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THE COSMIC RAYS AS A GENERATOR FOR A CURRENT RING IN THE GALAXY

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The bilateral character of the cosmic rays interaction with a magnetic field is emphasised: the field keeps the cosmic rays in the Galaxy and they are in their turn responsible for keeping a current ring and a global magnetic field. The current ring arises as result of a spatial separating of the charges and different rotational velocity of a dust and the electron subsystems.

Key words: cosmic rays, the Galaxy, current ring

Keeping the cosmic rays in the Galaxy and their small anisotropy up to energy 10^{18}eV are explained by existence of the magnetic field with the induction $B \approx 3 \cdot 10^{-10} T$ naturally. Such fields were discovered near the Sun by the observations[1]. These fields are parallel to a galactic plane or the spiral arms. The fluctuations in scale up to 0,3 pc that are comparable with the basic field impose on it. Sometimes directions of the fields may be different by some dimensions in adjacent arms or in the same arm but on the different sides of a symmetry plane. It says about a complex structure of the field, its topology in the Galaxy as whole is not known. Even the supposition on absence of a regular field in the Galaxy was said [1].

However, such regular structure is discovered in some galaxies, more often - di-polar and more rarely – bi-modal [2]. It gives a reason to suppose that our Galaxy has a general field besides a chaotic one. A di-polar field may be considered as the first approximation. In steady- state it must be supported also by a current ring. The spiral arm local fields may be considered in definite sense as the details of a general field but supporting of them may be a result of the other or additional processes connected with the density waves spreading for example.

The gravitating systems with the currents were considered in the papers [3,4], but comparing them with the real galaxies is difficult. In work [5] a model for currents and magnetic field of our Galaxy is proposed. This model allows not only comparison with the observations but explains some peculiarities of its dynamics. The model is totality of two constituents - stellar and current-conducting diffusion ones. It is supposed the stellar constituent has a conditional boundary at $R = R_2 = 20$kpc and diffusion one concentrates near the symmetry plane and goes out the limit R_2, although the last do not essential for the model. The current density projected on the symmetry plane i = jH (where H is an equivalent thickness of conducting layer). It increases from zero in centre to maximum value ($i_0 = - 10^{-2}$ A/m) at $R = R_1 = 3$kpc. Then it decreases quickly to zero at $R = R_3 = 30$kpc. Minus corresponds to the Galaxy rotation with the diffusion layer in direction of decreasing longitudes. The full current in a ring is $I = -10^{18}$A.

The magnetic field created by such rough flat current ring is poloidal and is written in a clear view through the elliptical integrals. Its vertical component may be approximated with sufficient accuracy at $z = 0$ by the simple equation

$$B_z = \frac{a - bR^3}{1 + cR^6},$$

where the constant a, b and c may be written through the initial parameters R_1, R_3 and i_0. The approximated values of the constants are

$$a = 10^{-8}\ \mathrm{T},\ b = 10^{-11}\ \mathrm{T\ kpc^{-3}},\ c = 10^{-5}\ \mathrm{kpc^{-6}}.$$

The whole flow of vector B is Ô = 10^{32} Wb. At R = R* = 9 kpc the field changes sign and at the large distances it is equivalent to a dipole with the moment $p_m \approx 1{,}57 R_1 R_3 I \approx 10^{59}\ A \cdot m^2$. The field energy is $5 \cdot 10^{49}\ J$ that is equal to the whole energy of the cosmic rays.

The distance of the Sun from the Galaxy centre is 8 kpc, that is near R^*. Therefore the dipolar field is small near the Sun and the Orion and Perseus arms. But an approximately azimuthal field in the arms displays just there.

Fig.1 shows structure of Galactic magnetic field in coordinates system ZR.

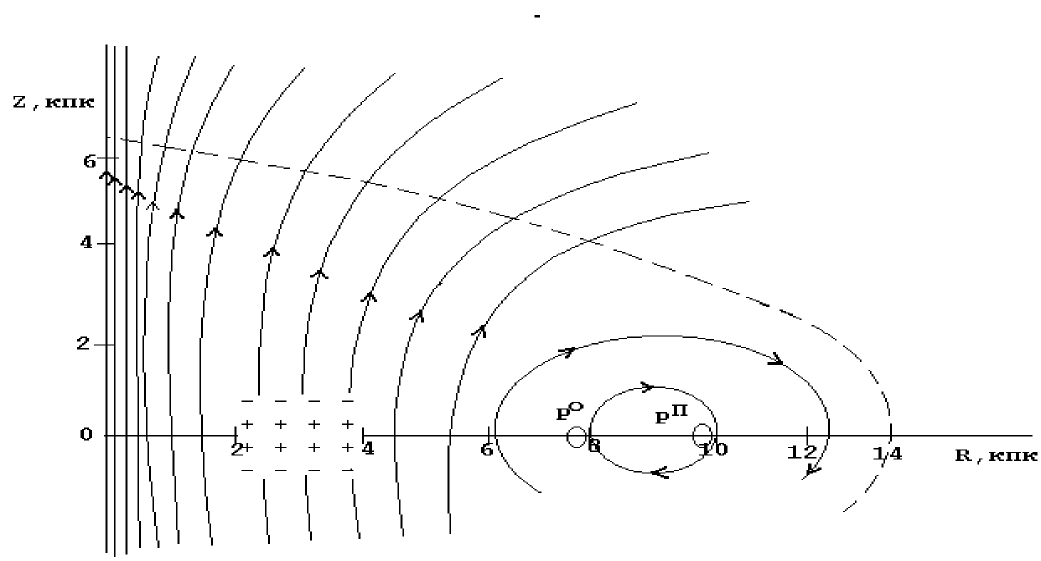

Fig.1 The scheme of global magnetic field of the Galaxy.

Alfvén [6] notes an analogy between the current layers of heliosphere and the Galaxy. In this picture the local fields of arms are analogical to bimodal field of the spots, although the mechanisms for excitement and supporting the fields may be not identical. Most probably they are really different but discussing this problem is not our goal. Here we want to turn our attention to the possible mechanism for generating a current ring in Galaxy. In our opinion it may be connected with ionisation of a galactic diffusive matter by the cosmic rays. A totality of free electrons forms more thick layer than a dust layer or a positive ion one. But dynamics of the galaxies rotating differentially [7] demands more slow rotation of the smaller flattened subsystems. A circular velocity of the electrons smaller than one of the positive charged particles brings to generating the electric current with the volume density $j = en\Delta v$, where Δv is the difference of the rotation velocities of two subsystems. The necessary value of a current density are in very broad variation limits of *n* and Δv. Alfvén [6] names such construction by a triple layer.

The cosmic rays penetrate the whole volume of the Galaxy and take part simultaneously in a number of interactions. A relative part of the different mechanisms for energy loss is calculated in [8]. The ionisation loss and loss for nuclear interactions are essential for hadrons with the energy

$E < 10^{15}\ eV$ bringing principal contribution in the full energy. The both processes bring ultimately to appearing the charges of different signs and heat of a matter. Photoionisation brings to the same results. However, it is most probably, its part in generating continuos current ring is secondary. Radiation from the region of Lymanian continuum of the hot stars leads to appearing the zones H II. Their dimensions do not exceed the hundreds of parsecs although the individual zones in the star generation regions may cover themselves.

The spatial separating charges is the result of simultaneous display of two tendencies viz. an aspiration to equal distribution of an energy between heavy and light particles and opposite aspiration to approaching of the charges of different signs and recombination. Absence of quasi-neutrality did not allow considering the medium as classic plasma. In particular the global electroconductivity is low. It is calculated $\gamma = 10^{-20}\ S\ /\ m$ for the Galaxy periphery in the region R > R_{2}. Such matter involves the magnetic field feebly. Nevertheless an azimuthal component $B_{\vartheta} \approx 0{,}1 B_{z}$ appears due to partial involving. A strong raggedy of a matter brings to the different conditions in the individual diffuse clouds where a matter conductivity and a race of magnetic field involving may be different. But it seems possible the raggedy must be minimum and smoothes out in the course of time beyond the star component of the Galaxy.

Evidently cosmic ray energy did not essentially exceed a magnetic one. Otherwise the problems with keeping the cosmic rays in the Galaxy will appear. It defines the lower boundary of field energy. The proposed scheme explains also existence of the upper boundary: the cosmic rays can not generate a stationary field with the larger induction. In a result the both energies are practically equal. Thus the cosmic rays are connected with the Galaxy magnetic field in two ways: from one side they are kept by the field, from another side they generate this field by supporting electric current. Of course this conclusion did not demand to refuse from considering other mechanisms for generating and supporting a magnetic field.

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