# PECULIARITIES OF GALACTIC COSMIC RAY (GCR) ANISOTROPY VARIATION IN CONNECTION WITH THE RECURRENT AND SPORADIC FORBUSH EFFECTS

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ABSTRACT

It has been establised, that the beginning of the change of vector of Solar-diurnal anisotropy of Galactic Cosmic Rays(GCR) preceeds the beginning of Forbush-decrease(FD), which is due to the disturbed region (DR) of Solar wind existing time of which is $\tau \gtrsim$ 8 days. The meridional gradient $\nabla_\theta n$ of density during the reccurent FD is valued.

## I. Anisotropy of GCR due to the long lived DR ofsolar wind

As is known, the sporadic Forbush decreases (SFD) are caused by thepowerful solar flares on the day-side of the solar disc. If the flare occurs near the central meridian of the Sun, then in this case DR of the Interplanetory medium, at the starting point of SFD will have the spatial sizes of order of one a.u. Considerable small size of DR of Solar wind, causing SFD, attaches some definite character on the behaviour of solar-diurnal anisotropy vector of GCR.

The typical case of behaviour of the anisotropy vector, according to the data of Kiel(FRG) during the SFD (06.09.1982) is given (on fig.Ia). Before the beginning of SFD, vector of anisotropy is not changed, while after the SFD the vector turns to the direction of the Sun. The behaviour of vector of the GCR anisotropy has essentialy distinctive feature during such FD-s, which aren't necessarily connected with the flares on the Sun, arising not far from the central meridian, but are due to the high-velocity flow of Solar wind existing in the interplanetory medium in the course of time $\tau \gtrsim T/4$ ( $T$ -is the period of Solar rotation). In such cases, it is easy to notice, that at the starting point of FD the DR of the SW occupies the space area with the sizes of $L \gtrsim 4$ a.u. The corresponding model configuration lines of forces of IMF is presented (in Fig.lb). The passage of the Earth through the inhanced regions of IMF corresponds to the beginning of FD. In front of this region, as it is seen in (Fig.lb) is the nondisturbed region of the Solar wind, however access of GCR into this region is complicated due to the compressing of the lines of forces of IMF at far distances, where the GCR particles come from, mainly directed across the IMF lines of forces. The latter means, that in this region of SW, similar to the charged particles trap, the diffusional flow of GCR must be greatly decreased. Hence, the GCR anisotropy in this non-dirturbed region of SW will be mainly due to the convectional flow of GCR, which is due to cause the turning of the anisotropy vector to the direction of the Sun. FD on 28.01.1978 serves as a good example of this case. Before the beginning of the FD in the course of 20 days, not a single Solar powerful flare with importance $\geqslant 2$ was observed. Consequently, FD must be due to the long-lived DR of SW. As it is seen from Fig. 1c. the anisotropy vector of GCR , for 8 days earlier before the beginning of FD, is essentialy turning to the direction of the Sun, but after the beginning of FD- tends to orientate to the direction of IMF. The latter is connected with that fact, that after the front passage through the DR, the Earth comes out of the "trap" region and the recovery of GCR intensity occurs due to the diffusional flow across the IMF lines of forces, which at far distances are spread, contributing to the free penetration of the GCR particles from the far distances of the Sun, where the GCR density is large.

## 2. The meridional gradient of GCR during the recurrent Forbush decreases.

In paper /I/ the classification of FDs is presented and in paper /2/ it is shown that the spectrum of the recurrent FDs is more rigid, than the one of the sporadic FDs. In the given paper the meridional gradient of CR during the recurrent FD is valued /3/.

The data of the world network of station of CR neutron component are analysed as well as the data of the SW, of the IMF, according to /4/ and of Solar activity (Solar Geophysical Data, NOAA). The considering of the FDs with the amplitude $\geqslant 1\%$ is mainly made according to the data of the high-latitudinal stations of CR. Superposition of effects, due to flaring and non-flaring flows complicates the view of recurrent FDs. If the recurrend FD is not preceeded by the chromosperic flare and FD is not created by interactional high-velocity flows of SW, then during the FD the IMF sign must not change. Therefore we've analysed only those FD-s, during which the IMF sign is not changed. Data for the period 1971-1978, when the polarity of the general magnetic field of the Sun was not changed, have been taken for the analysis.

After such selection 47 cases of FD were left. 22 cases out of them were arisen at a time, when IMF sign was negative (towards the Sun). In 25 cases, FDs were arisen at a time, when the IMF sign was positive (from the Sun). Each of these groups we divided into 2 subgroups, according to the IMF sign before and during FD, i.e. while dividing into subgroups, it was taken into account, whether the IMF signs coincided with each-other or not before and during the FD. Thus, we've obtained 4 groups of cases of FDs.

In DR of the SW the CR density is less than out of it, therefore the azimuthal gradient $\nabla_\varphi n$ of CR density changes its direction near the minimum of recurrent FDs, i.e. in the minimum of recurrent FDs it can be admitted that $\nabla_\varphi n$ =0. Therefore, the meridional gradient $\nabla_\theta n$ will cause the CR additional flow of the Hall type, directed perpendicular to the IMF and $\nabla_\theta n$ /5/.

The observed CR anisotropy $A$ near the minimum of the recurrent FDs can be presented as the sum of $A = A_0 + A_\perp$, when $A_0$ -is a general anisotropy connected with the convectional -diffusional transforming in the high-velocity plasma flow, $A_\perp$ - is the constituent, due to the appearance of $\nabla_\theta n$. The value of - $A_0$ was calculated by data averaging after the minimum of FDs.

In Fig.2a,b, where effective regions of CR modulation are denoted by the circles, the orbit of the Earth-by dashes, the neutral layer of IMF - by the solid line, the origination of the anisotropy under the influence of $\nabla_\theta n$, during those recurrent FDs, when the IMF is directed from the Sun, is shown schematically. The calculated values $A_\perp$ and values of IMF are also given ( in the right part of Fig.2a, b) in the minimum of FDs. It is seen, that in case of 2a (I7 cases of FDs are averaged) the vector $A_\perp$ is really directed perpendicular to the IMF. In case 2b( 8 cases of FDs are averaged) the vector $A_\perp$ is turned relatively towards $A_\perp$ corresponding to the case 2a almost by I80° as it was to be expected

In Fig. 3a,b the same as in Fig.2 , is presented only for those recurrent FDs during which IMF is directed to the Sun. In case 3a-I8 cases of FDs are averaged, but in 3b- 4 ones of FDs.

For the more exact definition of $A_\perp$, we've examined those FD-s, which correspond to the cases presented in Fig. 2a,b. The anysotropy $A$ in the minimum FD has the form: In case 2a $A_1 = A_0 + A_\perp$ ; In case 2b $A_2 = A_0 - A_\perp$. Hence, $A_\perp = (A_1 - A_2)/2 = (0,I2+0,06)\%$.

According to /5/ $A_\perp = \Lambda[\nabla_\theta n \times k]$, where $\Lambda$ is the transport path of CR; $k$ -unit vector along the lines of force of IMF.

In paper /5/ the following is shown

$$\Lambda = (1-F)\rho \quad \rho = R/(45B)$$

where $\rho$ -is the Larmor radius in a.u. F - degree of irregularity of IMF. R-rigidity (in Gv) B-value of IMF (in nTl ). Then $\nabla_\theta n = 45 A_\perp B (1-F)^{-1} R^{-1}$, where $\nabla_\theta n$ is expressed in %/a.u. $A_\perp$ -in %, If F =0,I÷0,3 then with R=IO GV, from the experimental data we obtained, that during the recurrent FD-s meridional gradient of CR density on the Earth orbit is $\nabla_\theta n = (3 \div 4)\ \%/a.u.$

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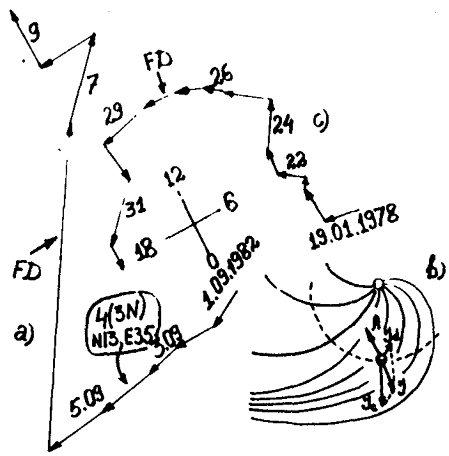


Fig.I

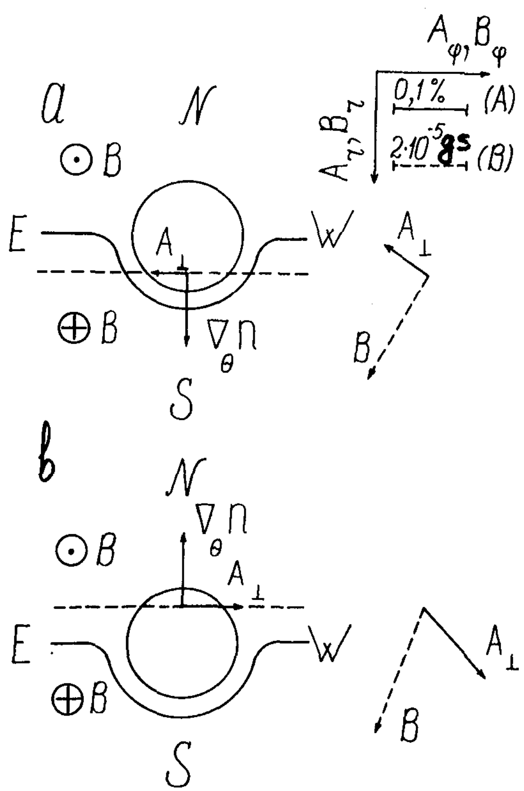


Fig.2

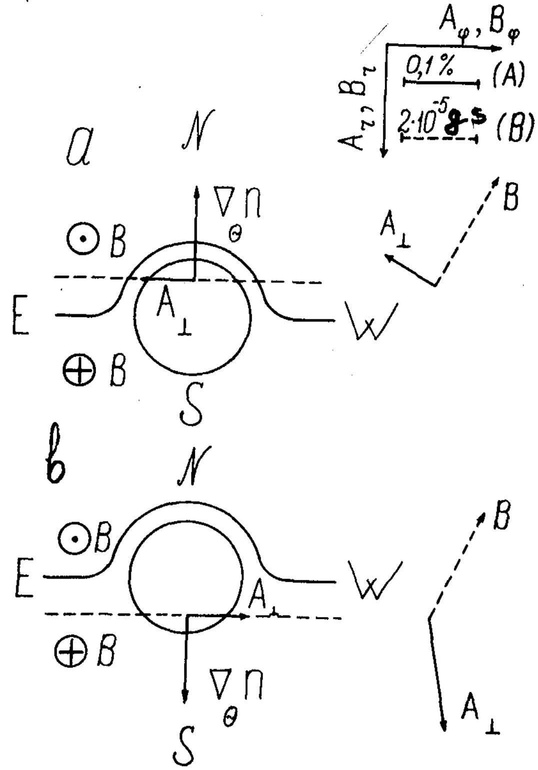


Fig.3