ON THE INFLUENCE OF THE HELIOMAGNETOSPHERIC PERIPHERY ON THE GALACTIC COSMIC RAYS

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ABSTRACT

The suggestion is substantiated that the periphery of the heliomagnetosphere - the region which properties depend on both solar wind and interstellar space parameters - play much more important role in the solar modulation of the galactic cosmic rays than usually believed.

1. INTRODUCTION.

As a rule the electromagnetic fields in the galactic cosmic ray modulation region are specified by the extrapolation of those known at $r \lesssim 30$ AU. Clearly the restriction imposed on the possible modulation region characteristics in this scheme also limits the range of the explicable by means of it galactic cosmic ray phenomena. Let us call the galactic cosmic ray modulation accomplished in conformity with the above scheme the "internal"modulation.

The mentioned extrapolation is valid only in the case when the whole modulation region is inside the supersound and superalfvenic solar wind which properties are controlled entirely by the Sun. In this work the suggestion is substantiated that the galactic cosmic rays should (and probably do) undergo considerable transformation in the transition region between the supersound solar wind and the undisturbed by the Sun galactic space.

2. THE THEORETICAL REASONS.

First of all note the discrepancy of the "internal" modulation scheme during the periods when the large-scale magnetic field distribution in the quiet (i.e.undisturbed from the outside) solar wind is a dipole-like one. In this case because of the space charge the potential of the inside of the modulation region boundary surface considerably depends on the heliolatitude while the exterior of the same surface conforming to the undisturbed galactic space is equipotential. To settle this contradiction the transition region should be included in the galactic cosmic ray modulation region/1,2/.

In /3-5/ the processes in this transition region are considered for the explanation of some galactic cosmic ray effects. It is important that for these explanations the fundumental difference of the modulation parameters from those of the Quiet solar wind is neeessary: the nonradial flow of plasma /4,5/ and the large latitude component of the interplanetary magnetic field /3-5/.

At the same time the qualitative character of /3-5/ should be noted as well as the obvious insfficiency of the method suggested in /1,2/ to allow for the transition region influence on the galactic cosmic rays. This method using the Liuville theorem and the potential difference between the inside points of the quiet solar wind and the infinity (so called the "external" modulation of the galactic cosmic rays) takes into account only the charge distribution in the quiet solar wind and completely disregard the galactic space characteristics: the presence of the galactic magnetic and electric fields, the movement of the solar system through the interstellar matter and so on.

3. THE EXPERIMENTAL REASONS.

A. The most dramatic feature of the galactic cosmic rays which is evidently beyond the scope of the "internal" modulation is their behaviour in the low energy range ($E \lesssim 80$ MeV/n) during 1971 -1978 - the "anomalous component" (AC), /6/. The characteristics of these particles - their elemental and isotopic compositions, energy spectra - so differ fromthe expected ones that there are many advocates of the hypothesis /7/, according to which the source of the anomalous component is the interstellar neutral gas, i.e. AC does not have any bearing to the galactic cosmic rays. Yet some features in cosmic ray behaviour force us to regard the "anomalous component" as the natural part of the complex galactic cosmic ray phenomenon taking place during this period:

1) The time behaviour of the anomalous component fluxes is very simillar to that of the protons and helium nuclei of higher energy;

2) The very important fact, connecting anomalous component with the protons, is the simillar (and anomalous) behaviour of their radial gradients. With the growth of the solar activity in 1979-1980 the gradients of both anomalous component and protons of E=29-67 MeV sharply drop off /8/.

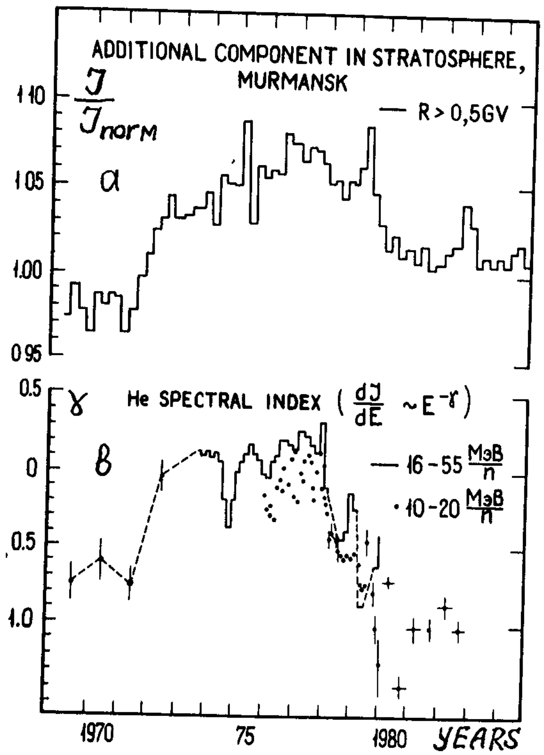

FIGURE 1

In Fig.1 the behaviour of the anomalous component (He spectral index: $dJ/dE \sim E^{-\gamma}$, /8,9/,β) is correlated with that of so called "the additional component in stratosphere",(a), which, as shown in /10/, is due to the primary H and He nuclei in the energy range 100-500 MeV/n.

The likeness of the behaviour of the anomalous component and of protons is rather difficult to understand from the viewpoint of the current hypotheses on their origin /6/. In /2/ we suggested the scheme of AC formation by the acceleration of low energy galactic cosmic rays in the process of their "external" modulation. The same process results in the considerable increase of higher energy particles.

B. The unusual from the viewpoint of the "internal" modulation the galactic cosmic ray phenomena take place during the periods of the inversion of the general magnetic field of the Sun (GMFS).

In /11-13/ we subdivided the galactic cosmic ray behaviour during GMFS inversion into two phenomena:

I - Due to the supposed attenuation of the interplanetary magnetic field strength the decrease of the galactic cosmic ray modulation so much the greater (and the more prolonged) the greater the particle energy is. This explanation of the "energetic hysteresis" is entirely in the scope of the "internal" modulation scheme.

II - The phenomenon depending on the type of GMFS inversion (characterized by the sign of the dM_z/dt, where M_z is the projection of the general magnetic field of the Sun magnetic dipole moment on the Sun rotation axis) delaying with respect to the first phenomenon by 1-2 years. We relate this delay to the location of the process responsible for the second phenomenon on the periphery of the helio-magnetosphere.

Fig.2 shows the galactic cosmic ray behaviour according to the stratospheric data (Murmansk, R_c=0.5GV) during the periods of GMFS inversions in 1969-71 ($dM_z/dt > 0$,a)

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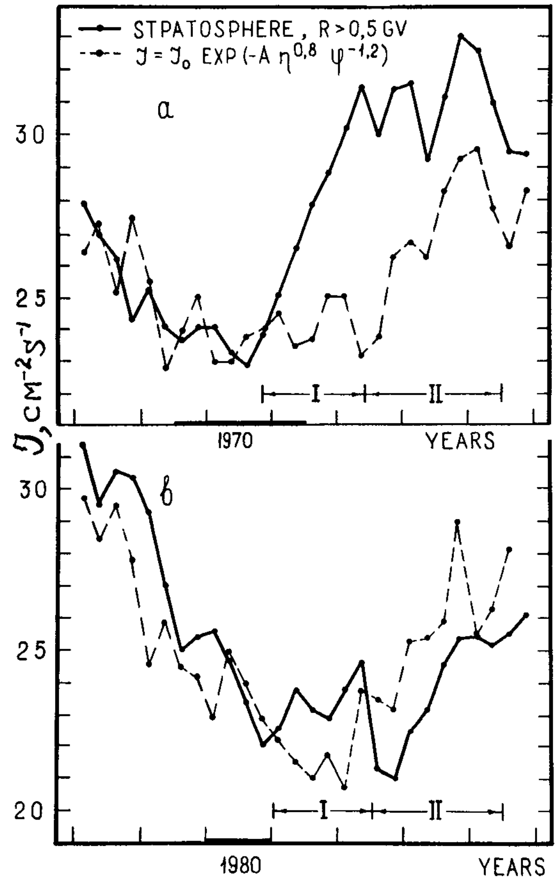

FIGURE 2.

and 1980 ($dM_z/dt < 0$,b) marked by the thick section on t-axes. The periods of I and II phenomena are shown as well. A dashed lines indicate the galactic cosmic ray intensity according to the expression

$$J = J_0 \exp(-A \cdot \eta^{0.8} \cdot \varphi^{-1.2}),$$

where η and φ are the number of sunspot groups and their mean heliolatitude, respectively. This expression is thought of as describing due to the Sun alone (i.e. "internal") and normal (i.e. in the absence of the "energetic hysteresis") galactic cosmic ray modulation. It is seen from Fig.2 that in the initial stage of the inversion anomaly (the first phenomenon) intensity quickly increases for both types of the inversion, this increase persisting during the second phenomenon in ($dM_z/dt > 0$)-inversion, but changing into decrease in ($dM_z/dt < 0$)-inversion.

4. THE CONCLUSION. To understand the galactic cosmic ray behaviour it is necessary to develope much more real model of the heliomagnetosphere than used now.

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