

On the 27-day variations of the galactic cosmic rays intensity and anisotropy

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Abstract— We study features of the 27-day variations of the galactic cosmic ray (GCR) intensity and anisotropy based on the isotropic component I , and the radial and tangential components of the three dimensional (3-D) anisotropy of GCR determined by the global spherical analyses method (GSM). Also, we use data of Kiel neutron monitor, solar wind (SW) velocity, Wolf Number (R_z) of solar activity and strength of the interplanetary magnetic field (IMF). We found that the greater amplitudes of the 27-day variations of the GCR anisotropy and intensity in the minima epoch of solar activity for the $A>0$ polarity period than for the $A<0$ polarity period are related with the heliolongitudinal asymmetry of the solar wind velocity. We reveal the long-lived (~ 22 years) active zones of heliolongitudes on the Sun which are considered as the source of the quasi-periodic (~ 27 -days) variation of the solar wind velocity. We assume that the continuous background 27-day variations of the GCR intensity and anisotropy are observed owing to the existence of the long-lived 27-day variation of the SW velocity, especially in the minima epoch of solar activity.

Based on the Chree's diagram and epicyclograms methods we confirm that the amplitudes of the 27-day variation of the GCR anisotropy are greater and phases are more evidently established in the $A>0$ than in the $A<0$ polarity periods of solar magnetic cycles.

We develop model based on the transport equation of GCR including the heliolongitudinal asymmetry of the turbulence of the IMF. We confirm that only the inclusion of the heliolongitudinal asymmetry of the solar wind velocity in the transport equation gives the results compatible with the neutron monitors experimental data.

I. INTRODUCTION

The Sun is relatively quiet, a direction of the Sun's global magnetic field is well established and the disturbances in the interplanetary space are minimal in the minima epoch of solar activity. For the minima epoch the contribution of the drift effect of the galactic cosmic rays (GCR) particles due to gradient and curvature of the regular interplanetary magnetic field (IMF) can be revealed reasonably purely in different

classes of the GCR variations; this is especially important for the GCR variations with relatively small amplitudes, e.g. for the 27-day variations of the GCR intensity and anisotropy. In previous papers [1], [2] we found that the amplitudes of the 27-day variations of the GCR intensity and anisotropy are greater in the minima epochs of solar activity for the positive ($A>0$) polarity period than for the negative ($A<0$) polarity period of the solar magnetic cycles. This relationship was found based on few neutron monitors data. It is of interest to study the behaviors of the amplitudes of the 27-day variations of the GCR intensity and anisotropy calculated based on the data of all the functioned neutron monitors by the global spherical analysis method (GSM). Also, in connection with this we first use the Chree's diagram and epicyclograms methods to study the behaviors of the amplitudes and phases of the 27-day variations of the GCR intensity and anisotropy in different polarity periods of solar magnetic cycles.

We study the role of the heliolongitudinal asymmetry of the IMF turbulence in the behaviors of the amplitudes of the 27-day variations of the GCR intensity and anisotropy using the modeling based on the Parker's transport equation [3]. Theoretical calculations show that the amplitudes of the 27-day variations of the GCR intensity and anisotropy are greater in the $A<0$ polarity period than in the $A>0$ polarity period being in contrary to the results obtained by the neutron monitor experimental data [1], [2]. We confirm that the experimental data of neutron monitors are in a good agreement with the theoretical results when the heliolongitudinal asymmetry of the solar wind velocity is included in the model describing the 27-day variations of the GCR intensity and anisotropy [4], [5].

II. EXPERIMENTAL DATA AND DISCUSSION

To find the amplitudes of the 27-day variations of the GCR intensity and anisotropy based on the all functioned neutron monitors the global spherical method (GSM) is used [6]-[9]. Scientific group of IZMIRAN have calculated the components (A_r, A_θ, A_f) of the three dimensional (3-D) anisotropy and the isotropic component I of GCR intensity based on the hourly data of all functioned neutron monitors using the GSM for a long period (<http://helios.izmiran.troitsk.ru/cosray/main.htm>).

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A. 27-day variations of the GCR intensity and anisotropy in the A>0 and the A<0 polarity periods.

The daily average values of the isotropic I and 3-D anisotropy components of GCR were found based on the hourly values obtained by GSM; then we calculated the amplitudes of the 27-day variations of the GCR intensity and anisotropy by means of daily data using the harmonic analyses method. For comparison the amplitudes of the 27-day variations of the anisotropy and intensity of GCR are presented in the Fig. 1ab found by Kiel neutron monitor data (triangles) and by the GSM (circles) for the minima epoch of 1985-1987 (A<0), and 1975-1977 and 1995-1997 (A>0); for the minimum epoch of 1965-1967 (A<0) only the Kiel neutron monitor data is presented. It seems from the Fig. 1ab that the amplitudes of the 27-day variations of the GCR intensity and anisotropy found by GSM are greater in the minima epochs of solar activity for the A>0 polarity period than for the A<0 polarity period of the solar magnetic cycles; these results are in a good agreement (in scope of calculation accuracy) with the changes of the amplitudes of the 27-day variations of the GCR intensity and anisotropy found by Kiel neutron monitor data. So, the results determined by GSM confirm the reality of this effect found by the individual neutron monitors [1], [2]. From the methodical point of view it is reasonable to underline that the general features of the anisotropy found based on the harmonic analyses method for the individual neutron monitors with the cut off rigidities < 5 GV coincide with the features of the anisotropy calculated using the radial and tangential components determined by the GSM.

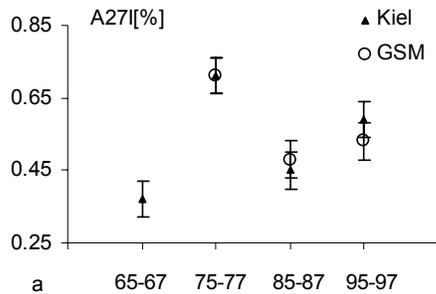


Fig. 1a. Changes of the amplitudes of the 27-day variation of the GCR intensity (A27I) obtained by Kiel neutron monitor data (triangles) and by GSM (circles) for A>0 (1975-77 & 1995-1997), and A<0 (1965-67 and 1985-1987) polarity periods.

The dependence of the amplitudes of the 27-day variations of the GCR intensity and anisotropy on the A>0 and the A<0 polarity periods we explained owing to the existence of the heliolongitudinal asymmetry of the solar wind velocity [4], [5]. The directions of the solar wind velocity and the drift velocity of the GCR particles coincide in the A>0 polarity period, while they are in the opposite directions in the A<0 polarity period.

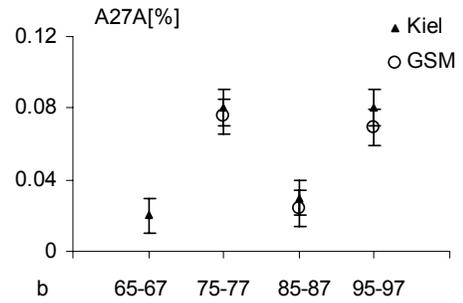


Fig. 1b As in Fig. 1a, but for the 27-day variation of the GCR anisotropy (A27A).

This phenomenon is considered as a basic reason that the amplitudes of the 27-day variations of the GCR intensity and anisotropy are greater in the A>0 polarity period than in the A<0 polarity period. However, the 27-day variations of the other parameters of solar activity and solar wind could contribute to the behavior of the amplitudes of the 27-day variations of the GCR intensity and anisotropy in different polarity periods. Thus, it is of interest to study the relationships of the 27-day variations of the GCR intensity and anisotropy (found by the GSM) with the 27-day variations of the SW velocity, relative sunspot numbers Rz and the strength of the interplanetary magnetic field.

B. On the relationship of the 27-day variations of the GCR intensity and anisotropy with the parameters of solar activity and solar wind

We found the amplitudes and phases of the 27-day variations of the GCR intensity and anisotropy, SW velocity, IMF's strength and Rz by the harmonic analyses method. In Fig. 2ab are presented the distributions of the phases of the 27-day variations of the SW velocity, IMF's strength and Rz versus the heliolongitudes for the A>0 periods of 1975-1977 & 1995-1997 (Fig. 2a), and for the A<0 periods of 1965-1967 & 1985-1987 (Fig. 2b). Data of all considered parameters (except Rz) consist of 6 years (~ 80 Carrington rotations) for the A>0 polarity periods. Data of the strength of the IMF and SW velocity are absent for 1965-1967 (A<0). Daily Rz equals zero very often in the minima epoch, so, the results of the harmonic analyses are not reliable for the Carrington rotation consisting ≥ 10 days with the zero values of the Rz; such 9 Carrington rotations were excluded from the consideration for the A>0 periods.

It seems from the Fig. 2a that the distribution of the phase of the 27 - day variation of the SW velocity has a sharply established maximum, while the IMF's strength and Rz have not any regular maxima (in scope of the existing statistics) for the A>0 polarity periods. Fig. 2b shows that there are not any visible regularities in the distributions of the phases of the 27 - day variations of the SW velocity, IMF and Rz for the A<0 polarity periods. It is remarkable that, unfortunately, statistics of the SW velocity and strength of the IMF are twice poorer for the A<0 polarity period than in the A>0 period. The distributions of the phases of the 27-day variations of the SW velocity, GCR intensity and anisotropy determined based on

the GSM are presented in the Figs. 3ab for the $A>0$ and the $A<0$ polarity periods, respectively. Fig.3a shows that the distributions of the phases of the 27-day variations of the SW velocity, the GCR intensity and anisotropy have maxima for the $A>0$ polarity period; the maxima for the 27-day variations of the GCR intensity and anisotropy basically coincide and they are opposite (about 180°) with respect to the maximum for the 27-day variation of the SW velocity. Fig.3b shows that the distributions of the phases of the 27-day variations of the SW velocity, the GCR intensity and anisotropy have not clear maxima for the $A<0$ polarity period. There are some tendencies of the existence of the second harmonics of the solar rotation period (~ 13 - 14 days).

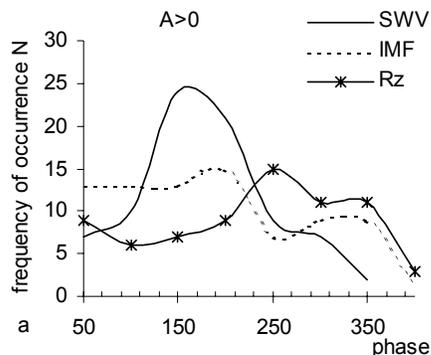


Fig. 2a. The heliolongitudinal distributions of the phases of the 27-day variations of the SW velocity, IMF strength and Rz. On the ordinate axes is presented the frequency (N) of the given phases of the 27-day variations and on the horizontal axes — heliolongitudes in degrees [$^\circ$] for the $A>0$ polarity periods of the solar magnetic cycle.

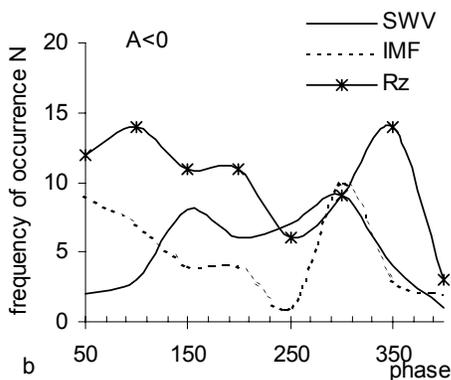


Fig. 2b As in Fig. 2a, but for the $A<0$ polarity period of solar magnetic cycle.

We assume that the clear 27-day variation of the solar wind velocity in the $A>0$ polarity period is the reason of the existence of the regular 27-day variations of the GCR intensity and anisotropy. The scattered distributions of the phases of the 27-day variations of the GCR intensity and anisotropy (Fig. 3b) for $A<0$ polarity period are one of the general motivations that the amplitudes of the 27-day variations of GCR intensity and anisotropy are greater in $A>0$ polarity period than in the $A<0$ polarity period [1], [2], [5]. Analyses of the phase distribution of the 27 – day variation of the solar wind velocity (Fig.3a) show that the long – lived (not

less than 22 years) active heliolongitudes exist on the Sun, especially for the $A>0$ polarity period of the solar magnetic cycles.

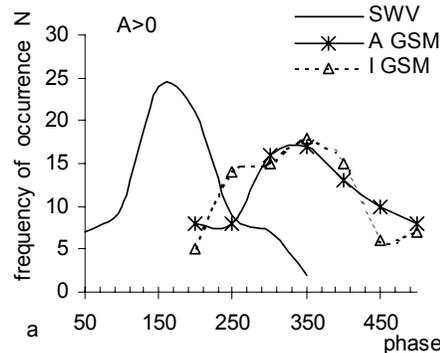


Fig. 3a. The heliolongitudinal distributions of the phases of the 27-day variations of the SW velocity, the GCR intensity (I GSM) and anisotropy (A GSM) obtained by GSM. On the ordinate axes is presented the frequency (N) of the given phases of the 27-day variations and on the horizontal axes — heliolongitudes in degrees [$^\circ$] for the $A>0$ polarity period of the solar magnetic cycle.

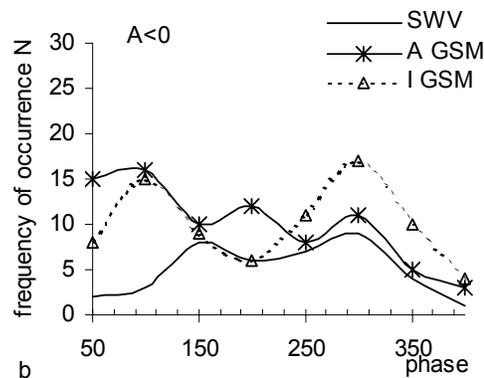


Fig. 3b As in Fig. 3a, but for the $A<0$ polarity period of solar magnetic cycle.

C. Chree's method of superposed epochs

The long – lived active heliolongitude is the source of the 27-day variation of the solar wind velocity which can be weakened or strengthened from time to time; then it can be considered as the general source of the existence of the background 27-day variations of the GCR intensity and anisotropy, especially in the minima epoch of solar activity. If it is the case there must be observed the synchronized 27-day variations of the GCR intensity and anisotropy for the long time, e.g. more than 22 years. To verify this supposition we employ the Chree's method of superposed epochs [10], [11] in the statistical investigation of the amplitudes of the 27-day variations of the GCR anisotropy [12], intensity and SW velocity. We study the time interval 1975-2004 including the $A>0$ and $A<0$ polarity periods and three minima epoch (1975-1977, 1985-1987 and 1995-1997). We use the daily averaged radial A_r and tangential A_f components of the anisotropy calculated by

Kiel neutron monitor data to construct the diagrams of the superposed epochs. Number of zero days for superposition were five days with the maximum and five days with the minimum values of A_r and A_f components of each month, respectively. The similar procedure were carried out for the GCR intensity and SW velocity. To provide a suitable accuracy the daily average values of each parameters of four month data were superposed, i.e. in the resultant daily series of the superposition each value is obtained as the average of 20 points. These procedure were carried out based on the maxima and minima zero days; then, the half values of the difference between the maximum and minimum superposed realization were found. For comparison we consider four solar rotation periods of the 1986-87 ($A < 0$) and 1996-97 ($A > 0$) minima epoch.

The Chree diagrams of the SW velocity, the GCR intensity I , and A_r and A_f components of the anisotropy calculated by Kiel neutron monitor data are presented in Figs. 4abcd for 1996-1997 ($A > 0$); the similar diagrams are presented in Figs. 5abcd, but for 1986-1987 ($A < 0$). Figs. 4abcd and 5abcd show that in 1996-97 for the $A > 0$ polarity period the 27-day recurrence is clearly observed for all considered parameters. Analysis of the Chree diagrams for the long period data (1975-2004) of the solar wind velocity show that for different intervals in the considered period there is appearing the synchronized quasi-periodic (~ 27 days) recurrence owing to existence of the long-lived active heliolongitudes [5]. Also, from time to time there is observed the 14-day variation of the solar wind velocity, mainly for the $A < 0$ polarity period.

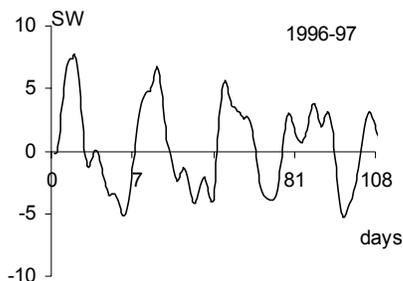


Fig. 4a. Chree diagram of the solar wind velocity (SW) for the period 1996-97 ($A > 0$).

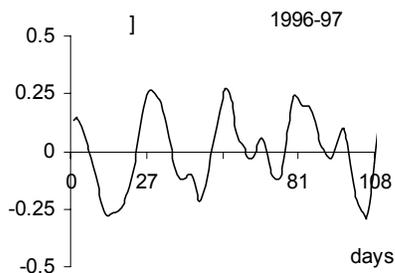


Fig. 4b. Chree diagram of the GCR intensity I for Kiel NM of the period 1996-97 ($A > 0$).

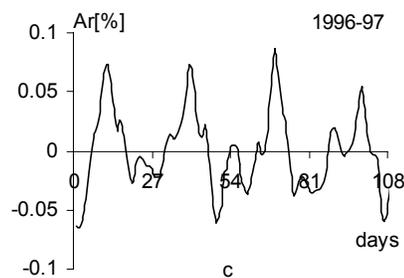


Fig. 4c. Chree diagram of radial A_r component of the GCR anisotropy for Kiel NM of the period 1996-97 ($A > 0$).

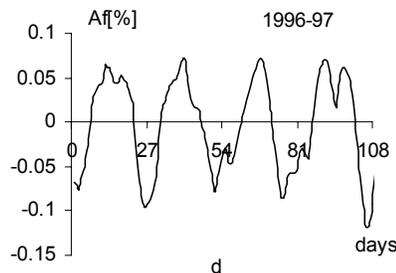


Fig. 4d. Chree diagram of the tangential A_f component of the GCR anisotropy for Kiel NM of the period 1996-97 ($A > 0$).

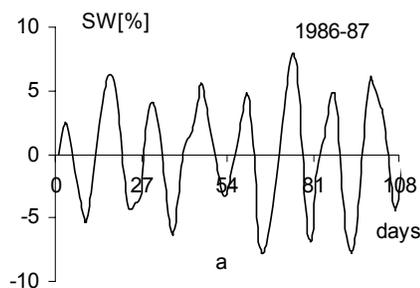


Fig. 5a. Chree diagram of the solar wind velocity SW for the period 1986-87 ($A < 0$).

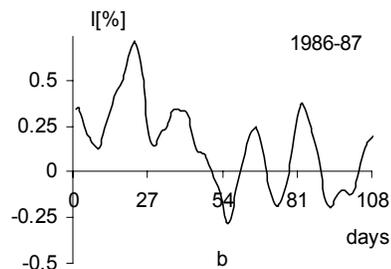


Fig. 5b. Chree diagram of the GCR intensity I for Kiel NM of the period 1986-87 ($A < 0$).

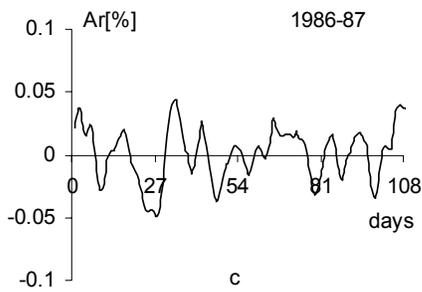


Fig. 5c. Chree diagram of the radial A_r component of the GCR anisotropy for Kiel NM of the period 1986-87 ($A<0$).

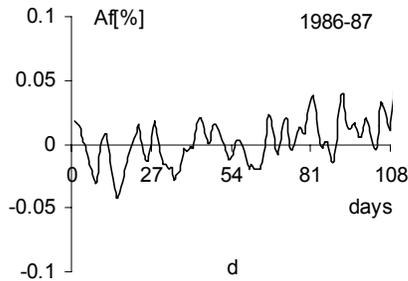


Fig. 5d. Chree diagram of the tangential A_f component of the GCR anisotropy for Kiel NM of the period 1986-87 ($A<0$).

Having available of the A_r and A_f components of the 3-D GCR anisotropy determined by GSM, we have constructed the averaged Chree diagrams for 1975-1977 ($A>0$) and for 1985-1987 ($A<0$). For each polarity period Chree diagrams were constructed using daily data of the A_r and A_f components for the one year period (12 months); then was omitted the first month (e.g. January 1975) and January next year was added.

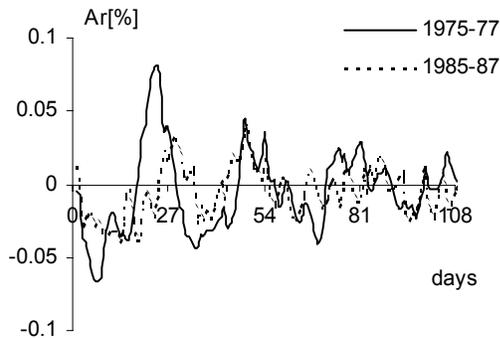


Fig. 6. Chree diagram of the radial A_r component of the GCR anisotropy obtained by GSM for the $A>0$ (1975-77) – solid line, and the $A<0$ (1985-87) - dashed line.

By this manner we constructed 25 Chree diagrams of the same statistics; then we averaged the first four rotation periods of the 25 Chree diagrams and obtained the average Chree diagrams for A_r and A_f components for each considered

1975-1977 ($A>0$) and for 1985-1987 ($A<0$) periods. The results are presented in Figs. 6 and 7.

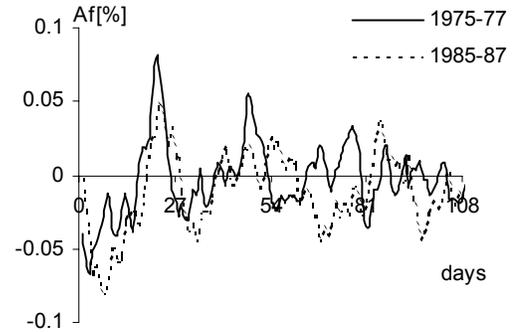
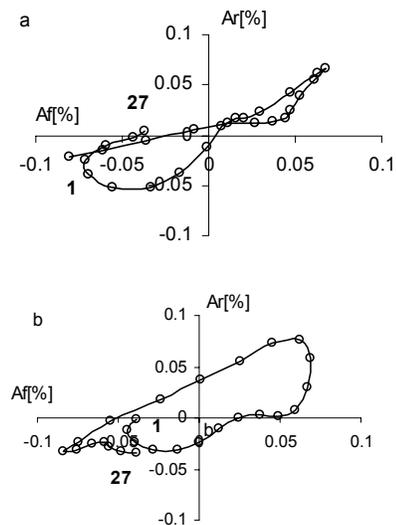


Fig. 7. The same as in Fig. 6, but for the tangential A_f component of the GCR anisotropy.

Figs.6 and 7 show that the amplitudes of the 27-day variation of the GCR anisotropy determined based on the GSM are greater and phases are more evidently established in the $A>0$ polarity period than in the $A<0$ polarity period for the minima epoch of solar activity.

D. 27-day epicyclograms of the GCR anisotropy

Using the values of the 27-day Chree's superposed daily series of the A_r and A_f components of the anisotropy (calculated by Kiel neutron monitor data) we construct the epicyclograms on the harmonic diagram for the periods of 1996-97 and 1986-1987 (Figs. 4cd and 5cd).



Figs. 8 ab. Epicyclograms of the GCR anisotropy for Kiel NM of the period 1996-97.

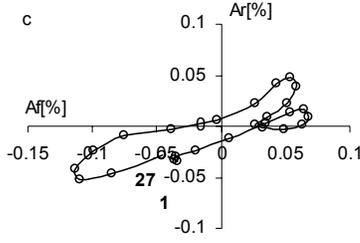
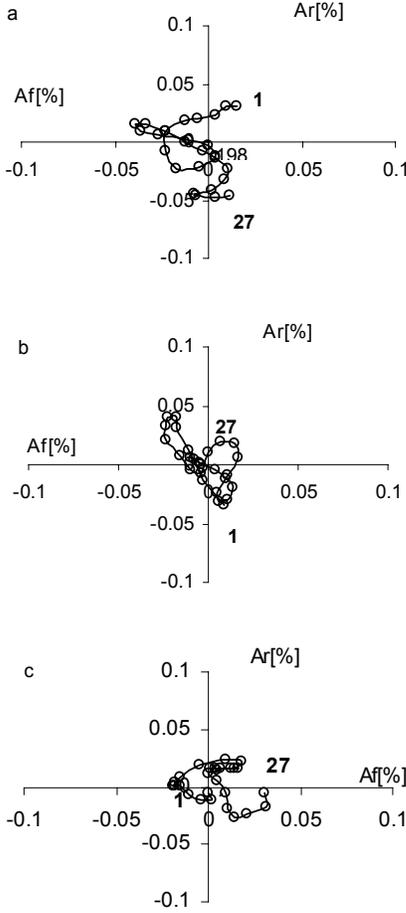


Fig. 8 c. Epicyclegrams of the GCR anisotropy for Kiel NM of the period 1996-97.



Figs. 9 abc Epicyclegrams of the GCR anisotropy for Kiel NM of the period 1986-87.

We draw each daily vector of the GCR anisotropy with pairs of the components of the A_r^i and A_f^i ($i = 1, 2, 3, \dots, 27$) of the 27-day Chree's superposed daily series and then link the ends of the 27 vectors in turn. In Figs. 8 abc and 9 abc are presented the epicyclegrams for three solar rotations for the A>0 and A<0 polarity periods, respectively. We see from the Figs. 8 abc that for the A>0 polarity period (1996-97) the epicyclegrams have the ellipse-like shapes; the major axes are oriented approximately along the IMF lines. In the creation of the 27-day variation of the GCR anisotropy take place

similarly the both the radial A_r and the tangential A_f components of the GCR anisotropy.

III. MATHEMATICAL MODELING AND DISCUSSION

To calculate the theoretically expected amplitudes of the 27-day variations of the GCR intensity and anisotropy, the GCR transport equation has been used [3]:

$$\frac{\partial f}{\partial t} = \nabla_i (\kappa_{ij} \nabla_j f) - \nabla_i (U_i f) + \frac{1}{3R^2} \frac{\partial (fR^3)}{\partial R} (\nabla_i U_i) \quad (1)$$

where $f(r, R, t)$ is the omnidirectional cosmic ray distribution function, R is the particle rigidity, r is the position, t is time and U - the solar wind velocity. The symmetric part of the tensor κ_{ij} consists of a parallel and perpendicular diffusion coefficient. The antisymmetric elements of the tensor describe gradient and curvature drifts in the large scale IMF. Generalized anisotropic diffusion tensor κ_{ij} of GCR for the three dimensional interplanetary magnetic field has the form [13], [14]:

$$\begin{aligned} K_{rr} &= K_{||} [\cos^2 \delta \cos^2 \psi + \alpha (\cos^2 \delta \sin^2 \psi + \sin^2 \delta)] \\ K_{r\theta} &= K_{||} [\sin \delta \cos \delta \cos^2 \psi (1 - \alpha) - \alpha_1 \sin \psi] \\ K_{r\varphi} &= K_{||} [\sin \psi \cos \delta \cos \psi (\alpha - 1) - \alpha_1 \sin \delta \cos \psi] \\ K_{\theta\theta} &= K_{||} [\sin^2 \delta \cos^2 \psi (1 - \alpha) + \alpha_1 \sin \psi] \\ K_{\theta\varphi} &= K_{||} [\sin^2 \delta \cos^2 \psi + \alpha (\sin^2 \delta \sin^2 \psi + \cos^2 \delta)] \\ K_{\varphi\varphi} &= K_{||} [\sin^2 \delta \sin^2 \psi (\alpha - 1) + \alpha_1 \cos \delta \cos \psi] \\ K_{\varphi\theta} &= K_{||} [\cos \delta \sin \psi \cos \psi (\alpha - 1) + \alpha_1 \sin \delta \cos \psi] \\ K_{\theta\varphi} &= K_{||} [\sin \delta \sin \psi \cos \psi (\alpha - 1) - \alpha_1 \cos \delta \cos \psi] \\ K_{\varphi\varphi} &= K_{||} [\sin^2 \psi + \alpha \cos^2 \psi] \end{aligned} \quad (2)$$

where ψ is the angle between the magnetic field lines and radial direction, δ is the angle between the magnetic field lines and radial direction in the meridian plane, in the spherical coordinate system (ρ, θ, φ) for the A>0 period of the solar magnetic cycle; $\alpha = \frac{\kappa_{\perp}}{\kappa_{||}}$, $\alpha_1 = \frac{\kappa_d}{\kappa_{||}}$, where

$\kappa_{||}$, κ_{\perp} , κ_d are parallel, perpendicular and drift diffusion coefficients of GCR in the regular IMF, respectively.

The intensity I_0 of the GCR particles in the interstellar space ($I_0 = R^2 f_0$) is taken according to [15], [16] as:

$$I_0 = \frac{21.17 T^{-2.8}}{1 + 5.85 T^{-1.22} + 1.18 T^{-2.54}}$$

where T is the kinetic energy of particles.

According to our finding [1], the amplitudes of the 27-day variations of the GCR intensity and anisotropy do not depend on the tilt angles of the heliospheric neutral sheet (HNS), so the flat HNS is considered. The neutral sheet drift was taken into account according to the boundary condition method [17]. The equation (1) was reduced to the linear algebraic system of equations by finite difference scheme and then was numerically solved using the Gauss-Seidel iteration method

[18] for one rotation period of the Sun, i.e. for instant state of the heliosphere, when the distribution of the GCR density is determined by the time independent parameters included in (1). In the model we assume that the heliolongitudinal changes of the turbulence of the IMF is the source of the 27-day variations of the GCR intensity and anisotropy. We include it in the parallel diffusion coefficient as,

$$K_{||} = K_0 K(\rho) K(\varphi) K(R)$$

$$K(\rho) = 1 + 50\rho$$

$$K(R) = R^{\alpha(\rho, \varphi)}$$

$$\alpha(\rho, \varphi) = 0.5(1 - 0.2 \sin \varphi \cdot e^{\rho^{(0.01-\rho)/0.001}})$$

It is taken into account that the changes of the parameter $\alpha(\rho, \varphi)$, is directly related with the power spectra density of the IMF turbulence.

The expected amplitudes of the 27 – day variation of the GCR anisotropy (A27A) were calculated based on the solutions of the transport equation (1) for the Parker's type IMF ($\delta = 0$ in the expression (2)) as follows:

$$A27A = \sqrt{A_r^2 + A_\theta^2 + A_f^2}, \text{ where}$$

$$A_r^\pm = -\frac{3}{v} [CU_r - \kappa_{rr} \nabla_r^\pm n \pm \kappa_d \nabla_\theta^\pm n \sin \psi + (\kappa_{||} - \kappa_\perp) \nabla_\varphi^\pm n \sin \psi \cos \psi]$$

$$A_\theta^\pm = \frac{3}{v} [\pm \kappa_d \nabla_r^\pm n \sin \psi + \kappa_\perp \nabla_\theta^\pm n \pm \kappa_d \nabla_\varphi^\pm n \cos \psi]$$

$$A_f^\pm = -\frac{3}{v} [(\kappa_{||} - \kappa_\perp) \nabla_r^\pm n \sin \psi \cos \psi \pm \pm \kappa_d \nabla_\theta^\pm n \cos \psi - \kappa_{\varphi\varphi} \nabla_\varphi^\pm n] \quad (3)$$

The signs “ \pm ” correspond to away (“+”) and toward (“-“) polarities of the Sun's global magnetic field, respectively; $v \approx C$ is the cosmic ray particles velocity, $C \approx 1.5$ is the Compton-Getting factor, U is the solar wind velocity;

$\nabla_r n = \frac{1}{n} \frac{\partial n}{\partial r}$, $\nabla_\theta n = \frac{1}{nr} \frac{\partial n}{\partial \theta}$, $\nabla_\varphi n = \frac{1}{nr \sin \theta} \frac{\partial n}{\partial \varphi}$ are radial, heliolatitudinal and heliolongitudinal density gradients, respectively [3], [19], [20].

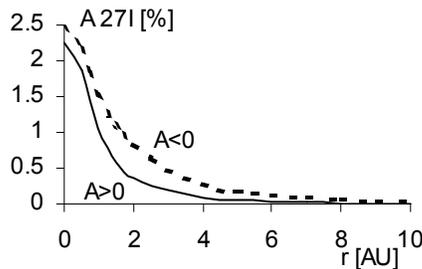


Fig. 10a. The changes of the amplitudes of the 27-day variation of the GCR intensity (A27I) versus the radial distance for the A>0 (solid line) and the A<0 (dashed line) polarity periods of solar magnetic cycle.

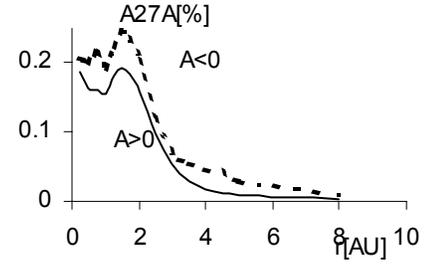


Fig. 10b. As in Fig. 10a, but for the amplitudes of the 27-day variation of the GCR anisotropy (A27A).

The changes of the amplitudes of the 27-day variations of the GCR intensity and anisotropy calculated based on the solutions of the turbulence model are presented in Figs. 10ab. For comparison in Fig. 11ab are presented the changes of the amplitudes of the 27-day variations of the GCR intensity and anisotropy calculated based on the solutions of the Parker's equation when the heliolongitudinal asymmetry of the solar wind velocity is taken into account [5].

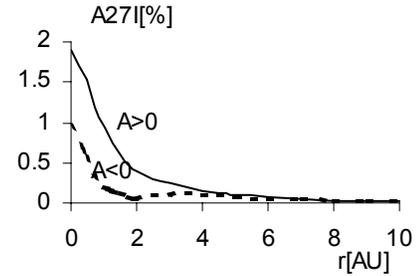


Fig. 11a. The changes of the amplitudes of the 27-day variation of the GCR intensity (A27I) versus the radial distance for the A>0 (solid line) and A<0 (dashed line) polarity periods of solar magnetic cycle when the heliolongitudinal asymmetry of the solar wind velocity is taken into account.

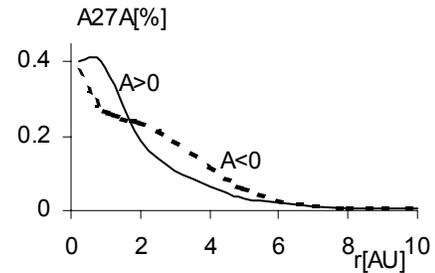


Fig. 11b. As in Fig. 11a, but for the amplitudes of the 27-day variation of the GCR anisotropy (A27A).

Figures 10ab show that the amplitudes of the 27-day variations of the GCR intensity and anisotropy are greater in the A<0 polarity period than in the A>0 polarity period at the Earth orbit. These results contradict the experimentally found dependence of the amplitudes for different polarity periods (Fig.1ab) and the results found by the theoretical modeling when the heliolongitudinal asymmetry of the solar wind

velocity is taken into account (Figs.11ab) are compatible with the neutron monitors experimental data (Fig.1ab).

IV. CONCLUSION

1. The long-lived active heliolongitudes are the source of the 27-day variation of the solar wind velocity; owing to which is observed the background 27-day variations of the GCR intensity and anisotropy especially for the minima epoch of solar activity. The phases of the 27-day variations of the GCR intensity and anisotropy are opposite with respect to the similar changes of solar wind velocity in the A>0 polarity period.
2. The amplitudes of the GCR anisotropy calculated using the radial and tangential components determined by the GSM basically do not differ from the amplitudes found by the harmonic analyses method for the individual neutron monitors with cut off rigidities < 5 GV. So, in great of majority cases the general features of the anisotropy of GCR could be study by the harmonic analyses method using the individual neutron monitors data (exceptions are the sporadic Forbush effects of the GCR intensity).
3. The Chree's diagram and epicyclegrams methods confirm that the amplitudes of the 27-day variation of the GCR anisotropy are greater and phases are more evidently established in the A>0 polarity periods than in the A<0 polarity periods for the minima epoch of solar activity.
4. Solutions of the Parker's transport equation with the heliolongitudinal asymmetry of the IMF turbulence show that the amplitudes of the 27-day variations of the GCR intensity and anisotropy are greater in the A<0 polarity period than in the A>0 polarity period; it contradicts the experimental results obtained by the neutron monitor data. So, we confirm that only the inclusion of the heliolongitudinal asymmetry of the solar wind velocity in the transport equation gives the compatible results with the neutron monitors experimental data.

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