Scientific session of the Division of General Physics and Astronomy of the Russian Academy of Sciences (24 June 1992)

Usp. Fiz. Nauk **163**, 101–102 (January 1993)

A scientific session of the Division of General Physics and Astronomy of the Russian Academy of Sciences was held on June 24, 1992 in the P. L. Kapitsa Institute of Physics Problems. The following reports were presented at the session:

1. *V. N. Oraevskiĭ, V. N. Obridko, and V. V. Fomichev.* Problems in solar-terrestrial physics: exoatmospheric and ground-based observations and experiments.

2. *V. V. Denisenko, N. V. Erkaev, S. S. Zamaĭ, A. V. Kitaev, A. V. Mezentsev, I. T. Matveenkov, and V. G. Pivovarov.* Mathematical modeling of large-scale processes in the earth's magnetosphere.

3. *G. Ya. Smol'kov.* New results on microwave emission from active regions of the sun.

Brief summaries of two reports are published below.

V. V. Denisenko, N. V. Erkaev, S. S. Zamaĭ, A. V. Kitaev, A. V. Mezentsev, I. T. Matveenkov, and V. G. Pivovarov. *Mathematical modeling of large-scale processes in the earth's magnetosphere.* The interaction of the solar wind with the earth's magnetic field has been studied extensively experimentally and theoretically for more than 30 years. The steady interest in this problem is explained by the fact that processes occurring in circumterrestrial space influence the state of the earth's ionosphere and atmosphere. In addition, circumterrestrial space is an interesting object for application of research in plasma physics, mechanics, and electrodynamics, which has stimulated the development of theory and experimental methods. Although the overall picture of the interaction of the solar wind with the geomagnetic field is now known, many and very significant details of the mechanism of formation of the earth's magnetosphere and the physical processes occurring in the magnetosphere are still not completely understood. The difficulties involved in the construction of a physical theory of the earth's magnetosphere are explained by the complexity and multisystem nature of the problems, and for this reason there are no grounds for believing that all cause-and-effect relationships between the phenomena occurring in this region can be understood at a qualitative level directly from satellite measurements. In such a situation the method of mathematical modeling is a productive method of theoretical research.

Magnetospheric phenomena can be divided into two classes according to their characteristic spatial scale: 1) large-scale flows, in which the plasma exhibits properties of a continuous medium, and 2) small-scale specific plasma processes occurring against the background of the large-scale phenomena. The theoretical methods employed for studying these phenomena are different, as are the results obtainable in such studies. The continuous-medium method enables studying the global interaction of the solar wind and the geomagnetic field, but it has the drawback that often the applicability of the method cannot be formally justified. In this case the adequacy of the physical model can be checked by comparing the theoretical results with observational data. The methods of plasma physics give the most accurate description of the properties of the object under study, but due to significant mathematical difficulties they cannot be used for describing large-scale global processes. In other words, these two approaches are complementary.

The authors concentrated their efforts on modeling the large-scale characteristics of the interaction of the solar wind and the geomagnetic field. In so doing, individual phenomena were separated from the global problem and mathematical models were constructed for them. Since the generation of electric fields in the magnetosphere and the transport of these fields into the earth's ionosphere are a central problem in the physics of the magnetosphere, attention was focused on constructing mathematical models of the chain of phenomena from generation of electric fields at the magnetopause and in the plasma sheet to the distribution of electric fields and currents in the ionosphere.[1,2]

The first model in this chain is a magnetohydrodynamic model of solar wind flow around the magnetosphere and the associated problem of reconnection of magnetic fields (IMF).[3–5] There are two possible regimes for reconnection of the IMF with the geomagnetic field, depending on the ratio of the dimensionless parameters characterizing the solar wind. When the transverse component of the IMF in the solar wind is sufficiently strong, the IMF reconnects with the geomagnetic field by a nonlinear mechanism. The theory of this process was examined. In the opposite case, when the transverse component of the IMF is weak, reconnection occurs by a diffusion mechanism. This question as well as the process of electric-field generation at the diffusion magnetopause are discussed.[6,7]

Both the magnetopause and the plasma sheet are sources of the magnetospheric electric field. The model of viscous flow in the plasma sheet as an electric generator is described in Refs. 8–10.

Due to the high field-aligned conductivity of the magnetospheric plasma, the electric fields generated in the magnetopause are transported along the magnetic lines of force to the level of the ionosphere. The magnetic-field distribution in the magnetosphere is determined by solving numerically a magnetostatics problem. The algorithm is presented in Refs. 11 and 12.

 1063-7869/93/010025-02$10.00

In the phenomena considered the ionosphere plays the role of a passive conductor in which the electric energy of magnetospheric generators is dissipated. The two-dimensional model of the ionospheric global conductor is described in Refs. 13 and 14.

After the currents in the ionosphere have been determined, it is necessary to calculate the magnetic disturbances which they produce at the earth's surface, since it is for the magnetic variations that the most extensive and systematic experimental data have been accumulated. This problem is solved in the approximation of magnetostatics. Some results are presented in Refs. 10–12.

Together with the construction of a unified mathematical model of large-scale magnetospheric processes, the models presented are also employed separately. In so doing, the input parameters are prescribed in accordance with existing empirical or theoretical models. The results obtained on this path, which make it possible to explain separate phenomena in the magnetosphere, are briefly presented together with a description of each model.

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[2]V. G. Pivovarov in *ibid.*, pp. 19–22.

[3]V. G. Pivovarov and N. V. Erkaev, *Interaction of the Solar Wind with the Earth's Magnetosphere* [in Russian], Nauka, Novosobirsk, 1978.

[4]N. V. Erkaev, *Solar Wind Flow Around the Earth's Magnetosphere* [in Russian], Moscow, 1989.

[5]N. V. Erkaev and A. V. Mezentsev, Magnitosfernye Issledovaniya, No. 9, 17 (1987).

[6]A. V. Kitaev, Magnitosfernye Issledovaniya, No. 11, 18 (1988).

[7]A. V. Kitaev and I. T. Matveenkov, Geomagn. Aeron. **28**, 380 (1988) [Geomagn. Aeron. (USSR) **27**, 292 (1988)].

[8]V. G. Pivovarov, *Generation of Electric Fields in the Magnetosphere* [in Russian], Apatity, 1991.

[9]V. G. Pivovarov, Geomagn. Aeron. **21**, 876 (1981) [Geomagn. Aeron. (USSR) **21**, 651 (1981)].

[10]I. T. Matveenkov and V. G. Pivovarov, Geomagn. Aeron. **21**, 382 (1981) [*ibid.*, **21**, 280 (1981)].

[11]I. T. Matveenkov, Geomagn. Aeron. **23**, 336 (1983) [*ibid.*, **23**, 276 (1983)].

[12]I. T. Matveenkov, Geomagn. Aeron. **20**, 352 (1980) [*ibid.*, **20**, 250 (1980)].

[13]V. V. Denisenko, Zh. Prikl. Mekh. Tekh. Fiz., No. 3(175), 69 (1989) [J. Appl. Mech. Tech. Phys. (USSR) **30**, 404 (1989)].

[14]V. V. Denisenko and S. S. Zamaĭ, Magnitosfernye Issledovaniya, No. 14, 5 (1990).

[15]V. V. Denisenko and S. S. Zamaĭ, Magnitosfernye Issledovaniya, No. 13, 48 (1989).