SPATIAL DISTRIBUTION OF COSMIC RAYS IN MAGNETIC CYCLES OF THE SUN

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Space-time distribution of CR density B is determined from the solution of anisotropic diffusion equation (Dorman, 1965). The boundary problem is solved in a quasistationary (the delay of CR relative to cyclic variations of solar activity is taken into account) axisymmetric case under the following boundary conditions

$$\left.\frac{\partial B}{\partial r}\right|_{r=0}=0; \quad B\Big|_{r_0=1}=1, \quad B\Big|_{r=350\,GV}=1,$$

where r is the distance from the Sun, r_o is the dimension of the modulation region, R is particle rigidity. The specificity of our modulation model is the use (in line with the works by Alaniya et al., 1981, 1983) of the empirical dependence of the free path of particles for scattering on the observed latitudinal distribution of solar activity. Another specific feature of the model is an account of an additional effect due to the drift of charged particles towards the helio-equator plane or backward, depending on the direction of the total magnetic field of the Sun.

The intensity of coronal radiation (λ = 5303A) and the area of solar spots were chosen as indices of helio-activity. Out of many observed manifestations of solar activity these characteristics have been chosen in the assumption that their cyclic variations are a reflection of a corresponding manifestation of poloidal and toroidal components of the magnetic field of the Sun. Such interdependence was also pointed out by Parker (1982). To confirm this assumption, the behaviour of the north-south assymetry of the chosen indices of solar activity was studied in detail in 18-21 cycles in the periods of inversion of the total magnetic field of the Sun. It has been shown (Alaniya et al., 1983) that inversion of magnetic fields in high-latitudinal regions of the Sun starts in the hemisphere where the activity is maximal, and the most convivcing proof of it is given by the intensity variation of the green coronal line. Thus, deter-

..ining the variation of the free path for particle scattering by means of the dependence which takes into account simultaneously the change in the solar spot areas and in the coronal radiation intensity (λ = 5303 A) and the delay of CR, one can associate the observed cyclically varying solar activity on the entire sphere and the spatial distribution of the diffusion tensor.

Under the above boundary conditions and under the assumptions concerning the dependence of the free path on the distance and rigidity (see Alaniya et al., 1981) the numerical solution of the CR transport equation makes it possible to estimate an additional effect induced by particle drift from poles to the equator and backwards depending on the direction of the large-scale magnetic field of the Sun. Figure I presents the latitudinal distribution of the expected modulation depth B for two different configurations of the total magnetic field of the Sun, as well as the modulation depth calculated for the case where the drift effect is disregarded.

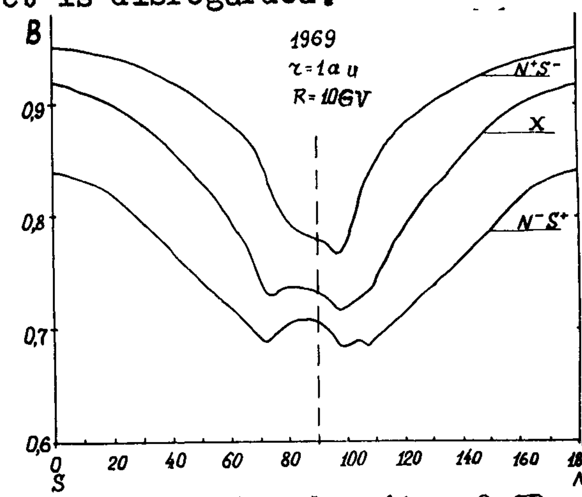

Fig. I The expected relative density of CR with a rigidity of 10 GV in 1969 at a distance r = I a.e. versus the heliolatitude with an account of drift fluxes (N^-S^- - towards the ecliptic plane, N^-S^- - backward and without an account of the drift x).

The calculations show that an account taken of this effect may increase or decrease (depending on the direction of the background magnetic field of the Sun) the modulation depth about by I/3.

According to our calculations for some periods in 19-21 cycles of solar activity, the expected amplitudes of long-term variations of CR with a rigidity of 10 GV (in the determination of which the drift of charged particles is taken into account)are in a good agreement with the ones observed on neutron monitors (which register particles with the effective rigidity of 10 GV).

From the obtained space-time distribution of the relative CR density we have determined the expected transverse gradients, which are the measure of nonsphericity of the modulation process. Increasing in the activity maxima, the latitudinal gradients whose value depends on the epoch of the solar activity cycle must show up the features of spatial distribution connected with the specificities of the CR modulation model under consideration (Fig.2).

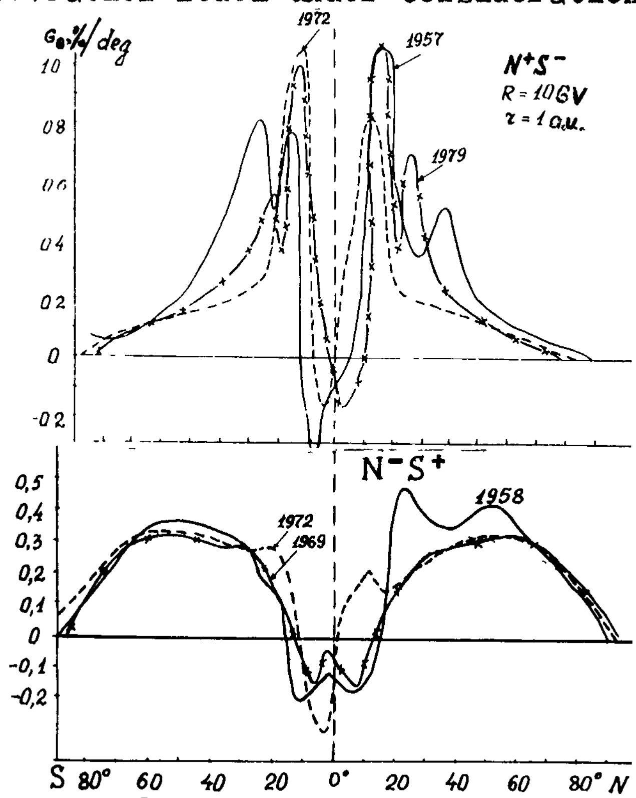

Fig. 2. The expected transverse gradient in the maxima of 19-21 cycles of solar activity for different configurations of the total magnetic field.

For the configuration of the total magnetic field of the Sun, where the magnetic field lines leave the North pole and enter the South pole (N^-S^-), the maximum of the transverse gradient must be observed at helio-latitudes $\pm(10^\circ - 15^\circ)$, and for the inverse configuration it shifts towards higher helio-latitudes ($\pm(40^\circ - 50^\circ)$). Besides, for both field configurations on the Sun, at low helio-latitudes the transverse gradient is signvariable, which confirms the results of meteorite studies (Lavrukhina, Ustinova, 1981).

Note that the agreement between the expected transverse gradients and those observed on cosmic apparates (according to Lockwood and Webber, 1984) is only of a qualitative character because one should bear in mind the difficulties in the interpretation of space measurements, which are connected with the fact that the angle of cosmic apparatus declination from the helio-equator plane is at the present time not large, and the problem of separation of radical and transverse gradients has not yet been clearly solved.

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