INTERNATIONAL JOURNAL OF GEOMAGNETISM AND AERONOMY
VOL. 3, NO. 1, PAGES 1–3, JANUARY 2002

Foreword

The International Conference on Geocosmos took place on 22–26 May 2000, at the University of St. Petersburg (Russia). About 100 of scientists (mainly from Russia but also from Austria, Germany, and Finland) took part in the Conference and presented about 200 papers.

The general topic of the Conference on Geocosmos suggests a wide variety of problems, including those of physics of the magnetosphere, solar wind, Sun, stars and galaxies. Respectively, presented in this issue are papers devoted to different problems of solar-terrestrial and space physics, which makes the task of reviewing them rather difficult. Nevertheless, some basic topics discussed in these papers may be revealed.

The majority of the papers in this issue are dedicated to the studies of fundamental problems of magnetospheric physics.

One problem concerns the shape and location of the Earth's bow shock and magnetopause depending on solar wind parameters. During the recent decade, there has appeared a series of publications dedicated to this problem [*Cairns and Grabble*, 1994; *Cairns and Lyon*, 1995; *Farris and Russell*, 1994; *Farris et al.*, 1991; *Grable and Cairns*, 1995; *Shue et al.*, 1998]. The shape and location of both the bow shock and the magnetopause have been studied in these papers, on the basis of experimental data and numerical simulations. According to the results of these studies, the ratio of the bow shock standoff distance to that of the magnetopause may be presented in the form

$$\frac{a_s}{a_m} = j + k\rho_2/\rho_1$$

where ρ_2/ρ_1 is the jump of the plasma density of the shock, and j and k are some empirical coefficients. However, the values of j and k are significantly different in different models. Thus the value of j varies from $j = 0.4$ in the *Cairns and Lyon* [1995] model to $j = 1$ in the *Spreiter et al.* [1966] model, and k varies within the range from $k = 1.1$ [*Spreiter et al.*, 1966] to $k = 3.4$ [*Cairns and Lyon*, 1995]. This dispersion of the experimental data, especially great in the case of low magnetosonic and Alfvén–Mach numbers, necessitates further investigation of the problem. In this connection, the paper by *Mühlbachler et al.* [this issue, pp. 5–18] is of certain interest. In this paper, analyzing numerous crossings of the bow shock and magnetopause on October 18 and 19, 1995, the authors have found that in the case of a negative IMF B_z, the Cairns and Lyon, and the Shue formulae are valid, whereas the experimental data agree rather well with the Grabbe and Cairns formula when the interplanetary magnetic field (IMF) B_z is positive. This result seems to explain the apparent disagreement of the models mentioned above.

The case analysis of the bow shock and magnetopause response to a change of the solar wind parameters is presented in the *Nicolaeva et al.* [this issue, pp. 19–26]. Using the data obtained on board the Geotail and Interball 1 spacecraft, the authors revealed two types of the response. In the first case, the bow shock and the magnetopause (at the magnetotail dawn flunk) moved almost simultaneously outward because of the decrease of the solar wind dynamic pressure. In the second case, an almost simultaneous displacement of the dayside bow shock from the Earth and the earthward motion of the magnetopause were observed. As a possible explanation of this phenomenon, the authors suggest the influence of the enhanced thermal pressure of the solar wind plasma, or the boundary wave propagation induced by the pulse of that pressure. However, the mechanism of this influence is not considered in the paper.

Some physical processes developing at and in the vicinity of the magnetopause are considered by *Arshukova et al.* [this issue, pp, 27–34] dedicated to the investigation of the interchange instability of the magnetopause taking into account the plasma flow along the magnetopause. The magnetopause is assumed to be a thin spherical layer with a thickness of $2a$ bounded by two tangential discontinuities. The plasma flow along the magnetopause is characterized by an arbitrary angle between the flow velocity and the magnetospheric magnetic field. The problem is studied in the framework of the ideal incompressible magnetohydrodynamics. The resulting instability is shown to be a mixture of the Rayleigh–Taylor and Kelvin–Helmholtz instabilities. The obtained dispersion equation is solved numerically, and the instability growth rate is shown to increase with the increase of the plasma velocity component perpendicular to the magnetic field and to decrease with the increase of the velocity component along the magnetic field.

With concern to the real magnetopause, the obtained results make it possible to suppose that the growth rate of the interchange instability has to decrease in the meridional

Paper number GAI01382.
CCC: 1524–4423/2002/0301–0382$18.00

plane of the magnetosphere and to increase in the equatorial plane.

Variations of the solar wind parameters are known to change not only the geometrical characteristics of the magnetosphere but also the structure and the state of the latter. An attempt to develop a global model of the magnetosphere response to the solar wind variations is presented by *Alexeev and Bobrovnikov* [this issue, pp, 35–44]. The authors emphasize the idea that the magnetospheric substorm is a single process developing at a global scale and describe it in the framework of the parabolic model of the magnetosphere proposed earlier by *Alexeev* [1978]. In this model, the magnetospheric magnetic field is presented as the sum of the fields of the Earth's dipole and of magnetospheric sources, such as the ring current, tail currents, and magnetopause currents, which dependends on the solar wind parameters. This, in turn, makes it possible to calculate model parameters (magnetopause standoff distance, the distance to the earthward edge of the tail current sheet, magnetic flux in the polar cap, ring current intensity) also as functions of the solar wind parameters.

One of the fundamental features of that model is the formation under certain conditions of a magnetic neutral line ($B_z = 0$) at the inner edge of the tail current sheet. Appearance of this line is determined by the relation between intensities of various magnetospheric magnetic field sources, and the moment of this line formation is considered by the authors as the onset of the magnetospheric substorm active phase. Though the mechanism of the X line formation in the presence of highly conductive magnetospheric plasma is not quite clear, the model seems to adequately describe the global changes of the magnetotail magnetic field configuration during the magnetospheric substorm preliminary phase.

Another feature of the substorm development which the model is supposed to explain, concerns the active phase triggering by a northward turn of the IMF [*Caan et al.*, 1975; *McPherron et al.*, 1986; *Pudovkin et al.*, 1970]. Unfortunately, this problem, though being very interesting, is discussed in the paper very briefly, which makes it impossible to see the concrete mechanism of the substorm trigger phase.

Large-scale solar wind disturbances responsible for geomagnetic storms are studied by *Shadrina et al.* [this issue, pp. 45–50]. From the analysis of about 20 interplanetary disturbances, the authors conclude that when the Earth crosses the western flank of the disturbance, the Forbush decrease occurs in the absence of geomagnetic storms, and when the Earth crosses the eastern flank, geomagnetic storms develop in the absence of the Forbush decrease. This result makes it possible to predict the geoefficiency of flare streams by the location of the corresponding flare on the solar disk.

Dalin et al. [this issue, pp. 51–56] present another type of solar wind disturbances: sharp pulses in the plasma density and ion flux. Disturbances of this type were earlier studied by *Shodhan et al.* [1999]. They associated the origin of these high-density structures with coronal mass ejections (CMEs) and corotating interaction regions (CIRs). Dalin et al. investigated sharp fronts of the above mentioned events on the basis of high-resolution measurements onboard the Interball 1 spacecraft. It is shown that the most probable duration of the pulse front is about 10–50 s. Considering the origin of these events, the authors conclude that they are related to the convective pressure balance structures or to the nonlinear magnetohydrodynamic (MHD) waves generated on the Sun or directly into the interplanetary space.

Meister [this issue, pp. 57–65] deals with the physics of the central object of our planetary system, the Sun. It is known that certain information on the conditions in the solar interior may be obtained using the data of helioseismology, in particular, the data on characteristics of the acoustic waves (p modes). At the same time, it is evident that for experimental data interpretation, one needs sufficiently realistic theoretical models of wave propagation through the Sun. In this connection, the C. V. Meister paper, in which the existing models of hydrodynamic atmospheric waves [*Souffrin*, 1972; *Staude et al.*, 1994; *Zhugzhda*, 1983] are extended to the case of non-adiabatic acoustic-gravity waves in a system with radiation transport, is of a considerable interest.

In two other papers [*Erkaev et al.,* this issue, pp. 67–76; *Dyadechkin et al.,* this issue, pp. 77–86] the problems are considered which are in no way related to each other. Nevertheless, there is a feature which makes these two studies related. And this feature is a common way of solving corresponding MHD problems. The method is based on an introducing a Lagrangean coordinate system moving with the magnetic tube under consideration, and on the use of the theory of non-linear strings [*Semenov and Erkaev*, 1989, 1992]. The use of new methods allowed the authors to obtain new and interesting results.

The MHD slow shocks propagating along the Io flux tube are considered in the paper by *Erkaev et al.* [this issue, pp. 67–76]. It is shown that the propagation of a slow shock along a magnetic tube is associated with a strong plasma flow behind the shock, which in turn results in a field-aligned electric voltage of about 1–3 keV. Besides, because the slow shock velocity is much less than that of Alfvén waves, the shock wave, originated in the vicinity of Io, reaches the Jovian atmosphere with a time delay corresponding to the longitude difference of about 50°–80°. This may explain the observed [*Genova and Aubrier*, 1985] 70° lag of the source field line relative to the instantaneous Io flux tube for the maximum decameter radio emission frequency.

The analysis of the motion of an isolated magnetic tube filled with a perfectly conducting plasma is presented in the *Dyadechkin et al.* [this issue, pp. 77–86]. paper As in the previous paper, the authors use the nonlinear string theory for the description of the magnetic tube motion. As a result, it is shown that the motion of a magnetic flux tube differs significantly from that of a free particle. In particular, a string with a nonzero impact parameter can be captured by the gravitational center, while a free particle with the similar parameter will never be captured.

And, finally, in the paper by *Mironova and Pudovkin* [this issue, pp. 87–90], the influence of solar activity on the lower atmosphere is studied. In particular, it is shown that accordingthe the data of the continental low-latitude observatories, the solar emission intensity increases with the increase of the cosmic ray intensity, this fact agreeing with the results *Veretenenko and Pudovkin* [1999] and seeming to contradict to the well-known results by *Svensmark and Friis-Christensen* [1997].

This discrepancy may be explained by the fact that the Svensmark and Friis-Christensen data concern the behaviour of the low-level cloudiness over oceans, while the sunshine variation studied by Mironova and Pudovkin may be caused by the changes of the atmospheric attenuation modulated by an aerosol layer in the upper troposphere.

Thus the papers presented in this issue explain some special problems of the magnetospheric and space physics and therewith contribute to the construction of the general picture of solar-terrestrial relationships.

M. I. Pudovkin

Convener of the Symposium

References

Alexeev, I. I., Regular magnetic field in the Earth's magnetosphere, *Geomagn. Aeron.* (in Russian), *18*(4), 656, 1978.

Caan, N. M., R. L. McPherron, C. T. Russell, Substorms and interplanetary magnetic field effects on the geomagnetic tail lobes, *J. Geophys. Res., 80*, 191, 1975.

Cairns, I. H., and C. I. Grabbe, Toward MHD theory for the standoff distance of Earth's bow shock, *Geophys. Res. Lett., 21*, 2781, 1994.

Cairns, I. H., and J. G. Lyon, MHD simulations of Earth's bow shock at low Alfvénic–Mach numbers: Standoff distances, *J. Geophys. Res., 100*, 17,173, 1995.

Farris, M. H., and C. T. Russell, Determining the standoff distance of the bow shock: Mach number dependence and use of models, *J. Geophys. Res., 99*, 17,681, 1994.

Farris, M. H., S. M. Petrinec, and C. T. Russell, The thickness of the magnetosheath: Constrains and the polytropic index, *Geophys. Res. Lett., 18*, 1821, 1991.

Genova, F., and M. G. Aubrier, Io-dependent sources of the Jovian decametric emission, *Astron. Astrophys., 150*, 139, 1985.

Grabbe, C. L., and I. H. Cairns, Analytic MHD theory for Earth's bow shock at low Mach numbers, *J. Geophys. Res., 100*, 19,941, 1995.

McPherron, R. L., T. Terasawa, and A. Nishida, Solar wind triggering of substorm onset, *J. Geomagn. Geoelectr., 38*, 1089, 1986.

Pudovkin, M. I., O. M. Raspopov, L. A. Dmitrieva, V. A. Troitskaya, and R. V. Shepetnov, The interaction between parameters of the solar wind and the state of the geomagnetic field, *Ann. Geophys., 26*(2), 389, 1970.

Semenov, V. S., and N. V. Erkaev, Non-linear strings, *Geomagn. Aeron.* (in Russian), *29*, 222, 1989.

Semenov, V. S., and N. V. Erkaev, MH analysis in terms of nonlinear string equations, in *Solar Wind–Magnetosphere Interactions,* vol. 67, edited by M. F. Heyn, H. K. Biernat, V. S. Semenov, and R. P. Rijnbeek, Verl. der Osterr. Akad. der Wiss., Graz, Austria, 1992.

Shodman, S., N. U. Crooker, R. J. Fitzenreiter, R. P. Lepping, and J. T. Steinberg, Density enhancements in the solar wind, in *Solar Wind Nine,* edited by S. R. Habbal, R. Esser, J. V. Hollweg, and P. A. Isenberg, *Proc. Ninth International Solar Wind Conference, AIP Conf. Proc., 471*, 601, 1999.

Shue, J.-H., et al., Magnetopause location under extreme solar wind conditions, *J. Geophys. Res., 103*, 17,691, 1998.

Souffrin, P., Radiation relaxation of sound waves in an optically thin isothermal atmosphere, *Astron. Astrophys., 17*, 458, 1972.

Spreiter, J. R., A. L. Summers, and A. Y. Alksne, Hydromagnetic flow around the magnetosphere, *Planet. Space Sci., 14*, 223, 1966.

Staude, J., N. S. Dzhalilov, and Y. D. Zhugzhda, Radiation hydrodynamic waves and global solar oscillations, *Solar Phys., 152*, 227, 1994.

Veretenenko, S. V., and M. I. Pudovkin, Variation of solar radiation input to the lower atmosphere associated with different helio/geophysical factors, *J. Atm. Solar-Terr. Phys., 61*, 521, 1999.

Svensmark, H., and E. Friis-Christensen, Variation of Cosmic Ray Flux and global coverage — a missing link in solar-climate relationships, *J. Atm. Solar-Terr. Phys., 59*, 1225, 1997.

Zhugzhda, Y. D., Non-adiabatic oscillations in an isothermal atmosphere, *Astrophys. Space Sci., 95*, 255, 1983.

(Received 25 December 2001)