Polar Geophysical Institute of Russian Academy of Sciences

5. Research and Supervision Results Obtained by Russian Scientists and Specialists during (in the course of) Implementation of Flight Scientific Programmes in cooperation and with assistance of Foreign Scientists and Specialists

Using magnetically conjugate ground-based optical and THEMIS spacecraft observations, it is found that the east-west (E-W) aligned auroral precursors of substorm onset are associated with the low-frequency perturbations in the magnetospheric plasma sheet.

As the polarization of the perturbations is predominantly toroidal, they cannot be produced by ballooning type instabilities, which are known to generate poloidal structures. It is shown that the observations can be interpreted by invoking to ballooning waves (or other wave modes, having a transverse component of propagation velocity) generated by non-stationary processes in the course of pre-onset arc evolution.

Publication:

Golovchanskaya I.V., I.A. Kornilov, and T.A. Kornilova, East–west type precursor activity prior to the auroral onset: ground-based and THEMIS observations, J. Geophys. Res., 120, doi:10.1002/2014JA020081 (2015)

Contact: Dr. Irina Golovchanskaya (golovchanskaya@pgia.ru)

The excitation of different branches of electrostatic turbulence is investigated inside nonlinear Alfvénic structures with transverse scale sizes of about 1 km in the topside auroral ionosphere. With the use of the FAST satellite observations it is shown that such structures are generally efficient in generation of the ion-cyclotron waves modified by the shear in the $E \times B$ velocity, associated with electric field inhomogeneity, as well as of the oblique ion-acoustic waves modified by the shear in the ion parallel drift velocity. The dominant branch of electrostatic turbulence is determined by interplay of destabilizing factors inside an Alfvénic structure. These factors do not always act in unison, so that the excitation of electrostatic waves of a certain type may be inhibited.

Publication:

Golovchanskaya I.V., B.V. Kozelov, A.A. Chernyshov, M.M. Mogilevsky and A.A. Ilyasov, Branches of electrostatic turbulence inside solitary plasma structures in the auroral ionosphere, Phys. Plasmas 21, 082903 (2014)

Contact person: Dr. Irina Golovchanskaya (golovchanskaya@pgia.ru)

An ion precipitation model was created which yields a global distribution of both the average ion energies and the ion energy fluxes depending on the magnetic activity expressed by *AL* and *Dst* indices. The ion precipitation model was used to calculate the plasma pressure at the ionospheric altitudes. The planetary distribution of integral ionospheric conductance depending on the magnetic activity was calculated by using both electron and ion precipitation models

Publication:

Vorobjev V. G., Yagodkina O. I., and Antonova E. E. Features of the planetary distribution of ion precipitation at different levels of magnetic activity // Geomagnetism and Aeronomy. Vol. 55. No. 5. P. 585–595. 2015.

Contact person: Dr. Vyacheslav Vorobjev (vorobjev@pgia.ru)

The comparison of plasma pressure in the magnetospheric equatorial plane with both the ion pressure and location of the electron precipitation boundaries at ionospheric altitudes (110 km) were carried out under the low geomagnetic activity level. It is shown that the equatorward edge of nightside auroral oval is located at the geocentric distances of ~6 Re that well corresponds to the boundary of energetic particles injections close to geostationary orbits. The poleward edge of the auroral oval is mapped to geocentric distances of about 10 Re that corresponds to the equatorward boundary of the region of large scale turbulence level within the plasma sheet of the Earth's magnetosphere.

Publications:

1. Antonova E. E., Vorobjev V. G., Kirpichev I. P., Yagodkina O. I. Comparison of the plasma pressure distributions over the equatorial plane and at low altitudes under magnetically quiet conditions // Geomagnetism and Aeronomy. Vol. 54. No. 3. P. 278–281. 2014

2. Antonova E. E., Vorobjev V.G., Kirpichev I.P., Yagodkina O.I., Stepanova M.V. Problems with mapping the auroral oval and magnetospheric substorms // Earth, Planets and Space. 67:166. DOI 10.1186/S40623-015-0336-6. 2015.

3. Кирпичев И.П., О.И. Ягодкина, В.Г. Воробьев, Антонова Е.Е. Положение проекций экваториальной и полярной кромок ночного аврорального овала в экваториальной плоскости магнитосферы // Геомагнетизм и аэрономия. № 3. 2016, в печати.

Contact person: Dr. Vyacheslav Vorobjev (vorobjev@pgia.ru)

Morphology of relativistic electron precipitation (REP) is investigated with data from NOAA POES. Three types of REP events are revealed. For each type a global distribution map of the occurrence rate is obtained and the relation to the cold plasma density in the equatorial plane is determined. For each REP type the conclusions are made on possible mechanisms of the precipitation.

Publication:

J. Geophys. Res. (submitted)

Contact person: Dr. Alexander Yahnin (ayahnin@gmail.com)

Some peculiarities of the source region of proton precipitations and electromagnetic ion cyclotron waves on the dayside during magnetospheric compression are considered. Flashes of proton emission observed by the *IMAGE* satellite in the dayside sector equatorwards from the proton aurora oval are used to localize this region. The data from the *LANL* geostationary satellites, the projections of which during magnetospheric compression were within the proton emission flash, made it possible to find that the source region of the proton precipitations is usually located outside the plasmasphere. Using *NOAA* satellite data, it is shown that in the dayside outer magnetosphere, precipitations of energetic protons with relatively low intensity are observed prior to magnetospheric compression. This fact shows that the conditions for the development of ion–cyclotron instability are fulfilled there. Magnetospheric compression leads to a sharp increase in the instability incre ment and, as a consequence, to a sharp growth in the fluxes of precipitating protons, exceeding the level needed for the registration of proton auroras on board the *IMAGE* satellite.

Publication:

Yahnin A. G., T. A. Popova, and T. A. Yahnina. Some Characteristics of the Magnetospheric Source of Dayside Subaroural Proton Precipitations during Magnetospheric Compression. Cosmic Research, 2015, Vol. 53, No. 1, pp. 80–87.

Contact person: Dr. Alexander Yahnin (ayahnin@gmail.com)

Geomagnetic pulsation observations made in two magnetic observatories Lovozero ((L=5.2) and New Life (L=2.6) during a strong magnetic storm revealed unusual electromagnetic emissions in the range 7-15 Hz with maximal intensity at low-latitude station. The proton aurora from IMAGE spacecraft and observations of proton precipitation onboard NOAA satellites showed that this emissions are associated with proton precipitation structures, which are typical for “classsical” Pc1, but located at rather low latitudes (CGLat=50-57). It is concluded that the observed “high-frequency” emissions are the result of the ion cyclotron instability developing in the vicinity of plasmapause, which was located at L~2.5. Estimates of the growth rate of the instability confirm this conclusion.

Publication:

E. N. Ermakova, A. G. Yahnin, T. A. Yahnina, A. G. Demekhov, and D.S.Kotik (2016) Sporadic Geomagnetic Pulsations at Frequencies of up to 15 HZ in the Magnetic Storm of November 7–14, 2004: Features of the Amplitude and Polarization Spectra and their Connection with Ion–Cyclotron Waves in the Magnetosphere. Radiophysics and Quantum Electronics, Vol. 58, No. 8, 547-560.

Contact person: Dr. Alexander Yahnin (ayahnin@gmail.com)

Detailed case study of a substorm event using the data from four THEMIS satellites located in the morning sector magnetosphere eastward the onset location revealed clear signatures of the fast magnetosonic mode associated with the substorm activation. This mode was observed at 7.5 RE in the morning sector at region of transition from dipole to tail-like configuration of the magnetic field. The increase of z-component of the magnetic field observed in magnetosphere during the non-diamagnetic structure is interpreted as an enhancement of westward ring (or partial-ring) current at closer to Earth distances. The appearance of the sub-keV plasma at 5.8 RE (used as a tracer of substorm injection) supports this supposition.

Publication:

Kozelova T.V., B. V. Kozelov, Particle injections observed at the morning sector as a response to IMF turning. Advances in Space Reseach (2015).Vol. 56, Issue 10, P. 2106-2116.doi: 10.1016/j.asr.2015.08.023.

Contact person: Dr. Tamara Kozelova (kozelova@pgia.ru)

The ELF/VLF wave disturbances by the DEMETER satellite above the HAARP heating facility (L = 4:9). The HAARP HF transmitter operated at the maximum available power of 3.6 MW, O-mode polarization, and the beam was directed towards the magnetic zenith. ELF/VLF waves caused by the HAARP heating are detected by the DEMETER satellite when the HF radio wave frequency was close to the critical frequency (foF2) of the ionospheric F2 layer, but below it. ELF/VLF wave disturbances observed above the HAARP transmitter were detected by electrical antennas in an area with characteristic size ~102 km. Amplitude and polarization spectra of the ELF disturbances were analyzed and compared with the characteristics of natural ELF hiss above HAARP. The VLF wave disturbances in the topside ionosphere above the HAARP transmitter were detected in the frequency ranges 8 -17 kHz and 15-18 kHz which are close to the lower hybrid resonance frequency f_{LHR} in the heating region and its second harmonic ($2f_{LHR}$), respectively. In the case when the HAARP HF power was modulated, the detected VLF waves were also modulated with the same frequency whereas in the ELF frequency range the modulation was not observed.

Publication:

Титова Е.Е., Демехов А.Г., Мочалов А. А., Гвоздевский Б.Б., Могилевский М.М., Парро М. Возмущения в КНЧ/ОНЧ сигналах в верхней ионосфере над передатчиком HAARP, регистрируемые на спутнике DEMETER, Известия ВУЗов, Радиофизика. Том LVIII, № 3, стр. 167 -186, 2015.

Contact person: Dr. Elena Titova (lena.titova@gmail.com)

A method of short-term forecast of formation of polar laws is suggested which is based on simulation results and analysis of satellite observational data, dealing with the configuration of the arctic front. In this method, the physical mechanism responsible for the initial formation of polar laws is utilized which has been established with the help of mathematical modeling. According to this physical mechanism, a key factor in the formation of polar lows is the origin of a convexity in the configuration of the arctic front. As a consequence, instability of the shear air flow, existing in the arctic front, arises. This instability leads to considerable transformation of the wind field. As a result, the arctic front may be broken and a polar low can be formed in the vicinity of the initial position of the arctic front in the course of time. The origin of a convexity in the configuration of the arctic front can be observed with the help of satellite monitoring of the Earth's atmosphere.

Publication:

Mingalev I.V., Orlov K.G., Mingalev V.S. A modeling study of the initial formation of polar lows in the vicinity of the arctic front // Advances in Meteorology, Volume 2014, Article ID 970547, 10 pages, http://dx.doi.org/10.1155/2014/970547.

Contact person: Dr. Victor Mingalev (mingalev@pgia.ru)

It is shown by means IMAGE magnetometer data and GPS recievers that magnetosphere MHD oscillations in the Pc5 frequency range are accompaimed by the simulataneous oscillations in the total electron content (TEC) of the ionosphere with the same frequency. The modulation depth of the Pc5 pulsations in TEC have the same value as modulation depth of the Pc5 pulsations in geomagnetic field but in some moments exceed the modulation depth in geomagnetic field in 2-3 times and reach the value 10%. So the TEC is quite sensetive to the MHD disturbances in the high latitutdes. By means EISCAT radar data in Tromso it is found that the main contribution to the Pc5 pulsations in TEC is provided by the low part of the ionosphere until the hight 200 km (E layer, low part of the F layer).

Publications:

1. Pilipenko V., Belakhovsky V., Murr D., Fedorov E., Engebretson M. Modulation of total electron content by ULF Pc5 waves // Journal of Geophys. Res. Vol. 119. Is. 6. PP. 4358-4369. 2014.
2. Belakhovsky V., Pilipenko V., Murr D., Fedorov E., Kozlovsky A. Modulation of the ionosphere by Pc5 waves observed simultaneously by GPS/TEC and EISCAT // Earth, Planets and Space. 2016. (in press).

Contact person: Dr. Vladimir Belakhovsky (belakhov@mail.ru).