Effect of Regular Increase in the Galactic Cosmic Ray Intensity

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Abstract

Using a great body of experimental data for the October 30, 1973 to October 26, 1999 period it is shown that the Jovian high-energy electron injection forms a "cavity" of the decreased IMF intensity. This cavity is near the IMF field lines passing through the Jupiter and acts as a "magnetic trap" where some "accumulation" of cosmic rays takes place. It is shown that at positive sign of general magnetic field of the Sun cosmic rays undergo the drift in the direction opposite to of the movement of the planets. For the negative sign the effect is reverse. A new result indicating that CR drifts are realized on the background of more general drift whose directions are also opposite to the movement of planets.

It is known that the Jupiter is a powerful source of high-energy electrons (0.2÷40) MeV. On the average, the electron flux is more intense than the solar one [1]. It undergoes very large fluctuations in which the intensity can be more by a factor of 3 and preserves for a few days [2, 3]. In such events their energy density can be appreciable portion of interplanetary magnetic field (IMF) energy density in the vicinity of the Earth. At approaching to the Jupiter it essentially increases (more quickly than the square of the distance [4]) and hence the influence of the Jupiter upon IMF increases.

According to [2, 3] high-energy Jovian electrons mainly propagate along field lines. The IMF field lines are of a form of the Archimedean spiral (see Fig. 1.) defined by the solar wind speed . For the October 30, 1973 to October 26, 1999 period its average values (excluding moments of a sign-change of general magnetic field of the Sun (GMFS), 1980, 1981 and 1991, 1992 [5]) are equal to $\approx 442\pm2$ km/s. For such a speed the spiral shown in Fig. 1. has been constructed. The boundaries of its changes are marked by the dashed line when the solar wind speed varies within $\pm$ 20%.

Near such IMF lines a high density of Jovian high-energy electrons are formed which will decrease the IMF modulus. It is caused by the fact that any charged particle gives rise to the magnetic moment opposite to the magnetic field

pp. 4073–4076

in which it moves.

As a result, near such a line a huge magnetic trap for cosmic rays (of "magnetic bottle" type) is formed in which the concentration of cosmic rays will be higher than in the neighboring region. Because CR should undergo the gradient drift then at the positive sign of GMFS inside of such a trap they have the direction opposite to the movement of planets (and inversely). As a result, the CR density will be shifted at the positive sign of GMFS from the Archimedean spiral towards the inner dashed line to a great extent than at the negative sign of GMFS. At least, such a effect is not yet discussed in scientific literature.

This paper is devoted to the experimental determination of influence effect of the Jupiter on CR during assign-change of GMFS periods.

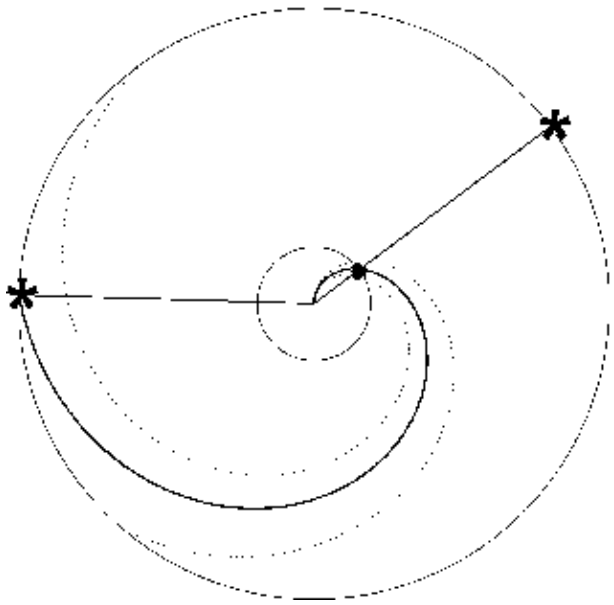

Fig. 1. The scheme of locations of the Earth and the Jupiter during the moment of opposition and in 243 days after.

According to the statement of the task it is necessary to find the CR distribution from the moment of opposition. This is the first situation the second one is when the Earth and Jupiter will stand on one field-line. As our calculation show, it will take place only in 243 days (or in 156 days before the opposition (see Fig. 1. on the left). Fig. 1. is the composition of these two situations. The asterisk denotes the Jupiter, the black circle is the Earth.

Fig. 2. presents the treatment results of neutron monitor data from the OULU station for the October 30, 1973 to October 26, 1999 period. These data have been filtered. They contain variations in the interval of 81÷801 days in which the 399^{th} day variation (values of the synodic period of rotation of the Jupiter and the Earth.is remained using the superposed epoch technique near the

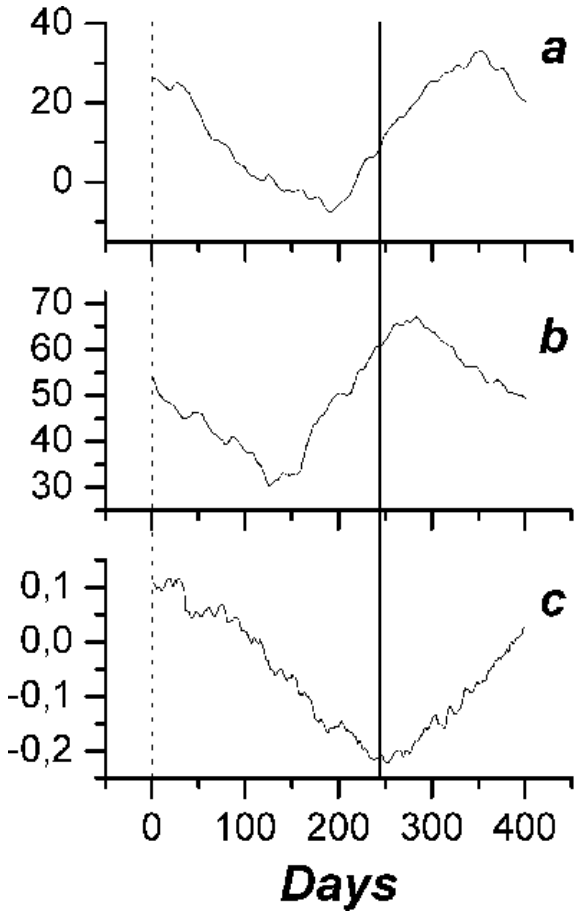

Fig. 2. The distribution of the excess number of cosmic rays in the "trap" caused by the opposition of the Jupiter and the Sun (dashed line); a - for periods of the positive sing of GMFS ; b - for periods of the negative one ; A solid line is the moment of the most influence of the Jupiter on the reconstruction of IMF; c - distributions of changes of the IMF modulus under the influence of the Jupiter

opposite moment (dashed line in Fig. 2.) the averaging separately both for the positive GMFS (see Fig. 2., panel a) and negative GMFS (see Fig. 2., panel b) have been carried out.

As seen, there is the CR drift at the positive GMFS in the direction opposite to the movement of planets because a maximum in Fig. 2.a is shifted towards the right to a greater extent than at the negative sign (see Fig. 1.b). In Fig. 2. the dashed line corresponds to the situation shown in Fig. 2. on the right. The solid line corresponds to the situation in Fig. 1. on the left.

At the same, time the completely unexpected new effect indicating to the systematic CR movement in the direction opposite to the movement of planets takes place. On its background, at sign-change of GMFS the gradient drifts

apparently exist, which are apparently identical, manifesting in the difference of positions of maxim at a sign-change of GMFS .

The fact that the calculated field line is really of such a form, namely, corresponding to the middle of the of Jovian electron flow indirectly shows the distribution of the IMF modulus. As seen, its minimum value coincides with the position of the calculated spiral (its values have been treated by the same method as CR). From this spiral CR undergo the drift at any sign-change of GMFS.

The authors suppose that this effect is apparently caused by the CR primary flow perpendicular to the solar equator plane. In this case, they emerge from the modulation region in the direction from the Sun, as it is not customary, along the equatorial plane towards the Sun.

The sense of such a supposition is as follows. CR are injected perpendicular to the solar equator plane continually, but in cases of positive sing of GMFS the "acute" pitch-angles with IMF field-lines are formed (with the account of gradient drift). As a result, the "pumping" of the modulation region by cosmic rays takes place.Their intensity during periods of the positive sign increases (and vice versa, in the case of negative sign).

1. The Jupiter forms in the IMF the cavity with the decreased intensity of the magnetic field near the field lines passing near it (on the Earth's orbit by $\approx 0.3\ \gamma$ (see Fig. 2.c).

2. In this region the accumulation of the CR concentration takes place. At the positive sign of GMFS the CR undergo the gradient drift in the direction opposite to the movement of planets (inversely for the negative sign).

3. The gradient drift is realized at the background of more general drift whose direction is also opposite to the movement of planets.

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