COSMIC RAY MODULATION BY HIGH-SPEED SOLAR WIND FLUXES

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Abstract. Cosmic ray intensity variations connected with recurrent high-speed fluxes (HSF) of solar wind are investigated. The increase of intensity before the Earth gets into a HSF, north-south anisotropy and diurnal variation of cosmic rays inside a HSF as well as the characteristics of Forbush decreases are considered.

I. Introduction. Recurrent high-speed fluxes of solar wind connected with coronal holes change essentially the cosmic ray density distribution in interplanetary medium. When such fluxes cross the Earth, different types of cosmic ray (CR) variations are observed. The characteristics of these CR variations may essentially differ from those observed when CR pass sporadic HSF of flare origin.

Below we consider a number of CR variations connected with recurrent HSF observed in I973-I974.

2. Intensity increase before Forbush effect. I2 fluxes of velocities $v \gtrsim 600$-800 km/s were considered, which were accompanied by Forbush effects. The data on the CR neutron component obtained on the Deep River station were used. After the low-frequency trend and the diurnal CR variation were eliminated by the method of superposition of epochs the CR variation was found before the Earth got into a HSF. It is seen from Fig.I that before Forbush effect CR intensity increases with amplitude by about 0.4 %.

3. N-S anisotropy of CR. The N-S anisotropy was investigated from the CR neutron component data obtained in the stations of Thule and Mc Murdo. I8 HSF with a positive IMF direction and I8 HSF with a negative IMF direction were picked. All of them were divided into three groups depending on their speed: I-$v \leq 600$ km/s, II - $v = 600$-700 km/s, III - $v > 700$ km/s.

The results of determining N-S anisotropy by the method of superposition of epochs are presented in Fig.2. The N-S anisotropy is seen to exist in the back part of a HSF (5%) and to be absent in the front part of a HSF. Such a peculiar behaviour of N-S anisotropy is qualitatively explained by a non-radial plasma outflow from the coronal hole - the flux is divergent. The sign of N-S anisotropy becomes inverse as the IMF direction changes. This means that N-S anisotropy results from the Hall effect. This conclusion is confirmed by the behaviour of the B_z-component of IMF at different IMF directions. The amplitude of N-S anisotropy does not depend on the HSF speed.

4. Diurnal CR variation. The behaviour of the diurnal CR variation was investigated from the data on the neutron component for 58 HSF. It turned out that the amplitudes of first and second harmonics are larger inside a HSF than in a quiet solar wind, that the phase of first harmonic shifts towards earlier hours, and the phase of second harmonic towards later hours (Fig.3). This difference increases with an increasing HSF speed. The characteristics of diurnal CR variation do not depend on the field direction in HSF.

5. Forbush effects of recurrent HSF. The analysis of data on the CR neutron component for 62 HSF has shown that if the HSF width $\Delta t \gtrsim 3$ days, a Forbush decrease is practically absent. Inside each HSF there exists a good correlation $(r \approx -.7)$ between plasma velocity and CR intensity decrease. The amplitude of Forbush effect A_F increases with an increase of the HSF velocity (about a 5-% increase for an increase of v by IOO km/s). The shape of Forbush decreases and their amplitude do not depend on the IMF direction. The energy spectra of Forbush decreases for HSF of different velocities have been determined. It turned out that as the HSF velocity increases, the spectral index γ monotonously decreases: from $\gamma = 0.7$ for $v \leq 600$ km/s to $\gamma = 0.5$ for $v > 700$ km/s.

All these results, as well as the results of analogous papers by other authors make it possible to conclude that the main parameter of recurrent HSF which determines the characteristics of various CR variations is their velocity.

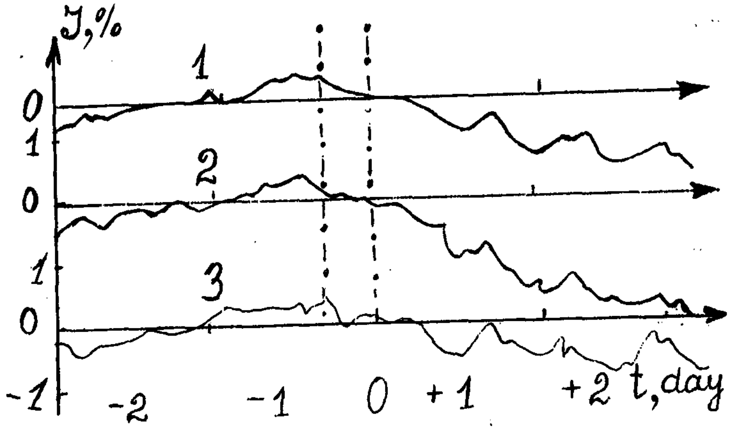

Fig.I. CR intensity increase before side-end of SHF calculated by superposition of epochs from I2 events. Curve 2-effect due to particles coming from transition region. Curve 3-effect due to particles coming from other directions. Curve I-effect averaged over all directions.

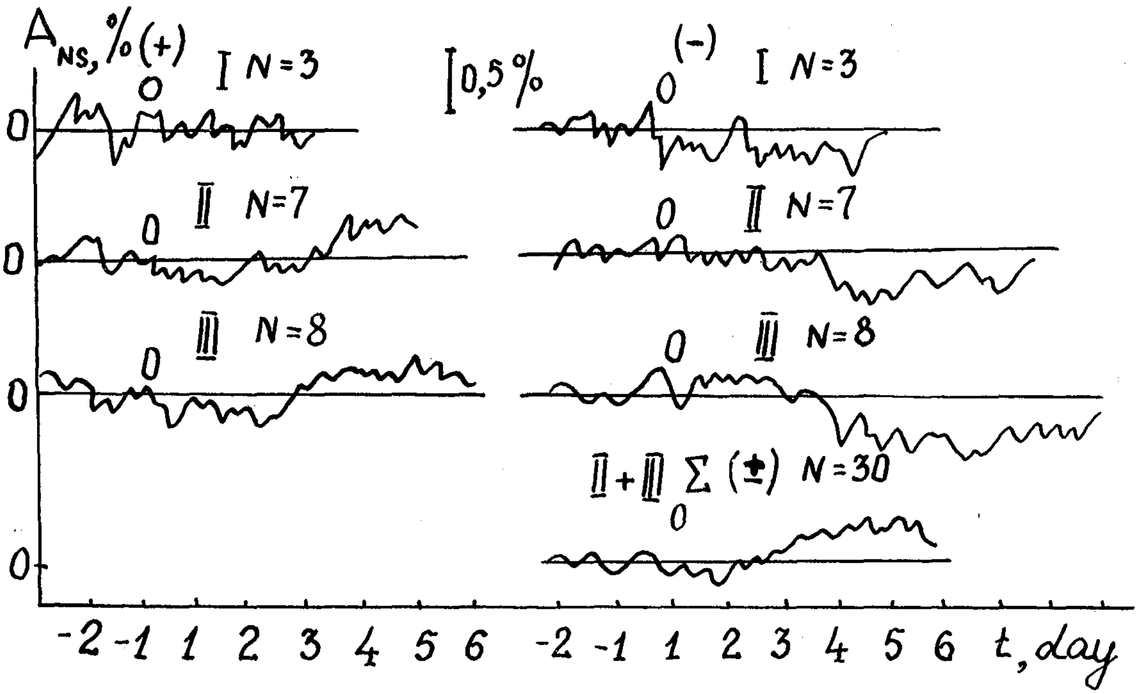

Fig.2. N-S anisotropy of CR inside a HSF. On the left - for the positive IMF direction, on the right - for the negative IMF direction. I - for HSF with v ≤ 600 km/s, II - for HSF with v = 600-700 km/s, III- for HSF with v > 700 km/s. At the bottom is the sum curve for the II-nd and III-d groups of HSF.

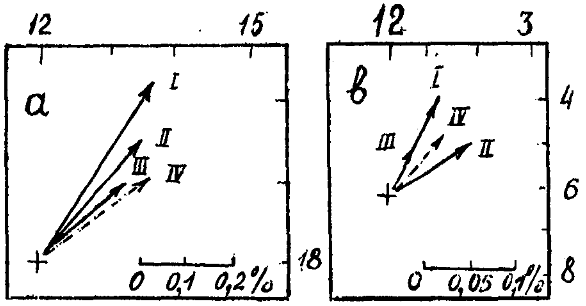

Fig.3. Vectors of a diurnal (a) and semidiurnal (b) CR variations: I - in the front part of HSF, II - in the middle part of HSF, III - in the back part of HSF, IV - in a quiet solar wind