PHYSICAL SCIENCES

QUANTUM SPONTANEOUS MAGNETIZATION

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Abstract

The problem of spontaneous generation of magnetic fields in plasma is one of the main problems in physics. The idea of this generation by the motion of a conducting fluid is based on the classical instability of the wave type. The amplification of the seed field or the transformation of one field component into another occurs through a dynamo mechanism, for example, toroidal to poloidal in a rotating ball. Superexchange in an ionized gas is considered . In a dense low-temperature plasma, the effects of overlapping of electron shells turn out to be significant even before the overlapping stage. The overlap integrals in the expression for the energy of ions interacting via electronic exchange reduce the latter. The decrease in energy is the greater, the closer to each other the projections of the orbital momenta of active electrons onto a fixed quantization axis. In this case, the orbital moments of the particles, and hence the magnetic moments, are co-directed . For the first time, a mechanism has been developed for the occurrence of magnetic fields in the central regions of planets, stars and on the surface of the Sun.

Keywords: Quantum mechanics, quantum computing, planets Sun, Earth, space plasma, solar plasma, magnetic tubes, Foucault currents, MHD-dynamo mechanism, freezing-in of magnetic fields, magnetic fields in space plasma, motion and evolution of bodies in the solar system.

Magnetic fields are extremely common in space plasma - stars and the interstellar medium. These fields, together with their invariably accompanying fast particles - cosmic rays, form a kind of symbiosis, which is recorded almost with complete certainty in all corners of the Universe. The total energy of magnetic fields and cosmic rays in relation to, for example, background or cosmic microwave radiation is no more than a few percent. However, magnetic fields manifest themselves primarily in the active regions of stellar and galactic flares; it is they that cause the transfer of energy into cosmic rays, radio emission, anomalous optical and X-ray radiation observed in active zones. In general, magnetic fields are very important in a wide variety of electromagnetic processes, which, in turn, also affect the dynamics of gas, plasma, and stellar systems. The planets - Jupiter, Earth and some others - also have a magnetic field. The movement and evolution of small bodies of the solar system - meteorites, comets - is also largely associated with interplanetary and intrinsic fields.

The solar plasma also contains a magnetic field, and this field is concentrated in the active zones of the Sun, reaching in solar spots of intensity on the order of several thousand gauss. And the very manifestation of solar activity is associated primarily with magnetic fields. Here is what the prominent astrophysicist E. Parker writes about this [1]: “If there were no magnetic fields, the Sun would represent a classically impersonal star, calm and quiet, and after scientists would understand the nature of the internal source of energy and would agree with the observations of theoretical calculations of neutrino radiation, the Sun would cease to be of particular interest to them. But in reality, the surface of the Sun is disfigured by cold spots, the fields in which reach 3000 H , distorted by quiet prominences, perturbed by frequent coronal mass ejections, flares and subflares , dotted with flares, and severely disfigured by spicules . Everywhere above the surface of the Sun, magnetic fields exhibit the remarkable property of being spontaneously concentrated into magnetic tubes of field lines with fields of 1500 N. Above the bipolar magnetic regions, the power of the corona increases ... "

What is the mechanism of generation of magnetic fields in the space environment? If we refuse the relic form of origin, in which the fields were introduced into the plasma, as they say, initially, then it is quite difficult to answer this question. And even if the relic hypothesis is recognized, questions related to the interpretation of the physical mechanism of the rapid temporal change in magnetic fields in active regions will remain unanswered. Space plasma has a high conductivity, for example, in the solar atmosphere $\sim 10^{b}$ ohm. m. This circumstance practically excludes the rapid introduction of fields from the outside: in a well-conducting medium, large Foucault-type currents that prevent the field from penetrating into the plasma. The main working hypothesis for explaining the generation of fields in space plasma is the MHD dynamo hypothesis. Just during movements of a complex and intricate nature, i.e. during turbulent motions of the plasma, the magnetic fields in it can be amplified by such motions. This is due to the property of the so-called freezing-in of magnetic fields in the conducting Alfvén waves or nonlinear magnetic solitons, and this property is precisely related to this property. Axisymmetric regular motions of the medium, for example, rotation that is inhomogeneous along the radius of a star, cannot support or generate magnetic fields. This forbids the so-called Cowling theorem [2]. According to modern versions of the MHD dynamo hypothesis, the effect of amplifying fields, starting from small seed fields, is possible with a turbulent motion of a medium with a special property - the helicity property [4]. The evolution of the fields is then described by the following equation:

$$\left(\frac{d\vec{v}}{d\tau} + \gamma k^2\right)\vec{b} = \mathrm{i}\,\Gamma \vec{k} \times \vec{b} \qquad (1)$$

where $\vec{b}$is the $\vec{v}$magnetic ть γinduction Γof the $\overline{\tau\vec{v}\cdot rot\vec{v}}$ amplified $\gamma -$ field $\vec{k}$; τThe helicity is nonzero if the turbulent motions of the plasma are accompanied by their rotation, and the direction of rotation must be in a certain way consistent with the direction of the general movement of the medium, for example, along the vertical - the direction of gravity. Spiral in this sense are the movements of gas in cyclones or anticyclones in the Earth's atmosphere. If the dynamo coefficient satisfies the inequality $\Gamma > \gamma k$,

then the field amplification effect takes place. Under conditions of near-surface solar plasma, $\gamma \sim 10^{4}$ cm ^{2}/s, $\kappa \sim L^{-1} \sim 10^{-9}$см$^{-1}$гдеL$\sim$109см, is the linear scale of activity zones, , $\tau \sim L/v$hence we get what should be Lv $>10^{13}$ cm ^{2}/ s or $v > 10^{4}$ cm / s. But movements of such a large scale both in terms of velocity and linear size are not observed on the surface of the Sun. And this, in fact, is the main difficulty in applying the MHD theory to the Sun [1]! There are other fundamental difficulties associated with the application of this theory. Global movements with helicity are observed on the Sun: these are movements associated with meridional circulation and convection. However, such motions should lead to a wave pattern of field changes, while magnetic fields on the Sun are concentrated in separate tubes with dimensions L ≪R , where R is the radius of the Sun. In A-type stars, in which the fields are strong, convection, on the contrary, is suppressed. It is not clear why regions with a strong magnetic field are noticeably cooled, while the presence of turbulence should contribute to the heating of the core due to the heat coming by mixing from deeper layers. One gets the impression of a certain incompatibility between magnetic fields and turbulence. This incompatibility is reflected in the famous Batchelor theorem [4].

Magnetically active stars appear to an external observer as relatively dark spots. In reality, these regions are tubular with relatively small diameters, and they are "scattered" over the core in a rather chaotic manner. Magnetic tubes resemble in their morphology domains in a ferromagnet. On the other hand, plasma in magnetic tubes is not degenerate, but its parameters correspond to non-ideal conditions . For example, in the depth of a typical spot at a distance L = 10 thousand km (at the base of the tube) temperature T = 10^5degrees K, particle concentration plasma n $\sim 3 \cdot 10^{21}$ см$^{-3}$[5],in this case, the De Broglie wavelength of thermal electrons is not more than several times less than the interelectronic distance, i.e. Plasma is indeed not ideal in terms of quantum parameters [2,3]. This implies the possibility of spontaneous quantum generation of magnetic fields in the region of spots. Estimates of the generation efficiency are also contained there. The transition to the magnetized state should be considered in the context of the presented theory as a phase transition to the liquid state of plasma with simultaneous "breaking of spontaneous symmetry", which is accompanied by field generation. The magnetic field "takes away" energy from the thermal background of particles, as a result, the plasma temperature decreases by a relative value[4]

$$\frac{\Delta T}{T_{K_Б}} = \frac{e^2 k_B}{T_{K_Б}} \mathcal{L} \approx 0{,}1 \div 0.3 \qquad (2)$$

which is consistent with the observations

We introduce quantum time, which, according to the uncertainty relation energy - time, is determined by the formula of the form[4]

$$\tau = \hbar / e^2 k_B \mathcal{L} \qquad (3)$$

This is the minimum time that determines the duration of the local phase transformation. If the size of the region is L , then the corresponding parameter of the propagation velocity of the phase jump is u $\approx L/\tau \sim 10^8$cm/s. This value of the magnetization propagation velocity in the spot also corresponds to the observational data.

The angular velocity of the Sun, due to the differential rotation, depends on latitude $\Omega = 3 \cdot 10^{-6}$(1-0.2 $sin^2\varphi$)1/ c (4)

In a reference frame rotating around the Sun's axis with an angular velocity of $\Omega_0 = 3 \cdot 10^{-6}$1/s, there remains a rotation occurring with the differential part of the angular velocity $\Delta\Omega \sim sin^2\varphi$. Projection the latter to the local vertical is proportional to $sin^2\varphi cos\varphi$.

The largest gradient of the linear velocity of rotation takes place at the latitude φ_0, which corresponds to the maximum of the function $\Delta\Omega cos\varphi$, i.e. $\varphi_0 = arctg\sqrt{2/7} = 28^{\circ},2$. It is in this zone, called the "royal" zone, that the seed field can be generated by the MHD mechanism [5]. In turn, the seed field in the regions belonging to the "royal" zones and filled with non-ideal plasma causes the effect of further self-generation of the field during a phase transformation of the ferromagnetic type [6]. Indeed, the formation of sunspots begins just in the zones adjacent to the indicated latitudes.

Here, the effect of quantum generation of magnetic fields on the surface of the Sun is considered in relatively detail. However, the mechanism proposed by us, obviously, operates in general in a nonideal plasma, which exhibits exchange quantum properties. Consequently, this mechanism is universal and operates, in particular, in a denser plasma. Therefore, such generation can take place in the central regions of stars and planets containing plasma in a non-ideal state. These centers are sources of magnetic fields, the lines of force of which, during diffusion and electromagnetic processes, are carried out into the peripheral regions and into the interstellar medium. In the "frozen" state, such fields are transported by plasma further beyond the limits of stellar systems. Takova brief scheme evolution space magnetic fields .

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