teide of the Instituto de Astrofisica de Canarias in the multi-line spectropolarimetric mode.
We use high-resolution Stokes I, U, and V profiles of six photospheric lines for the modelling. Semi-empirical models are derived from the inversion with SIR (Stokes Inversion based on Response functions) code, developed by Ruiz Cobo and del Toro Iniesta (ApJ, 1992, 398, 975). The models include two components: a thin magnetic flux tube and its non-magnetic surroundings. The height dependences of the temperature, magnetic field strength, and line-of-sight velocity are obtained for magnetic component from inversion for eight moments of the observations.
According to the received models all photospheric parameters changed during the main phase of the flare. The inferred flux tube models show the temperature enhancement in the photospheric layers relative to the quiet-Sun model atmosphere. Filling factor was in range from 0.13 to 0.23. The magnetic field strength in the models varied from 1200-1700 G in the lower photospheric layers to 400-1100 G in the upper ones. Line-of-sight velocities in the middle layers of the photosphere did not exceed 1 km/s. Downflows were up to 5-6 km/s in the lower and upper layers. The macroturbulent velocity was in range from 1.6 to 2.6 km/s at different times of observation.

TST spectra view - online service for solar images and spectra management

Roman Zhygalkin

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We present a web service to work with images and spectra of the Sun obtained with the telescope BST-2 Research Institute ”Crimean Astrophysical Observatory”. A brief description of the features of this application are monitoring and the integration of our data to other virtual applications (Specview, VOSpec).

Oscillations of the Chromospheric Line-Of-Sight Velocity in a Solar Microflare

Nina Kondrashova[1] *and Uliana Leiko*[2]

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We present the results of the study of the oscillations of the line-of-sight (LOS) velocity in the chromosphere of the active region NOAA 11024 before, during and after microflare on 4 July 2009. The spectral observations were carried out by E. V. Khomenko with the French Italian THEMIS telescope of the Instituto de Astrofisica de Canarias. We use one of the time series of the high resolution spectra over 21 minutes under good seeing conditions, obtained in the H alpha line. The pixel sampling was 0.2 arcsec, while the actual spatial resolution was below 1 arcsec. The time interval between the spectra was 2.84 s. We choosed the spectral images with step from 2.84 to 14 s. Doppler velocities were measured in the microflare location and its surroundings. We used the wavelength shift of the local minimum of the line profiles for the determination of LOS velocities. We revealed strong LOS velocity temporal variations in the chromosphere of the active region during the observations. The velocity changed from -25 km/s at the beginning of the observations to 5 km/s at the microflare maximum. The oscillations of the LOS velocity were revealed. There are 3- and 5-min oscillations in the chromosphere of the region studied over all the time interval. The power spectra were constructed to determine the periods of the oscillations for four time intervals: 13 min at the beginning of the observations, about 3 min before the microflare, 2 min of the microflare, and 3 min after it. The stable oscillations with the periods 5.2, 3.7, 2.9, 2.3 and 1.2 min took place during 13 min at the beginning of the observations. Before the microflare during 3 min the oscillations with the period of about 1 min were on one side of the flare only. The time interval between the chosen spectra for microflare was 2.84 s. It allows us to find the oscillations with chorter periods in the range 1.03 - 1.46 min, 0.60 - 0.76 min, 0.31 - 0.40 min, 0.47 - 0.52 min, and 0.24 - 0.26 min. After the microflare during last 3 min of the observations the oscillations with the period of about 1 min dominated. The shorter oscillation periods were found as well but they were observed uncertainly. We determined the oscillation periods for the quiet chromosphere in surroundings of the active region for the comparison as well. According to our measurements there are oscillations with periods 5.0, 3.0, 1.65, 1.15 min, and shorter than 1 min in the quiet chromosphere.

Spectroscopic investigation of three Ellerman bombs

Margarita Pasechnik[1] *and Svetlana Chornogor*[2]

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As are known, Ellerman bombs (EBs) are shot-lived, small-scale bright points observed in the wings of chromospheric lines. EBs $H\alpha$ spectra are the broad emission in the wings with maximum around ± 0.1 nm from the line center and deep central absorption. Although many works devoted to the study of this interesting phenomenon, however its nature is not clear enough. In our work we present of spectrophotometric analysis of three Ellerman bombs, which was observed on 4 July 2009 in areas of flux emergence of young rapidly developing active region NOAA 11024. We used high time and spatial resolution spectral data of the chromospheric line $H\alpha$ and four Fraunhofer lines formed in different layers of the photosphere (FeI 630.15, 630.25, 630.35 and TiI 630.37 nm), which were obtained with the French-Italian solar telescope, THEMIS. The data consist of a 20 min time series of the spectra, for which the spectra were obtained 400. In addition, space-borne data from SOHO/MDI, STEREO and GOES were also considered. The temporal variations of the intensity $H\alpha$ wings at a distance ± 0.1 nm from the line center and line-of-sight velocity field at photospheric and chromospheric levels in and near the locations of EBs were investigated. One of the observed EBs was located near the growing pore, the other two ones occurred in intergranular lanes and developed as a pair. The changes of the chromospheric velocity of the EBs, which accounted for a pair had good temporal correlation, so we could assume that they were physically connected and occurred at the footpoints of one loop. The distance between the pair components varied from 2.5 mM to 1.2 mM during observation. We found that temporal variations chromospheric velocities had two peaks of about 3 minutes and with intervals of 4 minutes, during which there was increasing the plasma velocities and reached to 1 - 2.5 km/s and 5 - 9 km/s, respectively. The second peak is composed of three individual peaks with intervals of 1.5 and 1 min. Probably, it indicated that the several successive reconnections had been during EBs. Since EBs developed in the area of flux emergence, mostly upward mass motions were observed in all the photospheric layers with a pronounced 5-minute oscillations. Their amplitude was about 0.8 km/s, but it decreased to 0.3 km/s during of EBs, the line-of-sight velocities decreased by 0.2 - 1 km/s, too. Two Ebs were accompanied by dark surges with upward velocities of about 60 km/s. Line-of-sight velocity variations in the chromosphere and photosphere of an active region during the EBs correspond to the model in which the triggering mechanism of EBs was magnetic reconnection in the lower chromosphere.
Key words: Ellerman Bomb, line-of-sight velocity, active region, chromosphere, photosphere

Characteristics of Turbulent Process in the Solar Photosphere

Liudmyla Kozak[1], *Roman Kostik*[2] *and Oleg Cheremnykh*[3]

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In work the range of different methods for the analysis of characteristics of turbulent processes in the active and quiet regions of the solar photosphere has been used. The changes of fluctuations distribution function and its moments were analyzed, spectral analysis was carried out. It was found out from the observations of active region carried out with the 70-cm vacuum tower telescope VTT in Isanie (Tenerife Island, Spain) that the turbulent processes in the sun photosphere are characterized by two different spectra of turbulence. The first one of them is well known Kolmohorov spectrum, which describes the plasma with zero mean magnetic field. The second one is the Kraichnan spectrum with a different from zero mean magnetic field. Transition from one spectrum type to another one occurs at scale of 3 Mm. For the quiet region of the solar photosphere the Kolmohorov spectrum was obtained. We have to note that the scale 3 Mm corresponds to one of mesogranulation and testifies about non-zero mean magnetic fields for the consideration of regions exceeding the granulation in active regions of the photosphere. Besides, this clears the possibility of appearance of self-organizing magnetic plasma structures such as spots, active regions and complexes of activity.
The work is done in the frame of complex program of NAS of Ukraine on space researches for 2012-1016, and under a partial support of the grant No. F 53.2/039.

Structure and dynamics of solar magnetic fields

Seismology of the Wounded Sun

Paul Cally

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Active regions are like wounds in the surface of the Sun. They let seismic waves from the interior escape into the atmosphere, where they mode-convert and partially reflect back into the interior, carrying infection from above. This can have profound consequences for helioseismology. In this talk I present the results of applying Time-Distance helioseismology to simulations of magnetic regions, and show that inferred ”travel time” perturbations of more than 40 seconds are easily obtained, and that these depend crucially on magnetic geometry.

Measuring the Magnetic Field Strength of the Quiet Solar Corona Using EIT Waves

David Long[1], *David Williams*[2], *Stephane Regnier*[3] *and Louise Harra*[4]

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Variations in the propagation of globally-propagating disturbances (commonly called ”EIT waves”) through the low solar corona offer a unique opportunity to probe the plasma parameters of the solar atmosphere. Here, high-cadence observations of two ”EIT wave” events taken using the Atmospheric Imaging Assembly (AIA) instrument onboard the *Solar Dynamics Observatory* (SDO) are combined with spectroscopic measurements from the Extreme ultraviolet Imaging Spectrometer (EIS) onboard the Hinode spacecraft and used to examine the variability of the quiet coronal magnetic-field strength. The combination of pulse kinematics from SDO/AIA and plasma density from Hinode/EIS is used to show that the magnetic-field strength is in the range 2-6G in the quiet corona. The magnetic field estimates are then used to determine the height of the pulse, allowing a direct comparison with theoretical values obtained from magnetic-field measurements from the Helioseismic and Magnetic Imager (HMI) onboard SDO using PFSS and local-domain extrapolations. While local-scale extrapolations predict heights inconsistent with prior measurements, the agreement between observations and the PFSS model indicates that ”EIT waves” are a global phenomenon influenced by global-scale magnetic field.

Solar abundances of CNO-elements, magnetic fields, and solar metallicity

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Carbon, oxygen and nitrogen are essential chemical elements that play a crucial role in determination of the solar metallicity. A downward revision of the metallicity from Z/X = 2.75 % to Z/X = 1.65 %, or Z/X = 1.81% corresponds to an anomalously low sound speed in the Sun, which contradicts the helioseismological data (see [1] and references therein). We studied how the magnetic flux in a series of 3D radiation-MHD model atmospheres influences the determination of the CNO-element abundances. The models resulting from a magneto-convection simulation with surface dynamo action have an average vertical magnetic flux density of 0.5, 7.6, 51, and 80 G respectively. The presence of magnetic fields causes both a direct (Zeeman broadening) effect on spectral lines with non-zero Landé factor and an indirect effect on temperature-sensitive lines via a change in the photospheric height stratification. The differential approach is used to quantify changes in the theoretical equivalent widths and, as a consequence, abundance corrections for a set of different spectral lines of C I, N I, and O I. The lines span wide ranges of wavelength, oscillator strength, Land-factor, and formation height.
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Dynamics of Solar Photospheric Granular and Facular Regions by Means of Correlation Tracking Codes Developed in Python

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Intergranular photospheric vortices, which have recently been discovered using simulations of photospheric magneto-convection, are a photospheric phenomenon that appears to be responsible for energy transport through the solar atmosphere. The vortices are horizontal motions characterised by relatively short lifetimes and small spatial scales, which makes them difficult to detect and observe. I will demonstrate the physical properties and spectropolarimetric signatures of intergranular vortex motions and discuss the ways to observe them.

Achievements of Solar Magnetic Turbulent Dynamo

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The analysis of the observed regularities and anomalies of solar cyclic magnetic activity is carried out on the basis of the alpha-Omega dynamo model and the newest helioseismological data on the inner rotation of the Sun. Two effects of ”magnetic antibuoyancy” in the solar convection zone (SCZ) are investigated. First effect is the macroscopic turbulent diamagnetism. Second effect is the transfer of magnetic field due to radial inhomogeneity of matter density with taking into account the inner solar rotation. The question on change of sign of the alpha-effect near the bottom of the SCZ is considered. Allowance for the radial inhomogeneity of turbulent velocity in derivations of the helicity parameter resulted in a change of sign of the alpha-effect from positive to negative (in the northern hemisphere) near the bottom of the SCZ. The problem of preference of the dipolar or the quadrupolar modes of the meriodional magnetic field during solar cycle is examined. The explanation of the extended duration (about 13 years) of 23th solar cycle in the non-linear regime of the turbulent dynamo is proposed. The possible role of the helical negative turbulent viscosity in formation of magnetic tubes in solar plasma is analyzed.

Structure and dynamics of solar magnetic fields

The velocity field of sunspot penumbrae: Return flow and magnetic fields of opposite polarity

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Significant progress has been made recently to advance our understanding of sunspot penumbra. Down-flows and opposite magnetic polarity are the crucial ingredients to understand penumbral structure. Numerical simulations have predicted well-defined properties of radiatively-driven magnetoconvection in inclinded magnetic fields. The observational challenge now consists in testing this theoretical paradigm. We will give an overview of observational results, and report on our own work. We search for penumbral magnetic fields of opposite polarity and for their correspondence with downflows. We used spectropolarimetric HINODE data of a spot very close to disk center to suppress the horizontal velocity components as much as possible. We focus our study on 3-lobe Stokes V profiles. From forward modeling and inversions, we show that 3-lobe profiles testify to the presence of opposite magnetic fields. They occur predominately in the mid and outer penumbra and are associated with downflows in the deep layers of the photosphere. Standard magnetograms show that only 4% of the penumbral area harbors magnetic fields of opposite polarity. If 3-lobe profiles are included in the analysis, this number increases to 17%.

Kinetic simulations of magnetic reconnection in null-points

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We perform three-dimensional particle-in-cell simulations of magnetic reconnection of a cluster of magnetic null-points. Magnetic field energy conversion into kinetic energy is much more efficient than in traditional Harris sheet configuration. More than 85particle energy during 25 reversed ion cyclofrequencies. Magnetic reconnection in the cluster of null-points evolves in three phases. During the first phase, ion beams are excited, that then give part of their energy back to magnetic field in the second phase. These flux ropes play major role in the overall energetics of the system. In the third phase the flux ropes are ruined, and magnetic reconnection occurs in many small patches around their remnants. Magnetic reconnection in the null-point cluster presents essentially three-dimensional features, with no two dimensional symmetries or current sheets.

Energy transport in flares: sunquakes and acoustic wave generation.

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Solar flares and coronal mass ejections (CMEs) are believed to be manifestations of a sudden and rapid release of the accumulated magnetic energy in the corona. Only recently, the photospheric changes due to the reconnection and coronal magnetic field reconfiguration has been seriously considered from the theoretical point of view. Analysis of seismic emission (sun-quakes) induced in the solar interior in the vicinity of flares offers us an opportunity to explore the physical processes of energy transport in flaring atmospheres. Only a limited number of M and X-class flares have been reported to show seismic signatures in the form or ripples or egression sources, revealing that some of the most powerful flares often do not produce any seismic signatures. In addition, the most powerful signatures were recorded from an M-class flare. This raises important questions about how the flare energy and momentum are transported to the solar surface and interior in order to produce sun-quakes. Using observations by Hinode, RHESSI and SDO we analyse and test the new theories, gaining insight into the flare physics using flare seismology.

Waves and flows in the Solar atmosphere

Forward modelling of solar atmospheric waves

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Since the largest part of the solar atmosphere is optically thin, it is very unintuitive to connect observed wave parameters with physical variables. Forward modelling is the technique in which synthetic observations are created from physical models. The forward modelling allows to relate observed wave properties to parameters in the physical model. In this talk, I will focus on the forward modelling of waves in flaring regions and the modelled signatures of waves in sunspots. The models will be used to perform MHD seismology of flares and sunspots.

Sausage Oscillations of Flaring Coronal Loops

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We performed a parametric study of linear axisymmetric fast magnetoacoustic (sausage) oscillations of coronal loops modelled as a field-aligned low-beta plasma cylinder with a smooth inhomogeneity of the plasma density in the radial direction. Numerical simulations of an initial value problem covered both trapped and leaky regimes. The period of the sausage oscillations was found to always grow with the increase in the longitudinal wavelength, with the saturation of this dependence in the long-wavelength limit. Deeper and steeper profiles of the Alfven speed across the cylinder correspond to more efficient trapping of sausage modes: the cutoff value of the wavelength increases with the steepness and the density (or Alfven speed) contrast ratio. In the leaky regime, the period is always longer than the period of a trapped mode of a shorter wavelength, and also is longer than the ratio of the wavelength and the Alfven speed far from the cylinder. For shallow profiles of the density and shorter wavelengths, the period grows with the wavelength. In the long wavelength limit, the period becomes independent of the wavelength and increases with the depth and steepness of the radial profile of the Alfven speed.

Evidence of decay-less kink oscillations in coronal loops from SDO/AIA

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Kink oscillations of coronal plasma structures are one of the most well-known example of MHD wave activity in the solar corona. They are transverse displacements of field-aligned plasma non-uniformities, typically observed with imaging telescopes. Kink waves are mostly detected and studied in coronal loops of active regions, but they have been observed also in prominence fibrils, hot jets and post flare arcades, in standing or propagating forms. An intriguing feature of standing kink oscillations is their rapid decay. Excited by a flare or an eruption, kink oscillations are usually observed to damp in about 3–4 periods. The physical mechanism responsible for the rapid damping has been subject to a number of theoretical studies, and the general accepted interpretation is the phenomenon of resonant absorption: linear coupling of the kink mode to unresolved torsional motions at a very narrow resonant layer.
The launch of the Solar Dynamics Observatory in 2010 has allowed us to get a more accurate view of the solar corona. Here, we present a detailed study of kink oscillations in coronal loops, supported also by three dimensional considerations of the loop shape, which demonstrates the presence of almost persistent low-amplitude (close to the spatial resolution of the telescopes) undamped kink motions, in addition to the well-known large-amplitude and decaying kink mode. Typical periods range from 2.5 to 11 min and the measured amplitude is lower than 1 Mm. We show that the observed behaviours are consistent with the empirical model of a damped linear oscillator excited by a continuous low-amplitude harmonic driver, plus a possible impulsive high-amplitude driver. The properties of this type of transverse oscillations make them interesting object of study, since they could play an important role in the process of coronal heating.

Waves and flows in the Solar atmosphere

Nonlinear damped standing slow waves in hot coronal magnetic loops

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We study the nonlinear standing slow waves in coronal magnetic loops. The wave amplitude is assumed to be sufficiently small, and it is used as a small parameter in the asymptotic expansions. In addition, it is assumed that the wave damping is sufficiently slow, which enables us to introduce the 'slow' time related to the evolution of the wave amplitude and shape. It is shown that, in the leading-order approximation, the nonlinear standing wave is a superposition of two identical nonlinear waves propagating in the opposite directions. The both waves are governed by the Burgers equation. Using the Cole-Hopfe substitution we obtain an analytical solution describing a standing wave that has the form of the linear fundamental eigenmode at the initial moment of time. This solution is used for the parametric study of nonlinear standing waves. In particular, the effect of nonlinearity on the oscillation damping time is investigated.

Tornadoes of Alfven and Internal Gravity Waves

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Equation for 3D internal gravity waves (IGWs) in atmosphere with finite vertical temperature gradients is derived. It is shown that this equation admits solutions in the form of a Laguerre-Gauss vortex beam or twisted internal gravity waves with density whirls in the atmosphere. Previous investigations of the inertial and kinetic Alfvenic tornadoes are modified. A twisted vortex beam can trap and transport momentum and energy in the Earth or solar atmosphere.

Rayleigh-Taylor Instability in Prominences from Numerical Simulations Including Partial Ionization Effects

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Solar prominences are blocks of cool, dense, and partially ionized chromospheric plasma remaining stable for days in the solar corona. The interface of such configuration is a subject to Rayleigh-Taylor instability (RTI), when a cooler material forms turbulent drops, mixing with a hotter underlying material. High-resolution observations indeed reveal turbulent up and down-flows propagating from the visible base of prominences. We study the physics of RTI by means of 2.5D numerical simulations in a single-fluid MHD approach including a generalized Ohm's law. Our aim is to understand the influence of a large fraction of neutral atoms into the the stability of prominences and the development of RTI. We find that the configuration containing neutral atoms is always unstable. The growth rate of the small-scale modes in the non-linear regime is always larger than in the purely MHD case. The negative diffusion velocities of the order of a few km/s are found at all stages of the instability (i.e. neutrals fall faster than the ions). The temperature differences of the bubbles between the ideal and non-ideal case are also significant.

Non-linear phenomena in space plasmas

Effects of Whistler Waves Oblique Propagation for and Electron Dynamics in the Radiation Belts

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ELF/VLF waves play a crucial role in the dynamics of radiation belts, and are responsible for the loss and the acceleration of energetic electrons. The modelling of wave-particle interactions requires the best possible knowledge of wave energy and wave-normal directions distribution in L-shells for different magnetic latitudes and magnetic activity conditions. On the basis of ten years (2001-2010) of Cluster STAFF-SA measurements the statistical study for ELF/VLF emissions in a whistler frequency range has been carried out and the distributions of the wave parameters (amplitude and wave normal direction) are obtained. We show that whistler wave normals are directed approximately along the magnetic field (with the mean value about 10-15 degrees) in a vicinity of the geomagnetic equator but the distribution changes with magnetic latitude, the angle for a given frequency tends to the resonance cone for L-shell<5.5. As a result at latitudes about 35-40 degrees, wave-normals become very oblique to the background magnetic field. The obtained results were proved by means of numerical ray tracing simulations. Wave obliqueness results in an important effect on electron scattering in the radiation belts: the scattering rates magnitudes increase up to 2 orders (in comparison with the conventional parallel waves propagation model). This growth of the pitch-angle diffusion rates is caused by the significant increase of the contribution of higher order cyclotron resonances at large latitudes, which is the most efficient for electrons with small equatorial pitch-angles. This tends to the substantial decrease of the electron life-time in the outer radiation belt. Whistler wave obliqueness also causes the existence of electric field component along the background magnetic field. Due to this, large amplitude oblique whistler waves can effectively trap and accelerate electrons. The new acceleration mechanism of radiation belts electron by oblique whistler waves based on Landau resonance has been proposed. This mechanism can explain a very rapid energy gain up to 1 MeV for electrons.

Non-linear phenomena and space weather: self-organization, Lyapunov exponents, and predictability

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In this report, we review the processes of the Sun-Earth interactions, self-organization fenomena and the predictability of space weather effects on satellites, devices and ground-based technological systems. This report also concentrates on applications of a dynamical-information approach to space weather prediction using satellite experimental data related to solar wind dynamics. Finally, some critical views on a space weather modeling system are being offered and targets for future research are highlighted. New results are: (1) improvements of solar wind models for space weather predictions; (2) the description of a space weather modeling system that starts at the Sun and extends to the Earth through a set of coupled components; (3) the formulation a numerical method to estimation of local Lyapunov exponents from time series of geomagnetic indices [1]; (4) the description a predictability analysis approach of time series using local Lyapunov exponents and the Kolmogorov-Sinai entropy; (5) the formulation a risk assessment methods for analysis of space weather influence on power systems [2]; (6) the description of an identification algorithm for nonlinear and bilinear dynamical models of geomagnetic indices; (7) the description a real-time adaptive algorithm for geomagnetic indices prediction. New methods developed here are applied to geomagnetic indices prediction, confirming and extending earlier results [2]. The model consists of a bilinear system that has been optimized to be a minimal without degrading the accuracy. Standard methods such as recursive least squares, extended least squares, recursive auxiliary variable, and recursive prediction error algorithms have been applied to identifying bilinear systems. Numerical experiments show that our models can be used for operational forecasts of the geomagnetic indices.

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Interplanetary Shock-Bow Shock Interaction and its Modification Due to Magnetic Field Rotation: A Comparison of MHD Model Prediction with Observations

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A statistical study showed that the interplanetary (IP) shocks are often accompanied with a rotation of the interplanetary magnetic field (IMF) over a large angle and this rotation can modify interaction with the bow shock and, consequently, with the magnetopause. According to already published papers, it was suggested that a fast forward shock passing through the bow shock generates a train of new discontinuities that differ along the bow shock surface. We show one example where data measured by Wind are used as an input to a global BATS-R-US MHD model and this model prediction is compared with Geotail observations. The IP shock was accompanied by a rotation of the IMF Bz component and we discuss the influence of the rotation on the IP shock-bow shock interaction. We try to find a method to classify the different discontinuities resulting from this interaction and to trace their propagation across the magnetosheath. We conclude that an identification of discontinuities in observations is possible with the MHD model support.

Distribution of energetic particles in the stationary model of the heliosphere

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We investigate propagation cosmic rays (CR) in the heliosphere as an environment which consist of two adjacent to each other spherically symmetric (relative to the Sun) regions. In the internal part of the heliosphere, the velocity of the solar wind is constant and supersonic. In the outer region of the heliosphere that is limited by heliopause, the initial speed of the solar wind is sonic and itŐs propagation decelerate. Such deceleration is presented in the form of a power law depending on the heliocentric distance with the index 'n'. CR dispersion in the interior region of the heliosphere and interstellar space is different, and proportional to the heliocentric distance. The different problems with 'n' is considered and solved. We obtain analytical expressions of CR modulation problems for high and low energetic particles in the corresponding regions of their propagation. It was analytically shown that the distribution of the CR low-energy particles corresponds to results obtained during Voyager mission. Also, it has been shown that with a strong deceleration of velocity of the solar wind $(n \geq 3)$ in the outer region of the heliosphere, on the heliosphere boundary appear more particles of low-energy CR than in interstellar medium, whereas the particles of high-energy are less.

Cosmic ray modulation in the turbulent solar wind with a regular component of the velocity in the form of a decreasing power function depending on the heliocentric distance

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We consider a spherically symmetric model of the solar wind where velocity is inversely proportional to the integral power (0,1,2,3) of the distance to the Sun. It is shown that for some values of the modulation parameter stationary solutions are not possible, i.e. for n = 3, whereas for n = 0,1,2, such solutions exist.

Non-linear phenomena in space plasmas

Plasmoid instability and transient fast Petschek-type magnetic reconnection

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We discuss high resolution MHD simulations of magnetic reconnection in a plasma with very large values of the Lundquist number. In this case the reconnective current sheet becomes unstable to the secondary tearing instability, which leads to formation of magnetic plasmoids. The latter initiate appearance of the slow-mode shocks that accelerate the reconnection rate up to 0.05. These shocks are not stable as they are repeatedly created and dissolved in the course of reconnection process. Thus, we demonstrate, for the first time,that fast dynamical Petschek-type magnetic reconnection can effectively operate even in a plasma with uniform resistivity, provided that the Lundquist number is large enough.

Knotty Structures in Magnetized Fluids

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Heliospheric magnetic fields are generally depicted as closed loops or curves anchored at physical foot-points, both deformed through a set of stretching and bending procedures. This classification allows one to describe most of the magnetic configurations as 2-D curves modified by slide, poke or twist. Hence, through set of simple stretching and bending procedures one may deform various structures into a simple loop or arc. However, 3-D evolving magnetic structures may form loops which cannot be transformed by these procedures to an equivalent closed (anchored) two-dimensional curve, and the resulting curves characterization may be generalized through their unique topology. An analogy between MHD and knot theory offers a new classification of magnetic flux tubes. Ideal MHD fluid describes non self-intersecting loops with smooth stretching and bending in the viscous surrounding fluid, identically to mathematical knots. Each crossing of a 3-D structure projection is assigned mathematical operation resulting in a set of new invariants which are preserved under stretching and bending, forming robust entities. It is conjectured that the field which emerges from the solar photosphere appears in the form of prime knots, knots which cannot be composed from two nontrivial knots. Conservation of invariants for small diffusivity and the large size of the emerging flux tubes make them impervious to large scale reconnection, making them observable as elongated prime knots at 1AU. Observations of intermittent ion flux drops in impulsive solar flares can be attributed to the formation of the simplest knotty structures - torus knots. Similarly, accumulation of small-scale localized spatial structures seen in simulations and inferred experimentally in the cascading solar wind plasma can be related to the stability of the 3-D knots. Implications for the stability of complex magnetic configurations due to preservation of topological invariants are considered.

Nonlinear coupling of kinetic ion-acoustic waves in the solar wind

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We study the three-wave resonant interaction among kinetic ion sound waves (KISWs). The nonlinear coupling equation describing both linear and nonlinear properties of KISWs is derived in the framework of two-fluid plasma model. Because of the KISW dispersion modification at small perpendicular wavelengths, these waves become a decay-type mode in the MHD frequency range below the ion cyclotron frequency. The nonlinear interaction rate is derived accounting for the wave dissipation. It is shown that the nonlinear spectral transport induced by three-wave KISW interactions can be faster than the wave damping in the solar wind conditions.

Statistical learning approach for geomagnetic storms prediction

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The geomagnetic storms are the most complex phenomena in the near-Earth space. They include a large number of physical processes and effect the near-Earth space environment, for example, accelerate charged particles in space, bring electric currents in space to intensification, cause global magnetic disturbances on the Earth surface, etc. Consequently, predictions of geomagnetic storms have a significant bearing upon the operation of a number of services. The influence of sun on near earth space is usually characterized by geomagnetic indices (Kp-index, Ap-index, Dst-index and other). Dst-index is a measure of the strength of a magnetic storm and it reflects the variations in the intensity of the ring current. In this thesis is presented an original approach for geomagnetic events prediction (geomagnetic storms) using spacecraft observation and Dst-index. It is assumed that the time series can be grouped into a number of different categories. For example, the Dst-index is clustered into four categories: Dst-index < -100 (nT); $-100 <$ Dst-index ≤ -50; $-50 \leq$ Dst-index ≤ -30; $-30 <$ Dst-index, which correspond to intense-, moderate-, small-storm and no-storm types respectively. In such approach were received four classes of geomagnetic events. For prediction model identification were used the range of informative characteristics and support vector machine learning technique. The prediction model was implemented as algorithm of adaptive geomagnetic storm warning for 6 hours using spacecrafts data. The reconstructed space events prediction model showed high value of the regularity criterion and the prediction accuracy. The correlation coefficient of the six hours of geomagnetic storms prediction with observed data is equal 0,8. Also, it was numerically discovered the dependence of the model prediction accuracy and several learning constraints using cross-validation technique. The accuracy of geomagnetic intense-, moderate-, small-storm prediction is equal 82%.

Dependence of plasma irregularities in the lower ionosphere on kinetic energy of neutral air turbulence

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Neutral air turbulence plays an important role in the lower ionosphere. The turbulence can cool or heat a gas due to eddy conduction and also heat a gas through viscous dissipation of turbulent kinetic energy. Appearance of plasma structures in the lower ionosphere can result from the eddy turbulence too. In this report we discuss small-scale plasma irregularities resulted from turbulent mixing of the lower ionosphere and their dependence on turbulent kinetic energy. The irregularity length-scales were restricted to the inertial range of turbulence and were smaller than the local scale of mean plasma-density gradient. We considered the irregularity spectra expected from measurements during rocket experiments and their dependence on the kinetic energy of turbulence. The consideration was based on the expression for 3D spectrum of the fluctuations induced by the neutral turbulence in the lower ionosphere. The derivation of this expression from three-fluid equations is briefly described. It was taken into account that spectrum of random velocity field of gas obeys the power law of Kolmogorov turbulence. The expression gave opportunity to write a formula for the evaluation of rms level of relative plasma-density fluctuations in the given wave-number range. Variability of the 1D spectra expected from experiments was analysed for irregularities in the altitude range 85-105 km under rise of turbulent kinetic energy (the turbulent energy dissipation rate increased from 10 to 100 mW/kg). It was shown that the enhancement of turbulent mixing results in the rise of the rms fluctuation level and in decrease in the slope of irregularity spectrum. The fluctuation level (for the irregularities with length-scales smaller 500 m) near 85 km altitude increased from 2.50 to 2.51 % and near 105 km from 4.35 to 4.92 %. If the irregularity spectrum was approximated by a simple power law then the power index increased from -2.40 to -2.17 for h=85 km and from -1.98 to -1.82 for h=105 km. The obtained results are explained by increase in the turbulent diffusion coefficient and decreasing of the dissipation length-scale from 3.3 to 1.8 m at h=85 km and from 54.1 to 30.4 m at h=105 km under the rise of the turbulent kinetic energy. The weak change in the fluctuation level results from increase in the eddy diffusion with energy of neutral air turbulence. The present result can be tested during rocket experiments.

Particle acceleration in the Sun and heliosphere

What we learn from Particle-in-cell (PIC) simulations about particle acceleration in solar flares and the heliosphere

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In this talk a review of most recent results will be given on the generation of accelerated particles in reconnecting current sheets occurring in the solar corona and the heliosphere as simulated with a PIC approach versus test particle approach. We discuss a role of the ambient plasma feedback and generation of the polarisation electric field caused by the separation of electrons from protons/ions across the current sheet midplane. It will be shown that magnetic field topology imposes strong signatures on accelerated particles which define not only the particle energy, density and pitch angle distributions inside and far from the current sheet. The magnetic field topology is shown to separate also the particles of the same charge into transit and bounced beams leading to generation of plasma turbulence at different parts of the current sheets. We also discuss possible diagnostic tools of accelerated particles derived from in-situ observation in the heliosphere and from HXR and gamma-ray emission in the solar corona.

The propagation of energetic particles in the distant heliosphere

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The interaction between the local interstellar medium and the solar wind defines the distant heliosphere, creating the heliosheath that plays an important role in the transport of energetic particle populations. At the termination shock (the standing shock wave bounded the supersonic solar wind) the radial velocity of the solar wind will decrease by a factor of 3. The velocity continues to decrease out to the heliopause. The propagation of charged energetic particles in the heliospheric magnetic fields is investigated on the base of cosmic ray transport equations. It is supposed that the velocity of the supersonic solar wind is radial and constant but the medium velocity decreases as $1/r^2$ (r is the heliocentric distance) after termination shock crossing. The cosmic ray transport equation is solved and the equilibrium spatial distribution of energetic particles is analyzed. The energetic spectra of particles accelerated at the termination shock are calculated. It is shown that particle spectrum exponent depends on the medium compressibility and on the magnitude of cosmic ray modulation parameter. Starting from the solution of cosmic ray transport equation the energetic particle anisotropy is estimated and the spatial dependence of cosmic ray energy flux is studied.

Solar driving of the Earth environment during the declining and solar minimum phases of a solar cycle

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Changes in the solar wind during a solar cycle have an important effect on structure of the global heliosphere and the Earth environment. We overview effects of solar driving during the declining phase of a solar cycle and solar sunspot minimum when the inner heliosphere is dominated by Corotating Interaction Regions (CIRs) and high-speed streams (HSSs). CIRs lead to acceleration of interplanetary ions (to energies of >1MeV/nuclei) observed at 1 AU by ACE and STEREO spacecraft. CIRs and trailing HSSs cause CIR-type geomagnetic storms. CIR storms have properties and dynamics different from geomagnetic storms occurring during solar maximum. HSSs and associated auroral activity cause acceleration of –killer electrons" in the outer radiation belt.
As an example we will analyze a portion of the WHI (Whole Heliospheric Interval) from 25 March to 26 April 2008. This period during a solar sunspot minimum is of moderate geomagnetic activity (with the minimum Dst ≈ -50 nT) and enhanced auroral activity. The solar wind data show several CIRs and HSSs. Ionospheric and thermospheric effects caused by these solar wind features will be briefly overviewed. There are increases in the low-latitude daytime GPS vertical total electron content (VTEC) during intervals of geomagnetic activity. Thermospheric infrared emission data obtained by SABER onboard TIMED are a proxy for energy influx into the ionosphere-thermosphere system. The data show an increase in thermospheric cooling during CIR-HSS intervals and correlate with auroral activity.
Energetic particle precipitation into the auroral region during CIR-type geomagnetic storms cause increases of ozone depleting species in the mesosphere and leads to catalytic ozone destruction. We emphasize the efficiency of heliospheric-magnetospheric-ionospheric-atmospheric coupling during the declining phase of a solar cycle.

The updated analytical approach to electron beam precipitation in flares and its effects on differential, mean electron energy spectra and HXR emission

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We present new fully analytical solutions of continuity equation for beam electron density taking into account the free terms omitted in the previous approaches for electron flux were obtained by the application of method of characteristics for pure colissional and pure Ohmic losses. The updated solution are found to be in a significant departure (by an exponential factor) from the original solutions presented by Syrovatskii and Shmeleva (1972). For the case of pure collisional losses there is a major decrease in depth of the electron differential density seen at lower energy range (10 - 100 keV) caused by this exponential term. In the case of pure Ohmic field losses, the corrected solution yield higher values of differential densities for the lower energy range of 1 keV to 10 keV, indicating their stronger dependence on precipitation depth and possible acceleration of the ambient electrons by the electric field induced by beam electrons. For either solution an increase in the initial energy flux of the beam electrons leads to a proportional increase of the beam densities at a given depth. Larger spectral indices result in lower differential electron densities at given depths and steeper decrease towards lower energies, comparing to harder beams (with lower spectral index). Hence, this correction is provn to lead to more accurate explanation of the differential density fluctuations at lower energy range and the improvement of the interpretation of HXR emission and mean electron spectra derived from pure analytical solutions close to those derived from Fokker-Planck numeric simulations.

Non-linear phenomena in space plasmas

Mirror and Weibel Instabilities: Similarities and Nonlinear Dynamics

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A commonality in nonlinear saturation mechanisms of Mirror and Weibel instabilities near threshold is demonstrated. In both cases the major contribution is provided by modification of the velocity distribution function in the vicinity of small parallel particle velocities (ions in Mirror case and electrons in Weibel). The final relaxation scenario is based on almost resonant particle interaction with Mirror/Weibel modes. This scenario differs from that in quasilinear plateau formation (or equivalent trapping effects). The analogy between nonlinear regimes of those instabilities developing far from thresholds becomes muted. The saturated plasma state can be considered as a magnetic counterpart to electrostatic BGK modes. Our analytical model is verified by relevant numerical simulations. Test particle and PIC simulations indeed show that it is a modification of distribution function at small parallel velocities that results in fading away of free energy driving Mirror/Weibel modes. The multipoint measurements in space plasma are used to validate a proposed scenario.

New collective processes in space dusty plasma

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The basic points of the consistent kinetic theory of dusty plasmas are formulated. The equations for microscopic phase densities of plasma particles and grains are derived with regard to electron and ion absorption by grains and the relevant kinetic equations are found. Obtained equations are used for kinetic description of collective effects in dusty plasmas, in particular, effective grain-grain potentials. Approximate analytical expressions for such potentials are derived and compared with the results of numerical solutions of the appropriate kinetic equations. The comparison shows satisfactory agreement between the analytical and numerical results. The influence of the external magnetic field on the asymptotic properties of the potential is also discussed. Obtained numerical solutions make it possible to study the dependence of stationary grain charge and the charging currents on plasma parameters and grain size. The screening of the moving grain is studied as well. It is shown that due to specific polarization of plasma the dynamical friction force acting on the particle under consideration can change its sign and thus to cause particle acceleration provided that the polarization force exceeds the friction force associated with neutrals. This effect was predicted using analytical estimates, but now it is confirmed on the basis of numerical solutions. The application of the obtained results to the description of space plasma is discussed.

Waves and flows in the Solar atmosphere

How close are we to solve the coronal heating problem?

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The latest satellite and ground-based observations have provided a wealth of evidence of waves and oscillations present in the magnetised solar atmosphere. Our understanding of the solar structures and dynamics has been considerably changed in light of the high spatial and time resolution observations (e.g. DST/ROSA, IBIS, CoMP, STT/CRISP; SOHO, TRACE, STEREO, Hinode, SDO, and now IRIS). Detecting MHD waves allows us to perform sub-resolution magneto-seismology of magnetic waveguides in the Sun.
I will concentrate on the role of Alfvén, kink and sausage waves present in the solar atmosphere, and will discuss the latest status of the sometimes controversial observations of these fundamentally important waves. The current theoretical (and often controversial) interpretations of the detected solar atmospheric wave and oscillatory phenomena within the framework of MHD will be shown. The photospheric origin and generation mechanism of these peculiar waves will be also addressed. I will report our latest observational findings of potential MHD wave flux in the solar atmosphere with some very surprising new results that may bring us closer to solve the solar atmospheric heating problem.

MHD-kinetic transition in Alfvenic turbulence

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Turbulent cascade of large-scale MHD Alfven waves proceeds towards progressively smaller length scales and eventually undergoes a transition to the kinetic regime. Various linear and nonlinear kinetic effects come into play at kinetic scales depending on the fluctuations anisotropy and plasma parameters. I will discuss the MHD-kinetic transition and related phenomena in view of recent theoretical results and observational evidences.

Waves and flows in the Solar atmosphere

One Possible Mechanism of Small-Scale Kinetic Waves Generation in Preflare Chromosphere of Solar Active Region

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On the base of Hasegawa-Chen model of three-wave interaction for laboratory plasma main necessary conditions have been investigated for the appearance of decay instability of kinetic Alfven waves, which can exist in solar plasma of the loop structures near its footpoints. The earliest stage of the flare process, well before the ”preheating” phase, has been studied. The modified expression for the growth rate of the process of decay of initial (’maternal’) kinetic Alfven wave (KAW) into kinetic ion-acoustic wave (KIAW) and secondary (’daughter’s’) KAW with making use of the ”conditions of synchronism” has been obtained. Two models of solar atmosphere have been used in calculations: a) model MAVN F1 for the ”faint” flares. It allows to neglect the influence of the high energetic particle beams in the area under investigation, when we study the process of energy exchange between corona and chromosphere; b) model FAL PM, which takes into account the influence of process of helium diffusion on the dynamics of solar flare. We supposed that magnetic field amplitude at the heights under investigation in chromosphere changes in the interval B0 10-40 G. These waves can be considered as frequently used in the modeling of different processes in solar chromosphere and are based on the observational data of SOHO, TRACE and RHESSI missions. It has been proved that KAW’s and KIAW’s generation in spatially nonuniform magnetoactive plasma with subdreicer electric field in the area under investigation is possible not only due to the temperature-drift instability, but due to parametric decay KAW’s instability too. Actually it means that there are two alternative channels of KAW’s and KIAW’s generation in addition to the two channels known before. ’Accidentally’ appeared unstable KAW with nonzeroth growth rate can transform through the decay instability (or through the finite number of such decays) into the KAW with zeroth growth rate, i.e. into the non-damped wave. It was shown that in considered special case, when we have studied the ’weak pump’ wave, the threshold value of the ratio of the wave amplitude to the amplitude of ’external’ magnetic field turns out to be essentially more high than in laboratory plasma. At the same time the obtained values of the wave amplitude get into the interval of the magnetic field’s amplitude changes, which have been fixed by the observers in the atmospheres of considerable number of the flares.

MHD Wave Propagation Through an Arcade-Shaped Magnetic Field with a Null Point

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MHD wave propagation from sub-photospheric layers through the transition region to the corona is still not well understood due to the complexity of the solar atmosphere. There are many obstacles for a wave on its way up, such as the cut-off layer; the transformation layer where plasma beta equals to unity; the discontinuity represented by the transition region; refraction and reflection on the magnetic canopy. Also, during their propagation in magnetized regions, the waves steepen and shock, leading to changes in the energy propagation. In order to understand the behavior of the MHD waves in the magnetized solar atmosphere, two-dimensional numerical simulations of the wave propagation in a model of a solar network are presented. The waves are excited by different driving mechanisms, to compare how much of the wave energy is able to reach the corona in each case.

The structure of fast sausage waves in the current-carrying coronal loops

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We study a model of flaring coronal loops that consists of a cylindrical core with axial magnetic field and coaxial annulus with purely azimuthal magnetic field. The magnetic field is discontinuous at the tube and core boundaries, and there are surface currents with opposite directions on these boundaries. The principal mode of fast sausage waves in such complex magnetic flux tubes admits an arbitrary wavelength. It is applied to the interpretation of observed periodic pulsations of microwave emission in flaring loops with periods of a few tens of seconds. Radial plasma motions about the tube and core boundaries have opposite directions, that leads to a contraction of the annulus. We assume, the principal mode of fast sausage waves in the current-carrying coronal loops is able to produce a current sheet near their apexes. However, a nonlinear analysis is needed for the confirmation of this assumption.

Physical nature and spacial-time structure of the sun global flows

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The authors propose and justify the physical mechanism of the origin and existence of global flows in the solar convection zone, which include the global meridional flow, global torsional oscillations [1, 2] and the recently discovered spatio-temporal variations of the poloidal flow [3]. The reason of existence of all the mentioned flows, as the authors have managed to find out, is a consequence of the loss of stability of the differential rotation of the plasma in the solar convection zone. We studied stability of the real profile of the Sun differential rotation [4], obtained by methods of helioseismology, and have determined the region, where the rotation of the plasma becomes unstable according to the Rayleigh criterion. To study the quantitative properties of flows arising from the loss of stability, the authors proposed a hydrodynamic model consisting of the Navier-Stokes equations and the continuity equation in the form of inelasticity [5]. The input parameters of the model are helioseismological data on the differential rotation of the Sun convection zone [6] and the data on the distribution of the plasma density in the convective zone, taken from the standard solar model. Solutions are obtained in the numerical study of the model by the finite element method. Comparisons of them with the observational data and the helioseismological data of spatiotemporal dynamics of global flows of the Sun revealed their qualitative agreement. In general the authors found that: - all of the global flows of the Sun that had previously been studied separately, based on the different perceptions of their physical causes, can be explained within the framework of the proposed hydrodynamic model; - the emergence and existence of global flows of the Sun is of purely hydrodynamic nature and these are the torsional oscillation (zonal flows) and the spatio-temporal variations of the poloidal flow, a period which coincides with the period of the solar magnetic cycle [5], which mainly affect the structure and dynamics of the global magnetic field of the Sun, and not vice versa; - torsional oscillations and spatiotemporal variations of the poloidal (zonal) flow, which were found at different times [5] and studied separately, although they have the same period of oscillation, are the toroidal and poloidal components of a 3-D spherical mode of standing oscillations. - the obtained numerical solution is represented as a set of two classes of functions: those which are anti-symmetric with respect to the Sun equator, and symmetric with respect to the Sun equator. These functions corresponds to anti-symmetric and symmetric flows with respect to the equator. Hence from our point of view the anti-symmetric flows theoretically can exist on the Sun. But the presence of symmetric flows on the Sun is not yet widely recognized, they are usually attributed to a hardware error, although they are recorded in the observational data [3].

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New physics in numerical modelling

The sources of the slow solar wind: observations and models

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The slow solar wind is characterized by the asymptotic outflow speed of 400 km/s, high density (compared to the fast wind), high variability, and heavy ion compositional signature different from the fast wind. During periods of solar maximum slow wind streams dominate the heliosphere. The sources of the slow solar wind are associated with streamers and quite Sun regions. However, the exact origin and the acceleration mechanism of the slow solar wind are still under study. I will review in-situ observations from ACE, Wind, and Ulysses of the solar wind plasma, as well as spectroscopic observations of the slow solar wind plasma emission in UV and EUV from SOHO/UVCS and Hinode/EIS. I will present the results of single-fluid MHD and multi-fluid model of slow solar wind in coronal streamers, and discuss the progress in the understanding of slow solar wind formation thanks to the combination of recent models and observations.

Multi-Source Modelling of Helioseismic Waves in the Sunspots and Quiet Sun Regions.

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We presented our recent results on 2.5D multi-source simulations of wave propagation into MHS sunspot atmospheres. We investigate two different models of random sources. In one case, the sources are located uniformly at fixed depth, while in the other case, the sources are placed at lower depth inside the sunspot umbra, following the Wilson depression, and also attenuated in strength. We found that the unmasked source model gives a realistic wave-field for the quiet sun, but unrealistic results for the sunspot model. The opposite behaviour was found for the masked source model.

Spectropolarimetric signatures of photospheric intergranular vortices

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Intergranular photospheric vortices, which have recently been discovered using simulations of photospheric magneto-convection, are a photospheric phenomenon that appears to be responsible for energy transport through the solar atmosphere. The vortices are horizontal motions characterised by relatively short lifetimes and small spatial scales, which makes them difficult to detect and observe. I will demonstrate the physical properties and spectropolarimetric signatures of intergranular vortex motions and discuss the ways to observe them.

New physics in numerical modelling

Solar convection simulated with the Mancha code: A progress report

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The visible solar surface at any moment is dominated by the bright granules separated by dark intergranular lanes. The physics behind this pattern is well understood and has been reproduced in realistic 3D hydrodynamical simulations. Therefore, reproducing the solar granulation became a sanity check and an important test for any new numerical code devoted to realistic simulations of the solar convection zone and the solar atmosphere. In addition to that, there are still open questions related to the transport and generation of the magnetic field in the granulation and to the coupling between the microscopic and macroscopic physics in the photosphere. Here we present the preliminary results of the solar convection simulations performed with the Mancha code. In particular we demonstrate the influence of the equation of state and the radiative transfer equation on the parameters of simulated granulation.

3D Simulations of Magnetohydrodynamic Waves Driven by Photospheric Motions

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The torsional/vertical/horizontal motions of the plasma at the base of magnetic flux tubes could excite various MHD wave modes which propagate upwards though the solar atmosphere into the solar corona. Here we examine numerically the generation and direct propagation of such MHD wave modes in such magnetic structures. Simulations are run as the motions propagate through a gravitationally strongly stratified atmosphere towards the solar corona. We analyse the excited MHD wave modes and determine the energy flux they carry along the magnetic field lines. Also, new analytical approach for the magnetic flux tube construction in the realistic solar atmosphere will be discussed. The model includes a number of free parameters, which makes the solution applicable to a variety of other physical problems and it may therefore be of more general interest.

Physics of magnetosphere and ionosphere

AFFECTS: Space Weather for the European Community

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Space Weather is caused by perturbations on the Sun, carried by the solar wind through the magnetosphere to the Earth. To effectively analyse and forecast such a complex phenomenon it is necessary to chain the models of different regions and processes and integrate them into a global framework. This was accomplished in the FP7 project 'Advanced Forecast For Ensuring Communications Through Space' (AFFECTS), which aims to predict the ionospheric conditions above Europe for GNSS applications and to issue a number of alerts and early warnings. In this report we present an overview of main findings and developed services achieved during the project lifetime. More details are available at the project website www.affects-fp7.eu.
The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under the grant agreement No. 263506 (AFFECTS).

Modeling electromagnetic and hydromagnetic wave coupling in LAIM/MIAL system and possible application to Space Weather studying

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We emphasize the wave aspects of the coupling between the regions of the Lithosphere-Atmosphere-Ionosphere-Magnetosphere (LAIM/MIAL) system. We concentrate, first of all, on the waves in the atmosphere and ionosphere (in particular Atmospheric Gravity Waves (AGW) and Planetary Electromagnetic Waves (PEMW)), but discuss also the connection between these waves and MHD wave activity in the LAIM/MIAL system. We outline the model of PEMW in the different (D, E and F) regions of the ionosphere and a qualitative model of AGW waveguiding propagation in the F region. We discuss also the perspectives of the application of our newly developed, for the metamaterial field concentrators, combined 'Complex Geometrical Optics (CGO)-Full-Wave Nonlinear Electromagnetic Modeling (FWNEM)' technique, to the Space physics wave problems. This method can be applied in particular, to the problem of penetration of electromagnetic (MHD) waves through the Ionosphere-Magnetosphere (MI) interface and MHD oscillations in the MI resonator. This approach can be developed and applied farther for treating the results of the Space experiments of the 'Resonance' type, where MI coupling may be critical, in particular under the conditions of active influence on the 'MI interface' by HAARP- like systems. We propose using the modeling AGW and their influence on MI resonator, to determine the variations of Q-factor of this resonator and the characteristics of PC 1,2 pulsations, observed on the satellites and ground observatories. We also discuss a direct evidence of the manifestation of Space Weather phenomena in the atmospheric electricity. We emphasize a necessity and importance of new models for AGW- and Quasistatic-Electromagnetic-Photochemistry channels of coupling in the LAIM/MIAL system for the Space weather processes and seismoionospheric phenomena. Namely, we discuss a necessity of an inclusion of nonlinearity and non-isothermicity into AGW model and the refuse from electrostatic approximation for the electro-photochemistry model. The new nonlinear analytical model of PEMW, valid (in local β-plane approximation) for arbitrary altitudes in D, E and F ionospheric regions, as well as for intermediate altitudes between D and E and between E and F regions, is developed. We propose, for the first time for the PEMW, the method of consistent utilizing 'nonlinear Ohm's law' and series expansion in relatively small non-stationary part of magnetic field. The new numerical method for the simulations of the evolution of PEMW is developed. This is highly stable and efficient hybrid

finite-difference-spectral-stable method, based on splitting by physical factors. The preliminary results of the application of this method are presented, first. Within the ionosphere F-layer, Z = 300 km, the pulse-like PEMW can preserve their shapes during 104 s. Within the magnetosphere, Z = 600 km, PEMW could preserve their shapes during much smaller times ¡103 s, because the Pedersen conductivity in the magnetosphere is much smaller than in the ionosphere. The perspectives of the practical application of developed model are: using PEMW, along with AGW, in the systems of monitoring of Space Weather and natural hazards, as a sensitive indicator of wave coupling processes and influences on the ionosphere 'from above' (magnetosphere, solar wind) and 'below' (lower atmosphere sources, such as cyclones etc.)

Effect of total ozone content variations on ground air temperature at middle latitudes of Earths Northern hemisphere

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The variations of yearly means of ozone layer amounts at different heights, as well as total ozone content, were compared versus ground air temperature deviations for the middle latitudes of the Northern hemisphere. Significant negative correlation between ground temperature and stratosphere (above 19km) ozone layer amounts were revealed; while variations of troposphere ozone content show positive correlation with such of ground temperature instead, although non-significant. Net correlation between total ozone content variations and ground air temperature yields also negative and statistically significant value. Yearly variations of temperatures at large Ukrainian cities were also compared with variations of total ozone content in atmosphere over the Eastern Europe region. It was shown that anti-correlation between ground air temperature and total ozone content also present in case of small geographical areas, as well as for zonal values. It is concluded that "anti-geenhouse" effect of the total ozone content overwhelms the positive greenhouse effect, caused by its tropospheric component.

Quasistatic-photochemistry channel of the coupling in the system Lithosphere-Atmosphere-Ionosphere-Magnetosphere (LAIM/MIAL) system and possible application to the Space weather and seismoionospheric phenomena.

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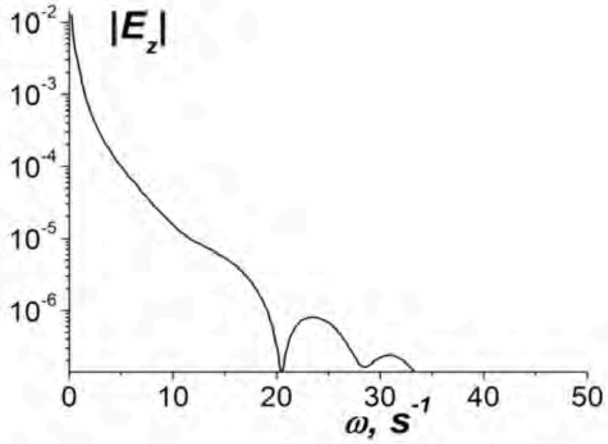
We build now the general model of the coupling processes between different regions in the Lithosphere-Atmosphere-Ionosphere-Magnetosphere (LAIM/MIAL) system. We search, in particular, the 'wave channel' of coupling in LAIM/MIAL system including hydromagnetic waves (such as Atmospheric Gravity Waves (AGW) and Planetary Electromagnetic (EM) Waves (PEMW)) and electromagnetic waves.
In this context, the present paper is devoted to the other channel of the coupling in the LAIM/MIAL system, namely 'quasistatic-photochemistry (QUAP) channel'. We are developing now the new quasistatic model for the coupling (including seismoionospheric and Space Weather processes) in LAIM/MIAL system, to refuse, in perspective, from widely accepted now electrostatic model. Indeed this is necessary because for any real non-stationary sources, electrostatic approximation fails at some altitude in the ionosphere with finite conductivity. This is principally important for coupling processes where the ionosphere and magnetosphere or/and 'magneto-conjugated ionospheres' are involved. We also propose both qualitative and numerical model of the coupling between atmospheric electricity and Space Weather processes. This manifests in the oscillations of the lower-atmosphere current with the frequency near to Alfvén resonant frequency. In particular, oscillations with frequency f close to 5 Hz ($\omega = 2\pi \approx 30.7s^{-1}$) had been observed in the near-ground electric current in the Negev dessert during 2 hours simultaneously with magnetic storm. The qualitative approach is based on the classic Vainshtein's theory of excitations of opened resonator (magnetosphere-Ionosphere (MI) in our case) by means of external EM field incident on the resonator from the magnetosphere. Numerical approach is based on the integro-interpolation method for the full-wave Maxwell equations. The results in the Figure show a presence of resonant response of the Alfvén resonator to the Alfvén wave excitation incident from the ionosphere at $\omega \approx 31s^{-1}$. Our interpretation of the observed data is that the resonant vertical electric field E_z during a magnetic storm caused oscillations in the vertical electric current with the same frequency. The present experimental results and interpretation constitute, as far as we know, the first direct evidence of the connection between

the Space Weather and atmospheric electricity phenomena.



The new propose 'quasistatic-fully electrodynamics' approach for electricity phenomena in the system MIAL/LAIM integrate quasistatic model for the lower ionosphere with full-wave modeling for the whole 'atmosphere-ionosphere', while quasistatic field, determined from the corresponding model, serves as an effective 'external source' for the 'curl electric and magnetic fields' in the ionosphere. Photochemistry processes may be incorporated in this model in the very natural way, yielding the nonlinear part of the conductivity in the atmosphere and ionosphere. Wave and QUAP channels of coupling in LAIM/MIAL system create a deep background for searching both Space Weather and seismoionospheric phenomena and distinguishing between different reasons of observed seismoionospheric precursors for different geophysical conditions and in different seismic zones.

Physics of magnetosphere and ionosphere

Analysis Of The Magnetic Field Fluctuations In The Boundary Regions Of Earths Magnetosphere

Alexander Tsupko[1], *Ludmila Kozak*[2], *S. Savin*[3], *A. Liu*[4] *and V. Ivchenko*[5]

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Statistical features of the magnetic field fluctuations in the boundary regions of Earth's magnetosphere are investigated on the different time scales. The Cluster-II mission measurements made from 2004 to 2009 are used for our analysis. Changes in the shape and parameters of the probability distribution function for magnetic field fluctuations are studied for the time intervals when the satellite was within the magnetosheath, solar wind plasma, and magnetopause regions. The evolution of the change of the probability distribution functions maxima and kurtosis values are considered, and the structure functions of different orders are investigated as characteristics of turbulent processes for different time scales. Two asymptotic modes of the change in the maximum height for the probability distribution function are found which can be described using different power laws. On the basis of the investigation of structure functions of high orders (up to the ninth order), the character of turbulent processes is determined, and diffusion in the regions under consideration is studied. It is found that the type of turbulent processes in solar wind plasma differ greatly from that observed in the magnetosheath. Besides, super-diffusion is revealed in transitional regions of Earth's magnetosphere. The work is done in the frame of complex program of NAS of Ukraine on space researches for 2012-1016, and under a partial support of the grant No. F 53.2/039.

Apply of Fractal Methods to Investigate Ionospheric Conductivity in the Auroral Region

Alexander Chernyshov[1], *Mikhail Mogilevsky*[2] *and Boris Kozelov*[3]

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Fractal geometry is used to describe the spatial structure of the ionospheric conductivity. Topological values of fractal dimension and connectivity index, characterizing the structure of the Pedersen and Hall conductivities on the night side of the auroral zone, are analytically obtained. Restrictions imposed on fractal structure of the ionospheric conductivity are analyzed in terms of the percolation of the ionospheric Pedersen and Hall currents. It is shown that the observed scaling for the fluctuations of electric field and for the auroral glow in the auroral region is well within the limitations imposed by the critical condition for percolation of Pedersen currents. The dimension of multiple arc structures corresponds well to fractal estimates of Hall conductivity. Correspondence of theoretical estimates and experimental results indicates validity of the fractal approach to describe processes in the auroral region.

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INFORMATION

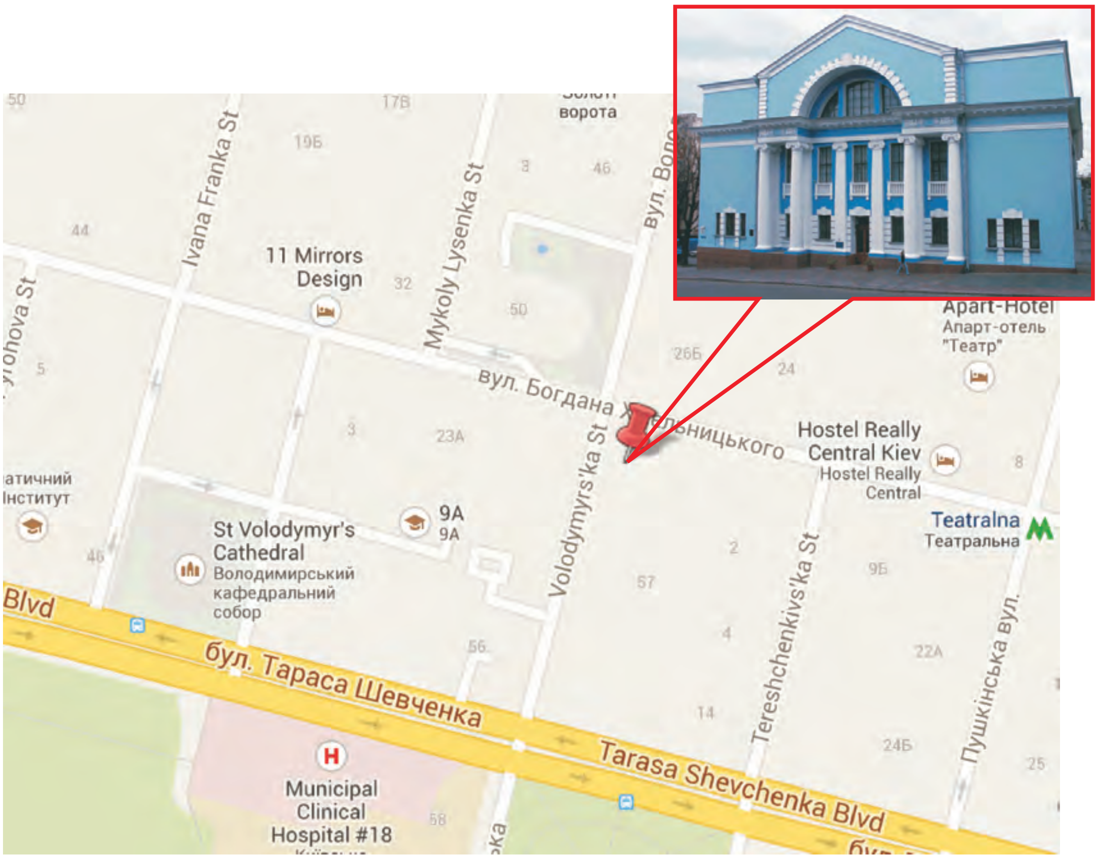
Important telephone numbers

Ambulance	**103**
Police	**102**
Fire	**101**

It is likely that emergency services staff may not be able to communicate in English. In this case, if the need arises, ask someone fluent in Russian/Ukrainian to help explain the nature of emergency to the services involved.

Meeting venue

The conference will take place in **Ukraine's National Academy of Sciences Section Hall**. The National Academy of Sciences is located in the picturesque part of the old Kiev City Centre. **Address: Volodymyrska Street 55** (marked as a red pin on the map below).



Money/shopping

Ukrainian local currency is Hryvnya - pronounced as **grivna** - (UAH). Approximate exchange rates:

1 GBP = 12.60 UAH
1 EUR = 10.85 UAH
1 USD = 8.145 UAH

Many, but not all shops, supermarkets and restaurants accept card payment. However, it is a good idea to have some pocket money while travelling. Hryvnyas may be withdrawn from ATMs (bankomat). Also, you can use exchange points (there are plenty of them) to get local currency. However, note that British pounds are not as widely accepted as Euros and US dollars.

Travel by taxi from/to Boryspil Airport

Boryspil International Airport has its own taxi service - '**Sky Taxi**'. '**Sky Taxi**' cars are available for hire in the **drop-off zone** in front of each terminal.

You can book a **Sky Taxi** directly with agents in Terminals B , D and F of **Boryspil** International Airport. The rate is **6,50 UAH/km**.

Boryspil Airport - Kiev/Bohdan Khmelnytsky Str,56A (CityHotel): $\approx$ 250UAH

This rate is charged for every kilometre starting from the first one and is applied for transportation of passengers to any destination at a distance exceeding 10 km from the journey's start point. A 1 UAH per minute independent charge is made for standstill moments, including traffic jams, if the vehicle is moving at speeds of less than 5 km/h and whilst waiting for passengers.

Travel by bus from/to Boryspil Airport

Boryspil Airport has 3 terminals in operation: B, D, and F. Most international flights arrive in the

terminals D or F, whereas terminal B is used for domestic flights.
The simplest way to get to the city centre from **Boryspil** International Airport is the '**Sky Bus**', which operates a regular bus service between the airport and **Central Railway** station. Buses depart every 15 minutes during rush hour, or every 45 minutes in the middle of the night, 24 hours per day, and the cost is 40 UAH (see details here http://skybus.kiev.ua/airport.html).

Tickets are bought directly from the driver or from '**Kiyavia**' booking-offices located in each terminal. The journey to the city center takes 40 to 70 minutes. The buses stop in the front of every terminal. Buses terminate at the southern side of the railway station. To get to the **metro ('Vokzalna station')** from the bus stop, enter the railway terminal, follow the bridge over the railway, leave the building, and turn left.

Kyiv International Airport '**Zhuliany**' http://www.airport.kiev.ua/en/ is located 8 kilometers southwest of the city center. It is mostly served by budget airlines. Wizzair is the major airline operating to this airport. From '**Zhuliany**' you can use Kiev's public transport to reach your accommodation or the train station. There are two terminals - they are around 1 kilometer away from each other. They're connected by trolleybus no. 22 that takes you further downtown.

Travel in Kiev by taxi

Taxis in Kiev are relatively cheap when compared to Europe. However, taxi drivers tend to make you pay more than the normal price. Always ask for the full price before you get into the taxi to avoid disappointment and unnecessary negotiation after you have already travelled. Taxi rides are paid by cash only, and it is unlikely you will get a receipt. The following is an approximate and is given as a guide for what you expect to pay:

Please use the following phone numbers to call a taxi:

+ 380 050 352 53 66 (Panda Taxi)

+ 380 044 455 95 95 (Absolut Taxi)

Don't expect the services to speak English. It would be best to contact the conference organisers or the hotel personnel to book a taxi and arrange your trip for you.

Travel in Kiev by metro

1. Finding the metro.
To find the entrance to the metro, look for the big green **M**.
The **M** marks the stairs that lead underground, but be aware that there is often a busy collection of kiosks, tunnels, cash machines (ATMs) and grandmas selling stuff like bread or knickers before you get to the metro itself.

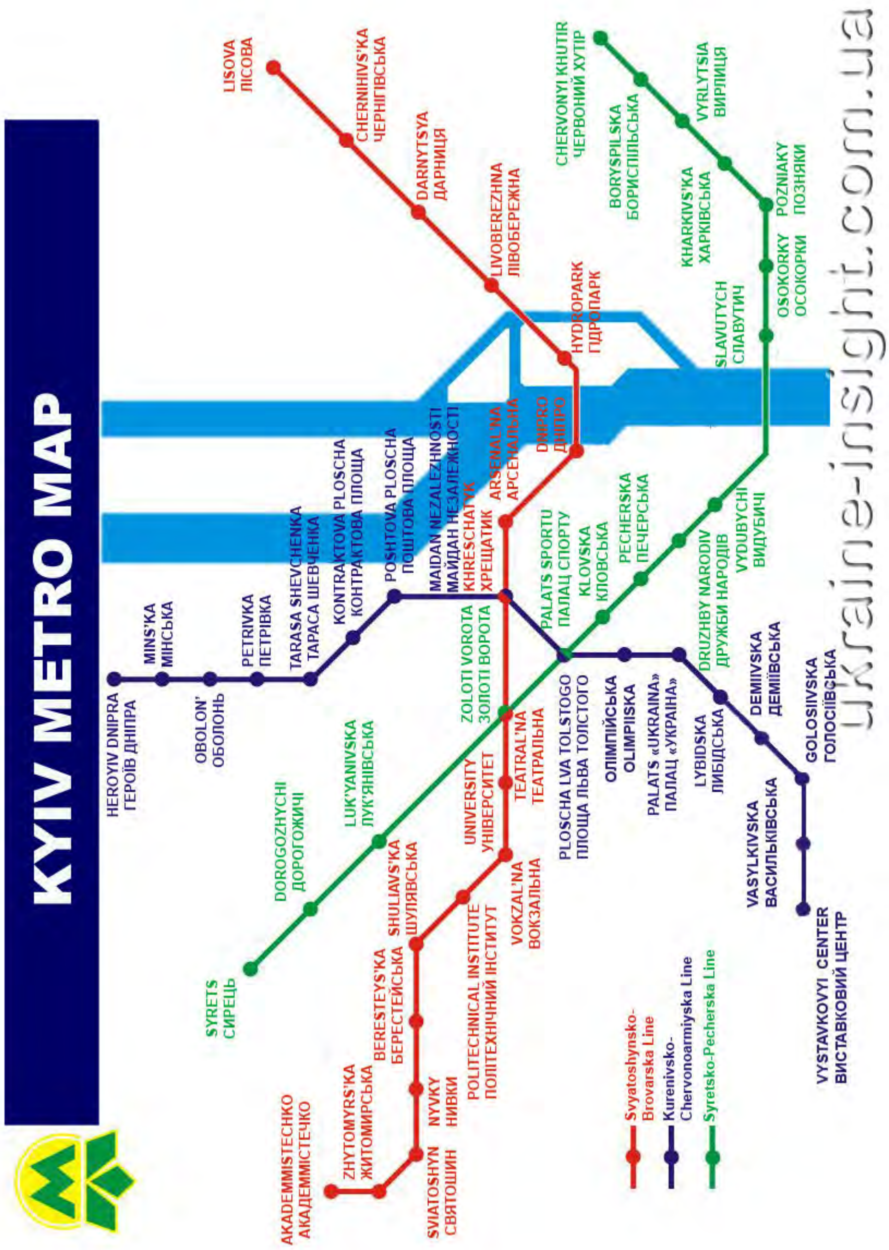
2. Accessing the metro.
Enter > buy a ticket > get through the gates.
Your first big challenge will be the swinging doors that guard the metro. These glass and metal doors swing (fast) in both directions, they are heavy enough to kill a bear and unless you're old, it is unlikely that the person in front of you will hold the door open for you. So, just be ready and be careful to catch the thing as it swings back in your face. If you're clever, you can pass the door as the wind coming from the station blows it open, or as it swings open after the last person entered. However, both of these are advanced metro skills and shouldn't be tried during your short visit.
There are two sets of doors for each station. One set to enter and one to exit.
вхід - enter
вихід - exit

Can you see the difference? No? Well, don't worry.
вхід (4 letters) - enter
вихід (5 letters) - exit

3. Buying a 'ticket'.
Actually you need a token or 'zheton'. These are small plastic coins and you need one token to enter. A token costs 2 UAH and there are two ways to buy them.

1. Go to the window, give the woman your money and indicate the number of tokens you need with your fingers.

2. Go to the small orange dispenser machines. It the dispenser has a 2 on it, enter 2 UAH and you'll get one coin. If the dispenser has a 10 on it, enter a 10 UAH and you'll get 5 coins. NB, the machines only accept the exact notes. If you try to enter anything but a 2 or 10 you will get nowhere and people will get annoyed with you.



Tourist attractions

There are plenty of them! To obtain more information on tourist attractions in Kiev please ask the hotel personnel or the conference organisers.

1. **Sofia Square** - one of ancient squares of Kiev. At Sophia Square is located the bell tower of St. Sophia Cathedral and the monument to Bogdan Khmelnitsky. According to legend, the site of the Sofia area, which was a field near the city walls, Yaroslav Mudry in 1036 defeated the Pechenegs, and then built the Hagia Sophia on the site, and the area in front of him named Sophia.

Kyiv Pechersk Lavra also known as the Kiev Monastery of the Caves, is a historic Orthodox Christian monastery which gave its name to one of the city districts where it is located in Kiev. Since its foundation as the cave monastery in 1051 the Lavra has been a preeminent centre of the Eastern Orthodox Christianity in Eastern Europe. Together with the Saint Sophia Cathedral, it is inscribed as a UNESCO World Heritage Site.

House with Chimaeras or Gorodetsky House is an Art Nouveau building located in the historic Lypky neighborhood of Kiev. Situated across the street from the President of Ukraine's office at No. 10, Bankova Street, the building has been used as a presidential residence for official and diplomatic ceremonies since 2005.

Mother of the Fatherland is a monumental statue in Kiev. The sculpture is a part of Museum of the Great Patriotic War, Kiev. Stainless steel statue stands 62 m (203 ft) tall upon the museum building with the overall structure measuring 102 m (335 ft) and weighing 560 tons.

The Andriyivskyy Descent is a historic descent connecting Kiev's Upper Town neighbourhood, begins on the summit of the Starokyivska Hora (Old Kiev mountain) near the ornate late-baroque Saint Andrew's Church (which gave the street its current name). The street continues on down and descends to the Podil district were it ends at the Kontraktova Square.

The Golden Gates of Kiev is a major landmark of the Ancient Kiev and historic gateway in the ancient city fortress. Currently it serves as a museum and can be found on the corner of Volodymyr street and Yaroslaviv Val Street (Yaroslav's Moat). The name Zoloti Vorota is also used for a nearby theatre and a station of the Kiev Metro.

Supported by The European Office of Aerospace Research & Development (EOARD)