LONG-TERM MODULATION OF GALACTIC COSMIC RAYS IN HIGH-ENERGY REGION

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ABSTRACT

The results of continious registration of the cosmic ray muon intensity on the ground and underground at 7, 20 and 60 m w.e. depths in Yakutsk for 1957-1983 are presented. In years of the solar activity maximum in cosmic ray density were found two minima or two-stepped decrease. The second intensity minimum appears to be not the result of the inversion of the general magnetic field of the Sun but caused by the increase of the solar wind speed.

In [1] it was shown that the galactic cosmic ray intensity in even cycles of the solar activity is associated mainly with the number of sunspots and in odd ones - with the solar wind speed.

In [2] to describe the galactic cosmic ray density the index is suggested which is as a function of the number of sunspot groups and of their average heliolatitude. In [2] it was found as well that correlation of the galactic cosmic ray intensity with the above index is violated during the periods of the inversion of the general magnetic field of the Sun. The violation of the close correlation between the temporal behaviour of high- and low-energy galactic cosmic rays at this period has been explained by the decrease of the regular interplanetary magnetic field intensity.

In [3] it is obtained that on the 11-year galactic cosmic ray intensity variation the effect of interaction of the general magnetic field of the Sun and of the galactic magnetic field is superimposed. The dependence of the galactic cosmic ray intensity on the solar activity in even and odd

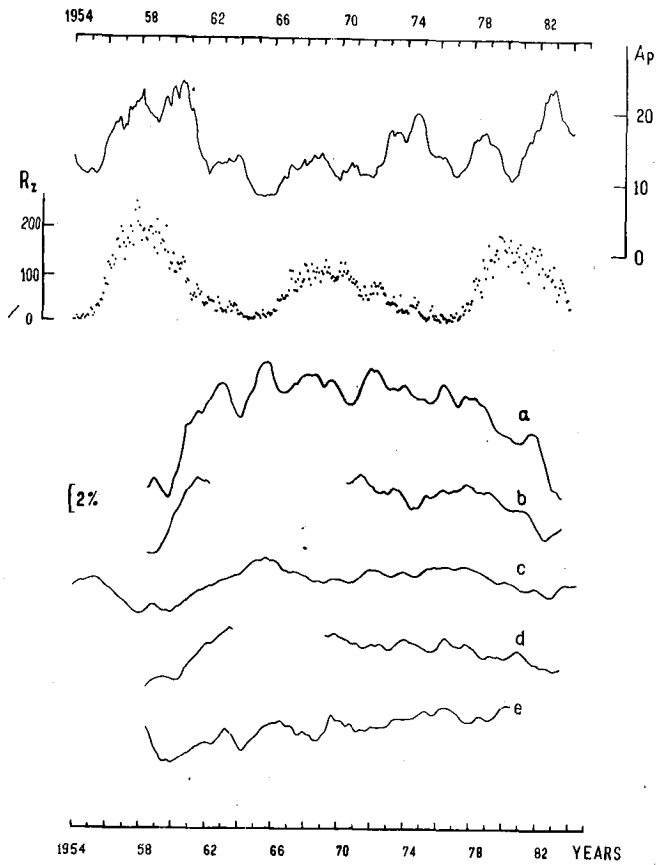
cycles forms a narrow and a wide loops of hysteresis, respectively.

The cosmic ray muon intensity by telescopes at 0, 7, 20 and 60 m w.e. depths in Yakutsk beginning from 1957 is continuously registered. The median values of energy for coupling coefficients at the above levels are 40, 78, 123 and 260 GeV, respectively. The average monthly statistical accuracy for vertical telescopes at these levels was 0.014, 0.017, 0.017 and 0.025%, respectively. In 1963-1964 the pit was reconstructed, i.e. the area at all the three underground levels was significantly enlarged. Because of this reason the telescopes at 7 and 20 m w.e. operated with breaks. Beginning from 1970 to 1982 at all the depths two and more telescopes were in operation. At present the statistical accuracy increased by ~ 2 times as compared with 1957. Beginning from June 1953 to present the ionization chamber of a large volume (the mean monthly statistical accuracy is 0.003%) is continiously operating [4] .

In the Figure the geomagnetic activity (A_p-index), sunspot numbers R_z, the galactic cosmic ray density smoothed in an annual interval on measurements by the muon vertical telescopes at 0, 7, 20, 60 m w.e. and by the ionization chamber in Yakutsk for the recent three solar cycles are presented.

During the 19-th solar activity cycle three peaks in geomagnetic activity were observed. The first increase of A_p was early in 1958 and it coincides with the maximum of R_z. The second peak is when the R_z started to decrease, the third one - near the minimum of the solar activity. The increases of A_p coincided with decreases of the galactic cosmic ray intensity at all the depths up to 60 m w.e. (in the Figure a scale for 60 m w.e. is twice larger in comparison with other levels).

In the 20-th cycle the two peaks in A_p were observed. The first peak coincides with the solar activity maximum, the second one was caused by the occurence of high-speed stationary solar wind streams with regular magnetic field in 1973-



Geomagnetic activity (A_p-index), sunspot number R_z and the galactic cosmic ray intensity smoothed in annual interval on Yakutsk measurements by the muon telescopes (vertical) at 0, 7, 20 and 60 m w.e. depths (a,b,d,e, respectively) and by ionization chamber (c)

1974. In the galactic cosmic ray density the two minima are observed. The first (deep) minimum was in 1970, the second one (less deep) - was in 1974.

In the 21-st cycle also two peaks in A_p were observed. The first peak coincides with the phase of the solar activity increase, the second one was at the R_z decrease. A_p minimum coincided with the R_z maximum. In the galactic cosmic ray density the two-stepped decrease is revealed. The first decrease appears to be caused by the solar activity maximum, the second one - by the A_p increase in 1982.

The moments of the galactic cosmic ray density maxima delay by 9-12 months with respect to the solar activity minima. The geomagnetic activity minima in the 19-20-th cycles coincide with the galactic cosmic ray density maxima. In the years of the solar activity maxima in the high-energy

galactic cosmic ray density the two minima or two-stepped decrease were observed. The second minimum in the galactic cosmic ray intensity appear to be not the result of the inversion of the general magnetic field of the Sun. This fact confirms the results of [1] . The enrgy spectrum of 11-year variation in the galactic cosmic ray density obtained based on underground data is of the form $\sim E^{-1.0}$.

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