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Astrophysical Effects Related to Gravity-Induced Electric Polarization of Matter.

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Abstract

The calculations in Thomas-Fermi approximation show that in a gravitational field each cell of ultra dense matter inside celestial bodies obtains a very small positive electric charge. A celestial body is electrically neutral as a whole, because the negative electric charge exists at its surface. The positive volume charge is very small, on the order of magnitude it equals to $10^{-18}e$ per atom only. But it is sufficient to explain the occurrence of magnetic fields of the celestial bodies and the existence of a discrete spectrum of steady-state values of masses of planets, stars, and pulsars.

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1 Introduction

According to the conventional point of view, gravity does not induce any electric polarization in the interior of celestial bodies and electric forces are never considered in the balance of matter of celestial bodies. Moreover, it is generally assumed that the electric interaction plays practically no role in astrophysics. It is a consequence of the comprehension that the appreciable electric polarization cannot arise in metals and other nonsegneto- and nonpiro-electric materials. It is entirely correct for all substances under action of small pressure. But, thus, one can disregard the fact that ultrahigh pressure transmutes all substances into plasma state and radically changes the properties of substance. In ultradense plasma, there is a different additional mechanism of the gravity-induced electric polarization.

In a large celestial body, consisting of ultradense plasma, this gravity-induced electric polarization (GIEP) can be rather great and can play a determining role in the formation of a number of features of the structure of a celestial body and its properties.

First of all, it concerns the following three problems, the statement and the solution of which change drastically:

- the distribution of pressure and density of matter inside a celestial body;
- the generation of a magnetic field by celestial bodies;
- the formation of a spectrum of steady-state values of masses of celestial bodies.

As a consequence, these features of the structure can influence the evolution of stars.

2 The gravity-induced electric polarization in conducting matter

The action of gravity on metals has often been a topic of discussion before [1]-[6]. The basic result of these researches is reduced to the statement that inside a metal gravity induces an electric field with an intensity

$$E \simeq \frac{mg}{e},$$

where $m_i$ is the mass of an ion,
\( g \) is gravity acceleration, 
\( e \) is the electron charge.

This field is so small that it is not possible to measure it experimentally. It is a direct consequence of the presence of an ion lattice in a metal. This lattice is deformed by gravity and then the electron gas adapts its density to this deformation. The resulting field becomes very small.

Under superhigh pressure, all substances transform into ultradense matter usually named nuclear-electron plasma [7]. It occurs when external pressure enhances the density of matter several times [8, 9]. Such values of pressure exist inside celestial bodies.

In nuclear-electron plasma the electrons form the degenerated Fermi gas. At the same time, the positively charged ions form inside plasma a dense packing lattice [9, 10]. As usually accepted, this lattice may be replaced by a lattice of spherical cells of the same volume. The radius \( r_s \) of such a spherical cell in plasma of the mass density \( \gamma \) is given by

\[
\frac{4\pi}{3} r_s^3 = \left( \frac{\gamma}{m_i} \right)^{-1} = \frac{Z}{n},
\]

where \( Z \) is the charge of the nucleus, \( m_i = A m_p \) is the mass of the nucleus, \( A \) is the atomic number of the nucleus, \( m_p \) is the mass of a proton, and \( n \) is the electron number density

\[
n = \frac{3Z}{4\pi r_s^3}.
\]

The equilibrium condition in matter is described by the constancy of its electrochemical potential [7]. In plasma, the direct interaction between nuclei is absent, therefore the equilibrium in a nuclear subsystem of plasma (at \( T = 0 \)) looks like

\[
\mu_i = m_i \psi + Ze \varphi = \text{const}.
\]

Here \( \varphi \) is the potential of an electric field and \( \psi \) is the potential of a gravitational field.

The direct action of gravitation on electrons can be neglected. Therefore, the equilibrium condition in the electron gas is

\[
\mu_e = \frac{p_F^2}{2m_e} - (e - \delta q) \varphi = \text{const},
\]
where $m_e$ is the mass of an electron and $p_F$ is the Fermi momentum.

By introducing the charge $\delta q$, we take into account that the charge of the electron cloud inside a cell can differ from $Ze$. A small number of electrons can stay at the surface of a plasma body where the electric potential is absent. It results that the charge in a cell, subjected to the action of the electric potential, is effectively decreased on a small value $\delta q$. If the radius of a star $R_0$ is approximately $10^{10}\text{ cm}$, one can expect that this mechanism gives on the order of magnitude $\frac{\delta q e}{e} \approx \frac{r}{R_0} \approx 10^{-18}$.

The electric polarization in plasma is a result of changing in density of both nuclear and electron gas subsystems. The electrostatic potential of the arising field is determined by the Gauss’ law

$$\nabla^2 \varphi = \frac{1}{r^2} \frac{d}{dr} \left[ r^2 \frac{d}{dr} \varphi \right] = -4\pi \left[ Ze \delta(r) - e n \right], \quad (6)$$

where the position of nuclei is described by the function $\delta(r)$.

According to the Thomas-Fermi method, $n$ is approximated by

$$n = \frac{8\pi}{3\hbar^3} p_F^3. \quad (7)$$

With this substitution, Eq.(6) is converted into a nonlinear differential equation for $\varphi$, which for $r > 0$ is given by

$$\frac{1}{r^2} \frac{d}{dr} \left( r^2 \frac{d}{dr} \varphi(r) \right) = 4\pi \left[ \frac{8\pi}{3\hbar^3} \right] [2m_e(\mu_e + (e - \delta q)\varphi)]^{3/2}. \quad (8)$$

It can be simplified by introducing the following variables [11]:

$$\mu_e + (e - \delta q)\varphi = Ze^2 \frac{u}{r} \quad (9)$$

and $r = ax$,

where

$a = \left( \frac{m_e}{128\pi} \right)^{1/3} a_0$

with $a_0 = \frac{\hbar^2}{m_e e} = \text{Bohr radius}$.

With the account of Eq.(11)

$$Ze^2 \frac{u}{r} = \text{const} - \frac{m_e \psi}{Ze} - \delta q \varphi. \quad (10)$$

Then Eq.(8) gives
\[
\frac{d^2u}{dx^2} = \frac{u^{3/2}}{x^{1/2}}. \tag{11}
\]

In terms of \(u\) and \(x\), the electron density within a cell is given by

\[
n_{TF} = \frac{8\pi}{3\hbar^3} \rho_F^3 = \frac{32Z^2}{9\pi^3a_0^3} \left( \frac{u}{x} \right)^{3/2}. \tag{12}\]

Under the influence of gravity, the charge of the electron gas in a cell becomes equal to

\[
Q_e = 4\pi e \int_0^{r_s} n(r)r^2dr = \frac{8\pi e}{3\hbar^3} \left[ 2m_e \frac{Ze^2 \gamma^{3/2}}{a} \right] \left( 4\pi a^3 \int_0^{r_s} x^2dx \left[ \frac{u}{x} \right]^{3/2} \right). \tag{13}\]

Using Eq. (11), we obtain

\[
Q_e = Ze \int_0^{r_s} xdx \frac{d^2u}{dx^2} = Ze \int_0^{r_s} dx \frac{d}{dx} \left[ x \frac{du}{dx} - u \right] = Ze \left[ x_s \frac{du}{dx} \right]_{x_s} - u(x_s) + u(0). \tag{14}\]

At \(r \to 0\) the electric potential is due to the nucleus alone \(\varphi(r) \to \frac{Ze}{r}\). It means that \(u(0) \to 1\) and each cell of plasma obtains a small charge

\[
\delta q = Ze \left[ x_s \frac{du}{dx} \right]_{x_s} - u(x_s) = Ze x_s^2 \left[ \frac{d}{dx} \left( \frac{u}{x} \right) \right]_{x_s}. \tag{15}\]

For a cell placed in the point \(R\) inside a star

\[
\delta q = Ze \frac{2}{r_s} \left[ \frac{d}{dR} \left( \frac{u}{r} \right) \frac{dR}{dx} \right]. \tag{16}\]

Considering that the gravity acceleration \(g = -\frac{d\varphi}{dR}\) and the electric field intensity \(E = -\frac{d\varphi}{dR}\)

\[
\frac{dr_s}{dR} = \frac{r_s^2}{e} \left[ \frac{m_e g + \delta q E}{\delta q} \right]. \tag{17}\]

This equation has the following solution

\[
\frac{dr_s}{dR} = 0 \tag{18}\]
\[
\frac{m_i}{Z} g + \delta q \mathbf{E} = 0. \tag{19}
\]

In plasma, the equilibrium value of the electric field on nuclei according to Eq. (18) is determined by Eq. (1) as well as in a metal. But there is one more additional effect in plasma. Simultaneously with the supporting of nuclei in equilibrium, each cell obtains an extremely small positive electric charge. As \( \text{div} \mathbf{g} = -4\pi G n m_i \) and \( \text{div} \mathbf{E} = 4\pi n \delta q \), the gravity-induced electric charge in a cell

\[
\delta q = \sqrt{G} \frac{m_i}{Z} \simeq 10^{-18} e, \tag{20}
\]

where \( G \) is the gravity constant.

However, because the sizes of bodies may be very large, the electric field intensity may be very large as well

\[
\mathbf{E} = \frac{g}{\sqrt{G}}. \tag{21}
\]

In accordance with Eqs. (18, 19), the action of gravity on matter is compensated by the electric force and the gradient of pressure is absent.

Thus, a celestial body is electrically neutral as a whole, because the positive volume charge is concentrated inside the charged core and the negative electric charge exists on its surface and so one can infer gravity-induced electric polarization of a body.

3 Pressure distribution inside a celestial body.

As at the surface of a celestial body pressure is absent, near this surface there is always a stratum where plasma and polarization are absent. For the large stars, the size of this stratum is insignificant. But for a small planet it can comprise a substantial part of a planet, and thus, only a small relatively internal region will be polarized. At the surface of this core, the electric field intensity falls to zero. The jump in the electric field intensity is accompanied on the surface of the core by the pressure jump \( \Delta p(R_N) \) (12-13). The important astrophysical consequence of the GIEP effect is the redistribution of the matter density inside a celestial body. In a celestial body, consisting
of matter with an atomic structure, density and pressure grow monotonously with depth. In a celestial body, consisting of electron-nuclear plasma, the GIEP effect results in the fact that the pressure gradient inside the polarized core is absent and the matter density is constant. Pressure affecting the matter inside this body is equal to the pressure jump at the surface of the core

\[ p = \Delta p(R_N) = \frac{E(R_N)^2}{8\pi} = \frac{2\pi}{9} G\gamma^2 R_N^2, \]

(22)

where \( \gamma \) is the matter density in the core and \( R_N \) is the radius of the core.

One can say that this pressure jump is due to the existence of the polarization jump or, which is the same, the existence of the bonded surface charge, which is formed by electron pushed out from the core and which makes the total charge of the celestial body equal to zero.

4 Earth’s structure.

It is important, that the GIEP effect gives the possibility to construct the intrinsically self-consistent theory of the Earth \cite{13}. Although it is rather a solution of a geophysical problem than an astrophysical effect.

Earlier models of the Earth assumed the existence of the monotonous dependence of pressure inside the planet. The division of the Earth into the core and the mantle was explained by the fact that at the creation of the Earth, on its share a certain amount of iron (and other heavy metals) and also a necessary amount of stone were given out. The core consists of metals and the mantle consists of stone. In these models, it was necessary to fit the parameters to get the densities of core and mantle and their sizes. It is not necessary to introduce any free parameters into the Earth theory based on the GIEP effect. Assuming that the Earth consists of homogeneous matter, the division on core and mantle is explained by the existence of the pressure jump on the surface of the core Eq.\,(22). The basic results of this theory are reduced to the calculation of the following five values:

a) the radius of the Earth’s core;
b) the density of core matter;
c) the density jump on the core-mantle boundary;
d) the mass related to one electron of the Fermi gas in the core;
e) the electric polarization of the core.

To express it in appropriate equations, one should substitute the following four parameters (the gravitational constant $G$ is known):

a) the mass of the Earth;

b) the radius of the Earth;

c) the matter density on the surface of the Earth;

d) the bulk module of matter at the surface of the Earth.

Thus, other parameters can be obtained, for example, the pressure distribution inside the Earth. The basic results of this theory are shown in Fig. 1.

In addition, from the obtained data it is possible to calculate the angular momentum of the Earth. This calculation gives the value of $0.339MR^2$. It is in agreement with the measured value of $0.331MR^2$ within several percent of the accuracy.

It is possible to calculate the magnetic moment of the Earth.

Apparently, using the appropriate data of other planets (the mass, the size, and the properties of matter at the surface), it is possible to construct models of these planets. It can be made, if these planets have electrically polarized cores and corresponding magnetic fields.

### 5 The gyromagnetic ratio of a celestial body

Another astrophysical consequence of the GIEP effect is coupled by the rotation of celestial bodies about their axes. A celestial body is electroneutral as a whole. The positive volume charge is concentrated inside the core and the negative charge is located at the surface of the core. When rotating, they move on different radii. As a result, all celestial bodies, when the GIEP effect is present, obtain magnetic moments

$$\mu = \frac{2}{15} \frac{4\pi}{3c} \rho \Omega R_N^5. \quad (23)$$

If the size of the body is sufficiently large, the core radius $R_N$ does not differ significantly from its external radius $R$. For this celestial body, the angular momentum of the core coincides by the order of magnitude with the angular momentum of the body as a whole.
Figure 1: The radial dependence of pressure and the matter density inside the Earth. The solid line is the calculated dependence of the matter density; the dashed line is the density of the Earth obtained by measuring the propagation velocity of seismic waves. The dash-dotted line is the calculated dependence of pressure inside the Earth over bulk module $B=1.3 \cdot 10^{12} \text{ dyn/cm}^2$. 
\[ L = \frac{2}{3} M \Omega R^2 \]  

(24)

where \( M = \frac{4\pi}{3} \gamma R^3 \) is the mass of a celestial body and \( \Omega \) is the velocity of rotation.

Finally, the gyromagnetic ratios for these bodies should be close to the universal value

\[ \frac{\mu}{L} = \frac{G^{1/2}}{3c}. \]  

(25)

The values of \( \mu(L) \) for all celestial bodies (for which they are known today) are shown in Fig.2. The data for planets are taken from [14], the data for stars are taken from [15], and for pulsars - from [16].

As can be seen from the figure with the logarithmic accuracy, all celestial bodies - stars, planets, and pulsars - really have the gyromagnetic ratio close to the universal value \( \frac{G^{1/2}}{3c} \). Only the data for the Moon fall out, because its size and inner pressure are too small to create an electrically polarized core.

The estimation of the magnetic moment of the Earth within the frame of the theory mentioned above [13] gives \( \mu \approx 4 \cdot 10^{25} Gs \cdot cm^3 \). It is almost precisely one half from the observed value of 8.05 \( \cdot 10^{25} Gs \cdot cm^3 \). For some planets, the values of magnetic moments are in a good agreement with Eq.(25) but they have an opposite sign. Apparently, it means that the hydrodynamic mechanism also plays a certain role.

For the majority of pulsars, there are estimations of magnetic fields [19] obtained using a number of model assumptions [16]. It is impossible to consider these data as the data of measurements, but nevertheless, they also agree in certain way with Eq.(25),(Fig.3)

6 The masses of celestial bodies.

The important astrophysical outcome of the GIEP effect is a discrete distribution of masses of celestial bodies. This spectrum is a result of the fact that electron-nuclear plasmas can exist in various states.

The equation of state of matter subjected to high pressure is usually described as a polytrope [4]:
Figure 2: The observed values of the magnetic moments of celestial bodies vs. their angular momenta. On the ordinate, the logarithm of the magnetic moment over $Gs \cdot cm^3$ is plotted; on the abscissa the logarithm of the angular momentum over $erg \cdot s$ is shown. The solid line illustrates Eq. (25). The dash-dotted line is the fitting of the observed values.
Figure 3: The estimated values of the magnetic moments of pulsars [19] vs. their angular momenta. Solid line is Eq.(25). The axes are as in Fig.2.
\[ p = C \cdot \gamma^{\frac{1+k}{2}}, \]  \hspace{1cm} (26)

where \( C \) is the dimensional constant,
\( k \) is the polytropy.

\section*{6.1 Nonrelativistic electron-nuclear plasma}

At relatively small pressure, substances are transmuted into nonrelativistic electron-nuclear (or electron-ion) plasma. It is peculiar to conditions existing inside cores of planets. According to \cite{7}, the state equation of the nonrelativistic electron-nuclear plasma (characterized by the polytropy \( k=3/2 \)) is

\[ p^{(3/2)} = \frac{(3\pi^2)^{2/3} \hbar^2 \gamma^{5/3}}{5m_e(\beta \cdot m_p)^{5/3}}, \]  \hspace{1cm} (27)

where \( \beta \cdot m_p \) is the mass of matter related to one electron of the Fermi gas system and \( m_p \) is the proton mass.

If the pressure inside a celestial body is formed by the GIEP effect and is determined by Eq.\((22)\), than from Eq.\((27)\) for the nonrelativistic Fermi gas of electrons, we obtain the steady-state value of mass for a core of planet

\[ M^{(3/2)} = C^{(3/2)} \cdot \left( \frac{\hbar^2}{Gm_em_p} \right)^{3/2} \cdot \frac{\gamma^{1/2}}{\beta^{5/2}m_p}, \]  \hspace{1cm} (28)

where \( C^{(3/2)} = \frac{54\pi}{8} \left( \frac{\pi}{10} \right)^{1/2} \approx 19. \)

The dependence of Eq.\((28)\) is shown in Fig.4. Therefore, any planet (even consisting from pure hydrogen) should have a mass less than \( 10^{31} \) g (if its density is approximately equal to \( 1 \) g/cm\(^3\)).

In Fig.4 the masses of the planets of the Solar system are marked. The mass of the Jupiter is \( 1.9 \cdot 10^{31} \) g. It is close to the specified limit. For the Jupiter Eq.\((28)\) gives \( \beta \approx 2 \). It is according to the data that the large planets have the deuterium-helium composition. For other planets the mantle is not small in comparison with their sizes. For this reason, Eq.\((28)\) can give an excessive estimation for other planets.
Figure 4: The dependence of the core mass of planets on \( \beta \) (Eq. (28)) at \( \gamma = 1 g/cm^3 \). On the ordinate, the logarithm of mass (over 1g) is plotted.
6.2 Relativistic electron-nuclear plasma.

When the pressure increases, the substances are transmuted into relativistic electron-nuclear plasma (the polytropy $k=3$). Its state equation is

$$p(3) = \frac{(3\pi^2)^{1/3} \hbar c^2}{4m_p^{4/3} \beta^{4/3}}$$

If this plasma is originated by the GIEP effect, then the steady-state value of mass of a star consisting of it, according to Eqs. (22, 29) is

$$M(3) = C(3) \cdot A_3^{3/2} \cdot \frac{m_p}{\beta^2}$$

where the dimensionless constants are

$$A_\pi = \left( \frac{\hbar c}{Gm_p^2} \right) = 1.54 \cdot 10^{38}$$

and $C(3) = (1.5^5 \pi)^{1/2} \simeq 4.88$.

Because of the electric neutrality, one proton should be related to electron of the Fermi gas of plasma. The existence of one neutron per proton is characteristic for a substance consisting of light nuclei. The quantity of neutrons grows approximately to 1.8 per proton for the heavy nuclei substance. Therefore, it is necessary to expect that inside stars $2 < \beta < 2.8$.

The masses of stars can be measured with a considerable accuracy, if these stars compose a binary system. There are almost 200 double stars which masses are known with the required accuracy [17]. Among these stars there are giants, dwarfs, and stars of the main sequence. Their average masses are described by the equality

$$\langle M_{\text{star}} \rangle = (1.36 \pm 0.05) M_\odot$$

where $M_\odot$ is the mass of the Sun.

The center of this distribution (Fig.5) corresponds to Eq. (30) at $\beta \simeq 2.6$.

6.3 Ultrarelativistic electron-nuclear plasma.

Further increase in pressure transmutes substances into ultrarelativistic plasma. Then nuclear reactions of capture of electrons by nuclei become favorable and
Figure 5: Mass distributions of stars and pulsars from the binary systems [17] - [18]. The curve shows $\beta$ (Eq.(30)).
the neutronization of matter takes place. Equilibrium pressure of ultrarelativistic plasma does not depend on its density. It is formally characterized by the polytropy $k=-1$ and its state equation is

$$p^{(-1)} = \frac{\Delta^4}{12\pi^2 (\hbar c)^3}. \quad (33)$$

Here $\Delta$ is the difference between the energy of the initial nucleus and the energy of the daughter nucleus.

The equilibrium mass of a star, consisting of ultrarelativistic plasma, according to Eqs.(22),Eq.(33) is

$$M^{(-1)} = C^{(-1)} \left( \frac{\Delta^6}{(\hbar c)^{9/2} G^{3/2} \gamma^2} \right), \quad (34)$$

where $C^{(-1)} = \frac{1}{4\pi^2} \left( \frac{3}{2\pi} \right)^{1/2} \simeq 6 \cdot 10^{-3}$.

According to the astrophysical data a neutronization of matter takes place at the density $\gamma \approx 10^7 \text{g/cm}^3$. Thus, Eq.(34) gives

$$M^{(-1)} \approx 8 \cdot 10^{32} \text{g} \approx 0.4M_\odot. \quad (35)$$

Certainly this result is the rough estimation on the order of magnitude only, but it is in a satisfactory agreement with measurements of the astronomers related to masses of white dwarfs from double systems.

### 6.4 Nonrelativistic neutron matter.

At higher pressure, the substance is transmuted into a nonrelativistic neutron matter with a small impurity of protons and electrons [7]. The state equation of the nonrelativistic neutron matter will coincide with Eq.(22) with a replacement of $m_e$ with $m_p$

$$p^{(n)}_{(3/2)} = \frac{(3\pi^2)^{2/3} \hbar^2 \gamma^{5/3}}{5m_p^{8/3} \beta^{5/3}}. \quad (36)$$

Together with Eq.(22), it gives the equilibrium mass of the nonrelativistic neutron star

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M^{(n)}_{(3/2)} = C_{(3/2)} \left( \frac{h^2}{G} \right)^{3/2} \frac{\gamma^{1/2}}{m_p^4 \beta^{3/2}}. \quad (37)

As the density $\gamma \simeq 4 \cdot 10^{13} g/cm^3$ and $\beta = 2.6$

$$M^{(n)}_{(3/2)} \simeq 0.05 M_\odot. \quad (38)$$

The astronomers have not found such neutron stars.

### 6.5 Relativistic neutron matter.

With further increase in pressure, the neutron Fermi gas becomes a relativistic one. Its state equation completely coincides with the state equation of the relativistic Fermi gas of electrons Eq.(22)

$$p^{(n)}_{(3)} = \frac{(3\pi^2)^{1/3} \hbar c \gamma^{4/3}}{4m_p^{4/3} \beta^{4/3}}. \quad (39)$$

As well as the masses of relativistic stars, the masses of relativistic pulsars do not depend on their density and can be directly expressed through world constants

$$M^{(n)}_{(3)} = C_{(3)} \cdot A_{*}^{3/2} \cdot \frac{m_p}{\beta^2} \quad (40)$$

(at $\beta = 1$ for the pure neutron Fermi gas).

As it is specified in [7], at this density of matter it is necessary to take into account nuclear forces and the presence inside nuclear matter except neutrons also of protons, $\pi^-$-mesons, and electrons. It can be made using $\beta$ as a parameter of the correction.

The mass of the neutron star can be measured with a considerable accuracy if it enters into a binary system. The astronomers have found 16 radio-pulsars [18] and 7 X-pulsars [16] in binary systems. They all are located in a very narrow mass interval (Fig.5)

$$\langle M_{pulsar} \rangle = (1.38 \pm 0.03) M_\odot. \quad (41)$$
The center of this distribution corresponds to Eq. (40) with the correction parameter $\beta \approx 2.6$ just as for relativistic stars. Thus, we come to the conclusion that Eq. (40) on the order of magnitude correctly describes the results of astronomical observations.

7 Conclusion.

It is expedient to underline the basic obtained results in summary.

1. The developed theory defines a concept of the steady-state values of masses of celestial bodies related to their equations of state and gives the possibility to calculate these values.

2. It gives the new way for the determination of the substance density distribution inside celestial bodies. According to early models, it was supposed that density of a substance inside celestial bodies grows more or less monotonically with depth and at the centre of a star, the density has the greatest value and even a black hole may exist there. According to the developed theory, the density of a substance inside a star is constant.

3. It is interesting to emphasize that the "biography" of such a star appears much poorer than in the Chandrasekar model. There cannot exist a black hole inside a star, and it should not collapse with a temperature decrease. All the considered effects are based on an equilibrium of the Fermi system. Temperature does not influence the parameters of relativistic plasma. Therefore, a star with a mass close to the steady-state value (Eq. (30)) is in a stable equilibrium not depending on temperature. The existing stars should retain the stability at any (even at zero) temperature. Therefore, a collapse of the already existing stars apparently is impossible. The instability of a star can arise with burning out of light nuclei - deuterium and helium - and with a related increasing of $\beta$. This growth leads to the reduction of a steady-state value of mass (Eq. (30)) and, probably, to the distraction of the stars with masses more than the steady-state value.

4. The developed theory determines the simple and essential mechanism of generation of the magnetic field by celestial bodies. All early models tried to solve the basic problem - to calculate the magnetic field of a celestial body. Such a statement of the basic problem of planetary and stellar magnetism is unacceptable at present. Space flights and a development of astronomy discovered a remarkable and earlier unknown fact: the magnetic moments
of all celestial bodies are proportional to their angular momenta and the proportionality coefficient is determined by the ratio of world constants. The explanation of this phenomenon is the basic problem of planetary and stars magnetism nowadays. Early models cannot explain this phenomenon. The developed theory used for this explanation a standard mechanism.

5. It is possible to consider that now the predicted steady-state values of masses of celestial bodies and the predicted values of their magnetic moments are in a satisfactory agreement with the data of observations. But it is tempting to obtain these data to closer limit of accuracy. Two arrows in the upper part of Fig.5 mark masses of stars consisting of extremely light and heavy nuclei. These values are obtained from Eq. (3) without the use of any fitting parameters. In agreement with the developed theory, if stars have a "usual" chemical composition, there must be no stars outside of this interval (or these stars should be unstable). The histogram on Fig.5 is somewhat wider. It is interesting to understand, whether there is a principal deviation from the developed theory or it is a result of measuring errors. First of all, it requires a more careful and precise measurement of masses of binary stars.

References

[1] Shiff L.I. and Barnhill M.V. - Phys. Rev., 1968, v.151, pp.1067-1071.
[2] Dressler A.I. a.o. - Phys. Rev., 1968, v.168, pp.737-743.
[3] Riegel T.J. - Phys. Rev. B, 1970, v. 2, pp.825-828.
[4] Kumar N. and Naddini R. - Phys. Rev. D., 1973, v.7, pp.1067-1071.
[5] Leung M.C. et al. - Canad. Journ. of Phys., 1971, v.49, pp.2754-2767.
[6] Leung M.C. - Nuovo Cimento, 1972, v.76, pp.825-929.
[7] Landau L.D. and Lifshits E.M. - Statistical Physics, 1980, vol.1, 3rd edition, Oxford: Pergamon.
[8] Vasiliev B.V. and Luboshits V.L. - Physics-Uspekhi, 1994, v.37, pp.345-351.
[9] Kirzhnitz D.A. - JETP, 1960, v.38, pp.503-508.
[10] Abrikosov A.A. - JETP, 1960, v.39, pp.1797-1805.

[11] Leung Y.C. - Physics of Dense Matter, 1984, Science Press/World Scientific, Beijing and Singapore.

[12] Vasiliev B.V. - Nuovo Cimento B, 1997, v.112, pp.1361-1372.

[13] Vasiliev B.V. - Nuovo Cimento B, 1999, v.114, pp.291-300.

[14] Sirag S.-P. - Nature, 1979, v.275, pp.535-538.

[15] Borra E.F. and Landstreet J.D. - The Astrophysical Journ, Suppl., 1980, v.42, 421-445.

[16] Beskin V.S., Gurevich, A.V., Istomin Ya.N. - Physics of the Pulsar Magnetosphere, Cambridge University Press, 1993.

[17] Heintz W.D. - Double stars, 1978, Geoph. and Astroph. monographs, vol.15, D.Reidel Publ.Comp.

[18] Thorsett S.E. and Chakrabarty D. - E-preprint: astro-ph/9803260, 1998, 35pp.

[19] Taylor J.H., Manchester R.N., Lyne A.G., Camilo F., Catalog of 706 pulsars, 1995, pulsar.prinstion.edu