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Unusual changes of solar diurnal variations of cosmic ray neutron and hard components intensity

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Abstract

According to the data of neutron monitors of Kiel and Tokyo Stations and Nagoya terrestrial Telescope 28 cases of anomalous increase of solar-diurnal anisotropy of cosmic ray (CR) intensity with duration of 3-14 days during 1976-1986 are revealed. Criterion for selection of anomalous increase of solar-diurnal anisotropy (A) is the condition A≥2A1, where A1 is an yearly average value of anisotropy amplitude. In 40% of these cases the amplitude does not decrease with the increase of effective energy of initial particles, and sometimes it even increases. We suppose that the reason of anomalous increase of solar-diurnal anisotropy of CR intensity in unusual cases can be the heating of the upper atmosphere due to the Earth's passage through the neutral layer of interplanetary magnetic field (IMF).

1. Introduction. The investigation of solar-diurnal variations of CR intensity gives very important information about fast changes of electromagnetic conditions in a limited region of space around the Earth, the knowledge of which is of great theoretical and practical importance. Therefore, it is natural that a lot of works deal with the study of the variations of that type. In the works of Belov et al 1993, Skripin et al 1993, Bieber and Evenson 1997, Ahluvalia and Ficani 1997) it is shown that the amplitude and phase of solar-diurnal anisotropy experience strong changes with the cycle and phase of solar activity.

The aim of the given work it is to reveal cases of anomalous increase of the amplitudes of solar-diurnal variations of CR intensity taking into account the dependence of them on the phase of solar activity cycle, and to try to connect them with the physical parameters characterizing solar-terrestrial relation.

2. Experimental Data and Methods. The hourly data of neutron monitors of Kiel and Tokyo stations and Nagoya terrestrial meson telescope corrected for barometric effect were used for analysis. Geomagnetic cutting-off thresholds of these stations equal 2.29GV, 11,50GV and 11,50GV, respectively. After removing the secular trend by the moving average method the Fourie -coefficients of corresponding harmonics were calculated for each station for each day of 1976-1986. At the further analysis the cases are neglected when there is at least one break-down in the observations of CR intensity for 48 hours with data of 25 hourly moving.

As it is shown in the works of(Bieber and Evenson 1997) and (Ahluvalia and Fikani 1997) yearly average values of the first harmonic of the solar-diurnal anisotropy experience strong changes from year to year and with the cycle of solar activity. However, it is not clear, how the influence of CR Forbush-decrease (FD) is accounted. Due to the fact, that energy spectrum, power and frequency of FD appearance are sharply changed near of the maximum of solar activity (SA) (Nachkebia and Shatashvili 1985), the increase of solar-diurnal anisotropy amplitude can be false. Thus, at the calculation of yearly average values of solar-diurnal anisotropy, FD cases the amplitude of which ≥3% according to the data of Kiel station were excluded, as well as the cases of well-known large CR flares.

Fig.1 shows the yearly average values of the first harmonic amplitudes of solar-diurnal anisotropy without FD cases for Kiel, Tokyo and Nagoya stations. Our results seem to be more smooth not far from the SA maximum, but they, in principle, agree with the results of (Bieber and Evenson 1997) and (Ahluvalia and Fikoni 1997).

Further, we have considered the cases, when the value of solar-diurnal anisotropy amplitude A≥2A1, where A1 is the yearly average value, at least in three cases from the four sequential days according to the data of any considered stations of CR observation. The latter condition excludes the small FD cases. Thus, only 28 cases of anomalous increase of the first harmonic of CR anisotropy with the duration of 3-14 days were revealed, 4 days on the average.

3. Discussion of the results. As a number of authors has shown, (see e.g. the work of Munakata et al, 1997) the solar-diurnal anisotropy has the constant energy spectrum resulting in the decrease but not to strong, of the observed anisotropy with the increase of effective energy of recorded particles. We hold the discussion of the spectrum nature by the analysis of amplitude anisotropy ratio at different stations of CR observations. Therefore we have calculated A_K/A_N and A_T/A_N, where A_K A_T and A_N - are amplitudes of the I harmonic of CR intensity anisotropy according the data of Kiel, Tokyo and Nagoya, respectively. Out of observed 28 number of cases of anomalous increase of solar-diurnal anisotropy 14 cases turned out typical (normal ordinary)-energy spectrum can be considered as constant, that is proved by analysis of Fig.2, showing the distribution of the first harmonic amplitudes at Tokyo and Nagoya stations relative to the mean level per cycle (line). 9 numbers of anomalous cases are unusual - the amplitude of the I harmonic is increased at Nagoya station (Fig.3). Other 5 cases of anomalous increase of solar-diurnal anisotropy cannot be classified among any groups. It should be noted that the well-known anomalous increase of solar-diurnal anisotropy on 30.II-4.12.1982, considered in the work of (Mishra and Agraval 1987) for the first time is usual (normal) according to our classification, due to the partial absence of data of Nagoya station.

The analysis of Figs.2 and 3 shows that from the revealed numbers of cases of anomalous increase of solar-diurnal anisotropy ~40% of cases are unusual. To identify these cases by physical parameters characterizing solar-terrestrial connections the parameters of solar wind, solar radio radiation of the II and IV type and the north-southern asymmetry of CR, determined according the data of polar stations were considered (Nagashema et al 1988). It was revealed that numbers of anomalous increase the I harmonic of solar-diurnal anisotropy:

1. Are not connected with the increase of interplanetary magnetic field and the velocity of solar wind.
2. In 60% of cases the increase of solar wind density, and solar radio radiation of the II and IV types is observed.
3. Geomagnetic storm is observed in ~60% cases.
4. In ~50% of cases the increase of north-southern asymmetry of CR is observed.
5. ~90% of cases of unusual increase of solar-diurnal anisotropy is connected with the sectorial IMF structure.

4. Main Conclusions. During 1976-1986 28 cases of anomalous increase of solar-diurnal anisotropy of CR intensity are revealed with duration of 3-14 days. From the revealed cases of the anomalous increase of solar-diurnal anisotropy - 40% of cases are unusual - with the increase of effective energy of particles the anisotropy amplitude is not decreased and sometimes even is increased. ~90% of cases of these cases is connected with the sectorial structure of IMF.

For the discussion we'll mention that behaviour of the I harmonic of "unusual" cases of anomalous changes of the amplitude according to Nagoya station (Fig.3) cannot be explained by the change of upper thresholds of cutting off energy spectrum, as, according to the data of Kiel and Tokyo stations reverse picture is observed (not shown). Thus we came to the conclusion, that if revealed changes of anisotropy of CR intensity are connected either with magnetospheric-atmospheric phenomena, or, if they are connected with the dynamics of physical processes proceeding in interplanetary space, then the energy spectrum has a break, that is scarcely probable, but possible. We think that the reason of anomalous increase of solar-diurnal anisotropy in unusual cases can be the heating of the upper atmosphere due to the crossing of a neutral layer of interplanetary magnetic field by the Earth. The further investigations are necessary to look into the problems.

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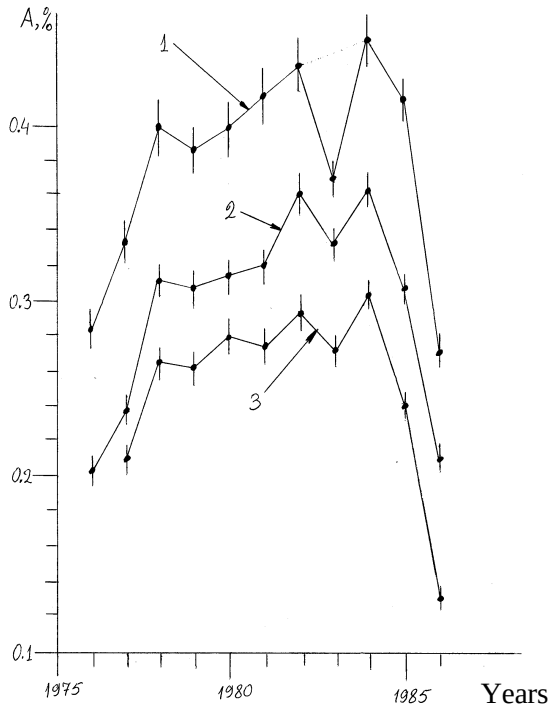

Figure 1 Yearly average values of the amplitude, A, of the I harmonic of solar-diurnal CR anisotropy according to the data of Kiel(1), Tokyo(2) and Nagoya(3) stations. Disturbed days of FD type and CR flares are excluded.

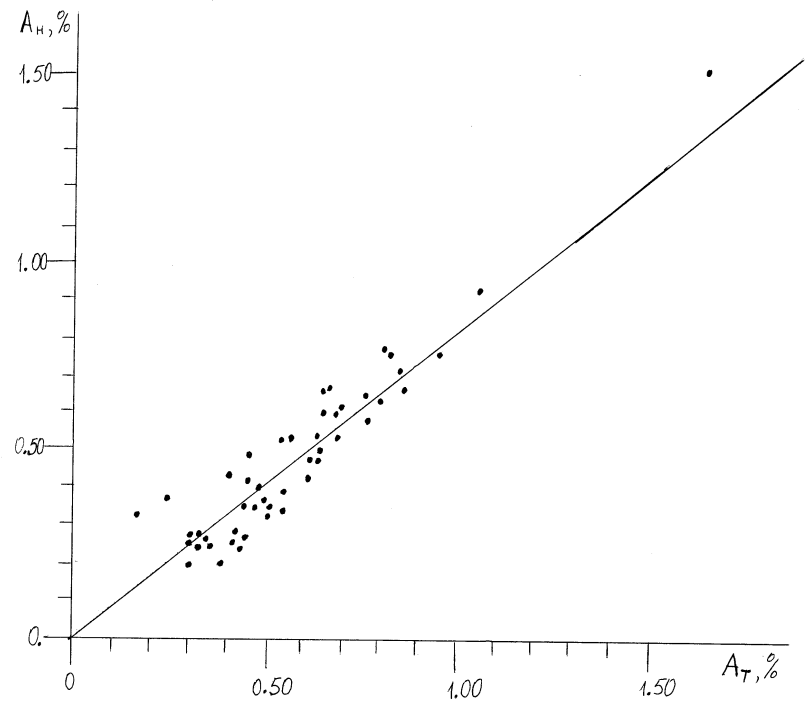

Figure 2 Distribution of the amplitudes of the I harmonic of Solar-diurnal CR anisotropy according to the data of Tokyo (A_T) and Nagoya (A_N) for 14 cases, usual case-energy spectrum can be considered as constant.

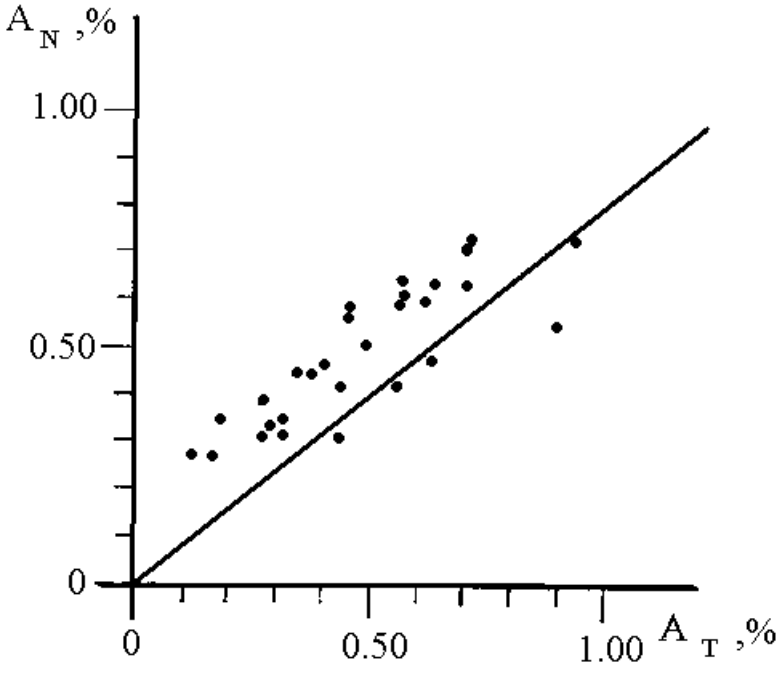

Figure 3 The same as in Fig.2, for 9 numbers - unusual case - the amplitude of the first harmonic increases at Nagoya station