Space Research Institute of Russian Academy of Sciences

2. The results of scientific research on completed space missions obtained by Russian scientists in 2014-2015

2.1 A guide B_Y field increase in a thin Current Sheets inside closed magnetic configurations

For the first time we propose a mechanism of a guide magnetic field enhancement in a thin Current Sheet (CS) inside the closed magnetic configurations in the Earth magnetotail.

According to this mechanism the strong guide B_Y field is generated by the electric current, which is produced by nonadiabatic ions in the course of their interaction with the CS. If even a small guide B_Y field exists in a thin CS (due to the penetration of the interplanetary magnetic field into the magnetotail) then the north-south asymmetry in the reflection/refraction of nonadiabatic ions from the CS is observed.

If there is a closed magnetic configuration (e.g. plasmoid or magnetic island) then the electric current carried by these ions forms a current loop in the Plasma Sheet (PS). In the central plane of this loop the guide B_Y field increases (see Figure 1, blue shaded region).

This scenario is confirmed by CLUSTER observations of the kinetic effects of ion dynamics in a thin CS tailward of the reconnection region and by the test particle simulations in the observed magnetic configuration.

Grigorenko E.E., IKI RAS, elenagrigorenko2003@yandex.ru
Malova H.V., IKI RAS, hmalova@yandex.ru
Malykhin A.Yu., IKI RAS, anmaurdreg@gmail.com
Zelenyi L.M., IKI RAS, lzelenyi@iki.rssi.ru

References

1. E.E. Grigorenko, H.V. Malova, A.Yu. Malykhin, L.M. Zelenyi, A possible mechanism of the enhancement and maintenance of the shear magnetic field component in the current sheet of the Earth magnetotail component, Plasma Physics Reports 41, No.1, 88-100, 2015.
2. Malova H.V., Mingalev O.V., Grigorenko E.E., Mingalev I.V., Melnik M.N., Popov V.Yu., Delcourt D.C., A.A. Petrukovich, Shen C., Rong D., Zelenyi L.M., Formation of self-organized shear structures in thin current sheets, J. Geophys. Res., Space Physics, 120, doi:10.1002/2014JA020974.2015, 2015.

3. E.E. Grigorenko, A. Yu. Malykhin, E.A. Kronberg, Kh.V. Malova, P.W. Daly, Acceleration of ions to suprathermal energies by turbulence in the plasmoid-like magnetic structures, J. Geophys. Res., 120, doi:10.1002/2015JA021314, 2015

2.2 New type of ionospheric wave activity

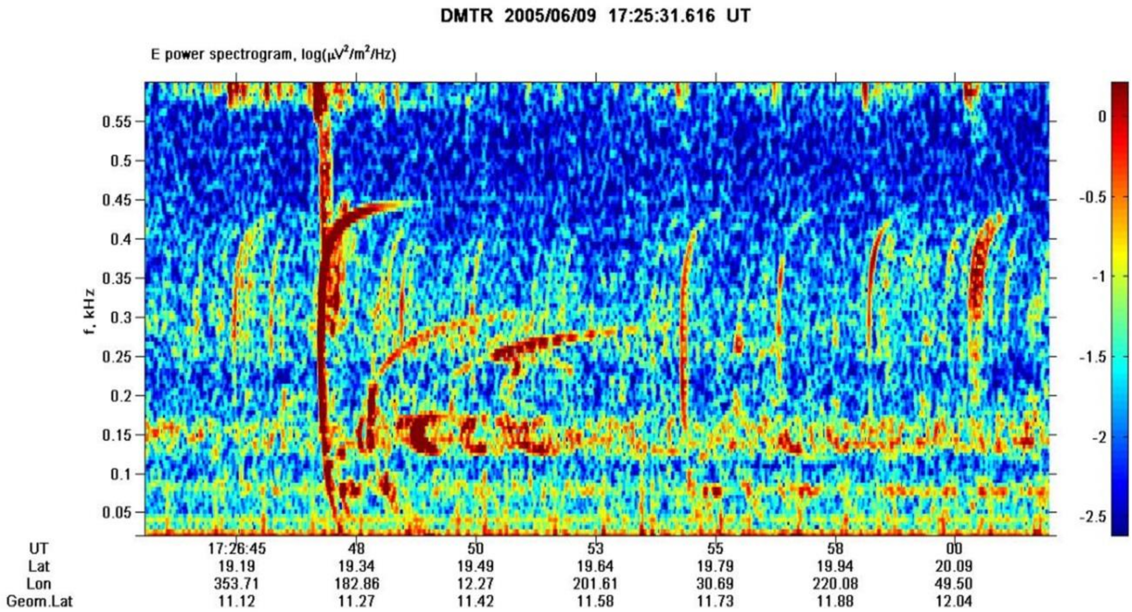

Fig. 1. Proton whistlers, ionospherically reflected whistler – third from the left.

A new wave phenomenon in ELF frequency band – Ionospherically reflected proton whistlers – has been predicted, found in DEMETER data and explained.

This wave phenomenon (see the spectrogram in Fig. 1) is observed at low latitudes in the upper ionosphere. It has been shown that formation of Ionospherically reflected proton whistlers is related to the features of ion-cyclotron wave propagation in plasma containing few types of ions and, in particular, with the possibility of wave reflection at ion-hybrid resonance frequency in such a plasma.

This reflection is similar to the well-known whistler-mode wave reflection near the lower-hybrid resonance frequency which leads to formation of magnetospherically reflected whistlers.

Vavilov D.I, IKI RAS, vavilov86@yandex.ru
Shklyar D.R IKI RAS, david@iki.rssi.ru

References

Vavilov, D. I., and D. R. Shklyar (2014), Ionospherically reflected proton whistlers, J. Geophys. Res. Space Physics, 119, doi:10.1002/2014JA020510.

2.3 Creation of the plasma pressure model at geocentric distances from 6 till 12R_E using data of THEMIS mission

Empirical model of plasma pressure including ion and electron contributions under quiet conditions is created based on the analysis of observational data from the THEMIS mission.

A global averaged picture was obtained for the first time for the distribution of plasma pressure in the equatorial plane. Empirical model includes the 2-D distribution of plasma pressure, as functions of the incoming solar wind dynamic pressure and Bz component of interplanetary magnetic field (IMF), at distances from 6 till 12 R_E under magneto quiet conditions.

2-D distribution of full plasma pressure for solar wind dynamic pressure from 0.5 nPa till 2.1 nPa, IMF Bz from -3.5 nT till 3.5 nT and corresponding digital information is possible to receive freely from http://stdad.iki.rssi.ru/pressuremodel/pressure.php.

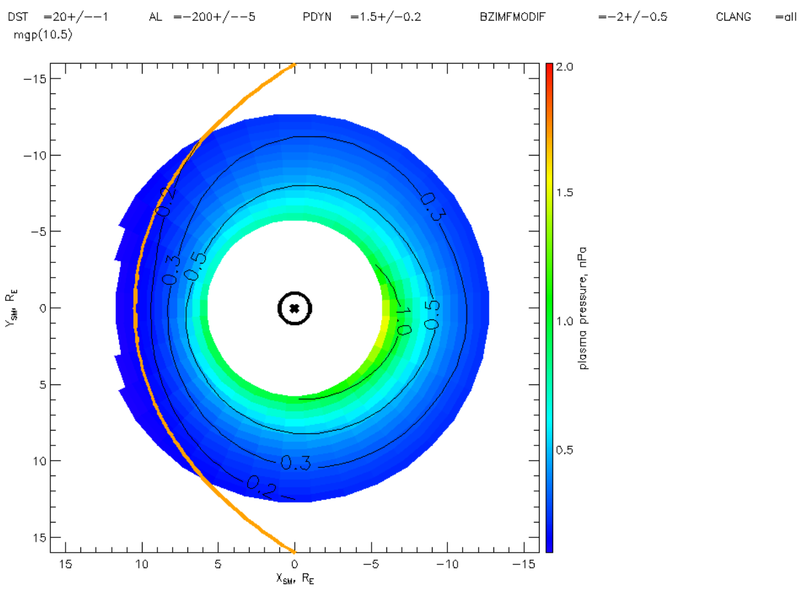

Fig.1 shows an example of pressure distribution when solar wind dynamic pressure Pdin=1.5 nPa, IMF Bz=-2nT. Orange curve on the picture is the magnetopause position in accordance with Shue et al. [JGR, 1998, doi:10.1029/98JA01103] model.

Model is used for the solution of actual magnetospheric problems, including auroral oval mapping to the equatorial plane without using magnetic field models.

Kirpichev I. P., IKI RAS, ikir@iki.rssi.ru

References

1. Kirpichev I. P., and E. E. Antonova, Estimation of the current density and analysis of the geometry of the current system surrounding the Earth, Cosmic Research, Vol. 52, No. 1, pp. 52–60, DOI:10.1134/S0010952514010043, 2014.
2. Antonova E. E., I.P. Kirpichev, M.V. Stepanova, Plasma pressure distribution in the surrounding the Earth plasma ring and its role in the magnetospheric dynamics, Journal of Atmospheric and Solar-Terrestrial Physics, DOI:10.1016/j.jastp.2013.12.005, 2014.
3. Antonova E. E., V. G. Vorobjev, I. P. Kirpichev, and O. I. Yagodkina, 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, pp. 278–281, DOI:10.1134/S0016793214030025, 2014.
4. Antonova E. E., V. G. Vorobjev, I. P. Kirpichev, O. I. Yagodkina, 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.

2.4 Hot flow anomalies’ internal structure analysis

Hot Flow Anomalies (HFAs) are hot plasma congestions that are formed as a result of interaction of interplanetary current sheets with planetary bow shocks. Five HFAs observed on Interball Tail Probe were chosen due to their long duration to analyze their internal structure.

All these HFAs were located at the transitions between quasi-perpendicular and quasi-parallel foreshock regions and were bounded by detached shocks at flanks of HFA.

It was found that several areas with similar properties can be distinguished within each of studied HFAs. We distinguished leading and trailing part of HFA’s body and a short intermediate region separating them. Intermediate region appears to be the region of the current sheet and shock intersection where reflected ion beam is injected in the current structure thus providing the energy for formation of decelerated and heated HFA’s body.

Convection velocities of plasma within these HFAs were calculated by subtracting average velocity from measured ion velocities along spacecraft trajectory through anomaly. These convection velocities viewed in coordinate system based on calculated IMF current sheet normal and shock normal clearly show separation of HFA region in 3 parts: leading part, narrow central part, and trailing part.

Two types of convection within five HFAs were identified. First type HFAs exhibit convection velocities directed away from current sheet plane on both sides. Momentum equation was used for estimation of reflected ions fraction within HFA that can lead do observed deceleration of whole HFA body. For HFAs of first type calculated fraction of reflected ions was about 25% that is close to maximum value for strong quasi-perpendicular shocks. It is consistent with assumption that these HFAs are in the state of quasi-static reformation. That is also supported by observation of plasma convection within whole HFA body directed from the central region.

HFAs of second type exhibit convection velocities directed along current sheet plane on both sides. For HFAs of second type calculated fraction of reflected ions was about 70% that does not support assumption that these HFAs are most probably reforming structures.

Shestakov A.Yu., IKI RAS, sartiom1@yandex.ru

2.5 Mars atmospheric losses induced by the solar wind

Solar wind induced atmospheric losses of Mars were discovered in 1970th on Mars-2,-3, and -5 and were studied in more detail on Phobos-2 and Mars Express.

Three channels were identified:

1. Solar UV ionized exospheric neutrals pick-up leading to formation of Martian magnetosphere and escape of these ions through magnetospheric tail,
2. Atmospheric ions accelerated by VxB force in the magnetospheric tail, and
3. Ionospheric ions leakage.

Solar cycle dependence was found with factor of 10 larger losses at maximum solar activity phase compared to the solar minimum phase. An average mass loss induced by the solar wind, as follows from 4 decades of observations on Mars satellites, amounts to 2×10^{24} heavy ions per second.

The loss induced by the solar wind during cosmogonic time of 4.5 billion years is comparable to the current mass of Martian atmosphere. Thus the solar wind induced atmospheric losses plaid the crucial role in evolution of the atmosphere and of the water content of the Mars.

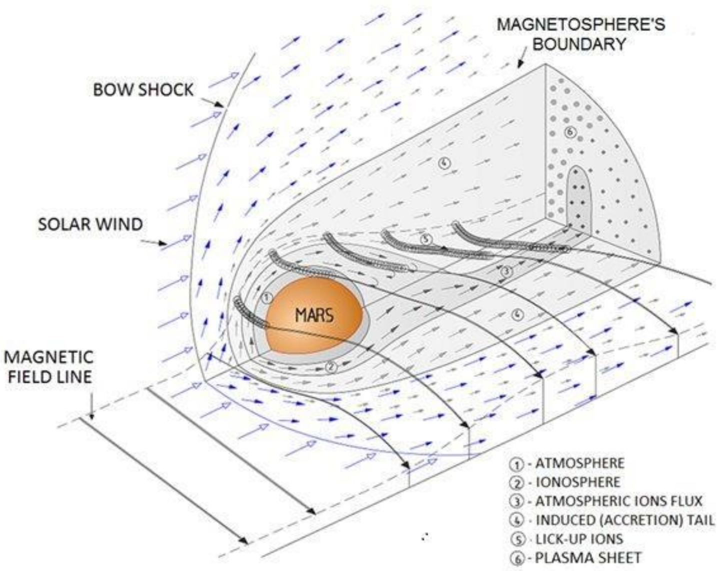

Fig. 1. Martian magnetosphere model and atmospheric losses induced by the solar wind.

Vaisberg O.L., IKI RAS, olegv@iki.rssi.ru