RUSSIAN ACADEMY OF SCIENCES
NATIONAL GEOPHYSICAL COMMITTEE

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NATIONAL REPORT
Presented to
the International Association of Geomagnetism and Aeronomy
of the International Union of Geodesy and Geophysics
1999 – 2002

Национальный отчет,
представленный
Международной ассоциации геомагнетизма и аэрономии
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Отчет, подготовленный Национальной комиссией по геомагнетизму и Аэрономии к XXIII генеральной ассамблее МАГА и МГГС, отражает некоторые основные результаты исследований, выполненных российскими учеными в 1999 - 2002 гг по следующим разделам: 1) внутреннее магнитное поле Земли; 2) аэрономия; 3) магнитосфера; 4) солнечный ветер и межпланетное магнитное поло; 5) приборы, обсерватории, службы и анализ данных.

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The report is prepared by the Russian National commission on the Geomagnetism and Aeronomy to the XXIII IAGA/IUGG General Assembly. Some main results of 1999 – 2002 are presented on the following subjects: 1) internal Earth`s magnetic field; 2) aeronomy; 3) magnetosphere; 4) solar wind and interplanetary magnetic field; 5) observatories, instruments, surveys and analysis.

The electronic version of the Report can be found at the Russian National Geophysical Committee web page:

http://www.wdcb.rssi.ru/NGC

Editors: Prof. Victor N. Oraevsky
Prof. Vadim P. Golovkov
Prof. Igor` S. Veselovsky

Foreword

This report containing a review of the activities and scientific researches in 1999-2001 in Russia has been compiled for

the presentation to the International Association of Geomagnetism and Aeronomy at the XXIII General Assembly of IUGG.
There are five sections in the report according to the IAGA Divisions I-V
The preparation of this report has been organized by the National Commission on the Geomagnetism and Aeronomy and the National Geophysical Committee as a collective effort of the team of authors, who compiled the greater parts of the Sections: S.I. Avdiushin, I.V. Chashey, A.N. Didenko, A.I. Efimov, V.P. Golovkov, A.M. Gorodnitsky, G.A. Kotova, N.G. Kleimenova, A.P. Kropotkin, S.N. Kuznetsov, V.E. Pavlov, A.S. Potapov, E.N. Sosnovets, V. Spichak, P.M. Svidsky, E.D. Tereschenko, I.S.Veselovsky. Some additional information has been provided by several institutions and researchers. Only minimal editorial work has been done when putting all these parts together, preserving, thus the diversity in styles and approaches.
The report cannot be considered as comprehensive review of the principal achievements during this period of time in this field of science in Russia. Moreover, some arbitrariness in the choice of the material makes the report far from being complete. Many important results are not mentioned at all.
Bearing in mind all these restrictive circumstances we hope that the readers who are interested in this field of science can find useful sources of information in this report.

Acknowledgements

We are grateful to the authors, institutions and many researches who provided the information for this report. We are especially grateful to Prof. A.N. Didenko, the Chairman of the Council on Geomagnetism and Aeronomy of the Russian Academy of Sciences.

The Editors

Abstract

The Report is prepared by the Russian National Commission on the Geomagnetism and Aeronomy to the XXIII IAGA/IUGG General Assembly. Some main results of 1999-2002 are presented on the following topics: 1) Internal Earth's magnetic field; 2) Aeronomy; 3) Magnetosphere; 4) Solar wind and interplanetary magnetic field; 5) Observations, instruments, surveys and analysis.

Editors: Prof. V.N.Oraevsky, Prof. V.P.Golovkov, Prof. I.S.Veselovsky

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THE MOST SIGNIFICANT RESULTS OF THE INSTITUTE OF TERRESTRIAL MAGNETISM, IONOSPHERE AND RADIO WAVE PROPAGATION (IZMIRAN) OF THE RUSSIAN ACADEMY OF SCIENCES

(compiled by Prof. V.P.Golovkov)

CORONAS-F MISSION PROCEEDS WITH SOLAR OBSERVATIONS

The Russian-Ukrainian satellite CORONAS-F with 15 scientific instruments on board, launched on July 31, 2001, continues observing the Sun and studying the solar-terrestrial coupling. The DIFOS spectrophotometer records have been

used to isolate p-modes in the global oscillations of the Sun and to study their amplitude characteristics in a broad spectral range from 350 to 1500 nm. The X-ray spectrometers DIOGENESS and RESIK detected emission in numerous spectral lines during the most powerful solar flares, when the other available facilities fell off-scale; i.e., the line profiles were cut-off in amplitude. The X-ray spectra obtained have been used for detailed diagnostics of the flare plasma and investigation of the energy release and dissipation processes in solar flares. Fast dynamic regions of super-hot (10^7 K) plasma, reflecting fast processes in the flare-associated magnetic arcs, were revealed and studied during the SPIRIT experiment in the solar corona. The high-resolution (10 ms) data on the flare-generated X-ray emission obtained with the flare X-ray spectrometer IRIS allowed us to identify the main signatures of pre-flare situation in the Sun and to study the particular features of the flare process itself. The spectral analysis of the flare X-rays in different phases of the flare evolution (pre-flare, eruptive, and post-flare phases) has shown that a characteristic feature is the appearance of the oscillation periods typical of each phase reflecting the particularities of the preparation, evolution, and decay of a solar flare.

For the present, the CORONAS-F mission has provided about a million X-ray spectra and more than 300 thousand high-resolution X-ray images of the Sun, many time profiles of the flare-generated emissions in a broad energy range, as well as new Solar Cosmic Ray and UV data.

V.N.Oraevsky, I.I.Sobelman. Comprehensive Studies of Solar Activity on the CORONAS-F Satellite. Astronomy Letters, Vol.28, № 6, 2002, pp.401-410. (Translated from Pis'ma v Astronomicheskii Zhurnal, Vol.28, № 6, 2002, 457-467).

V.N.Oraevsky, I.I.Sobelman, I.A.Zitnik, V.D.Kuznetsov. Comprehensive solar studies by CORONAS-F satellite: new results. Physics – Uspekhi **45**(8), p.886-896, 2002.

TERRESTRIAL MAGNETIZM

1. Main geomagnetic field and its secular variations

Using magnetic surveys, data from satellites Oersted, Champ and Magsat developed new methods for global modeling the space-time structure of the geomagnetic field. The ST model was developed with this new technique and use both satellite and observatory data from 1980 till nowadays Based on this STM candidate models of a new generation of IGRF were developed for epoch 1985, 1990, 1995, 2000 as well as a candidate model of SV for 2000-2005 [Bondar et al., Oersted, 4th International Science team Meeting, Proceedings, Copenhagen, Denmark, 2002, 5 p.] investigated using different approaches. All available data series from geomagnetic observatory global network from the end of XIX century to nowadays were carefully analyzed in search of jerks epochs [Golovkov et al., 4th International Science team Meeting, Proceedings, Copenhagen, Denmark, 2002, 4 p.].

Method of the wavelet analysis was adapted for time series of data from observatories of the global network. The data of the time interval of the XX century was analyzed with this method. Power, dispersion and fractal characteristics were derived.

As outcome of this study the following results were obtained:

- A rather large downfall in the SV power spectra was discovered about a=28-30 of the wavelet transform.
- Sharp changes of SV of duration about ten yrs were discovered in 1969-1970 and 1989-1990 yrs. They are of the undoubtedly inner origin. It corresponds to the averaged electroconductivity of the mantle about 10^3 Cm/m [Rotanova et al., Geomagnetism I Aeronomiya, 2002, V.42, №5, pp. 708-720].

New interesting results were obtained in the hydromagnetic geodynamo. The first spherically symmetrical analytical solutions of the basic linear heat conduction and admixture diffusion equations was derived for planets of Earth type by Starchenko and Kotelnikova in Journal of Experimental and Theoretical Physics, Vol.94, P.459. Starchenko and Jones in Icarus, Vol.157, P.426 considered the possible dynamical regimes in the cores of the Earth, Jupiter and Saturn, and hence estimated typical velocities and magnetic fields to be expected in their interiors. These estimates are in reasonable agreement with observations of the large-scale internal fields of those planets. Frick, Reshetnyak and Sokoloff proposed the first geomagnetic shell model of turbulence for the Earth's core in Europhys. Lett. Vol.59, P.217. This approach has made possible the resolution of MHD turbulence on a wide range of spatial scales: from 1000 km up to millimeters.

2. External variations

Using magnetic data from observatory global network as well as data from low and high altitude satellites some new results were obtained.

Slow dynamics and interactions in ensamples of solar photospheric of open magnetic fields lines have been found [Ivanov et al., 2001]. It was shown that these interactions are responsible for sunspot generation and decay.

Ivanov K.G., Kharshiladze A.F., Mel'nic A.N. Slow dynamics of open field lines as an indicator of subphotospheric interactions and its relation to solar activity events and Near-Earth disturbances: 1. Events of July – October 1999. Geomagnetism and Aeronomia (English Translation), 2002, V.41, №6, p.689.

It is established an approximately comparable contribution of the ring current (DR) and the magnetotail current (DT) during the storm main phase with calculating of Dst variation as superposition of the magnetic fields due to the current on the magnetopause (DCF), DR and DT.

Dremukhina, L. A., Y. I. Feldstein, I. I. Alexeev, V. V. Kalegaev, M. Greenspan, Structure of the magnetospheric magnetic field during magnetic storms, J. Geophys. Res., 104, 28351-28360, 1999

Alexeev, I. I., and Y. I. Feldstein, Modeling of geomagnetic field during magnetic storms and comparison with observations, J. Atmosph. Sol.-Terres. Phys., 63, 431-440, 2001.

Analyzing data from new missions Oersted and Champ the annual magnetic variation nature was clarified. Annual series of the daily sets of the spherical harmonic coefficients was expanded into the natural orthogonal components. One of these components was annual periodicity. In this way spherical-harmonic model of the annual variation was developed. It was found, that zonal terms of this model prevail very much over other terms. It gives us very significant argument in favor of a hypothesis by Pogrebnoy about circumpolar current systems in middle ionosphere over geographic poles [Zvereva et al., 4th International Science team Meeting, Proceedings, Copenhagen, Denmark, 2002, 4 p.].

3. Magnetic anomalies

Magnetic anomalies were studied using data from magnetic surveys near the Earth surface, in middle stratosphere (20-40 km) and on the satellite altitudes.

These were developed new approaches to reveling of singularities in the geomagnetic field structure and their use for determination of the equivalent dipole depth. Using wavelet transformation of the profile surveys of different altitudes over the Kursk magnetic anomaly the depth of its epicenter was estimated as about 15 km. The altitude dependence of magnetic anomalies was studied and used for the depth of their sources. This method gives the same results as the wavelet transformation.

Studying magnetic anomalies, obtained from the satellite surveys data over Atlantic and Pacific oceans, a rather high correlation was discovered between some peculiarities of the magnetic anomalies and depth of earthquake epicenters as well their magnitudes.

IONOSPHERE

A new theoretical model of the Earth's low and middle latitude ionosphere and plasmasphere has been developed [Pavlov, 2003]. The new model uses a new method in ionospheric and plasmaspheric simulations. It takes advantage of a combination of the Eulerian (an Eulerian computational grid is fixed in space co-ordinates) and Lagrangian (it is needed to solve only one dimensional time dependent ion and electron continuity and energy equations along a magnetic field **B** in the moving Lagrangian frame of reference) approaches. New equations which determine the trajectory of the ionospheric plasma perpendicular to **B** and an electric field **E** and take into account that magnetic field lines are "frozen" in the ionospheric plasma are derived and included in the new model. Different new strategies for solving the continuity and energy equations and a new direction splitting technique are developed and employed at the same time with the use of low and middle latitude boundary conditions. The model takes into account the role of vibrationally excited N_2 and O_2 and electronically excited O^+ ions in the ionosphere and calculates altitude profiles of electron and ion densities N_e and N_i and temperatures T_e and T_i above 130 km. We have presented a comparison between the modelled NmF2 and hmF2 and NmF2 and hmF2 which were observed at the anomaly crest and close to the geomagnetic equator simultaneously by the Huancayo, Chiclayo, Talara, Bogota, Panama, and Puerto Rico ionospheric sounders during the 7 October 1957 geomagnetically quiet time period at solar maximum. The revision of the empirical model local time dependence of the equatorial upward **ExB** drift velocity is found from the model calculations. It is found that T_e at F2-region altitudes become almost independent of electron heat flows along **B** above the Huancayo, Chiclayo, and Talara ionosonde stations because of the near-horizontal **B** inhibits the heat flow of electrons. The morning T_e peaks which are found above the ionosonde stations at hmF2 altitudes are explained by the sunrise physical processes.

There were very serious problems with explanations of existence of high plasmaspheric electron temperatures T_e (~7200-10700 K) measured by the instruments on board of the EXOS-D satellite and low T_e

measured by the Millstone Hill radar in the topside ionosphere within the same magnetic field line tube. The additional heating of electrons found brings the measured and modelled T_e into agreement in the plasmasphere and into very large disagreement in the topside ionosphere (up to 1000-2000 K) if the classical Spitzer-Harm electron heat flux is used. The discovery of the phenomena of the reduced and nonlocal electron temperature conductivity of the plasmasphere and the topside ionosphere [Pavlov et al., 2000] solves this problem. The new approach are derived leads to a heat flux which is much less (up to a factor of 2-3) than that given by the classical Spitzer-Harm theory. As a result, the high plasmaspheric T_e and low ionospheric T_e can exist at the same time.

1. Pavlov, A.V., New method in computer simulations of electron and ion densities and temperatures in the plasmasphere and low-latitude ionosphere, Annales Geophysicae, Vol. 21, No. 8, 2003, in press (http://www.copernicus.org/EGU/annales/ag_pt.htm).
2. Pavlov, A.V., Abe, T., and Oyama, K.-I., Comparison of the measured and modelled electron densities and temperatures in the ionosphere and plasmasphere during 20-30 January 1993, Annales Geophysicae, Vol. 18, No. 10, P. 1257-1272, 2000.

RADIOPHYSICS

It has been shown that the influence of superheat electrons essentially increases the pumping of plasma oscillations, excited by a powerful HF radiation, into the short-wavelength band.

Powerful wave beams in a medium with saturated nonlinearity have been analytically studied. The dynamic range of maximum nonlinear effect is found, the possibility of the beam bistability is investigated.

Theoretical modeling of the nonlinear interaction of EM waves with the ionospheric plasma has been performed. Creation, stability and decay of a multisoliton wave packet have been studied.

Long-range HF propagation in waveguiding cavities appearing at sunrise in the equatorial ionosphere has been described. Anomalous long pulse delays about 150 msec have been reveald by numerical simulation, which exceeds the round-the-world propagation time.

Theory of radio wave propagation in oversized waveguides, based on the vectorial parabolic equation, has been developed.

Dispersion of ultrawide-band EM pulses propagating over nonuniform earth surface has been studied.

1. V.V.Vaskov, N.A.Ryabova. Excitation of additional spectrum of short-wavelength plasma oscillations in powerful HF ionosphere heating experiments (in Russian). Izvestiya VUZ, Radiophysics, v. 45, No 6, pp.482-501 (2002).
2. D.Anderson, V.A.Eremenko, I.A.Molotkov and M.Lisak. Stationary high intensity wave beams in media with saturateable nonlinearity. Physica Scripta. v. 61. No 4, pp.472-475 (2000).
3. Yu.N.Cherkashin, V.A.Eremenko. Evolution of concentrated solution of nonlinear Schroedinger equations in regular non-uniform medium. Soliton-driven Photonics, NATO Science Series II, v.31. pp. 69-72 (2001).
4. A.V.Popov, I.B.Egorov, O.P.Kolomijtsev, V.A.Surotkin, Yu.N.Cherkashin. Modeling the peculiarities of HF propagation in the equatorial ionosphere at sunrise (in Russian). Geomagnetism and Aeronomy (in print).
5. A.V.Popov, N.Y.Zhu. Modeling radio wave propagation in tunnels with a vectorial parabolic equation. IEEE Trans Antennas Propagation, v. 48, No 9, pp. 1403-1412. (2000).
6. A.V.Popov, V.V.Kopeikin, N.Y,Zhu, F.M.Landstorfer. Modeling EM transient propagation over irregular depressive boundary. Electronics Letters, v. 38, No 14, pp. 691-692 (2002).

SOLAR-TERRESTRIAL PHYSICS

A semi-empirical model has been developed to provide an adequate description of density variations of the 10-GeV cosmic rays during the past three solar cycles. The model involves the solar magnetic field parameters calculated for the solar wind source surface (tilt of the heliospheric current sheet, magnetic field mean strength, and polarity of the global magnetic field). The proposed model can be used for short-term (1 to 12 months) prediction of the cosmic ray modulation depth.

Observations of the total solar eclipses of February 26, 1998, and August 11, 1999, have shown that uniformly spread interplanetary dust (the inner part of the zodiac dust cloud) is absent in the near solar environment (at heliocentric distances of ~20 solar radii). Instead, one can observe discrete sporadic features (dust condensations and/or clusters of solid fragments) that are likely to be the meteor streams (residuals of comet nuclei).

The data of the radio occultation experiments in the solar plasma environment carried out in 1995-1997 have been analyzed to reveal a correlation between the position of the inner boundary of the solar wind transition region and the

calculated intensity of the coronal magnetic field. Three types of the flows have been found to exist, differing by the solar wind acceleration rates. These flows are associated with different configurations of the coronal magnetic field, which correspond to different morphological features in the white-light corona.

The SOHO/EIT data have revealed a new kind of the dimmings or transient coronal holes observed on the solar disk after the halo-type coronal mass ejections (CME). Along with the relatively compact dimmings adjacent to the eruption center, the major events produce strongly anisotropic, canalized dimmings, which are stretched along several narrow, extended structures (channels) and may cover the entire visible disk. These transient features are due to strong disturbance and reconstruction of large-scale magnetic structures involved in the CME process, and the channeling of the dimmings manifests the complex nature of the global solar magnetosphere in the vicinity of the solar maximum.

THE MOST IMPORTANT RESULTS OF THE SPACE RESEARCH INSTITUTE (IKI) OF THE RUSSIAN ACADEMY OF SCIENCES

(compiled by Dr. G.A. Kotova)

DIVISION II

Long-lasting ground based measurements of a polarization jet (PJ) by the latitudinal chain of ionospheric stations in Yakutia ($3 < L < 5$; MLT = UT + 9 h) and by 5 subauroral Russian stations were analyzed together with energetic ion observations by AMPTE/CCE (1984-1989). It was discovered that in the near midnight sector of subauroral zone PJ develops during 5-10 minutes at the substorm expansion phase after injection of energetic ions into the inner magnetosphere. It was also revealed that PJ develops along the equatorward injection boundary of energetic ions from the partial ring current at almost constant invariant latitude in the longitudinal sector of 60 - 120°. It was shown that inside the PJ band of 1 - 2° width the subauroral red arcs appear having the intensity of 100 - 500 R. (Khalipov et al, 2001)

INTERBAll 2 measurements were used for the detailed study of energy-dispersed proton structures observed at polar edge of auroral zone. These structures are the auroral signatures of ion beams in the magnetosphere. A new type of dispersed structures accelerated at the front of large-scale instabilities in the magnetotail during break-up phase of substorm was found. These new type sporadic structures are associated with different times of flight of different energy protons along magnetic field from the source in the plasma sheet at 10-30 Earth radii to the auroral zone (Stepanova et al., 2002).

DIVISION III

A new analytical model of the bow shock surface is suggested for accurate and fast prediction of this boundary position near obstacles of different shape. For axially symmetric obstacles the model was verified by comparison with experiments and results of GD code application for a wide range of upstream polytropic indexes $1.15 < (< 2$, and Mach numbers $1 < Ms < ($. The model can be also used for prediction of the bow shock position around non-axially symmetric obstacles.(Verigin et al, 2003)

Analysis of Magion 4 (subsatellite of Interball 1) and Wind observations of the subsolar bow shock position as a function of Alfvenic Mach number (Ma) revealed fine effect that this boundary tends to approach the Earth when Ma is decreasing for magnetic field aligned flow of the solar wind, while for non field-aligned flow the bow shock moves away from the planet in accordance with traditional expectations. It was also found that inclined solar wind flows with high anisotropy of phase velocity of fast magnetosonic wave result in the formation of the bow shock with terminator cross section elongated in north - south GIPM direction and shifted toward positive Ygipm values. (Verigin et al., 2001).

First exact analytical solution was accomplished for determining the asymptotic downstream slope of planetary MHD Mach cones at any clock angle for arbitrary Ms, Ma, and (bv. The solution obtained includes all previously known symmetric cases. The elongation and shift of the asymptotic fast mode shock cross-section are studied for a wide range of upstream plasma parameters as well as its unusual 'chopped' shape under certain conditions. (Verigin et al., 2003a.)

The unique energy and time resolution of the INTERBALL 1,2/DOK-2 instrument permitted to obtain principally new results on energetic ion features, the processes of their acceleration and propagation.

* Almost Monoenergetic Ion (AMI) beams (E=50-600 keV) were discovered in different parts of the Earth's magnetosphere: in the magnetosheath, upstream of the bow shock and in the magnetotail plasma sheet. These beams

originate as a result of solar wind ion acceleration in bursts of potential electric field by current sheet disruptions. A connection of some AMI events with collisions of current sheets in the solar wind with the bow shock was established.
* In the auroral zones Fine Dispersion Structures (FDS) in ion and electron spectra (50-800 keV) were discovered. They appear as a result of the gradient-curvature drift of particles after their pulse injection on the closed field lines on the night side of the magnetosphere. Analysis of these structures provides new important information on particle acceleration processes during substorms: accurate time and duration of the acceleration, position of the acceleration site and particle spectra in the source. The periodic modulation of FDS by PC-5 type magnetic field oscillations was found in several cases ("wavy" FDS). Longitudinal amplitude of field line oscillation in "field line resonance" phenomenon was estimated (Sarafopoulos et al., 2001, Lutsenko et al., 2002)

Observations of ions with SCA-1/Interball frequently show bi-directional ion velocity distribution within LLBL . Analysis of these velocity distributions indicate that they are formed during multiple reconnection at the dayside magnetopause. (Vaisberg et al., 2001)
Analysis of high latitude reconnection under northward component IMF confirms that in sub-alfvenic magnetosheath flow the reconnection site is stable. (Avanov et al., 2001)

The Interball spacecraft ion plasma measurements in the magnetotail revealed the net vertical plasma drift towards equatorial plane equal to 7 km/s during southward IMF. This is the first observation of the vertical component of the global convection cycle in the Earth's magnetosphere (Petrukovich andYermolaev, 2002).
Interball, Geotail and Wind spacecraft data comparison shows that the northward-Bz (contracted oval) substorms are similar to normal substorms and are actually associated with azimuthal but not northward IMF . Comparison of the solar wind energy input to the magnetosphere as measured by Wind and Interball-1 spacecraft, shows that the spacecraft-distant monitor adequately measures solar wind input during storms and large substorms, while the use of solar wind measurements for small substorm predictions is unreliable due to natural variability of solar wind and IMF (Petrukovich et al., 2000).

Multispacecraft data from INTERBALL 1, MAGION 4, POLAR, GEOTAIL, WIND, and DMSP revealed that magnetosheath plasma flow is thermalized through the formation of "long-operating" vortex streets and local discontinuities and solitons in a distributed region over polar cusps (stagnation region). Plasma percolation through the structured boundary and secondary reconnection of fluctuating magnetic fields in a high-latitude turbulent boundary layer can account for the main part of solar wind plasma inflow into the magnetospheric trap. The ion thermalization is accompanied by the generation of coherent Alfven wave cascades with scales ranging from ion gyroradius to the radius of curvature of the averaged magnetic field, as well as by the generation of 'diamagnetic bubbles' (of few 100-1000 km thick) with a demagnetized heated plasma inside. This 'boiling' plasma has kinked power-low spectra with two characteristic slopes (1.2 & 2.4), that differ from the Kolmogorov law. Despite similar scale and spectral characteristics, topologies of the summer and winter exterior cusps are different. (Dubinin et al., 2002).
Just inside the magnetopause, the 'plasma balls' (few RE thick) are regularly encountered, which contain highly reduced field and heated magnetosheath plasma. We suggest micro-reconnection of fluctuating fields and percolation of the 'diamagnetic bubbles' as most effective mechanisms for filling of the 'plasma balls'. (Mainard et al., 2001).

Self-consistent kinetic description of turbulent plasma and fields at the nonequilibrium stationary states (NESS's) of the Earth's magnetotail is proposed. We argue that the inherent dynamics of the NESS's is manifested in the power law fluctuation spectrum 1/f in the lower frequency range (i.e., the Flicker noise). Meanwhile, the fluctuation spectrum at the higher frequency range is related to the self-consistent structural properties of the magnetotail turbulence and has the power law form 1/f^{7/3} near the marginal state. The basic dynamical processes operating at the NESS are described by a nonlinear fractional kinetic equation which includes the following principal effects: (1) stochastic particle acceleration in the turbulent magnetic field varying in time, and (2) self-interaction of the turbulent medium associated with the generation of the magnetic turbulence cells by the energetic particles accelerated therein. We found that the particle energy distribution in presence of the self-interaction events revealed a high-energy nonthermal tail with a slope varying between -6 and -7. The results obtained are in close agreement with spacecraft observations on the Earth's magnetotail. (Milovanov and Zelenyi, 2001).

The self-consistent theory of thin current sheets, where the tension of magnetic field lines is balanced by the ion inertia is created and investigated. Based on the assumptions that ions are the main current carriers and their dynamics is quasi-adiabatic, the original system of Maxwell-Vlasov equations is reduced to the nonlocal analogue of the Grad-Shafranov equation. It is demonstrated that the non-adiabaticity of particle motion influences significantly the structure and

evolution of TCSs. The accumulation of quasi-trapped ions with large magnetic moments ("aging" process) leads to the local reduction of the current near the neutral plane and the decay of current sheet equilibrium. This effect provides a new evolutionary mechanism, which might explain the disruption of CS structure on a time scale comparable with the duration of the substorm growth phase. (Zelenyi et al., 2002).

MARS

Data recently retrieved from the High Energy Neutron Detector (HEND), a Russian instrument currently operating onboard NASA's Mars Odyssey mission, allowed for the first time to estimate the abundance of subsurface water on Mars. Large areas of permafrost have been detected. At high latitudes, mass mixing ratio of water reaches 35% and there are also two sites in equatorial latitudes with high water content. Data involved are related to the depth of 1-2 meters. (Mitrofanov et al., 2002).

In cooperation with GFDL (Princeton, USA) a comprehensive numerical model of Martian climate, capable of simulating water cycle on the planet, is developed (Richardson et al., 2002).

Detailed analysis of the Martian magnetotail boundary crossings by Phobos 2 orbiter revealed that highly localized strong magnetization of planetary crust increases the downstream magnetotail thickness by 500-1000 km (Verigin et al., 2001a). Existence of this effect was confirmed by subsequent analysis of MGS orbiter data and should be taken into account during Martian obstacle modeling.

VENERA

From infrared spectroscopy on Venera 15-16, new results on structure and composition of the Venus atmosphere have been obtained, in particular water vapor abundance, structure of thermal tides, and sun-synchronous variations of cloud deck upper boundary. (Ignatiev et al., 1999).

DIVISION IV

The coordinates of x-ray solar flares in 8-20keV energy range with 2 arcmin precision were found with the help of WATCH/GRANAT and SIGMA/GRANAT data. For one of the flares (2 hour long June 10, 1990, Solar Flare) the movement of x-ray source at the distance of ~(4-11) arc.min. across the solar disc was observed. For the same flare strong quasiperiodic oscillations of x-ray flux with the 143.+/-.8 s period were found.

INTERNATIONAL CONFERENCES

Once per year international conferences on the topics covered by INTERBALL mission were held in different countries with significant input of IKI scientists. Symposium "Dynamics of the magnetosphere and its coupling to the ionosphere on multiple scales from INTERBALL, ISTP Satellites and Ground-Based Observations" was held near Zvenigorod, Russia, from February 8 to 13, 1999. In February 2000 the international symposium "From solar corona through interplanetary space, into Earth's magnetosphere and ionosphere: Interball, ISTP Satellites, and Ground-Based Observations" was held in Kiev, Ukraine. In February 2001 the COSPAR-ESA Colloquium "Acceleration and Heating in the Magnetosphere" was held in Poland. And on 5-10 February in 2002 the COSPAR Colloquium "Plasma processes in the near-Earth space: INTERBALL and beyond", was organized in Sofia, Bulgaria. The proceeding of the last 2 symposia are published in Advances of Space Research.

20-22 January 2003 International conference "Plasma theory, space research and international cooperation: horizons and challenges" devoted to the 70-th anniversary of academician Roald Sagdeev was held in Space Research Institute of Russian Academy of Sciences in Moscow. Famous Russian and foreign scientists participated in the conference presenting interesting reviewing reports.

4-7 February, 2003 International Symposium devoted to the memory of Professor Yuri Galperin "Auroral Phenomena and Solar-Terrestrial Relations" was held in Space Research Institute of Russian Academy of Sciences in Moscow. Yuri Galperin, one of the pioneers of space research and our friend, passed away in the late December of the year 2001. The scientific program included the following sections: Thermal Plasma, Auroral and Ionospheric Current Systems, Auroral Particles and Waves, Solar Wind - Magnetosphere Interactions, Magnetospheric Tail and Substorms, Inner

Magnetosphere and Ring Current, Ground Based Measurements, Space Weather, and special memory section devoted to the memory of Yu.I. Galperin. The conference was attended by ~ 40 scientists from Bulgaria, Canada, Czech Republic, France, Finland, Germany, Italy, Japan, Poland, Romania, USA and about 200 Russian scientists. Proceedings of the conference will be published.

PARTICIPATION IN INTERNATIONAL MISSIONS

THE INTERBALL MISSION

INTERBALL is the solar-terrestrial program aimed to study various plasma processes in the Earth magnetosphere by a system of spacecraft consisting of two satellite-subsatellite pairs above the polar aurora and in the magnetospheric tail respectively. The two pairs of satellites study the cause-and-effect relationships in the solar wind/magnetosphere interactions. Tail Probe with its subsatellite MAGION 4 was launched on 3 August 1995 to an orbit with a low angle with the ecliptic plane to reach high altitude cusp and subsolar magnetopause regions on the dayside and then, the neutral sheet in the nightside tail. Auroral Probe was launched on 29 August 1996 together with its subsatellite MAGION 5, into an elliptic orbit with apogee 20000 km and inclination of 65°.
MAGION 5, the INTERBALL-Auroral Probe Subsatellite was successfully reactivated on May 7, 1998 after 20 months in space. After only one day of operation, on 30 August, 1996, MAGION 5 went out of control and ceased to transmit telemetry data for a critical deficit of power. The orbit of MAGION 5 is essentially the same as the orbit of the AURORAL PROBE and the distance between two spacecraft has been estimated to be about 15 minutes and 20 seconds. Regular sessions with the MAGION 5 continued till the end of June 2001. The data acquisition continues now in a limited amount only.
On 16 October, 2000 in accordance with orbit calculations the INTERBALL / Tail Probe entered dense layer of the Earth`s atmosphere and finished its operation in space. The INTERBALL 2 data were transmitted to the Earth till February 1999.
The INTERBALL project involved the efforts of a large international community of Russia together with Austria, Bulgaria, Canada, Czech Republic , ESA, Finland, France, Germany, Hungary, Italy, Kirgizia, Poland, Romania, Slovakia, Sweden, United Kingdom and Ukraine. Besides that a close cooperation within the project with the ground-based geophysical observations was provided. The INTERBALL project became an inherent part of the vast international cooperation within the IACG (Inter-Agency Consultative Group) with the other major space missions: GEOTAIL, WIND, POLAR, SOHO, and FAST.
The INTERBALL scientific instrumentation includes 16 experiments designed for a wide range of plasma and wave, UV, magnetic and electric field measurements in different regions of the magnetosphere and in the solar wind. IKI scientists using the INTERBALL data obtained the most important recent results.

HEND/2001 MARS ODYSSEY

In April 7th, 2001, NASA launched the spacecraft "2001 Mars Odyssey" to Mars. The research of chemical composition of the Martian surface is a key item of Mars exploration, especially including the search for water (the NASA keystone strategy of "Following the Water"). These investigations iare performed by the Gamma Ray Spectrometer (GRS), which includes the Russian-made High Energy Neutron Detector (HEND) for detection of high-energy neutrons. The High Energy Neutron Detector HEND was developed in the Laboratory of space gamma ray spectroscopy of the Space Research Institute (Moscow, Russia). It was constructed under contract with Russian Aviation Space Agency (Rosaviakosmos) in accordance with the Federal Program of Basic Space Exploration of Russia. Joint Institute for Nuclear Researches (Dubna, Russia) participated in development of the physical concept of HEND.

FUTURE MISSIONS

Scientific instrumentation for Mars Express ESA mission has been developed and prepared for space flight. IKI participates in such experiments as ASPERA (versatile exosphere and circumplanetary plasma analyzer), OMEGA (mapping IR spectrometer for surface studies), PFS (IR Fourier spectrometer for atmospheric studies), and SPICAM (integrated UV and IR spectrometer targeted at Martian water cycle studies). Mars Express spacecraft is expected to be launched in April-May 2003, observations will begin in 2004.
Some of instruments listed above (ASPERA, PFS, and SPICAM) will be employed in for Venus studies in the framework of Venus Express ESA mission finally approved in 2003. The spacecraft is scheduled for launching in November 2005.

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MOST IMPORTANT RESULTS OBTAINED DURING 1922-2002 IN THE INSTITUTE OF SOLAR-TERRESTRIAL PHYSICS (ISTP) OF THE SIBERIAN BRANCH OF THE RUSSIAN ACADEMY OF SCIENCES

(compiled by Dr. A.S.Potapov)

Research results

In the years of the 23-rd solar cycle maximum, the closest attention was devoted to a comprehensive study of strong geomagnetic disturbances, and to their manifestation at high and mid-latitudes.

Thus, the incoherent scatter radar [1] provided unique experimental data on magnetosphere-ionosphere coupling effects caused by the geomagnetic superstorm of July 15-16, 2000, and storm of September 25, 1998 [2]. The observations showed very strong changes in the structure and thermal regime of the mid-latitude ionosphere. During the main storm phase, the main electron density peak of the ionosphere was almost totally suppressed, with an abrupt increase in density in its lower-lying regions. Electron and ion temperatures increased nearly twice, to 5500 K and 2500 K, respectively. In the same period, an uncommon phenomenon for mid-latitudes was recorded: a powerful coherent echo (radio aurora). An analysis of the characteristics of echo-signals showed that they were produced by the scattering from plasma two-stream instability irregularities, the effect that is usually observed in high latitudes in the presence of strong electric currents. Coherent echo power fluctuations with a period of 25-30 min were detected, and oscillations with the same period were recorded in the variations of the magnetic field and total electron content of the ionosphere, based on the data from the worldwide network of GPS stations.

An analysis was made of the emission variations in the mid-latitude airglow during a major magnetic storm of March 31, 2001. The 630 nm emission disturbance is interpreted as an intense stable auroral red arc (SAR-arc), which was observed for the first time in mid-latitudes of the Asian region at a high level of geomagnetic disturbances. The overall level of 630 nm emissions is due to suprathermal fluxes of plasmaspheric electrons. The 558 nm emission disturbances that are correlated with substorm activity are caused by precipitation of high-energy auroral electrons and are associated with the plasma sheet dynamics [3, 4].

Data from the international network of receivers of the navigation GPS system were used to construct a global picture of the mid-latitude ionospheric electron density response to sudden magnetic storm commencements, and it was established that this response includes the phases of instantaneous and delayed response. The instantaneous response manifests itself with a delay of 3-5 min with respect to the sudden commencement and is characterized by a short-lasting (about half an hour) decrease in electron density throughout the entire dayside. In the delayed response phase with a delay of about 2-6 hours, with the equatorward expansion of the auroral oval, the mid-latitude ionosphere is taking the features of the auroral ionosphere, which is accompanied by the development of medium- and small-scale ionospheric plasma irregularities, causing radio signal distortions and malfunctions of satellite-borne navigation systems. [5-10].

It was found that the electric field of the polar cap ionosphere is screened by the system of the highest-latitude field-aligned currents. The system is produced in the course of the magnetospheric substorm during southward IMF. The screening is ideal before and after the substorm, but it decreases (sometimes to zero) in the course of loading and is restored during the active (unloading) substorm stage [11].

The other effects of strong heliophysical and geomagnetic disturbances have been considered in papers [29-36].

At the ISTP, a series of theoretical and experimental investigations was carried out into impulsive disturbances of the ionosphere of a natural and technogenic origin (earthquakes, solar flares, explosions, rocket launchings, underground nuclear testing). Within the framework of these research efforts, the following results have been obtained:

* The theory of MHD oscillations generated in the magnetosphere by pulsed sources localized in the ionosphere has been constructed. As a result of such an effect, the field of quasi-Alfv(n oscillations of a universal kind is excited in the magnetosphere, which is determined by magnetospheric parameters on those magnetic shells where the source is localized [12, 13].

* The method has been developed for detection and locating the sources of pulse disturbances of the total electron content in the ionosphere, based on processing the data from the global navigation GPS system. Whatever the type of source, the pulse disturbance has the character of an N-wave with the amplitude exceeding the level of background fluctuations by a factor of 2-5. The source position corresponds to the portion of the trajectory of carrier rockets at a distance no less than 500-1000 km from the launching pad, and at the flight height no less than 100 km. During earthquakes, the source position coincides with the epicenter. [14, 15].

The theory of eigen-oscillations of the magnetosphere was further developed. In particular, the self-consistent problem of resonance MHD oscillations in the axisymmetric dipole-like model of the magnetosphere was solved. Magnetosonic waves are incident on the magnetosphere from the solar wind region and excite Alfv(n waves on resonance magnetic shells. The amplitude of the magnetosonic oscillations, when they penetrate inside the magnetosphere, decreases several

orders of magnitude. The amplitude of the Alfv(n oscillations excited inside the magnetosphere can be comparable with or even exceed the magnetosonic wave amplitude in the solar wind region. [16-23].

A new mechanism has been proposed for the formation of the cosmic-ray energy spectrum by coronal mass ejections. The parameters of the resulting spectrum determine the electromagnetic and scale characteristics of solar wind features, which are responsible for the sporadic phenomena in the heliosphere. This is an essential prerequisite to the development of monitoring and forecasting techniques for electromagnetic and radiation conditions in interplanetary space, which is extremely necessary when dealing with the "space weather" issues [24].

The model of the galactic cosmic ray origin has been suggested. It was shown that within the framework of the "surfing-tron" acceleration mechanism it is possible to explain the formation of the energy spectrum right up to the most ultimate energies observed on the ground. A detailed consideration was given to: the acceleration mechanisms, the injection problem, the galaxy sources of cosmic rays, the cosmic ray energy losses during the propagation in galactic plasma, and others. Acceleration characteristics of both the ion and electron components of cosmic rays have been determined [25].

The model has been developed for the open ion-cyclotron resonator that forms in the neighborhood of the equatorial region of the magnetosphere because of the presence in plasma of an addition of heavy oxygen and helium ions. Ion-cyclotron waves with a frequency of about 1 Hz are confined within the resonator and are enhanced through the wave-particle interaction with resonance ions. Some of the wave energy leaks through the end walls thus penetrating to the ground and is observed there as discrete wave packets (geomagnetic Pc1 pulsations). The proposed model readily explains satellite observations, which bring to a deadlock the previous models of generation of discrete ion-cyclotron emissions. The model gives significantly greater insight into the role of ion-cyclotron wave activity in magnetospheric processes and opens up brand new vistas for the diagnostics of geospace plasma. [26-28].

International activities that were carried out on the IAGA topics

A development of important international significance was the creation of the Joint Russian-Chinese Research Center on Space Weather. It was established in 1999 under the Agreement on Scientific Cooperation between the Chinese Academy of Sciences and the Siberian branch of RAS on the basis of the ISTP and the Center for Space Science and Applied Research of China. In accordance with the signed agreement and the Charter of the Joint Center, 23 cooperative projects on solar-terrestrial physics have been implemented. Results of work on the projects were presented to three Russian-Chinese conferences on space weather that were held alternately at Irkutsk (2000 and 2002), and at Beijing (September 2001).

Furthermore, three Russian-Mongolian conferences on astronomy and geophysics were held to discuss results of cooperation in the field of geomagnetism and solar-terrestrial connections.

The Institute organized and participated in the preparation of two international symposia on "Atmospheric and Ocean optics. Atmospheric Physics" held in 2001 and 2002 at Irkutsk and Tomsk, respectively.

Participation in international projects

Institute staff members are engaged in collaboration with the Research Center for Astronomy and Geophysics of the Academy of Sciences of Mongolia under the projects on "Investigation of the chromosphere of solar active regions".

In accordance with the ongoing international "Active cavity radiometer for measuring solar luminosity" project (Columbia University, USA), extraatmospheric solar radiation fluxes are studied.

Cooperative investigations into solar activity are carried out under agreements on scientific cooperation with Nobeyama Radio Observatory (Japan), Beijing Astronomical Observatory, and Purple Mountain Observatory (China).

Magnetic observatory "Irkutsk" transmits observational data in quasi-real time to the INTERMAGNET network.

Under the agreement on scientific cooperation with the MIT Haystack Observatory (USA), programs of joint ionospheric research by the method of incoherent scatter have been worked out and are being implemented.

Institute staff members are engaged in a number of international INTAS projects. In particular, under infrastructure project IA-01-01 CRENEGON, initiated by the ISTP, upgrades to magnetic observatories Irkutsk, Arti, Alma-Ata and Kiev are being made.

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BRIEF REPORT ABOUT THE MOST IIMPORTANT SCIENTIFIC RESULTS OBTAINED DURING 1999-2002 BY THE POLAR GEOPHYSICAL INSTITUTE (PGI) OF THE KOLA CENTER OF THE RUSSIAN ACADEMY OF SCIENCES

(Compiled by Dr. E.D.Tereschenko **)**

1. Main Science Results

A modern type observatory has been constructed and put into operation at the Spietzbergen archipelago with the aim of multi-instrumental monitoring of geophysical phenomena at high latitudes. The observatory facilities provide digital registration of geomagnetic pulsations in the 0.1 through 20 Hz frequency range, satellite radio probing of the ionosphere, all-day-round television registration of auroras during winter seasons, measurements of total ozone content and of meteorological parameters. In coordination with the satellite, radar, and other types of measurements the observatory major operation objectives are to study the complex processes of the solar wind interaction with the terrestrial magnetosphere, to provide data for theoretical modeling and forecasting of the state of the high latitude ionosphere, to study the effects of the solar and geophysical factors on the climate and biological systems in the Arctic.

A unique facility, territorially extended over a wide area, for measurements of extra low frequency (ELF) and ultra low frequency (ULF) electromagnetic fields, incorporating receiving stations on the Kola peninsular and the Spietzbergen archipelago has been also constructed and put into operation recently. The facility allows registration of signals in both the wide band channel (0.1–1.0 kHz) and in narrow band channel (~5 Hz) simultaneously at several frequencies. The developed measuring system allows to obtain experimental data of a new type on the structure of the lower ionosphere and magnetosphere. At the same time, the greater penetration depth into the natural conducting media for the ultra low frequency fields makes it possible to use them for the development of the deep terrestrial sounding techniques.

By the analysis of low altitude satellite data and on the basis of comparison with ground observations of Pc1 pulsations, for the first time, a type of energetic proton precipitation closely related to generation of electromagnetic ion-cyclotron (EMIC) waves was found and described. It is localized (~1˚ in latitude) precipitation burst within the zone of highly anisotropic fluxes equatorward the isotropy boundary. Theoretical predictions on generation of the EMIC waves (Pc1 pulsations) in the near-Earth equatorial plane region, where drifting energetic proton contact the cold plasmaspheric plasma, were, for the first time, experimentally confirmed using complex observations of cold plasma, hot particles, and

waves onboard several high- and low-orbiting satellites. The EMIC wave generation occurs within localized tubes with enhanced cold plasma density. The observations suggest multiple sources of the waves and related proton precipitation.

Using the data of the high-resolution induction magnetometer installed at the Lovozero observatory of the PGI, the main features of a new kind of magnetic pulsations at the Pc1 frequency range are investigated. The pulsations have a form of series of 3-20 short-living bursts initiated by sudden increase of solar wind dynamic pressure. It is shown that the necessary condition for the excitation of a series of pulsations is the presence of hot protons in the dayside magnetosphere. The first burst in a series is delayed by about 1 minute with respect to the auroral riometric absorption enhancement, which allows to estimate the velocity of the Alfven wave propagating in the magnetosphere.

The first experimental evidence of the VLF/ULF chorus generation in the backward wave oscillator (BWO) regime of the magnetosphere cyclotron maser has been found from the results of ground-based and satellite observations. A new numerical model of the VLF/ULF chorus generation to explain the dynamics of the VLF/ULF chorus elements is developed. The model is based on the assumption that the chorus element generation is the same as in the backward wave oscillator (BWO). However, the BWO-like generator is driven by some other dynamic system, which has a noise component. In such a case the occurrence of the so-called "on-off" intermittency regime is possible if the BWO-like generator is near the generation threshold. A power-law distribution of the time intervals between bursts of generation is a manifestation of the intermittency regime. Just this power-law distribution has been found from the ground-based and satellite observations.

Temporal intensifications of the auroral hiss observed by the INTERBALL-2 satellite well poleward from the auroral oval have been found to correlate with the auroral intensifications during substorms or pseudobreakups. The hiss frequency correlates with the distance between the satellite footprint and the location of bright auroral arcs. The frequency increases (or decreases) when the distance also increases (decreases). Such behavior can be explained by the propagation of quasi-electrostatic whistler waves coming from a localized source placed near the aurora.

Using the data of the high-resolution TV registration of auroras, a new type of multiple arc-like forms has been found in pulsating and diffuse auroras. The forms look like a spatial series of narrow bands of luminosity drifting poleward at the velocity of ~300 м/s at ionospheric altitudes. It is suggested that these forms result from the ionospheric manifestation of the specific MHD waves propagating inside the internal blur edge of the magnetospheric plasma sheet. The forms are frequently observed before the onset of the magnetospheric substorms and may be regarded as substorm precursors.

The Polar UVI Imager observations in the Northern Hemisphere have been used to examine morphological features of the dayside auroral transient events which are identified as the sharp increase in the auroral luminosity with duration lasting for 5-30 min and accompanied by longitudinal auroral displacement. Two types of the phenomena with the initial brightening have been found: one in the prenoon (08-10 MLT), and the other in afternoon (14-16 MLT) time sector, which exhibit distinctive characteristics. The ground magnetograms and the IMF signatures indicate that the auroral transients may result from variations in the dynamic pressure applied to the prenoon or afternoon magnetopause following abrupt changes in the foreshock geometry.

DMSP spacecrafts observations have been used to construct the empirical model of the midnight auroral precipitation during a substorm. The model includes the dynamics of different auroral precipitation boundaries and simultaneous changes in average electron precipitation energy and energy flux in different precipitation regions during all substorm phases as well as the IMF and solar wind plasma signatures during a substorm. The analysis of the model shows a few important features of precipitation. In particular, for about 5 min before the substorm onset a decrease in the average precipitating electron energy in the equatorward part of auroral zone was observed simultaneously with an increase in both the average electron energy and energy flux in the poleward part of the auroral zone.

The experimental reconstructions of the two-dimensional polar aurora volume luminosity distributions for the 427.8 and 557.7 nm emissions have been obtained along the geomagnetic meridian using the tomography method. The particular feature of the derived distributions is the lowering of the luminous structure bottom edge and maximum volume luminosity heights in the northward direction. This result testifies for the systematic increase of the precipitating electron flux hardness for the studied auroras in the northward direction.

Using the radiotomography method, for the first time an experimental reconstruction of the ionospheric F-region electron density structure has been carried out simultaneously with the reconstruction of the electron density in the E-layer. Tomographic reconstruction of the electron density structure simultaneously at the E- and F-layer heights allows to study the coupling of processes that take place in different ionospheric regions. It also allows to compare the electron density structure with the optical luminosity data.

From the analysis of the simultaneous EISCAT data on the electric field in the F region of the high latitude ionosphere and the radio tomography data obtained in the northern Scandinavia during the international heating experiment in November 1997, it has been shown that both artificial and natural electron density irregularities in a plane perpendicular to the magnetic field were elongated in the direction of the F region plasma convection.

For the first time the reduction of the first and second Schumann resonance frequencies (7.8 and 14.2 Hz) during solar proton events has been found and investigated in details. The effect duration is about several hours. The mean decrease of the first resonance frequency is about of 0.2 Hz and it agrees fairly well with the results of theoretical calculations using the ionosphere model for solar proton events.

Using the database of atmospheric ozone measurements by the Arctic stations lasting for many years of observations, it has been found that violation of the tropopause quasistationarity condition in the region of the polar jet flow can result in the formation of tropopause "folds" which are filled by the stratospheric ozone. The quasihorizontal advection process in the troposphere then leads to the formation of lenses-like structures that have enhanced ozone content and the lifetime of 3 to 5 days. Because of atmospheric drift these structures can move over large distances from the original polar jet area where they are generated. So the ozone data analysis presents the evidence of irreversible stratosphere - troposphere exchange.

2. Participation in the International Projects (abriged).

INTAS 99-0078 «Quantitative description of the magnetospheric dynamics on the basis multi-satellite and ground observations». Head organization - INTAS, Brussels, Belgium. Coord. – Dr. Jean-Andre Sauwaud. Term: 2000-2001.

INTAS 99-0335 «Ionospheric Alfven resonator, ULF waves, and particles in the near-Earth space». Head organization - INTAS, Brussels, Belgium. Coord. – Dr. Tilmann Bosinger, Finland. Term: 2000-2002.

INTAS 99-0502 «Fine space-time correlation between discrete electromagnetic emissions and energetic particles in the near-Earth space». Head organization - INTAS, Brussels, Belgium. Coord. – Dr. David Nunn, Great Britain. Term: 2000-2002.

INTAS 2000-752 «Development of the Key Parameter Set for Space Weather prediction». Term: 2001-2003.

INTAS 01-0016 Spatial and temporal variations of tropospheric ozone and precursors over Russia.

INCO-Copernicus ERB IC 15 CT 98-0123 EXTRATERRESTRIAL. Head organization - INCO-Copernicus. Participants –SPbO IZMIRAN. Term: 1999-2001.

NATO EST.CLG 975144 «Fine structure of electromagnetic emissions and precipitation of energetic electrons». Chief –Dr. David Nunn, Great Britain.

IMAGE. Participants - Finish Meteorological Institute, Finland.

ICA2-CT-2000-10038 "The formation of the phytotoxic substance trichloroacetic acid – its significance for desertification of semiarid and arid regions in southern Russia and its influence on the natural resources of Arctic regions in northern Russia". Head organization - UFZ Centre for Environmental Research Leipzig-Halle; Germany. Participants: IPHA RAS, Moscow; Institute of Meteorology and Geophysics of Karl-Franzens-University Graz; Austria. Term: 2001-2003.

Barents-INTERREG-2. Head organization – EISCAT. Participants: Russia, Finland and Norway. Term: 1998-2000.

Tropospheric Ozone Research (TOR-2). Head organization - Swedish Environmental Research Institute; Sweden. Participants: IPHA RAS, Moscow; MSU, Moscow; Institute of Environmental Sciences (The Netherlands), University of Leicester (Great Britain), University of Berne (Switzerland), Norwegian Institute for Air Research (Norway). Term: 1998-2003.

Network Detection Stratospheric Change (NDSC) – "Studies of the nitrogen dioxide vertical distribution variations". Head organization - National Institute of Water and Atmospheric Research (New Zealand). Participants: IPHA RAS, Moscow; SPbSU, S-Peterburg; Nagoya University (Japan), Hampton University (USA), University of Miami (USA). Term: 1999-2003.

3. Major Recent Publications

Aladjev G.A., Evstafiev O.V., Mingalev V.S., Mingaleva G.I., Tereshchenko E.D., and Khudukon B.Z.. Interpretation of ionospheric F-region structures in the vicinity of ionisation troughs observed by satellite radio tomography. // Annales Geophysicae. –2001. –V.19. -P.25-36.

Beloglazov M.I., A.Yu. Karpechko, G.N. Nikulin, S.A. Roumjantsev. Surface ozone dynamics in the Kola peninsula // Physics and Chemistry of the Earth. Part B. –2000. -V.25, N.5-6. -P.431-433.

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Galperin Y.I., J.-M. Bosqued, R.A. Kovrazhkin, A.G. Yahnin, Stationary Magnetospheric Convection on November 24, 1981. 2. Small-Scale Structures in the Dayside Cusp/Cleft During // Annales Geophysicae. – 1999. -V.17. -P.375-388.

Kozelov B.V., Titova E.E., Trakhtengerts V.Y., Jiricek F., Triska P. Collective Dynamics of Chorus Emissions Inferred from MAGION 5 Satellite Data // Geomagnetism and Aeronomy. –2001. -V.41, N.4, -P.457.

Moretto T., M. Hesse, A.G. Yahnin et al. Magnetospheric signatures of ionospheric traveling convection vortices // J.Geophys. Res.- 2002. -V.107, N.A6. - 10.1029/2001JA000049, SMP 5 1-9.

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Roldugin V.C., S.Kirkwood, Yu.P.Maltsev, A.A.Galakhov. EISCAT radar reflections from the vicinity of a noctilucent cloud // Physics and Chemistry of the Earth. Part B. –2000. –V.25, N.5-6. -P.507-509.
Roldugin V.C., Yu.P. Maltsev, A.N. Vasiljev, E.V. Vashenyuk. Changes of the first Schumann resonance frequency during relativistic solar proton precipitation in the 6 November 1997 event // Annales Geophysicae. –1999. -V.17, N.10. –P.1293-1297.
Roldugin, V.C., Y.P. Maltsev, G.A. Petrova, and A.N. Vasiljev. Decrease of the first Schumann resonance frequency during solar proton events // J. Geophys. Res. – 2001. –V.106. –P.18,555-18,562.
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Safargaleev V.V., Lyatsky V.B., Gazey N. et al. The response of the azimuthal component of the ionospheric electric field to auroral arc brightening // Annales Geophysicae. –2000. -V.18, N.1. -P.65.
Safargaleev V.V., Osipenko S.V., Vasilyev A.N. Spatially periodic arc-like forms in pulsating auroras // Geomagnetism and Aeronomy. –2000. -V.40, N.6. -P.38.
Tagirov V.R., Ismagilov V.S., Titova E.E., Perlikov A.M. Arinin V.A. Manninen J., Turunen T., K. Kaila. Auroral pulsations and accompanying VLF-emissions // Annales Geophysicae. –1999. –V.17. –P.66-78.
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Tereshchenko E.D., B.Z. Khudukon, M.O. Kozlova, T. Nygren. Anisotropy of ionospheric irregularities determined from the amplitude of satellite signals at a single receiver // Annales Geophysicae. –1999. - V.17. -P.508-518.
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Vorobjev V.G. Yagodkina O.I., Sibeck D., Liou K., Meng C.-I. Polar UVI Observations of dayside auroral transient events. // J. Geophys. Res. -2001. -V.106, N.A12. -P.28897-28911.
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Yahnin A.G., V.A. Sergeev, B.B. Gvozdevsky, S. Vennerstrom. Reply on Comment by Y.I. Feldstein and Y.I. Galperin // Annales Geophysicae. – 1999. -V.17. –P.42.
Yahnin A.G., V.A. Sergeev, M.V. Kubyshkina, T.I. Pulkkinen, K. Liou, C.-I. Meng, V. Angelopoulos, N.L. Borodkova, T. Mukai, S. Kokubun, Timing and Location of Phenomena During Auroral Breakup: A Case Study // Adv. Space Res. -2002. -V.30, N.7. -P.1775-1778.
Yahnina T.A., A.G. Yahnin, J. Kangas, J. Manninen, Proton precipitation related to Pc1 pulsations // Geophys. Res. Lett. -2000. -V.27, N.21. –P.3575-3578.

THE MOST IMPORTANT RESULTS OF THE D.V. SKOBELTSYN INSTITUTE OF NUCLEAR PHYSICS, M.V. LOMONOSOV MOSCOW STATE UNIVERSITY (SINP MSU)

Magnetospheric studies

The nature of explosion-like nonlinear processes in the dynamics of current sheets was studied as applied to particular nonlinear mechanisms of a substorm burst in the geomagnetic tail. When the magnetospheric system, during the substorm growth phase, has approached the marginal stability condition, a catastrophe of equilibrium takes place. Models are constructed of both "rigid" and "soft" regimes of the equilibrium loss, when the substorm activation arises either under action of external disturbance or autonomously, without such an external trigger.

A. P. Kropotkin, O. O. Trubachev, and K. Schindler. Nonlinear Mechanisms for the Substorm Explosion in the Geomagnetic Tail. Geomagnetism and Aeronomy, Vol. 42, No. 3, pp. 277-285, 2002.

A. P. Kropotkin, O. O. Trubachev, and K. Schindler. Substorm Onset: Fast Reconfiguration of the Magnetotail Caused by Explosive Growth of the Turbulence Level. Geomagnetism and Aeronomy, Vol. 42, No. 3, pp. 286-294, 2002.

Sporadic fluxes of relativistic electrons play a crucial role in space weather. It has been suggested that generation of such electrons in the magnetosphere is due to intense nonstationary processes characteristic of a magnetospheric substorm. Such intense electromagnetic disturbances are field-line-resonant poloidal Alfven waves. The spatio-temporal model of their generation in the nightside magnetosphere where they are observed as time-dependent substorm current wedges and Pi2
pulsations, was elaborated.

Antonova, A. E., Yu. I. Gubar', and A. P. Kropotkin. A model of spatio-temporal structure of the substorm electromagnetic disturbance and its consequences. Phys. Chem. Earth (C), vol. 25, no1/2, pp. 43-46, 2000.

Model concepts of drift shell branching for energetic charged particles, and of their trapping in the dayside high-latitude outer magnetosphere, in the neighbourhood of the off-equatorial magnetic field minima, have been put forward as long ago as 1968, by Shabansky and Antonova. There was a considerable experimental support of those concepts, both in the missions of 60ties and 70ties and in recent missions (Interball, Polar). Recently, the motion of energetic charged particles was examined in a simple axially symmetric model of the magnetic field near the neutral points in the outer dayside magnetosphere forming and adiabatic trap [Antonova et al., 2001]. The boundaries of the particle trapping region are determined in the coordinates which are similar to the McIlwain (L,B)-coordinates. In the paper [Antonova et al., 2003], violation of adiabaticity of the energetic particle bounce motion was studied, caused by the change from one field minimum to two minima and back, along the particle longitudinal drift path. A "jump" of the second adiabatic invariant was evaluated. It was demonstrated that the shell branching accompanied by this jump happens in a rather narrow zone on the equatorial plane adjacent to the dayside magnetopause. The particles mirroring near the equator and traveling on the nightside through a region with a relatively
weak field (about 40 nT), can, consequently, be globally trapped: instead of escaping through the magnetopause, they come into the dayside cusps regions.

Antonova, A.E., Gubar', Yu.I., Kropotkin, A.P., Trapped Energetic Particles in a Model Magnetic Field of the Magnetospheric Cusp, Geomagn. Aeron., 2001, vol. 41, no. 1, p. 8.

Antonova, A.E., Gubar', Yu.I., Kropotkin, A.P., Effects in the Radiation Belts Driven by the Second Adiabatic Invariant Violation in the Presence of High-Latitude Field Minima in the Dayside Cusps, Geomagn. Aeron., 2003, vol. 43, no. 1, p. 3-8.

A method has been developed of kinetic numerical simulation of evolution of the magnetotail current sheet, situated in a background plasma, under the action of a weak MHD disturbance
arriving from outside. It is shown that, due to nonlinear processes, the forced kinetic current sheet (FKCS) with extremely anisotropic ion distributions and a characteristic scale length of an order of background ion gyroradius, is formed. All of the features of this structure correspond well to those predicted by the theory we developed earlier. The FKCS formed in this way is a site of magnetic field merging in the magnetotail. Electromagnetic energy flux brought from both sides to the CS, is transformed there into the energy of field-aligned ion flows.

Domrin V.I., Kropotkin A.P. Kinetic model of fast current sheet evolution in the magnetotail during a substorm. Sixth

International Conference on Substorms, March 25-29, 2002, University of Washington, Seattle, Washington, USA. Proceedings, p.239-244, 2002.

V. I. Domrin and A. P. Kropotkin. Kinetic Current Sheet Generation in the Geomagnetic Tail:
A Particle-Code Simulation, Geomag. Aeron., 2003, v. 43, no. 3.

New experimental data on relativistic (1-5 MeV) electron flux dynamics from geosynchronous satellites EXPRESS-A2 and A3 and on magnetosphere plasma fluxes (0.1-12 keV) from meteorological satellite METEOR-3M were obtained for the solar activity 23-d cycle maximum (2000-2002).

N.A.Vlasova, E.V.Gorchakov, T.A.Ivanova, V.A.Iozenas, Yu.V.Kutuzov, et al. Monitoring System of Radiation Conditions in the Earth's Magnetosphere aboard Russian Communication, Navigation, and Television Satellites, Cosmic Research, vol. 37, No. 3, pp. 230-239, 1999.

The theory conclusion about coincidence of position of the injected during magnetic storms relativistic electron flux maximum with location of the ring current maximum and the minimal geomagnetic latitude of the western electrojet was confirmed experimentally. The Lmax value is determined from an empirically obtained formula:
(Dst (max = 2.75 (104 / L4max . This formula is true in the whole range of known magnetic storms, including the strongest one with (Dst (max = 600 nT on March 13 and 14, 1989. The seasonal variation of outer radiation belt relativistic electron flux was discovered. The flux maxima were observed in spring and autumn.

L.V.Tverskaya. Diagnosing the Storm-Time Ring Current and Other Magnetospheric Plasma Domains Using Relativistic Electron Data, Adv. Space Res., Vol. 25, No. 1-2, pp. 2315-2318, 2000.

A concept - "Geocorona of Hot Plasma" - was developed. This approach allows to explain uniformly particle flux dynamics at the outer radiation belt, the ring current, and the near plasma sheet and a complex of associated geophysical phenomena.

A.S.Kovtyukh. Geocorona of Hot Plasma, Kosmicheskie Issledovaniya, vol. 39, No. 6, pp. 563-596, 2001.

The developed theory of the Earth's magnetosphere plasma sheet with medium scale turbulence has predicted a value for the plasma sheet diffusion coefficient in the Z direction, makes possible to explain observed features and the amplitude of electric field variations.
A geomagnetic storm model based on experimentally observed radial and azimuth gradient of plasma pressure was suggested.

E.E.Antonova. Magnetostatic equilibrium and turbulent transport in Earth's magnetosphere: A review of experimental observation data and theoretical approaches. International Journal of Geomagnetism and Aeronomy, Publ. by American Geophysical Union Vol. 3, No 2, pp. 117-130, 2002.

The series of works was prolonged on studying the energetic charge particle nonadiabatic motion in the dipolar magnetic field. The Poincare mapping equation system for the description of particle motion with c(e) < 0.4 was proposed.

S.N. Kuznetsov, B.Yu. Yushkov, Boundary of the Adiabatic Motion of a Charged Particle in a Dipole Magnetic Field, Plasma Physics Reports, Vol. 28, No. 4, 2002, pp. 342-350.

Solar wind and the heliosphere

A data base (http:// dec1.sinp.msu.ru/apev) is compiled for the study of the solar and heliospheric origins of all geomagnetic perturbations with the daily average index Ap>20 observed during the period of current 23-rd solar cycle in 1997-2002 comprising its rising and maximum phases. This work represents a part of the ESA -INTAS Project 99-00727 fulfilled currently by Max Planck Institute fur Aeronomie (Germany), Imperial College (United Kingdom), Institute of Nuclear Physics, Moscow State University and IZMIRAN (Russia). Key parameters of the space weather are investigated in the ongoing INTAS Project 00-752 with the participation of many Institutions and Universities of Russia.

Bothmer V., Veselovsky I.S., Dmitriev A.V., Zhukov A.N., Cargill P., Romashets E.P., Yakovchouk O.S. Solar and heliospheric reasons for geomagnetic perturbations during the growth phase of solar cycle 23. Solar System Research, 36, #6, 2002.

A simple analytical model of the polarity reversal of the heliospheric magnetic field is developed.

Veselovsky I.S., Zhukov A.N., Panasenko O.A. Reversal of heliospheric magnetic field polarity: theoretical model. Solar System Research, 36, #1, 2002.

Nonlinear self-gravitation oscillations of the subphotospheric layers on the Sun coupled to the luminosity variations are considered as a hypothetical physical mechanism responsible for the empirical inverse relation between the duration of the rising phase and the maximal amplitude of the solar cycle.

Veselovsky I.S. and Tarsina M.V. Intrinsic nonlinearity of the solar cycles. Adv. Space. Res., 29, #3, 417-420, 2002.

Variations of the solar wind and the heliospheric magnetic field parameters with time scales greater than an hour during three solar cycles are investigated. The variations in all time scales from hours to many years are related to the regular and irregular changes of the solar wind sources with open, closed and intermittent magnetic configurations.

Dmitriev A.V., Suvorova A.V., Veselovsky I.S. Solar wind and interplanetary magnetic field parameters at the Earth's orbit during the three solar cycles. Phys.Chem. Earth (C), 25, #1-2, 125-128, 2000.

The concept of the turbopause around the Sun is introduced and developed based on the dimensionless scaling approach to the analysis of physically distinct radiation MHD and plasma kinetic regimes in the solar wind formation region. New dimensionless parameters like Faraday F, velocity-emission Ve and Trieste T numbers are introduced to evaluate the relative role of potential and inductive electric fields (F), radiation and plasma losses of the solar corona (Ve) and the openness degree of different morphological elements on the Sun (T).

Veselovsky I., Turbulence and waves in the solar wind formation region and the heliosphere. Astrophys. and Space Sci., 277, 219-224, 2001.

The analysis of the SOHO/EIT data for the period of several years revealed the existence of the significant contribution of the numerous intermediate brightness elements that are globally distributed over large areas of the Sun (up to 2/3 of the whole surface) to the global asymmetry and hence to the 27- day variability of the solar radiation. During the low activity years this contribution is comparable or even dominate over the more localized contribution of active regions and bright points.
Veselovsky I.S., Zhukov A.N., Dmitriev A.V., Tarsina M.V., Clette F., Cugnon P., Hochedez J.F. Global asymmetry of the Sun observed in the extreme ultraviolet radiation. Solar Phys. 201, 27-36, 2001.

CORONAS-F satellite was launched on July 31, 2001. The SCR instrument developed in the Institute of Nuclear Physics, Moscow State University measures X - and gamma emissions in range 0.028 – 100 MeV and neutron fluxes during solar fluxes and also fluxes of energetic particles: electrons 0.3 – 110 MeV, protons 1 - > 90 MeV, ions 1.5 – 30 MeV/nuc. Scientific instruments were switched on August 14. CORONAS-F data together with GOES, ACE, SOHO, WIND satellites data permits to study the chain of connected phenomena from solar flares to magnetosphere and radiation belt dynamics during magnetic storms. Solar flares measured by SPR-N and SONG instruments onboard CORONAS-F during August - December 2001 are studied and their influence on the near-Earth space is investigated.

A.V. Bogomolov, A.P. Ignat'ev, K. Kudela, S.N. Kuznetsov, Yu.I. Logachev, O.V. Morozov, I.N. Myagkova, S.N. Oparin, A.A. Pertsov, S.I. Svertilov, B.Yu. Yushkov, Parameters of the Intense X-ray and Gamma_ray Radiation from Solar Flare of May 20, 2002, as Observed from Coronas-F Spacecraft, Asrtonomy Letters, Vol. 29, N. 3, 2002, pp. 199-204.

In the frame of the reflection model, created at SINP, a concept about Sun's Local Radiation Belts was suggested.

G.P.Lybimov Sun's Local Radiation Belts, Kosmicheskie Issledovaniya, vol. 40, No. 6, pp.610-615, 2002.

Systematic description of structures and dynamics of flows originating at the thermal convection on the Sun and in a flat horizontal layer of liquid heated from below, Rayleigh-Benard convection, was performed.

A.V.Getling "Rayleigh-Benard Convection: Structures and Dynamics", Moscow, Pub. by "Editorial URSS", 248 pp., 1999.

I. Internal Magnetic Fields

The magnetic laboratory of the P.P.Shirshov Institute of Oceanology of the Russian Academy of Sciences (Gorodnitsky A.M., Filin A.M., Popov K.V., Brusilovsky Y.V., Lukjanov S.V., Ivanenko A.N.) performed following works on the topic "Anomalous Magnetic Field of the World Ocean Investigations":
1.Petrographic and petromagnetic studies of a collection of peridotites from various localities on the Mid-Atlantic Ridge. Petromagnetic characteristics were obtained of 26 samples from 14 localities near the axis of the Mid-Atlantic Ridge, collected on the cruises of the R/V "Akademik Boris Petrov" and the R/V "Faranaut" (samples collected by the manned submersible Nautile). The study of the present collection show the correlation to be strongest for peridotites that experienced extensive medium-temperature metamorphic recrystallization, are characterized by broadly variable contents of the magnetic phase at a rather large value of its grain size which corresponds to some 20 micron. Overall, the increase in the degree of serpentinization of the rocks during the mesh serpentinization stage is accompanied by a moderate increase in the abundance of the magnetic phase. The relative size of magnetic grains is small, averaging corresponds to 3 micron. It increases somewhat with the degree of serpentinization. Rocks with an increased degree of medium-temperature recrystallization occasionally exhibit an increased size of magnetic grains. Increased mean sizes of magnetic grains, just as in rocks with green serpentines, are detected only in rocks with intensive (over 25%) manifestation of the preceding medium-temperature metamorphic recrystallization. Therefore, the mean grain size of the magnetite that is formed at various stages of serpentinization of oceanic peridotites is 1-7micron, the increase in magnetite content with the degree of rock serpentinization and with the transition to the subsequent serpentinization stage involving no perceptible change in the mean integrated size of magnetite grains in the rocks. The data obtained afford the corollary that the origin of magnetization in oceanic peridotites is due not only to their serpentinization, but also to the preceding medium-temperature metamorphism of the rocks. Hence, the thickness of the lithospheric magnetic layer beneath MOR axes, evidently, is constrained not by the depth of the 350-400 C isotherm, as is assumed in the current petromagnetic models for the structure of oceanic lithosphere, but by the 580 C isotherm depth. The depth of this isotherm in axial MOR regions, according to geothermal gradient estimates Bazylev and Silantiev, may range from 6 to 15 km. This suggests that the uppermost layer of the lithospheric mantle beneath MORs should also be attributed to the MOR magnetic layer. This suggests that medium-temperature metamorphism of oceanic peridotites may be a factor of influence on the formation of the linear magnetic anomalies in the oceanic lithosphere.
The conclusion is that the magnetization in MOR peridotites takes origin not only from their serpentinization, but also from the preceding medium-temperature recrystallization. The grain size of the magnetite that is formed at various stages of serpentinization of oceanic peridotite averages 3-4 micron. For the lower boundary of the magnetic layer of oceanic lithosphere, one should adopt the depth of the 580C isotherm, corresponding to the Curie point for magnetite. Accordingly, the thickness of this layer in MOR axial parts may reach 15 km.

B. A. Bazylev, K. V. Popov, and V. P. Shcherbakov, Petrographic features of oceanic peridotites as reflected by their magnetic characteristics. Russian Journal of Earth Sciences, Vol. 4, No. 3, June 2002 (in Russian).

2.The study of the thin structure of the anomalous magnetic field on aquatories.
On the basis of an original hardware - methodical complex using the gradient method of measurements of a magnetic field on oceans and seas, large volume of precision geomagnetic survey in various regions of World ocean is executed to investigate thin spatial structure of an anomalous magnetic field (AMF). The received experience testifies to high efficiency of research of thin spatial structure of the magnetic anomalies for the decision of problems of fundamental geology, and also for the decision of a wide circle of applied tasks. The main and most urgent is the task of detection on sea bottom of the flooded vessels and other iron objects, and also ammunition creating ecological threat.

A.Gorodnitsky & A. Filin. Techniques and results of magnetic detection of dumped weapons in Bornholm and Skagerrak

dump sites. Workshop in Gent University, Volume 1, Belgium, 2002.

3. The analysis of a magnetic field of a late cenozoic volcanos in the northern part of the Kuril island arch.
With the purpose of division of an anomalous magnetic field into components connected with different depths of a field sources, the analysis of an abnormal magnetic field of three late cenozoic volcanos located in the northern part of the Kuril island arch was executed. For this purpose the materials of detailed geomagnetic surveys obtained in the cruises of the R/V "Vulkanolog" were used. For the analysis of fields the program complex ""SAPFIR" was used developed in by A.N. Ivanenko in the Laboratory of Geomagnetic Researches. This software allows to carry out every possible transformation and spectrum analysis. All accounts are carried out in an interactive mode and are based on 2-D fast Fourier transformation, that allows for short time to consider set of variants and to choose most realistic one. The analysis of a magnetic field of these volcanos consist in reduction of an initial field to a pole with meanings of magnetic declination -6 degree., and inclination 60 degree, that meets to a modern site of volcanoes. After a reduction to a pole a number of transformations was executed and the spectrums of initial fields were calculated. For the analysis the maps of anomalous magnetic fields of three volcanoes were used. The analysis showed high efficiency of the offered technique and allowed us to make conclusions that the deep character of sources of magnetic anomalies probably is connected with deep eruption channels is for a volcano 1.4. whereas local extremums are connected with internal heterogeneity in a structure of this volcano.The basic contribution into magnetic field above the Edelshtein volcanic complex bring basis of construction, probably, generated on a deep break of northeast extending. For a underwater volcano 3.18., the significant contribution to an observable field brings the component connected directly to the top part of a cone, as well as, component connected with deep roots of a volcano. The age of all three volcanos does not exceed 0.7 ml. years.

A.Gorodnitsky. Nature of magnetic anomalies and structure of an oceanic crust in slow-spreading ridges. Izvestiya, Earth Sciences Section Russian Academy of Natural Sciences, 2000, Issue 4, pp. 19-36 (in Russian).

A new scheme of terrestrial paleoclimate evolution during the last 1.5 ma in the western Black Sea region is proposed on the basis of paleopedological reconstructions coupled with magnetic susceptibility, and other rock magnetic parameters, and Mossbauer spectroscopy data. This scheme matches well with oxygen isotope stages despite local variations in erosian/deposition, strong welding of paleosols and subtle discrepancies in the position of the Matyama/Bruhnes boundary. These limitation are reduced by optimizing resolution of magnetic cycles and paleosol identification. Comparison with the oxygen isotope curve shows that the apparent major driving force of regional soil/loess cyclicity is the 100 ka eccentricity period.

On the base of archaeomagnetic investigations according the data for different regions in longitudinal sector 4-136 degrees E it is shown the existence of the eastward drift of 8000-annual variation in the geomagnetic field intensity. This fact is required the change viewpoint on nature of secular variation of geomagnetic field.
The correlation between the magnetic moment and climate variations with characteristic times of 10-10 yr is traced for 450 kyr, but the observed relationship is complex: the relation between the geomagnetic moment and paleoclimate changes becomes substantially weaker, which is shown in high correlation coefficients outside the periods of the geomagnetic excursions and in a very low correlation during these periods. A revised time scale of excursions of the geomagnetic field in the Brunhes epoch is created. The relation between excursions and the magnetic moment minima is confirmed.
The large volume of the magnetostratigraphic investigations of the Lower Paleozoic key sections of the Siberian platform has been carried out. The obtained data indicate the occurrence of a reversed polarity superchron between the Uppermost Tremadoc and the Middle Llandeilo, including the Arenig and the Llanvirn. This superchron would have duration of about 25 to 30 Myr. Our new results indicate that the Middle Cambrian is characterized by at least 60 magnetic intervals that give a magnetic reversal frequency not less than ~5.5 to 7.0 reversal frequency per Myr during the Middle Cambrian. It confirms that a strong decrease in magnetic reversal frequency happened between the Middle Cambrian and the upper part of the Ordovician when a superchron probably existed. This behavior is clearly reminiscent to the one prevailing before the Cretaceous normal superchron. It is also in agreement with the persistence of a ~150-200 Myr time constant in changes in magnetic reversal frequency over the whole Phanerozoic.

Tsatskin, F. Heller, T.S. Gendler, E.I. Virina, S. Spassov, J. Du Pasquier, J. Hus, E.A. Hailwood, V.I. Bagin, S.S. Faustov. A new scheme of terrestrial paleoclimate evolution during the last 1.5 ma in the western Black Sea region: integration of soil studies and loess magnetism. Phys. Chem. Earth (A), 2001, v26, N11-12, pp.911-916
Morner N.-A., Petrova G.N., Pilipenko O.V., Raspopov O.M., Trubikhin V.M. Excursions in relation to the variation in the Earth's magnetic moment file://Fizika Zemli. 2001. N 10. P. 24-32. (in Russian and English).

Petrova G.N., Pilipenko O.V., Raspopov O.M., Trubikhin V.M. The Relation between geomagnetic field variations and climate changes at different characteristic times // Geomagnetism and Aeronomy. 2001.V. 41. N 2. P. 272-288 (in Russian and English).
Nachasova I,E., Burakov K.S., and Bernabeu J. Archaeomagnetic studies of ceramic from the Spain multilayered Neolithic Cendres Cave monument // Geomagnetism and Aeronomy, 2002, T.42, N.6, pp.845-851, (in Russian, translated in English).
V. Pavlov, Y. Gallet. Middle Cambrian high magnetic reversal frequency (Kulumbe river section, northwestern Siberia) and reversal behaviour during the Early Palaeozoic.// Earth and Planetary Science Letters. 2001 V. 185. N 1-2.Pp 173-183.
Didenko A.N., Bondarenko G.E., Sokolov S.D., Kravchenko-Berezhnoy I.R. Jurassic-Cretaceous history of the Omolon massif, northeastern Russia: Geologic and paleomagnetic evidence // In: Tectonic evolution of the Bering Shelf - Shukchi Sea - Arctic Margin and adjacent landmasses. Ed. E.L. Miller, A. Grantz, and S.L. Klemperer. Pub. by the Geological Society of America. Boulder, 2002. P. 225-241.

Geoelectromagnetic Research Institute RAS has organized in Moscow (September, 3-6, 2002) III International Workshop on Magnetic, Electric and Electromagnetic Methods in Seismology and Volcanology (MEEMSV-02, LOC Chairman - Dr. Vjacheslav Spichak). More than 130 researchers from 15 countries (including Japan, China, Australia, USA, Italy, Greece, France, India, etc.) participated in the meeting.
Scientific program of MEEMSV-02 included 7 sections:

- electromagnetic investigations in seismic and volcanic areas;
- electromagnetic images of active zones;
- Earth's crust structure and physical properties of rocks;
- studies of seismo-electric and seismo-magnetic effects;
- electric, magnetic and electromagnetic monitoring of seismic and volcanic activity;
- ionosphere – lithosphere EM coupling;
- data processing and instrumentation.

The Workshop was followed by the first business meeting of the IAGA/IASPEI/IAVCEI Working Group EMSEV (Electromagnetic Studies of the Earthquakes and Volcanoes, Chairman – Prof. S. Uyeda), established in January 2003.

II.Aeronomic Phenomena

4. In 1999 when the MIR space station stopped functioning joint Russian-French works on the atmospheric lidar sounding from the station have been accomplished (ALISSA project). During 1996-99 about 60 sounding sessions of different types of clouds were conducted under night conditions. Engineering methods of lidar information processing were developed and data on geometric and optical characteristics of cloudiness were obtained in the E.K.Fedorov Institute of Applied Geophysics.

3. New data on absolute values and variations in the solar ultraviolet emission fluxes at the initial phase of a solar activity decline in the 23-rd cycle were obtained as a result of measurements with SUFR and VUSS equipment onboard CORONAS-F satellite in 2001 - 2002. Processing of data on the extreme ultraviolet irradiance from CORONAS-F satellite made it possible to determine radiation fluxes at the epoch of the onset of a solar activity decline in the 23 cycle. The main task which had to be solved with the SUFR equipment was to obtain a flux value of the solar EUV irradiance and to determine possible variations associated with solar activity. From SUFR measurement data in the period of observations the solar radiation (emission) intensity in a hydrogen line was 10 erg cm-2s-1, the solar emission flux in the EUV-region at (< 130 nm) on the average, amounted to 11-11,5 erg cm-2s-1.
Flux values correspond to the maximum solar activity phase that confirms the assumption about an unusual behavior of the Sun in the 23-rd cycle.
Investigations of the line intensity variations during flares showed that the increase in line Lyman-alpha flux does not exceed a few percent even during the most strong flares.
It is essential for aeronomy tasks that from VUSS equipment measurements onboard CORONAS-F intensity variations in this line from day-to day do not exceed 1% as well.
Measurements of the extreme ultraviolet radiation complement considerably continuous time series of data on the UV radiation. These data were used for a model of a EUV background flux as part of a general model of electromagnetic radiation variations in the solar cycle.

A.A.Nusinov, T.V.Kazachevskaya, V.V.Katyushina, D.A.Gonykh Instruments and measurements of the solar EUV irradiance onboard CORONAS-F at the solar activity maximum period \\Conference Innovative Telescopes and Instrumentation for Solar Astrophysics (AS20) 22-28 August 2002, Waikoloa, Hawaii USA.
Nusinov A.A., Kazachevskaya T.V., Katyushina V.V., Gonyukh D.A. Measurements of the Solar EUV Irradiance Onboard Coronas-F at the Solar Activity Maximum Period \4 th (Virtual) Thermospheric\Ionospheric Geospheric Research (TIGER) Symposium. DATE: June 10-14, 2002. Location: Internet http://www.ipm.fhg.de/english/meetings /workshops/tiger/papers.html)

2. Data on the F2-layer critical frequencies observed at 25 ionospheric stations of the Eastern hemisphere have been analyzed. A special method developed at the Institute of Applied Geophysics for eliminating an impact of long-term variations in geomagnetic activity was used. Negative trends foF2 were obtained for the period between I958 and early in 90-for all 25 stations. Trends depend on neither the geomagnetic latitude nor the local time that makes it possible to expect that the impact of geomagnetic activity was completely removed. The trend average value is k(tr)= - 0.0012 per year with the standard deviation 0.00043. The data analysis for the earlier period (1948-1985) gives smaller values of the trend (ratio of the latter trends to the earlier ones is 1.7) which is indicative of the trend increase over the last decades. Along with an analysis of the hmF2 layer height trends the obtained result points to the existence of long-term trends in the thermosphere which are, most likely, of an anthropogenic origin associated with space activity of the mankind.

A.D.Danilov. Trends of the F2 layer critical frequencies independent of the geomagnetic activity. Geomagnetism and Aeronomy, v.43,N 2, 2003

The ionosphere was investigated at "Mir" manned space station during 1998-1999 by the method of radio sounding from extremely low heights of 340-370 km. The experimental results have confirmed the stated earlier hypothesis about an opportunity of definition of all necessary ionosphere parameters for a radio communication at an ionosonde location at these heights. At sounding from heights lower than a maximum of ionization were received new unknown earlier ionograms. The quantitative data processing has shown, that these ionograms testify the existence of macro scale and rather specific ionospheric heterogeneities.

Danilkin N.P. The results of the satellite radio sounding of the ionosphere below the F-layer maximum. International Journal of Geomagnetism and Aeronomy, 2001, vol. 3, № 2, pp.173-180.
Danilkin N.P., Review of the results of the satellite radio sounding of the ionosphere in the vicinity of the F-layer maximum Proc. GA URSI, August 2002, (Session: Gji); №625;
Danilkin N.P. and Kotonaeva N.G., The features of ionospheric radio sounding performed using the "Mir" space station; Radiophysics and Quantum Electronics, Vol. 45, No. 6, 2002, pp. 431-439.

III.Magnetospheric Phenomena

The main wave geomagnetic response of the interaction of the front edge of an interplanetary magnetic cloud with the Earth's magnetosphere represents the Pc5-6 (1-3 mHz) geomagnetic pulsations generation at the polar cap with the highest intensity near dayside polar cusp. The critical role in these processes plays the existence strong wave IMF fluctuations under high and variable solar wind dynamic pressure. The time of the appearance and main spectral and wavelet structure of geomagnetic pulsations on the ground and IMF fluctuations on the front edge of the magnetic cloud sometimes were roughly similar. We assume that the polar Pc5-6 geomagnetic pulsations could be results of a direct penetration and transformation of turbulent hydromagnetic IMF waves into the open magnetosphere as well as wave generation at the ionosphere altitudes by quasi-periodic particle precipitation modulated by compression IMF oscillations.
Kleimenova N.G., Kozyreva O.V., Bitterly M., Schott J.-J. Long period (1-6 mHz) geomagnetic pulsations in the initial phase of the large magnetic storm on February 21, 1994//Geomagnetism and Aeronomy, Vol.40. No.4, pp.16-25, 2000.
Kleimenova N.G., Kozyreva O.V. Daytime high-latitude geomagnetic pulsation response to the front edge of the magnetic clouds //Physics of Auroral Phenomena, 25 Annual Seminar, Apatity, 26 Feb.-02 Mar.2002. Abstracts, p.46.
Manninen O., Kleimenova N. G., Kozyreva O.V., Ranta A. High-latitude geomagnetic pulsation response to the passage of the front edge of the interplanetary magnetic cloud of January 10, 1997 //J. Atm. Solar-Terr. Physics. Vol. 64/17. pp. 23-32, 2002.

IV. Solar Wind and Interplanetary Magnetic Field

P.N.Lebedev Physical Institute and the Institute of Radioengineering and Electronics of the Russian Academy of Sciences performed the joint studies of the solar wind and the heliosphere in the following directions:

1. The estimates of the turbulence outer scale are deduced in the range of heliocentric distances between 7 and 80 solar radii from the processing of very long observation series of the frequency fluctuations by the solar radio occultation experiments with the GALILEO and ULYSSES spacecraft. The radial dependence of the turbulence outer scale is shown to be approximately linear with the typical scale value of order of 1011 cm. The outer scale is one of the most important characteristics of turbulence because the spectral energy flux from the large scale to small scale disturbances is formed in the spectral range near this scale providing a quasi-steady regime of turbulence in the moving plasma flow. The model of turbulence evolution is developed based on assumption that the outer scale is formed as a result of competition between the linear amplification of Alfven waves in smoothly irregular moving plasma and nonlinear cascading of turbulence energy to small scale spectral range. The comparison between the observational data and the possible versions of theoretical model shows that the main nonlinear processes responsible for the formation of the inertial spectral range are three-waves decays with the participation of Alfven and magnetosonic waves.

Chashei I.V., Bird M.K., Efimov A.I. On the outer scale of turbulence in the solar wind // Proc. Solar Wind 10 Conf. 2003 (in press)

2. The turbulence regimes in the solar wind acceleration region are investigated in a wide range of heliolatitudes and heliocentric distances using frequency fluctuations measurements of the occulted radio signals of the GALILEO and ULYSSES spacecraft. It is shown that the power exponent of 1D large scale turbulence spatial spectrum changes from 1 to 1.6-1.7 by the increase of heliocentric distance from < 10 solar radii to > 20 solar radii at low heliolatitudes, while the turbulence spectrum remains flat up to heliocentric distances about 30 solar radii at high heliolatitudes. In the several observation series the unusual turbulence spectra with sharp break at the fluctuation frequencies about 0.02 Hz were for the first time detected. Break spectra were observed only at heliocentric distances less than 10 solar radii and only by sufficiently low fluctuations levels.

Samoznaev L.N., Efimov A.I., Andreev V.E., Bird M.K., Chashei I.V., Edenhofer P., Plettemeier D., Wohlmuth R. Turbulence regimes of the solar wind in the region of it's acceleration and initial stage of supersonic motion // Proc. Solar Wind 10 Conf. 2003 (in press)

3. The analysis of the statistical characteristics of the frequency fluctuations of ULYSSES and GALILEO spacecraft occulted radio signals was carried out using the solar wind speed values estimated from simultaneous fluctuation measurements at widely spaced ground based receiving sites. The estimates of the fractional plasma density fluctuations are obtained in the range of heliocentric distances between 7 and 31 solar radii. Some tendency to the fractional turbulence level increase with heliocentric distance increasing was found from the observational data.

Efimov A.I., Armand N.A., Samoznaev L.N., Bird M.K., Chashei I.V., Edenhofer P., Plettemeier D., Wohlmuth R. Characteristics of the near Sun solar wind turbulence from spacecraft radio frequency fluctuations // Proc. Solar Wind 10 Conf. 2003 (accepted)

4. Two-fluid hydrodynamics model was developed describing protons and pick-up ions in the outer heliosphere. Thermal properties of particles in this model are defined by the competition of three effects: 1) adiabatic cooling, 2) heating by damped MHD waves of the solar wind background turbulence, 3) heating by MHD waves generated by pick-up ions by the evolution of their pitch angle distribution from unstable toroidal distribution to stable bi-spherical distribution. The comparison between two heating sources of the protons shows that heating process is connected mainly with pick-up ions at heliocentric distances greater that 10 AU while heating at smaller distances is dominated by background turbulence. The radial profiles of protons temperature and effective polytrope index found from the model are in a good agreement with the measurements of distant spacecraft PIONEER 10,11 and VOYAGER 1,2. The expected latitudional profile of the proton temperature was found taking into account the dependence of solar wind speed on heliolatitude. The radial

dependence of the pick-up ions temperature was also calculated showing that the pick-up ions temperature approach asymptotically to a constant value which is dependent only on solar wind speed.

Fahr H.J., Chashei I.V. On the thermodynamics of MHD wave-heated solar wind protons // Astron. Astrophys. 2002. V.395. P.991-1000

Chashei I.V., Fahr H.J., Lay G. A consistent thermodynamics of the MHD wave-heated two fluid solar wind // Annales Geophys. 2003 (in press)

5. Quasi-periodic magnetic field fluctuations with typical period about 4-5 min were for the first time detected in the solar wind acceleration region. This result was deduced from the analysis of temporal Faraday rotation fluctuations of the HELIOS spacecraft polarized radio signals by the coronal occultation experiments. The value of fractional magnetic field amplitude of quasi-periodic fluctuations is about 0.1 at heliocentric distances 3-10 solar radii as it follows from our estimations. Quasi-periodic magnetic field fluctuations can be explained by the isolated Alfven waves trains propagating away from the Sun from the inner solar atmosphere. The conclusion was drawn that the 5 min Alfven waves can be of considerable importance in the energy balance of the outer solar corona and of the solar wind acceleration region. Typical transversal scale of the propagating 5 min magnetic field disturbances projected to the Sun's surface is about 30 000 km. That means that quasi-periodic Alfven disturbances seem to be generated initially in anisotropic non-steady magnetic structures of the chromospheric network.

Chashei I.V., Bird M.K., Efimov A.I., Andreev V.E., Samoznaev L.N., Five minute magnetic field fluctuations in the solar wind acceleration region // Solar Phys. 2000. V.189. P.399-413.

The model of large scale magnetic variations at the coronal base was developed and applied to the interpretation of line-of-sight magnetic field behavior peculiarities at solar polar caps.

Yu.V.Pisanko. A model of the magnetic field long-term evolution at the coronal base and polar heliospheric regions. Space Science Reviews, vol.97, pp. I83-I87, 2001.

Report on activity of Solar and Cosmic Ray Research Laboratory of Lebedev Physical Institute (Moscow, Russia).

Long-term cosmic ray monitoring in the Earth's atmosphere has been performed since 1957 up to now with balloon borne Geiger counters at a number of latitudes several times a week. During 1999-2002 the observation were made at the Arctic, Antarctic and Moscow region. The results are used for study of galactic cosmic ray modulation in the range of E = 0.1 - 20 GeV, solar energetic particles (E=100-500 MeV), and magnetospheric electron precipitation (Ee=0.3-3 MeV).
The main results in 1999-2002 are the following:
(1) Analysis of the cosmic ray fluxes in four consecutive minima of solar activity showed the negative trend of (0.01-0.09)% per year. It was suggested that the trend in the cosmic ray fluxes is due to supernova explosion at the distance of 30-150 parsec 104-5x105 years ago.
(2) From the correlation between the interplanetary magnetic field and the cosmic ray fluxes on the Earth's orbit and from analysis of cosmic ray measurements by the ground-based and balloon borne detectors, it was shown that the average magnetic flux from the Sun was constant within limits of (5-7)% in the period from ~1940 up to now.
(3) About 100 solar proton events were observed in the polar atmosphere in 1958-2002. It was found that protons with E<500 MeV generated in the solar flares are accelerated further at the shocks associated with coronal mass ejections, their energy losses in the solar corona being compensated. However, the acceleration rate is not enough to compensate the energy losses of protons with E>500 MeV and the later do not reach an observer at the Earth in the case of a flare occurred eastward from the Sun's central meridian.
(4) Simulation of phenomena in the solar corona for a well known Bastille Day event (July 14, 2000) on the base of the observed photospheric field distribution was performed using a PERESVET code. The simulated current sheet accumulated more then 1032 erg, and the plasma was overshot upward producing a coronal mass ejection. A possibility of vertical current sheet formation and flare energy accumulation by the floating up of new oppositely directed magnetic fluxes even in absence of singular line in the initial field configuration was shown.
(5) It was shown that a phenomenon of local minimum in solar activity around the maximum phase of the 11-year cycle (double-peaked structure or the Gnevyshev Gap) could be a sequence of superposition of quasi-biennial and 11-year oscillations, the amplitude of the former changing in phase with the 11-year cycle. The result was found from the sunspot

area, optical solar flares, and photospheric magnetic field data considered separately for the northern and southern solar hemispheres in solar cycles 21 and 22.

(6) More than 400 events of relativistic electron precipitation were observed in the cosmic ray balloon experiment (1957 to 2002). The occurrence rate of electron precipitation demonstrates an 11-year cycle with a maximum at the descending branch of a solar cycle in accordance with the rate of corotating solar wind streams from solar coronal holes. A special kind of electron precipitation with a rather hard energy spectrum happens against a background of solar particle events.

(7) Close correlation was found between cosmic ray fluxes and atmospheric processes such as thundercloud electricity, lightning production, cloudiness coverage, and precipitation. The chain of solar-terrestrial relationship was established: solar activity - cosmic ray modulation - changes in the global electric properties of the atmosphere - changes in weather and climate

Main publications.

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Ermakov V.I., Stozhkov Y.I. New mechanism of thundercloud electricity and lightning production. - Proc. 11th Int. Conf. on Atmospheric Electricity, 1999, p. 242-245.

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V.Observatories, Instruments, Surveys, and Analysis

1. During past four years the E.K.Fedorov Institute of Applied Geophysics has been performing within the framework of the National Heliogeophysical Service and Regional Warning Center (RWC) Russia of the International Space Environment Service (ISES) the following works-

-conducted heliogeophysical observations using its own ground-based and space facilities,

-coordinated works of other observatories in the Russian region incorporated into the observational network of the Service (I0 ionospheric and 13 magnetic stations).

-collected and analyzed data from the network, prepared and issued current summaries and forecasts, performed an operative exchange of the information with other RWCs.

Ionospheric, magnetic forecasts as well as forecasts on the radiation situation in the NES have been regularly issued.

During the period under consideration the Valkarkai station has been put into operation, the Tomsk ionospheric station was returned to service, magnetic and ionospheric equipment in Podkamennaya Tunguska was repaired.

With the launch of the "Meteor-3M" satellite monitoring observations of the penetrating radiation fluxes were renewed in 2002 (solar and galactic cosmic rays, energetic particles and the Earth's radiation belts) at 1000 km heights (almost a 30-year series of observations at these orbits was interrupted in I998).