SOVIET PHYSICS USPEKHI VOLUME 13, NUMBER 5 MARCH-APRIL 1970

# *SCIENTIFIC SESSION OF THE DIVISION OF GENERAL PHYSICS AND ASTRONOMY OF THE USSR ACADEMY OF SCIENCES*

(25–26 February 1970)

Usp. Fiz. Nauk 102, 313-319 (October, 1970)

A scientific session of the Division of General Physics and Astronomy of the U.S.S.R. Academy of Sciences was held on 25 and 26 February 1970 in the conference hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. A. B. Severnyĭ. Certain New Results of Measurements of the Total Magnetic Field of the Sun and of the Stars.
2. A. A. Mikhaĭlov. Motion of the Earth's Poles.
3. K. I. Gringauz. Characteristics and Spatial Distribution of Low-Energy Plasma in the Magnetosphere and its Connection with Geomagnetic Storms.
4. G. A. Smolenskiĭ and V. V. Lemanov. Hypersonic Waves in Crystals.
5. S. A. Akhmanov. Nonlinear Optics of Picosecond Pulses.

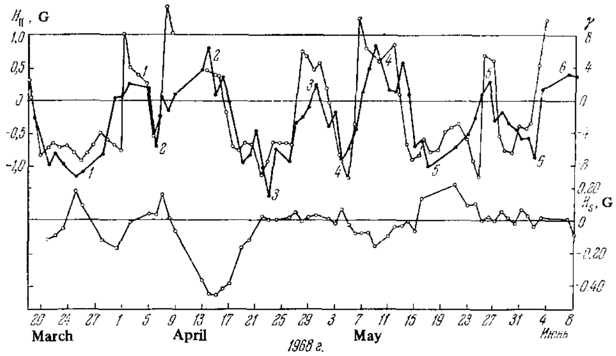
We publish below a brief summary of the papers.

## **A. B. Severnyĭ**. Certain New Results of Measurements of the Total Magnetic Field of the Sun and of the Stars.

A photoelectric magnetograph and the solar telescope of the Crimean Astrophysical Observatory were used in 1968–1969 to measure the longitudinal component of the total magnetic field of the sun as a whole, as a star, in a parallel beam, without first constructing the image of the sun on the slit of the spectrometer. The measurements have shown periodic fluctuations of the sign and of the magnitude of the field, with a period half as long as the period of the rotation of the sun, i.e., the sun behaves as a whole as a rotating quadrupole.

These changes of the total field are more readily in antiphase with the oscillations of the total magnetic flux from all the sunspots, i.e., in antiphase with the solar activity.[1] The measurements show, furthermore, that the period of the oscillations of the N polarity is somewhat shorter than the period of the oscillations of the S polarity and corresponds to an accelerated rotation of the equatorial parts of the sun, i.e., one observes a "runout" of the N polarity on the equator relative to the S polarity of the higher latitudes. It is possible that this process is connected with the formation of a toroidal field and a short of dynamo-mechanism of generation of the total field.

A comparison of the fluctuations of the measured (longitudinal) total field of the sun with the longitudinal component of the interplanetary magnetic field, measured on the satellites "Explorer 33" and "Explorer 35" has shown a very good correspondence between the two measurements both with respect to sign and with respect to magnitude (provided that the delay due to the transport of the solar field by the solar wind amounts to 4.6) (see the figure). This shows that the interplanetary magnetic field has a solar source and that the photospheric magnetic fields are carried out by the solar wind (joint work of I. M. Wilcox, A. B. Severnyĭ, and D. S. Colburn[2]). The observed rapid synchronous fluctuations (with duration on the order of a day) in the magnitude and sign of the solar and interplanetary field in relatively narrow tubes that emerge from small regions on the sun.



Top—measured total magnetic field of sun (dots) and measured magnetic field of solar wind (circles). Bottom—magnetic field flux of sunspots.

The method of measuring the total field of the sun, ensuring an accuracy of ±0.15 G, being applicable (with some modifications) for stars to the large 2.6-meter reflector of the Crimean Astronomical Observatory, makes it possible to detect weak magnetic fields at stars (on the order of 10 G in the case of bright stars), where they were never observed before. The method was verified for the star $\beta$ CrB, whose magnetic field is variable in accordance with previously known photographic measurements. Magnetic fields were observed at the supergiant star $\gamma$Cyg. These fields vary rapidly in magnitude and in sign, from +200 to −200 G (with an error of ±28 G, whereas the usual error of the photographic method amounts to ±100–200 G). This apparently indicates that the field of this star is concentrated in small sections of its surface, if the changes are due to relatively slow rotation. Appreciable fields are possessed also by the slowly rotating stars $\beta$Ori and $\alpha$Tau. The well known star Sirius was found to have a field of approximately 40 G (error ± 12 G), whereas no magnetic field is observed in Procyon ($\beta$ Cmi).

Investigations of such relatively weak fields at stars of different spectral classes, besides disclosing the role of magnetism in the construction and evolution of stars, can explain also the appearance of stellar "wind" in the phase of development of convection in envelopes of stars and clarify the role of rotation and the appearance of magnetic fields on surfaces of stars.

## **A. A. Mikhaĭlov**, Motion of the Earth's Poles.

A study of the motion of the earth's poles was initiated 70 years ago, by means of systematic observations of the latitudes of five astronomical stations organized by international agreement and placed around the entire globe on the 39°8′ parallel of northern latitude. One of these stations is in Kitab (Uzbek S.S.R.). A summary of the observations and the derivation of the coordinates of the pole are carried out in a central bureau which presently is located in Mitsuzawa (Japan).

The international latitude service was organized when it became clear that the pole has two periodic motions about its central position: one with a period of 14 months and an amplitude of about 0.2″, corresponding to oscillations of the elastic earth's sphere, and the other with a period of one year, with amplitude 0.1″, due to meteorological phenomena, mainly seasonal changes of the barometric pressure and the snow cover on dry land. As a result of these two motions, the pole describes a complicated irregular spiral, alternately winding and unwinding, moving up to 10 meters away from its average position. In addition, however, the average pole has experienced a noticeable general motion during the last 70 years.

At the Prague Congress of the International Astronomical Union in 1967, it was resolved to refer the motion of the pole to its average position for 1903, called arbitrarily the international reference. Even a cursory glance at the trajectory of the instantaneous pole of the earth's rotation shows that at the present time the pole has moved from its origin and that in 1962–1967 it executed periodic oscillations around a point located approximately 0.2″ from the arbitrary origin in the direction of the 75° meridian of western longitude, i.e., in the direction of North America. More detailed investigations by a number of astronomers confirms the existence of such a secular motion of the pole with an average velocity of 0.0035″ annually, corresponding to 11 centimeters. It is not known whether such a motion existed in the remote past and whether it will continue in the future; at any rate it is utterly insufficient to explain the changes of the climate and the geological epochs, particularly the ice ages.

The motion of the pole relative to the earth's surface causes changes of astronomically determined geographical coordinates—latitude, longitude, and azimuth. If the entire earth's crust moves as a whole, a hypothesis for which there are definite indications, then the changes of the coordinates should be connected by certain relations, deviation from which points to individual displacements of individual sections, for example the drift of continents. However, the errors in the proper motions of the stars, even in the best catalogs, are of the same order as the observed or expected motions of the continents, and therefore the observations should be organized in such a way as to eliminate these errors. To this end, all the stations should observe the same stars with the same types of instruments and in accordance with a unified and coordinated program. In this sense, a corresponding recommendation was adopted at the aforementioned Prague Congress.

The secular motions of the earth's poles must be taken into consideration when using geographic coordinates determined by astronomical methods at different times, particularly in a general reconciliation of the geodetic trigonometric grids. Although this influence is very small, it will probably increase in the future.

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[1] A. A. Mikhaĭlov, Astron. Zh. **45**, No. 3 (1968) [Sov. Astron.-AJ **12**, No. 3 (1968)].

[2] A. A. Mikhaĭlov, ibid. **47**, No. 3 (1970) [Sov. Astron.-AJ **14**, No. 3 (1970)].

### **K. I. Gringauz**, Characteristics and Spatial Distribution of Low-Energy Plasma in the Magnetosphere and Its Connection with Geomagnetic Storms.

In a review article devoted to a low-energy plasma in the earth's magnetosphere (with particle energies $\sim 200\ \mathrm{eV} < E < 50\ \mathrm{keV}$), it was noted that the development of experimental research on magnetospheric particles of low energies in 1959–1963 lagged far behind research on particles with subrelativistic and relativistic velocities, captured in the radiation belts (out of hundreds of publications on the radiation belts, there were only a few papers on low-energy plasma, mainly in the Soviet Union). The situation has now changed appreciably.

The present-day stage of research in the field of physics of the earth's magnetosphere (1966–1969) is characterized by the use on satellites of new high-sensitivity detectors for the registration of charged particles of low energies (canalotron multipliers) and a sharp increase in the volume of information obtained as a result of direct experiments in the magnetosphere. These experiments have shown convincingly that both the main features of the magnetosphere's structure and the phenomena such as magnetic storms and auroras are determined precisely by the low-energy magnetospheric plasma and its convection (large-scale motions). The particles making up the radiation belts are only a very small fraction of the charged particles populating the magnetosphere, and have little influence on the structure of the magnetic field in the space around the earth.

The magnetosphere has a tail that is elongated in the antisolar direction and has a quasistable structure, occupying a region with diameter $\sim 40 R_E$ ($R_E$ = radius of the earth), and extending over millions of kilometers. The magnetic field in the tail, which differs appreciably from the interplanetary field, is the result of the superposition, on the magnetic field of the earth's dipole, of magnetic fields produced by a sufficiently stable system of electric currents which can be formed only by particles of the low-energy plasma.

Investigations by Vasyliunas (MIT), carried out with satellites OGO-1 and OGO-3, have confirmed that in the equatorial plane the regions of existence of the low-energy plasma in the daytime and nighttime parts of the magnetosphere are joined together, forming a single zone (Fig. 1). In the meridional plane near the earth, a layer of low-energy plasma, inside of which is located a magnetically-neutral layer of the tail of the magnetosphere, enters into the polar regions of the night part of the upper atmosphere along "open" (unclosed) force tubes (Fig. 2).

The reduction of the electron energy spectra obtained on the satellites OGO and "Vela" made it possible for Vasyliunas to determine the following average parameters of the quasi-isotropic streams of electrons in the center of the plasma layer of the tail of the magnetosphere: electron energy $\sim 1$ keV, density $\sim 0.1$–