Scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics, Academy of Sciences of the USSR (18–19 November 1981)

Usp. Fiz. Nauk 137, 529–534 (July 1982)

PACS numbers: 01.10.Fv

A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciencies was held on November 18 and 19, 1981 at the P. N. Lebedev Physics Institute of the USSR Academy of Sciencies. The following papers were delivered:

November 18

1. *N. E. Alekseevskiĭ*, Lev Vasil'evich Shubnikov.
2. *Yu. N. Ovchinnikov*, Special features of properties of the "Shubnikov Phases."
3. *N. B. Brandt and S. M. Chudinov*, The Shubnikov–de Haas effect and its use in studying the energy spectra of metals, semimetals, and semiconductors.

November 19

4. *G. B. Gel'freĭkh*, RATAN-600 measurements of the Sun's magnetic fields.
5. *L. I. Dorman*, The Sun and galactic cosmic rays.
6. *G. E. Kocharov*, New data on the generation of nuclear particles and radiations during solar flares.

The first three papers are being published in their entirety in the "From the History of Physics" section of this issue. The contents of the others are presented in brief below.

G. B. Gel'freĭkh. RATAN-600 *measurements of the Sun's magnetic fields.* Although the structure of the solar corona and chromosphere and the energetics of the basic processes that take place in them, including all manifestations of solar activity, are governed by magnetic fields, there is, for practical purposes, no optical method for measurement of field intensities in the sun's corona.

Spectral-polarization observations of the sun with high-resolution instruments offer an important approach to solution of this problem. Over a number of years, the Main Astronomical Observatory (GAO) and Special Astrophysical Observatory (SAO) of the USSR Academy of Sciences have engaged in work on a joint program of this kind, using the RATAN-600 radio telescope. Observations have been made at five wavelengths in the 2–4 cm band with circular-polarization analysis (the resolution in one coordinate is 17 seconds of arc at the 2-cm wavelength).

Three magnetic-field measurement procedures have been developed on the basis of analysis both of the thermal mechanisms of generation of the various centimeter-band radio-emission components of the sun's active regions and of the propagation of this radiation in the magnetoactive plasma of the corona.

1. In the case of plasma thermal bremsstrahlung in a magnetic field, polarization results from the difference between the absorption (and, accordingly, emission) coefficients for the ordinary and extraordinary waves. For optically thick layers, polarization appears only in nonisothermal plasmas. It has been possible in the case of fields that are not too strong to find a solution of the radioemission transfer equations that can be used to determine weak floccular magnetic fields from the degree of polarization P and the logarithmic slope n of the spectrum at the wavelength λ:

$$B_l\,(G)=\frac{107}{\lambda n}\,P\%.$$

Application of this procedure to RATAN-600 sun observations made it possible, for example, to show that the large-scale magnetic fields of flocculi in the upper chromosphere are practically identical in magnitude and sign to those at photosphere level.

2. Use of Zheleznyakov and Zlotnik's theory of the thermal cyclotron radio emission of the solar corona in strong sunspot magnetic fields has made it possible to identify the shortwave part of the emission from the local-source nucleus with the emission of corona electrons at the third harmonic of the gyrofrequency. By observing the spectra of these nuclei with the RATAN-600, it is possible to find the cutoff wavelength λ' of third-harmonic generation and thus to measure the field at the base of the corona above the sunspot (at altitudes of about 2000 km above the photosphere):

$$B\,(G)=\frac{3570}{\lambda'\,(\mathrm{cm})}.$$

Close coupling of these fields with the field intensities at photosphere level was observed, and it was also shown that the field in the corona may reach values as high as 2000 G or more.

3. The effect in which the polarization of the radiation from local-source nuclei changes sign with wavelength, which appears at certain active-region longitudes, has been used to measure field intensities in regions of quasitransverse propagation in the corona. Using the theory of radio propagation developed by Cohen and Zheleznyakov and Zlotnik, it is possible to establish a relationship between the cutoff wavelength λ_t of the polarization sign change and the magnetic field intensity in the region of the transverse field:

$$B\,(G)=\frac{157}{\lambda_t\sqrt[3]{NL_B\lambda_t}}\,,$$

 0038-5670/82/070530-05$01.80

where the units of measurement of the characteristic scales of the field and electron density are $[l_B] \approx 10^{10}$ cm and $[N] \approx 10^8$ cm^{-3}. As measured with this formula, the magnetic fields at heights of $(50-100) \cdot 10^3$ km are in the tens of oersteds, in general agreement with the conception of the potential nature of the field in the corona.

Special interest attaches to the results of coordinated studies of active regions in which radioastronomical magnetic-field measurements made by all three of the above methods were combined with observations of the same region in other wavelength bands. Several coordinated observations of this kind have been within the framework of the international Solar Maximum Year program. An interesting example was the study of the arches of a behind-limb coronal condensation that was observed on November 19, 1980 jointly with the Mountain Astronomical Station at Kislovodsk. Among other things, it was shown that the magnetic fields within the coronal arch and outside of it at the same altitude were of the same order of magnitude (about 20 G at a height of 75 000 km).

L. I. Dorman. *The Sun and galactic cosmic rays*. The sun is not only a generator of powerful electromagnetic radiation and high-energy particles (solar cosmic rays, SCR), but also strongly influences the intensity, anisotropy, and spectrum of the high-energy particles arriving from the galaxy (galactic cosmic rays, GCR). This modulation gives rise to local effects that are shaped in a comparatively small volume with dimensions of, say, a few astronomical units (the Forbush decrease of the GCR, the solar anisotropy, the false "stellar" anisotropy, the 27-day variations, effects in which GCR are intensified before strong interplanetary shock waves arrive at the earth, GCR scintillations), and global effects, which are shaped throughout the entire solar-wind region with dimensions running to many tens of astronomical units (the 11-year and 22-year GCR variations).[1-6]

The modulation effects are classed as extraterrestrial CR variations. In the variations that can be observed with ground-based instruments for continuous CR registration (neutron monitors and supermonitors, muon telescopes, etc.),[5] we have the sum of all three classes: those of atmospheric,[7] magnetospheric,[8] and extraterrestrial origin. They are separated, and the extraterrestrial CR variations isolated, by spectrographic analysis of the results of simultaneous measurements of several components with different sensitivities to the primary CR (with different coupling coefficients; see Chap. VIII of Ref. 9). For this purpose, two mountain CR spectrographs were built in the Sayan Mountains and on Mt. El'brus in the Soviet Union between 1968 and 1975; they are still the only installations of their kind in the world. They can be used to separate the variations of magnetospheric origin, apply the appropriate corrections to observational data from the worldwide station network, and find the planetary distribution of the manifestations in the secondary components of variations in the extraterrestrial primary CR. Then the coupling coefficients and computed particle paths in the real geomagnetic field are used to make the corresponding conversion beyond the limits of the earth's magnetosphere for each station. The planetary CR distribution found for each instant of time is subjected to spherical analysis to find the temporal variations of CR density (of the isotropic intensity component) and the parameters of the spherical harmonics (see Refs. 4, 6, and 10 and Chap. IX in Ref. 9). In this procedure, therefore, the world station network (with its approximately 100 stations) is used as a unified multidirectional planetary instrument. The results obtained in this way are exceptionally accurate and reliable. They form the basis for acquisition of detailed information on both local and global CR modulation effects.

Using this approach, it has been possible in recent years to make a thorough study of the interaction of the flare plasma and the high-velocity solar wind fluxes with the GCR and to obtain a rather complete picture of the formation of the diurnal and semidiurnal components of the anisotropy vector, the radial and transverse gradients, and the 27-day variation of the GCR.

Study of the global modulation—the 11- and 22-year variations of GCR intensity and anisotropy—is considerably more difficult. This is because these variations are governed by processes that are related to the cyclic activity of the sun and unfold in interplanetary space at such great distances from the earth (both in the radial direction and in the direction transverse to the sun's equatorial plane) that practically no direct information on them is available or can even be expected within the next few years. However, it is possible to obtain some indirect information on these processes by comparing the theoretically expected effects with the observed global modulation.

First of all, it was possible to establish back in 1967 that the relation between the long-term variation of the GCR and solar activity is not linear, but has a complex hysteretic nature because of the large size of the region of global GCR modulation (50–100 a.u.).[11] This relationship has been found to differ significantly for GCR particles of low hardness (~1 GV, observations on space vehicles and in the stratosphere), medium hardness (~10 GV, neutron-monitor observations), and high hardness (~100 GV, ground and underground observations using muon telescopes). To explain these features, it was proposed that the dimensions of the solar wind are quite large (50–100 a.u.), so that the variations of electromagnetic conditions in interplanetary space (which determine the global GCR modulation) occur with a considerable lag behind the processes on the sun. Since the intensity of the interplanetary magnetic field decreases with distance from the sun, the effective dimensions of the modulation region decrease with increasing particle hardness. In accordance with these conceptions, computer calculations were made to determine the expected global modulation[13] within the framework of the theory of anisotropic GCR diffusion in interplanetary space.[12] It was believed at that time that the magnetic field has a sector structure in interplanetary space, and that the directions of the force lines reverse at the transitions between sectors. Therefore the off-diagonal components of the anisotrop-