MODULATION EFFECTS AT $\sim$ 1-4 AU OVER FOUR SOLAR CYCLES

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In the study of cosmic rays in the heliosphere the uniform sets of data are of paramount importance, because the temporal and spatial effects are superimposed and mask each other. It is just the uniform sets of data that make it possible to derive regularities of cyclic variations of the galactic cosmic ray (GCR) intensity and to understand the mechanism of the solar modulation. The data of the world set of the neutron monitors as well as of the stratospheric balloon observations provide the continuous information on the GCR status in different energy range at 1 AU. However, at other heliocentric distances the episodical spacecraft measurements only exist, the interpretation of which is rather inadequate due to the superposition of possible space and term variations. Meanwhile, the indirect method of the GCR investigation by using cosmogenic radionuclides with different half-lives in the successively fallen meteorites provides an uniform set of data on the GCR intensity along the meteorite orbits (up to ~ 4 AU). Nowadays, we have such information for the period of 1954-1998, i.e. for the 19-22 solar sycles. Moreover, due to ^{26}Al with $T_{1/2} = 0.74$ Ma the average GCR intensity and integral gradients over the last ~ 1 Ma are evaluated too.

The results demonstrate the strong dependence of the GCR radial gradients on the phase of the solar cycles at the heliocentric distances of 1.5-3.33 AU. It testifies to the variable specific conditions of the GCR diffusion in that heliocentric range over the solar cycle, perhaps, due to the accumulation of the solar wind magnetic irregularities during the phase of the high solar activity and their dissipation over the years of the calm sun. The average GCR gradients for the solar cycles ($20 - 30\%/AU$, $R > 0.5$ GV) are similar to those for the last ~ 1 Ma in that heliocentric range, which testifies to the constancy of the solar modulation mechanism, at least, over a million years.

The obtained data on the GCR gradients are related to various heliographic latitudes (from $23°S$ to $16°N$), which makes it possible to evaluate the latitudinal gradients and to derive the N-S asymmetry for some periods. In particular, the opposite character of the N-S asymmetry is noticed after the inversion of the solar magnetic field in the 20th and 22nd cycles. Thus, in 1991-1992 the radial gradients in the N-hemisphere were three times higher than those in the S-hemisphere. It testifies to the existence of large GCR latitudinal gradients and the high tilt of the neutral current sheet in the heliosphere for that time.