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POSITION OF THE SOURCE OF THE COSMIC RAY DIURNAL ANISOTROPY RELATIVE TO THE ECLIPTIC PLANE

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Employing the data from cosmic ray neutron monitors on Mawson and Churchill (between 1957–1967), the position of the source of the diurnal variation is investigated. Possible causes of the changes of this position during the 11-year cycle of solar activity are discussed.

In studying the diurnal variation of the cosmic ray intensity we usually assume that the maximum of the source of the diurnal variation lies in the plane of the Earth's equator. Due to the fact that the diurnal variation is caused by solar activity, it is quite natural to expect that the spatial distribution of the source of anisotropy is determined by heliocentric coordinates. In geocentric coordinates the position of the source will vary in time even when its real position in space will be constant. The cosmic ray anistropy, which is the cause of the diurnal variation, has its origin in anisotropic diffusion of the cosmic rays in interplanetary magnetic fields [1–4]. The measurements of these fields by means of satellites and interplanetary probes (such results from IMP-1 were published e. g. in [5–8]) show that the interplanetary magnetic field is sloping mainly southwards from the ecliptic plane. This is proved also by the fact that the activity on the northern hemisphere of the Sun has a far greater influence on the Earth than the activity on the southern hemisphere of the Sun [9–11].

To determine the real position of the effective maximum of the source of the daily variation we can use measurements of the cosmic ray intensity made at two stations that are, as far as possible, in identical conditions in the possibly highest geographic latitudes in the northern and southern hemisphere. We have already investigated this problem in [12, 13, 15] having used measurements of the neutron component of the cosmic rays done at the Antarctic station Mawson (geographic coordinates 67·60° S, 62·88° E) and the Canadian station Churchill (58·75° N, 94·09° W) during the years 1957–1964. On the basis of measurements done at these stations after 1964, when the solar activity increased again (after the minimum of the activity of the 11-year cycle in the summer of 1964), we can complete our former conclusions [12, 13, 15].

Both the Mawson and Churchill station lie at sea level and both have practically the same cut-off magnetic rigidities (0.21 GV and 0.22 GV). According to the calculations in [14] the first harmonics of the diurnal variation at the two stations should be equal, independent on the exponent in the power spectrum of the primary variation of the type

$$\frac{\delta D(R)}{D(R)} \sim R^{\gamma};$$

where R means the magnetic rigidity. In varying γ from 0 till -1.5 the expected ratio of the amplitudes of the first harmonics Mawson-Churchill, according to [14], lies between 0.96–0.97.

In Table 1 we have the annual means of the ratios of the amplitudes of the first harmonics of the daily variation Mawson-Churchill. The solar activity is characterized also by the total area of the sun-spots (in 10^{-6} of the total area of the solar hemisphere) which are given here summarised for the whole year both for the northern and the southern hemisphere of the Sun. As, since the year 1957 we had at our disposal only measurements of the cosmic rays of the second half of that year, the area of the sun-spots is twice that from 1 July to 31 December 1957.

The values of the ratios of the amplitudes given in the Table show that the maximum of anisotropy which is the cause of the diurnal variation of the cosmic rays was shifted in the years of high solar activity to the north of the ecliptic plane. The value of the deviation of the anisotropy axis from the ecliptic plane can be determined only very roughly because it is strongly dependent on the energy spectrum of the diurnal variation and on the spatial distribution of anisotropy. Especially the second parameter is very variable and even the mean parameters for different energy intervals have not been so far determined exactly. In [12, 13] it was esteemed that the annual mean of the inclination of the anisopropy axis to the ecliptic plane varied from about 15° in the time of maximum solar activity to 0° in the years of the minimum of the 11-year cycle of the solar activity. The values in Table 1 show that the inclination of the anisotropy axis to the ecliptic is not given by the ratio of the activity on the northern and southern hemispheres of the Sun, but is more closely related to the activity on the northern hemisphere. If the solar activity increases, the axis of anisotropy deviates (in the mean) more from the plane of the solar equator and, vice versa, if the solar activity decreases, the axis gets closer to the plane. The values of the ratios of the first harmonic amplitudes Mawson-Churchill following the years of the minimum of the solar activity evidently disprove the hypothesis [13] claiming that the changes of the mean annual deviation of the anisotropy axis may be related to the motion of the

Table 1

Year	Ratio of the first harmonics Mawson-Churchill	Area of the sunspots on the northern hemisphere	Area of the sunspots on the southern hemisphere	Total area of the sunspots	Ratio of the solar activity on the southern hemisphere to that on the northern hemisphere
1957*	0.66 ± 0.06*	671 134*	841 190*	1 512 324*	1.25*
1958	0.65 ± 0.05	542 390	610 917	1 153 307	1.13
1959	0.63 ± 0.04	796 845	205 677	1 002 522	0.26
1960	0.78 ± 0.05	412 113	224 117	636 230	0.54
1961	0.74 ± 0.05	173 760	75 014	248 774	0.43
1962	0.75 ± 0.04	123 426	53 610	177 036	0.43
1963	1.01 ± 0.08	85 202	21 377	106 579	0.25
1964	1.05 ± 0.09	16 731	3 822	20 563	0.23
1965	0.93 ± 0.07	33 844	5 231	39 075	0.15
1966	0.97 ± 0.05	182 583	20 542	203 125	0.11
1967	0.91 ± 0.06	340 730	158 888	499 618	0.47

* only the second half of the year 1957 — see the comment in the text

active latitudes on the northern hemisphere of the Sun (the royal zones) from the higher latitudes to the equator during the 11-year cycle of the activity. If this should be so, then after 1964 there should have taken place a very pronounced change of the ratio of the diurnal variation amplitudes.

We therefore come to the conclusion that the position of the maximum of anisotropy is influenced by the combination of two factors: the total level of the solar activity together with the position of the active regions of the Sun, the first factor being more important. The values of the ratios of the amplitudes compared with solar activity testify further that even here some sort of hysteresis of the mean values, analogical to the hysteresis of the intensity of cosmic rays during the cycle of solar activity, can take place.

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