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ЦЕНТРАЛЬНЫЙ НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ИНСТИТУТ
ИНФОРМАЦИИ И ТЕХНИКО-ЭКОНОМИЧЕСКИХ ИССЛЕДОВАНИЙ
ПО АТОМНОЙ НАУКЕ И ТЕХНИКЕ

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THE PRIMEVAL HADRON: ORIGIN OF ROTATION AND MAGNETIC FIELDS IN THE UNIVERSE

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We ought then to regard the
present state of the Universe
as the effect of its preceding
state and as the cause of its
succeeding state.

P.-S.Laplace

1. Introduction

The mankind has been preoccupied with the problem of origin and structure of astronomical Universe for many centuries. From the modern viewpoint, all the existing scientific (not mythological) cosmological theories may be grouped with one of the following three types:

1. Kinematical (Ptolemy, Copernicus, Kepler).
2. Dynamical (Newton, Einstein).
3. Physical.

We have listed above the names of scientists who have made the most decisive contribution to the appropriate approach and have omitted the names of numerous investigators, who have essentially supported its development.

The detailed consideration of all the above approaches does not enter into the purpose of the present paper. Note only, that the kinematical system deals with the coordinates and velocities of celestial bodies, without analyzing the reasons and forces responsible for their motion. The dynamical systems are based on the law of universal gravitation and its relativistic generalization given by the general theory of relativity. Both these approaches have played (and continue to play) a significant role in the development of cosmology. However, many important cosmogonic and cosmological problems in the framework of these approaches are left unanswered.

The third, physical approach is at present in the stage of formation and development. Among the various competing trends in the construction of physical system of the world Ambartsumian's cosmogonic approach [1-3] seems to be the most promising and realistic. It is based on the concept that all the presently observed celestial bodies, including galaxies, stars, diffuse matter and their systems, were formed due to the decay, fragmentation and subsequent evolution of the primordial superdense material with nearly nuclear density.

In the present paper we consider the problem of the origin of rotation and magnetism of celestial bodies, proceeding from the concept of superheavy strongly interacting elementary particles termed superhadrons [4-8].

The basic assumption consists in the fact that Ambartsumian's superdense pregalactic D-bodies are identical with superhadrons possessing a huge spin. Thanks to the work by the Italian physicist T.Regge and its further generalization the

quantitative relationship has been determined between the spin and the mass of these superhadrons (see below the formulae (1)-(7)).

The significance of the problem of the origin of the rotation of celestial bodies is beyond all question. As the best illustration of this may serve the fact that N.Copernicus's revolutionary work "De Revolutionibus Orbium Coelestium" is, in fact, based on the new kinematic interpretation of rotational motions in the solar system.

We have the reason to assume that the superhadron hypothesis may, in the end, be a help in the understanding not of rotation only but also of other parameters and properties of celestial bodies, such as the magnitude of magnetic fields, presence of non-thermonuclear sources of energy, abundance of chemical elements, origin of cosmic rays etc.

Thus, the understanding of the quantum nature of the rotation origin mechanism in astrophysics may shed light on the grand mystery of the origin of Universe and its structural parts and will be a help in the construction of a consistent physical picture of the world.

The plan of the paper is as follows: in sec. 2 the concept of superhadrons is introduced and their possible properties are discussed. In sec.3 a solution is proposed of the problem of the origin of the rotation of celestial bodies proceeding from the concept of superhadrons. In sec.4 a relation is deduced between some parameters of celestial bodies and fundamental constants of Nature. In particular, new expressions are obtained for the limiting angular momenta, which are the analogs of the relations of Eddington-Dirac and Chandrasekhar for limiting masses. In sec. 5 we consider the origin of magnetic fields of the astrophysical scale due to the dipole magnetic field of superhadrons. In sec. 6 the possible rotation of astronomical Universe as a whole is discussed, and some numerical predictions are given.

The basic conclusion of the present paper (see also [7, 8]) is that as a primeval state of the presently observed Universe might have served the superhadron with a mass of the order 10^{56} g, a huge spin 5×10^{92} g $cm^2 s^{-1}$ and a pancake shape.

2. Concept of Superhadrons and Their Expected Properties

From the viewpoint of modern physics the matter can exist in the following three qualitatively different forms:

A. Ordinary atomic-molecular matter consisting of atoms and molecules of density $\rho \approx$ several grams/cm^3.

B. Nuclear (or baryonic) matter of density $\rho \approx \approx 3\times10^{14}$ g cm^{-3}, which represents a closely connected system of baryons (protons, neutrons and hyperons). Atomic nuclei of ordinary chemical elements as well as neutron stars may serve as an example of objects composed of nuclear or baryonic matter (see e.g. [9,10]).

C. Hadronic (or quark) matter, which ordinary hadrons (protons, neutrons, other baryons and mesons) are commonly composed of, has a density $\rho \gtrsim 6\times10^{14}$ g cm^{-3}, which is merely twice that of nuclear matter.

All the three types of matter can transform into each other by means of phase transitions with the variation of external conditions - pressure and temperature.

The hadronic matter, which, in accord with the modern viewpoint, consists of elementary constituents termed quarks, is the most fundamental.

The macroscopic amount of hadronic matter, in principle, may be obtained in the following way. Consider the gas of free neutrons, protons and atomic nuclei and begin to compress it. At high enough densities, the quarks contained in neutrons and protons will begin to freely exchange, and the matter will perform a transition from nucleons to quarks.

The hadronic matter possesses a number of remarkable properties. We consider now its most significant property to possess a large inner angular momentum (spin) of a quantum-mechanical nature.

The superheavy bunch of hadronic matter is termed superhadron. If it possesses an astronomically large baryon charge, such a superhadron is termed also superbaryon. Such superbaryons have never been observed experimentally, but the assumption on the existence of a whole spectrum of such "particles" does not contradict the spirit of modern semi-phenomenological theories of strong interactions.

The superhadron with a spin cannot be presented as a rapidly spinning top, since the velocity of the rotation of surface may then surpass the velocity of light, which is unacceptable. Therefore, it is assumed that the spin of superhadrons has no classical analog. Like the spin of ordinary hadrons, it may be understood only basing on the laws of quantum mechanics. It is namely this fact that allows such superdense objects with relatively small dimensions possess a huge rotational momentum.

It has been recently found that there exists a deep interconnection between the spin and the mass of hadrons. A remarkable linear dependence was established between the square of mass and the spin of hadrons and hadronic resonances, which has the form

$$J = \alpha' m^2 + \alpha_0 \qquad (1)$$

The constant α_0 that determines the point of intersection of the J-axis at $m^2 = 0$, varies from one particle family to another, and $\alpha' \approx 1\ (\mathrm{GeV})^{-2}$ is the universal constant. This universality results in the fact that all the known Regge trajectories are practically parallel to each other. In fig. 1, which is known as the Chew-Frautschi plot (see e.g. [11] and refs. therein), examples of satisfying the relation (1) are presented. In the formula (1) J is measured in the units of Planck's constant $\hbar$, and the slope $\alpha' \approx 1\ (\mathrm{GeV})^{-2}$ may be approximately replaced by m_p^{-2}, the inverse square of the proton mass. For large values of masses one may ignore the parameter α_0. Then the formula (1) will take the form:

$$J = \hbar \left(\frac{m}{m_p} \right)^2 \qquad (2)$$

A more general formula, relating the maximum spin J to

the mass m of heavy hadrons, has been obtained in [4] and reads:

$$J = \hbar \left(\frac{m}{m_p} \right)^{1+\frac{1}{n}} \qquad (3)$$

Here $\hbar = 1.06\times10^{-27}\,\mathrm{g\ cm^2 s^{-1}}$ is Planck's constant; $m_p = 1.67\times10^{-24}$ g is the proton mass.

The number n characterizes the geometrical shape of the hadron: $n = 1$ for one-dimensional "string-like" objects; $n = 2$ for two-dimensional pancake objects; $n = 3$ for three-dimensional sphere-like objects. At $n = 1$ the formula (3) transforms into (2), which is consistent with theoretical representations that ordinary hadrons and hadronic resonances observed experimentally are one-dimensional extended string-like objects.

In fact, the formula (3) is obtained from the simpler formula (2) by means of dimensional analysis, and the requirement of physical similarity. This fact can be qualitatively understood by means of the classical formula for the angular momentum $J = m v r$. Since $m \sim r^n$ for the n-dimensional object, $r \sim m^{\frac{1}{n}}$ which results in the relation $J \sim m^{1+\frac{1}{n}}$ at v=const. We shall later see that the identification of superhadrons with Ambartsumian's superdense D-bodies allows to obtain a number of interesting consequences, in particular, it results in the qualitative explanation of the observed rotation of astronomical objects. Besides, the expressions for the parameters of celestial bodies are quite naturally obtained via fundamental constants.

3. Origin of Rotation of Celestial Bodies

The overwhelming majority of astrophysical objects, from stars and star clusters to clusters and superclusters of galaxies rotate. Still Galilei has observed the rotation of the Sun and has explained the movement of sunspots namely by it. The assumption on the rotation of Milky Way was proposed by I.Kant as an explanation of the oblateness of our Galaxy and was confirmed at the beginning of the 20th century. In present-day astrophysics the rotation plays an important role in explaining the mechanism of the rotation of pulsars which are, apparently, rotating neutron stars. Hypotheses have been put forward that there are fast rotating dense bodies in galactic nuclei and quasars. There are indications that the Universe as a whole rotates as well.

It is clear from this brief enumeration that rotation is not a random property of celestial bodies but is an inherent attribute of matter.

There are reasons to suppose that for the majority of celestial bodies - galaxies, stars and planets - the rotation has not essentially changed since their origin. Therefore, the understanding of the mechanism of the origin of rotation of various cosmic objects would help to find an answer to the more general problem of the origin of the object itself. In other words, can we assume that the conserved value of the angular momentum is a clue to the cosmogonic problem ?

All preceding cosmogonic theories have either ignored the problem of the origin of rotation or considered it be means of

additional artificial hypotheses. Many apparently elegant cosmogonic theories were considered incorrect due to their inconsistency with the law of conservation of the angular momentum. Even the great Newton, who has laid the foundations of the dynamical picture of world, was obliged to give up the search for the original cause of the rotation of celestial bodies and resort to the help of an antiscientific hypothesis ascribing it to a "reasonable and almighty being" and violating his own well known statement "hypoteses non fingo".

Modern classical theories of the origin of rotation of astronomical systems and bodies are unsatisfying, since they give no numerical predictions and are unable to explain, at least, the order of magnitude of angular momenta of celestial bodies and, therefore, are completely post hoc structures. There is also a difficulty of principle character, which consists in the following: when the rotating "initial cloud", of which, in accord with the classical cosmogony, objects are formed, begins to compress under the action of gravitation, the rotation energy increases faster than the gravitational binding energy, which results in the instability known as the gyro-gravitational catastrophe.

On the other hand, it has been pointed out by V.Ambartsumian back in 1947 [2] that the angular momentum problem is one of the difficulties in the framework of his superdense cosmogony. Indeed, the typical galaxy possesses a mass $m = 10^{44}$ g and an angular momentum $J = 10^{74}$ g cm^2 s^{-1}. From the relation $J = mc\tau$, where c is the velocity of light, one may easily compute that the minimum radius of the classical object with such parameters is approximately 10^{20} cm, which corresponds to the maximum density of the order 10^{-16} g cm^{-3}. Such an object can in no way be termed superdense. It is clear that the ordinary (atomic-molecular) matter cannot simultaneously possess a large angular momentum and be superdense.

The way out of this situation is nontrivial and requires the attraction of ideas from the physics of strongly interacting elementary particles, hadrons. As is known, one of the simplest amd most interesting properties of elementary particles is their ability to possess inherent intrinsic angular momentum, otherwise termed spin. In some simplified sense, elementary particles behave like spinning tops. However, there is a rather strong difference between the rotating classical body and such a quantum object as the elementary particle.

In order to illustrate this difference, consider as an example the simplest elementary particle, electron. As is known the electron mass is $m_e = 9 \times 10^{-28}$ g, and the intrinsic angular momentum is 0.5×10^{-27} g cm^2 s^{-1} or $\frac{1}{2}\hbar$ in the units of Planck's constant. Let us assume that the electron mass is concentrated in the sphere of the radius r_e, which rotates at a maximum permissible velocity, the velocity of light c. It then follows from the elementary equality $\frac{2}{5} m_e c r_e = \frac{1}{2}\hbar$ that the radius of the electron in the considered model should be of the order of the Compton wavelength $\hbar / m_e c$, i.e. of the order 10^{-11} cm, while, according to present-day experimental data, the dimensions of the electron are less than 10^{-15} cm.

Handbooks of quantum mechanics give a clear and brief definition: spin is a specific quantum effect and excludes the classical interpretation, so there is no sense in trying to imagine the angular momentum of the elementary particle as a result of simple mechanical rotation round its axis.

In modern hadronic physics a deep connection is found to be between the spin and mass of strongly interacting elementary particles, hadrons. The experimentally observed correlation between the spin and mass of hadrons shows that the heavier hadron the larger the spin it can possess, the increase in the spin with the mass proceeding faster than the linear dependence between them. Clearly this can be presented so that with the increase in mass the hadron rotates faster and faster. As a macroscopic analogy may serve the comparison of the rotation of Earth and Jupiter: Jupiter possesses not only a considerably bigger mass but also an angular velocity 2.5 times higher than that of Earth.

Proceeding from this, we have proposed several years ago a simple solution of the problem of the origin of the rotational momentum of celestial bodies, which consisted in the assumption [4,6] that Ambartsumian's **primerdial superdense D-bodies** were special quantum-mechanical objects, namely, superbaryons with a huge spin J, connected to the mass m by a Regge-like relation (3). In addition, the analysis of the observational data on the rotation of cosmic objects has shown that they can be classified into two groups, in which spin-mass relations are given by the formula (3) at n = 2 and n = 3, respectively:

A. The first group (n=2) includes clusters of galaxies, single galaxies, globular and open star clusters and, possibly, stellar associations and super-associations. The angular momentum-mass distribution for these objects is described by the formula

$$\mathcal{J} = \hbar \left(\frac{m}{m_p}\right)^{3/2} \qquad (4)$$

or, in CGS system, if mass is measured in grams and the angular momentum in g cm^2 s^{-1}, after the substitution of the values of fundamental constants, the formula (4) can be presented as

$$\mathcal{J}\,(g\ cm^2\ s^{-1}) = 4.87 \times 10^8\ m \quad (g) \qquad (5)$$

Note that these formulae are possibly applicable also for the description of the rotation of the Metagalaxy and the observed Universe as a whole.

B. The second group (n=3) includes stars and planets. The angular momentum-mass distribution for these objects is given by the formula (3) in the special case n=3

$$\mathcal{J} = \hbar \left(\frac{m}{m_p}\right)^{4/3} \qquad (6)$$

or in the CGS system

$$\mathcal{J}\,(g cm^2 s^{-1}) = 5.31 \times 10^4\ m \quad (g) \qquad (7)$$

A more detailed description of these formulae is given in [7,12].

The available observational data on the rotation of various cosmic objects, along with theoretical straight lines, are presented in fig. 2. The observational data are in a good

enough agreement with theoretical predictions, and in some sense fig. 2 represents a generalized Chew-Frautschi plot for astronomical objects. Note that theoretical straight lines correctly describe both the slope and absolute values of data in a huge interval of masses and angular momenta. Note that there are no fitting parameters in the formulae, and the result is expressed via fundamental constants only. Proceeding from these facts one may come to the following cosmogonic conclusion [4,7]: the observed cosmic objects have originated as a result of the evolution of products of the decay of superhadrons with a Regge-like spin. The observed angular momentum of celestial bodies and their systems is the result of conservation of superhadron spins.

Let us make some remarks concerning the dependence of $\mathcal{J}$ on m. The obtained dependence for galaxies is in a good agreement with the results of Genkin and Genkina [17], who also have obtained the 3/2 dependence for galaxies basing on a large amount of statistical material. Other authors are inclined to believe that the exponent for galaxies in the dependence $\mathcal{J} \sim m^{\gamma}$ is $\gamma = 5/3$ or 7/4 and even 2 (see refs. [17-22]). The effect of selection at observational data processing is sure to play an important role here.

Regardless of the above fact, the following two circumstances show evidence for our choice:

First, unlike all other approaches, the hypothesis of superhadrons predicts not only the value of the exponent but also the absolute value of the angular momentum of celestial bodies in a huge interval of masses and momenta. In addition, in the appropriate formulae (4) and (6), as parameters there occur fundamental constants and not arbitrary fitting parameters used in other semiempirical approaches.

Second, the indirect but significant proof of the correctness of our choice of $\gamma = 3/2$ (for galaxies and their systems) and $\gamma = 4/3$ (for stars and planets) is the fact, that basing on the formulae (4) and (6) one may quite naturally obtain the known relations for limiting masses of the Universe and stars as well as new relations for limiting angular momenta expressed via definite combinations of classical and quantum fundamental constants. The next section deals with these relations.

4. Angular Momenta of Celestial Bodies and Fundamental Constants

One of the problems that has been for a long time attracting the attention of scientists, is the problem of establishing the relation between the physics of micro- and megaworld. One of the reasons of causing a special interest to this problem are the well known numerical coincidences between different combinations of cosmological and atomic quantities. These relations connect the gravitational constant, Hubble's constant, the velocity of light, the mass and charge of elementary particles and Planck's constant.

In the present section it will be shown, how, making use of the Regge formulae (4) and (6) for angular momenta, one may advance in the understanding and interpretation of known relations, obtain a number of new ones and express limiting

values of angular momenta of stars and Universe via fundamental constants G, c, m_p and $\hbar$ (see below, the formulae (10)-(16)).

Among cosmological relations the Chandrasekhar formula for the limiting mass of stars and the analogous formula for the mass of the Universe, sometimes termed the Eddington-Dirac formula (see e.g. [23,24]), are of special importance. The simplest deduction of these relations is based on the requirement of the equality of the gravitational energy of the particle-fermion and its degeneracy energy in the ultrarelativistic limit

$$\frac{Gmm_p}{r} = pc \qquad (8)$$

where m and m_p are the mass of the object and fermion, respectively, r is the object radius, p is the Fermi momentum which should be set equal to $p \approx \frac{\hbar}{d}$, where d is the mean distance between fermions.

For the spherical (three-dimensional) configuration the radius is expressed through the number of nucleons and the distance between them as follows: $r = \left(\frac{m}{m_p}\right)^{1/3} d$. Substituting the values of r and p into (8), we obtain after the reduction by d

$$\frac{Gmm_p}{\left(\frac{m}{m_p}\right)^{1/3}} = \hbar c \qquad (9)$$

Solving this equation with respect to m, we obtain the known Chandrasekhar expression for the limiting mass of a typical star (to within the factor of the order of unit):*

* The more exact expression for the limiting mass obtained by Chandrasekhar by means of the theory of inner structure of stars, has the form

$$m_{ch} = m_p \left(\frac{\hbar c}{Gm_p^2}\right)^{3/2} \frac{3.10}{\mu_e^2} = \frac{5.75}{\mu_e^2} m_\odot$$

where μ_e is the number of free electrons per nucleon.

$$m_{\odot} = m_p \left(\frac{\hbar c}{G m_p^2}\right)^{3/2} \qquad (10)$$

For the plane (two-dimensional) configuration the radius is expressed through the number of nucleons $\frac{m}{m_p}$ and the mean distance d as follows: $r = \left(\frac{m}{m_p}\right)^{1/2} d$. Substituting this value into (8), we find after similar simple calculations the Eddington-Dirac formula:

$$m_u = m_p \left(\frac{\hbar c}{G m_p^2}\right)^2 \qquad (11)$$

These two deductions may be united if we note that in the general case $r = \left(\frac{m}{m_p}\right)^{1/n} d$, where n=2 and 3 for the plane and three-dimensional case, respectively. Substituting this value of into (8), we find after elementary calculations:

$$m = m_p \left(\frac{\hbar c}{G m_p^2}\right)^{\frac{n}{n-1}} \qquad (12)$$

From this at n=2 follows the Eddington-Dirac formula, and at n=3 the Chandrasekhar formula.

These relations may be obtained in a principally new way using the generalized Regge formula for the angular momentum (3). Note that the relation (3) by its nature is quantum-mechanical. On the other hand, using the classical constants G and c , one may express the angular momentum in the form *

$$J = \frac{G m^2}{c} \qquad (13)$$

* This follows from dimensional considerations. On the other hand, if we put $v=c$, $r=\frac{Gm}{c^2}$ (the Schwartzschield gravitational radius) into eq. $J=mvr$, we obtain (13). Note also that the momentum (13) possesses an extremal property in the sense that it is the maximum angular momentum, at which Kerr's solution of the Einstein eqs. still makes sense.

Equating the quantum and classical relations (3) and (13)

$$\hbar \left(\frac{m}{m_p}\right)^{1+1/n} = \frac{G m^2}{c} \qquad (14)$$

we obtain from the solution of this equation for m the result $m = m_p \left(\frac{\hbar c}{G m_p^2}\right)^{\frac{n}{n-1}}$, which coincides with (12). Thus we can state that the formula (4) along with (13) results in the Eddington-Dirac relation and (6) along with (13) - to the Chandrasekhar relation. However, it is now possible to obtain relations for the limiting angular momenta as well. Substituting the Chandrasekhar formula (10) into our formula (6) for stars we obtain

$$J_{\odot} = \hbar \left(\frac{\hbar c}{G m_p^2}\right)^2 \qquad (15)$$

Here the limiting value of the star's angular momentum is expressed via well known dimensionless combination of fundamental constants and Planck's constant. The substitution of numerical values of constants gives a quantity of the order $J_{\odot} \approx 10^{50}$ g cm^2 s^{-1}, which may be compared with the data on rotational momenta from table II.

In much the same way one may obtain relations for the angular momentum of the Universe, substituting the Eddington formula (11) into our formula (4):

$$J_u = \hbar \left(\frac{\hbar c}{G m_p^2}\right)^3 \qquad (16)$$

The results obtained allow an interesting geometrical interpretation.

On the $\log J/\log m$ plane (fig.3) the point of intersection of the straight lines $J = \hbar \left(\frac{m}{m_p}\right)^{4/3}$ and $J = \frac{G m^2}{c}$ has the following coordinates: the coordinate along the m-axis is given by the Chandrasekhar formula (10), and the coordinate along the J-axis by the formula (15) for the limiting angular momentum of star.

Similarly, the intersection of straight lines $\mathcal{J}=\hbar\left(\frac{m}{m_p}\right)^{3/2}$ and $\mathcal{J}=\frac{Gm^2}{c}$ occurs at the point, whose mass coordinate coincides with the mass of the Universe given by the Eddington-Dirac formula (11), and the coordinate along the J-axis by the formula (18) that expresses the angular momentum of the Universe via fundamental constants.

Unconsciously there arises a question: isn't the proposed approach a fragment of a deeper theory, that radically unifies gravitation with particle physics ? Regardless of this fact, the simplicity and elegance of the results presented in fig.3 may be considered a weighty proof of the validity of the super-hadron hypothesis.

The possible angular momentum of the Universe may be expressed as well via its parameters, the mass m_u and the radius r_u and classical fundamental constants G and c by means of the so-called generalized dimensional analysis introduced by Huntley.

Making use of the anisotropy of the problem due to the presence of a preferred axis (rotation axis), we obtain, basing on the method proposed in [25]:

$$\mathcal{J}_u = G^{-1/2} m_u^{1/2} c^2 r_u^{3/2} \qquad (17)$$

or identically:

$$\mathcal{J}_u = \frac{Gm_u^2}{c}\left(\frac{c^2 r_u}{Gm_u}\right)^{3/2} \qquad (18)$$

Note that a similar result was obtained in a quite different way in [26] just on the basis of the solution of equations of general relativity theory with consideration of spin (Einstein-Cartan equations).

In the formula (18) the quantity in parenthesis, the ratio of the radius of the Universe to the gravitational radius, may be set equal to unit as a result of Mach's principle:*

$$\frac{Gm_u}{c^2 r_u} = 1 \qquad (19)$$

From (18) and (19) it follows that the angular momentum of the Universe may be presented in two different forms:

$$\mathcal{J}_u = \frac{Gm_u^2}{c} \qquad (20)$$

and

$$\mathcal{J}_u = G^{1/2} m_u^{3/2} r_u^{1/2} \qquad (21)$$

As is shown above, equating the relation (4), extrapolated for the whole Universe, to the formula (20)

$$\hbar\left(\frac{m_u}{m_p}\right)^{3/2} = \frac{Gm_u^2}{c} \qquad (22)$$

we obtain the Eddington-Dirac formula for the mass of the Universe:

$$m_u = m_p\left(\frac{\hbar c}{Gm_p^2}\right)^2 \qquad (23)$$

*Mach's principle results in equality $mc^2 = \frac{Gm_u m}{r}$, which implies that the particle mass m owes its origin to gravitational interaction with the rest part of the Universe. From here, as it is easy to see, follows equality (19).

If we equate (4) to (21)

$$\hbar\left(\frac{m_u}{m_p}\right)^{3/2} = G^{1/2}\, m_u^{3/2}\, r_u^{1/2}$$

we may easily obtain the relation between the radius of the Universe and the Compton wavelength of a proton

$$r_u = \lambda_p \frac{\hbar c}{G m_p^2} \quad * \qquad (24)$$

Thus, the basic parameters of the Universe, the radius, mass and angular momentum are proportional, respectively to the first, second and third degrees of dimensionless combination $\frac{\hbar c}{G m_p^2}$ of fundamental constants:

$$r_u = \lambda_p \left(\frac{\hbar c}{G m_p^2}\right)$$

$$m_u = m_p \left(\frac{\hbar c}{G m_p^2}\right)^2 \qquad (26)$$

$$J_u = \hbar \left(\frac{\hbar c}{G m_p^2}\right)^3$$

It is interesting to note that these relations satisfy the condition $r_u = \frac{J_u}{m_u c}$, that expresses "the Compton wavelength" of the Universe via its spin and mass.

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* If we exclude from this equality the radius r_u by defining it through the Hubble constant $r_u = c/H_0$, we shall come to the remarkable cosmological relation for the mass of the elementary particle: $m_p = \left(\frac{\hbar^2 H_0}{G c}\right)^{1/3}$ (25)
Earlier the relation of this type was deduced "by the method of tests and errors" by J.Stewart [27]: $m_e = \alpha\left(\frac{\hbar^2 H_0}{G c}\right)^{1/3}$ where m_e is the electron mass, $\alpha = \frac{e^2}{\hbar c} = \frac{1}{137}$ is the fine structure constant.

Table 1

Masses and angular momenta (spins) of clusters of galaxies, spiral galaxies and globular clusters *

Object	Mass, m (g)	Angular momentum J (g cm^2 s^{-1}) Observed	Computed from (4)
Clusters of galaxies			
Local Supercluster	5×10^{48}	6×10^{81}	5.4×10^{81}
A 1656 (Coma)	1×10^{47}	0.9×10^{80}	1.2×10^{80}
A 2199	2×10^{47}	2.2×10^{79}	1.5×10^{79}
Virgo	4×10^{46}	2.6×10^{78}	3.9×10^{78}
Shakhbazian I	2.4×10^{46}	1.4×10^{77}	1.8×10^{78}
Spiral Galaxies			
NGC 0224 (M31)	6.78×10^{44}	2.36×10^{75}	3.58×10^{75}
Our Galaxy	3.38×10^{44}	1.92×10^{75}	3.02×10^{75}
NGC 3031 (M81)	2.78×10^{44}	1.30×10^{75}	2.26×10^{75}
5005	1.98×10^{44}	6.82×10^{74}	1.36×10^{75}
7331	1.86×10^{44}	6.82×10^{74}	1.24×10^{75}
5055 (M63)	1.31×10^{44}	2.91×10^{74}	7.30×10^{74}
1832	1.11×10^{44}	2.85×10^{74}	5.70×10^{74}
1808	9.55×10^{43}	2.11×10^{74}	4.54×10^{74}
5194 (M51)	9.54×10^{43}	2.48×10^{74}	4.54×10^{74}
0681	7.76×10^{43}	1.67×10^{74}	3.33×10^{74}
6574	8.15×10^{43}	1.18×10^{74}	3.58×10^{74}
1084	4.97×10^{43}	7.44×10^{73}	1.71×10^{74}
3504	2.19×10^{43}	1.61×10^{73}	4.99×10^{73}
Globular Clusters			
NGC 104(47 Tuc)	2.1×10^{39}	1.3×10^{65}	1.7×10^{67}
362	3.6×10^{38}	2.4×10^{64}	3.3×10^{66}

* For clusters of galaxies and globular clusters the observed spin is estimated from the data on velocity dispersion and linear size. The data from [13] on clusters of galaxies are used. Masses and spins of spiral galaxies are taken from [14]

Table 2

Masses and angular momenta (spins) of stars and planets *

Object	Mass m (g)	Angular momentum J (g cm^2 s^{-1}) Observed	Computed from (6)
Main Sequence Stars			
O5	7.92×10^{34}	7.07×10^{53}	1.81×10^{51}
B0	3.54×10^{34}	1.46×10^{53}	6.17×10^{50}
B5	1.28×10^{34}	3.12×10^{52}	1.60×10^{50}
A0	6.44×10^{33}	8.56×10^{51}	6.36×10^{49}
A5	4.16×10^{33}	3.01×10^{51}	3.55×10^{49}
F0	3.38×10^{33}	1.27×10^{51}	2.70×10^{49}
F5	2.56×10^{33}	2.57×10^{50}	1.85×10^{49}
G0	2.18×10^{33}	2.54×10^{49}	1.50×10^{49}
Solar System	1.99×10^{33}	3.15×10^{50}	1.33×10^{49}
Sun (G2)	1.99×10^{33}	1.63×10^{48}	1.33×10^{49}
K0	1.54×10^{32}	$< 3.65\times10^{48}$	9.42×10^{48}
M0	9.31×10^{32}	$< 1.63\times10^{48}$	4.83×10^{48}
Planets			
Jupiter	1.90×10^{30}	4.32×10^{45}	1.25×10^{45}
Saturn	5.68×10^{29}	7.68×10^{44}	2.50×10^{44}
Uranus	8.72×10^{28}	2.09×10^{43}	2.05×10^{43}
Neptune	1.02×10^{29}	2.10×10^{43}	2.53×10^{43}
Earth/Moon	5.97×10^{27}	2.81×10^{41}	5.75×10^{41}
Earth	5.97×10^{27}	5.91×10^{40}	5.75×10^{41}
Pluto	6.6×10^{26}	2.3×10^{38}	3.05×10^{40}
Venus	4.87×10^{27}	1.8×10^{38}	4.38×10^{41}
Mercury	3.33×10^{26}	6.5×10^{36}	1.23×10^{40}

* Observational data are taken from [15,16]. The total angular momentum of satellites in the systems of Jupiter, Saturn and Uranus is much smaller than the spin momentum of the central planet. In the Jupiter system the total orbital moment of satellite is 4.24×10^{43} g cm^2 s^{-1}, of Saturn - 9.6×10^{42} g cm^2 s^{-1} and of Uranus - 0.7×10^{41} g cm^2 s^{-1}.

In conclusion of this section, for convenience let us gather in table III the values of limiting masses and angular momenta expresses via fundamental constants.

Table 3

Object	Mass, m	Spin, J
Universe	$m_p\left(\frac{\hbar c}{G m_p^2}\right)^2$	$\hbar\left(\frac{\hbar c}{G m_p^2}\right)^3$
Stars	$m_p\left(\frac{\hbar c}{G m_p^2}\right)^{3/2}$	$\hbar\left(\frac{\hbar c}{G m_p^2}\right)^2$

The structure of these relations points to the fact that there is a deep interconnection between quantum-mechanical and macroscopic gravitational phenomena.

5. Origin of Cosmic Magnetic Fields

The problem of the origin and evolution of large-scale magnetic fields in the Universe is one of the main problems of astrophysics [28,29]. Large-scale magnetic fields play an important role in the generation of the emission of radio galaxies, Seyfert and Markarian galaxies, quasars and other nonthermal sources, emitting due to the magnetic bremsstrahlung (synchrotron radiation) mechanism. Cosmic magnetic fields are responsible for the isotropy of cosmic rays and, possibly, for the stability of spiral arms of galaxies.

Several theories of the origin of galactic magnetic fields have been proposed based on the condensation cosmogonic hypothesis, but none of them can be considered satisfactory due to difficulties of principle character.

In the present section, following ref. [6], we discuss the hypothesis of the origin of galaxies due to the decay of superhadrons with the Regge spin, which allows to quite naturally reveal the source of the origin of magnetic fields of galactic scale. As it will be shown below, the configuration and value of the galactic magnetic field may be explained by the fact that the presently observed magnetic field is the relict of the dipole magnetic field of the protogalaxy-superhadron.

As is known, most astrophysical objects - planets, stars, galaxies and intergalactic space - possess magnetic fields. The magnitude of the magnetic field strength in various objects varies in a wide range. For example, the magnetic field strength of Earth is 0.6 G at poles and 0.3 G at the equator. On the surface of white dwarfs there exist fields of the strength 10^6 G, and pulsars possibly possess fields of the order 10^{12} G. The magnetic fields of the majority of the above objects are approximated by the point dipole field placed nearly in the center of the object with the direction of the equivalent dipole axis, as a rule, coinciding (or forming a small angle) with the rotation axis of the object. For example, the magnetic field of Earth is well described by the point dipole field with the magnetic moment $\mu_{\oplus} = 8.1\times10^{25}$ G cm^3, placed in the center of Earth and forming an angle 11.4° with its rotation axis. The strength of the galactic interstellar

magnetic field in the vicinity of the Solar system is of the order 6×10^{-6} G, and in the intergalactic space there is, apparently, a field of the strength 10^{-9} G. In our Galaxy the magnetic field appears during the measurements of the polarization of light of stars, rotation of the polarization plane of polarized radiosources and the Zeeman splitting of the line $\lambda = 21$ cm. Proceeding from the observational data on the configuration of magnetic fields of some active galaxies, in particular, of the exploding galaxy M 82, a hypothesis of the existence of magnetic dipoles of galactic scale has been proposed in ref. [30]. The structure of magnetic fields of some "tailed" radiosources, e.g. 3C 129 and NGC 1265, moving in clusters of galaxies, also shows evidence for the existence of galactic magnetic dipoles.

Where do these magnetic fields come from ? It is quite natural to assume within the framework of the developed approach, that the presently observed galactic magnetic field is a remnant of the primeval field of the protogalaxy-superhadron in much the same way as the angular momentum of the galaxy is the remnant of the superhadron's spin. Proceeding from the correspondence to the classical electrodynamics and quantum theory of particles with a spin, one may assume that there is a direct proportionality between magnetic and mechanical moments of the superhadron with the mass m

$$\mu = \frac{Q^*}{mc} J \qquad (27)$$

Here Q^* is some effective charge. Theoretical calculation of the charge at present seems impossible. However, one may use indirect considerations for the estimate of the order of the magnitude of magnetic moment. Let us assume that the effective charge for superheavy hadrons is determined, in the main, by gravitational effects. Then the dimensional analysis results in the value

$$Q^* = \sqrt{G}\, m \qquad (28)$$

where $G = 6.67 \times 10^{-8}$ cm^3 g^{-1} s^{-2} is the gravitational constant, and m is the superhadron mass.* Making in (27) the substitution $Q^* \to \sqrt{G}\, m$ we obtain the known formula [31]:

$$\mu = \frac{\sqrt{G}}{c} J \qquad (30)$$

In the CGS system, when the magnetic moment is measured in G cm^3, and the angular momentum in g cm^2 s^{-1}, this equality may be presented as

$$\mu\ (\mathrm{G\ cm^3}) = 8.6 \times 10^{-15} J\ (\mathrm{g\ cm^2\ s^{-1}}) \qquad (31)$$

It is known that the direct laboratory experiments with rotating bodies of different materials have not confirmed this relation. The observed magnetization proved to be much less than that predicted on the basis of the relation (30). However, it is not excluded that while the ordinary atomic-molecular

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* If we measure the charge in Coulombs and the mass in grams, it will follow from (28)

$$Q^*(\mathrm{Coulomb}) = 8.6 \times 10^{-14}\ m\ (\mathrm{g}) \qquad (29)$$

For example, for our Galaxy $Q^*_G = 3 \times 10^{31}$ Coulomb, for Sun $Q^*_\odot = 1.7 \times 10^{19}$ Coulomb, for Earth $Q^*_\oplus = 5 \times 10^{14}$ Coulomb. As is known, even electrically neutral bodies may nevertheless possess a nonzero effective charge. For example, if the positive charges in the electrically neutral sphere are concentrated near the center, and an equal quantity of negative charges is distributed on the surface, the magnetism arising due to the sphere rotation will correspond to the negative effective charge.

matter does not obey the relation (30), the macroscopic quantities of hadronic (quark) matter, that compose a superhadron, may possess properties needed to fulfil the relation (30). Note that the magnitude of the charge $\sqrt{G}\, m$ possesses an extreme property in the sense that it plays a special role in Einstein's gravitation theory, being the maximum allowed charge of the black hole in the Kerr-Newman metric, since the mass m, the spin J and the charge Q of the black hole should satisfy the condition

$$Q^2 G m^2 + J^2 c^2 \leq G^2 m^4 \qquad (32)$$

Here is another indirect foundation for the relation (30). In accord with the classical electrodynamics, the magnetized sphere of the radius r with the dipole moment μ possesses magnetic energy of the order μ^2/r^3. The kinetic energy of the rotation of the same sphere, by order of magnitude is equal to J^2/mr^2, where m is the mass, and J is the angular momentum of the magnetized sphere. As is easy to see, the magnetic energy is equal to the kinetic energy of rotation provided $\mu = \sqrt{\frac{r}{m}}\, J$. For the black hole, whose radius is equal to the gravitational one, $r = \frac{Gm}{c^2}$, whence the formula (30) follows.

It has long been noticed that the relation (30) is fulfilled for some astrophysical objects (for example, for Earth, Jupiter, Sun and some stars). Below, in table 4, the observed values of dipole magnetic moments of planets are compared with predictions of (30).

Table 4. Spins and Magnetic Moments of Planets *

Planet	Spin ($g\ cm^2\ s^{-1}$)	Magnetic moment ($G\ cm^3$) Observed	Theoretical
Mercury	6.5×10^{36}	2.4×10^{22}	5.6×10^{22}
Earth	5.9×10^{40}	8.1×10^{25}	5.1×10^{26}
Jupiter	4.3×10^{45}	1.6×10^{30}	3.7×10^{31}
Saturn	7.7×10^{44}	2.2×10^{29}	6.6×10^{30}

It is seen from table 4 that the proportionality between the magnetic moment and the spin of planets is approximately satisfied, but the proportionality constant is a little smaller than the quantity $\frac{\sqrt{G}}{c} = 8.6\times10^{-15}$ CGS.

In the case of galaxies the observational data on the magnitude and configuration of magnetic fields are unfortunately too scarce to draw up a table similar to table 4. For our Galaxy, whose spin is $J_G = 2\times10^{75}$ g cm^2 s^{-1}, according to (30). we obtain the following value for the dipole magnetic moment: $\mu_G = 1.7\times10^{61}$ G cm^3 which for the strength of the field near the Solar system ($r_o \approx 2.7\times10^{22}$ cm) results in the value $H = \mu_G / r_o^3 \approx 10^{-6}$ G that agrees with the observed value of the field.

Making use of the dimensional analysis one can estimate the magnitude of the possible high multipole moments of the protogalaxy-superhadron. The dimensions of the K-th electric $\varepsilon^{(K)}$ and magnetic $\mu^{(K)}$ multiploe moments are

* Observational data are taken from ref. [32].

$$[\varepsilon^{(K)}] = QL^K$$
$$[\mu^{(K)}] = \mu L^{K-1} \qquad (33)$$

where L is the dimension of length, Q - of charge and μ - of magnetic dipole momentum $\mu = [\mu^{(1)}]$. In virtue of the law of the conservation of parity, the elementary particle may possess even electrical ($K = 0,2,4,...$) and odd magnetic ($K = 1,3,5,...$) multipole moments.

By means of the dimensional analysis we obtain the following formula for magnetic and electric multipole moments

$$\left.\begin{matrix}\mu^{(K)} \\ \varepsilon^{(K)}\end{matrix}\right\} = \sqrt{G}\, m \left(\frac{J}{mc}\right)^K \quad \begin{matrix}K = 1,3,5,... \\ K = 0,2,4,...\end{matrix} \qquad (34)$$

From here the generalization of the formula (30) follows for magnetic multipoles:

$$\mu^{(K)} = \frac{\sqrt{G}}{c} J \left(\frac{J}{mc}\right)^{K-1} \quad K = 1,3,5,... \qquad (35)$$

Let us estimate, as an example, the possible octupole ($K=3$) magnetic moment for our Galaxy:

$$\mu_G^{(3)} = \frac{\sqrt{G}\, J_G^3}{m_G^2\, c^3} \approx 10^{102} \text{ G cm}^5 \qquad (36)$$

It is easy to see that the octupole moment gives a vanishingly small contribution in the vicinity of the Solar system

$$H^{(okm)} = \mu_G^{(3)} / r_o^5 \approx 10^{-11} \text{ G} \qquad (37)$$

and, thus, one may neglect it with respect to the contribution of dipole. However, the contribution of the octupole may be compared with that of the dipole at distances of the order $r_o \approx Kpc$. In immediate proximity to the galaxy nucleus the field should have a fairly complex structure determined by the contribution of higher multipole moments.

In active galaxies the structure of magnetic field may be studied by measuring the polarization of nonthermal radio emission. Thus has been revealed, for example, the dipole structure of the magnetic field of the giant elliptic galaxy NGC 1265 with a "radiotail" of the length of the order of one light year, which is, apparently, the result of the ejection of matter, from the active nucleus of the galaxy, interacting with the intergalactic medium in the cluster through which the galaxy moves at a velocity of the order 2000 km s^{-1}.

In ordinary nonactive galaxies the basic method of revealing the magnetic field structure consists in the measurement of the star light polarization. This method was used to investigate, along with our Galaxy, the magnetic fields of Magellanic Clouds.

It has been found that LMC and SMC are immersed in a common large-scale "Panmagellanic" magnetic field. The origin of this field is apparently connected with the protosystem, from which, as a result of a process of explosive character, LMC and SMC have originated.

It is known that a dipole type magnetic field has been observed around the superassociation 30 Doradus, which apparently plays the role of the galactic nucleus. This magnetic field is surely of a primary character, since no known dynamo-mechanism is able to generate the observed large-scale field. ...ng into account the mechanism of the origin of magnetism ...smic objects due to the rotation, we have proposed in

ref.[6] to try to find the rotation of 30 Doradus. In a recent paper [33] the authers reported the discovery of independent rotation of a supercluster, or otherwise, a giant H II region in the galaxy NGC 2814.

In conclusion of this section note that unlike the angular momentum, which is conserved in the process of evolution, the magnetic moment of the decaying particle is conserved not completely. However, due to high conductivity and considerable self-induction of the evolution products, the original magnetic field attenuates very slowly, and the relaxation time (of the order 10^{30} years) considerably surpasses the age of the Galaxy. Thus, during the lifetime of the Galaxy comparatively small changes may occur in its magnetic field connected with the motions of the ionized interstellar matter.

Therefore, one may, in some sense, speak of the quasiconservation of the superhadron dipole magnetic moment in the process of evolution of its decay products. In fig.4 the possible picture of the origin of the topology of magnetic field of a typical spiral galaxy is shown.

A more detailed elaboration of the problem of the origin of cosmic magnetic fields will probably become possible after the construction of a unified theory of gravitation, electromagnetism and strong interactions.

6. Expanding and Rotating Universe

G.Gamow's hot Big Bang hypothesis, which is the concretization of Lemaitre's "Primeval atom" hypothesis, has served as a basis for the construction of a cosmological model - the expanding Universe - resting on a number of observational confirmations. However, there are observational facts, which give rise to well-founded doubts about the validity of some Big Bang concepts in its present-day formulation and indicate the necessity in its substantial modification. The established situation is characterized by S.Weinberg, one of the ardent popularizers of the Big Bang model [34]: "I can't get rid of the feeling of unreality when writing of the first three minutes as if we really know what we are speaking about".

Consider the basic arguments that testify to and against the Big Bang model. As a proof of its validity the supporters of the Big Bang model usually refer to the following two facts:

A . All the known methods of definition of the age of the oldest stars and globular clusters agree with the age of the Universe, which, according to relativistic cosmological models, in the order of its magnitude is equal to the inverse value of Hubble's constant: $H_0^{-1} = 2x10^{10}$ years (see e.g. ref. [35]).

B . The recent discovery of the background radio radiation with $T \approx 2.7^\circ$ K, earlier predicted in the hot Big Bang model, is considered as another striking demonstration of the validity of the model. It should be however noted that more detailed spectral investigations are needed before making conclusions on the relation of the observed submillimeter background to the considered model. Besides, the variation of the value of $T \approx 2.7^\circ$ K for ten times, both increase or decrease, practically does not affect the amount of primeval helium [36]. Thus, there arises a quite legitimate question: is the predicted 30% abundance of helium not an amazing but accidental coincidence ?

Along with this there are two serious arguments against the Big Bang model, at least in its orthodox formulation:

1. The Big Bang cosmology does not explain the origin of the Universe structure composed of galaxies and their clusters. There is no natural explanation of the mechanism of transition from the initial homogeneous state to the actually observed inhomogeneously distributed objects [37,38]. Most probably the Universe has already possessed a lumpy structure at a relatively early stage of evolution and has not been an isotropic and homogeneous gruel termed as "ylem" in the Big Bang hypothesis [39].

2. The problem of the rotation of galaxies, their clusters and superclusters remains unsolved in the framework of the Big Bang hypothesis. At the same time the observed rotation of cosmic bodies cosmologically is as important as the background radio radiation. The discovery of the rotation of the Universe as a whole would have been the most serious argument against the present formulation of the Big Bang hypothesis.

In the present section we consider the problem of the possible rotation of astronomical Universe as a whole and discuss the quantitative prediction for its angular momentum.

According to eq. (4), extrapolated for the whole Universe, its angular momentum is

$$J_u = \hbar \left(\frac{m_u}{m_p}\right)^{3/2} \qquad (38)$$

Substituting the presently accepted value of the mass of the observed Universe $m_u \approx 10^{56}$ g into (38), we obtain [5] (see also [40])

$$\mathcal{J}_u \approx 10^{120}\hbar \ ^{*} \qquad (39)$$

or, a little more exact [7]:

$$\mathcal{J}_u \approx 5 \times 10^{92} \text{ g cm}^2 \text{ s}^{-1} \qquad (40)$$

Note that the extrapolation of the relation of the form $\mathcal{J} \sim m^2$ considered in [18-20] will give $\mathcal{J}_u \approx 10^{97}$ g cm^2 s^{-1}, which is five orders higher than our value (40), and exceeds even the constraint imposed by the performed below classical consideration, which is unacceptable (see below).

Basing on the obtained prediction (40) for the rotational momentum of the Universe, let us estimate its angular velocity. If in the relation

$$\mathcal{J}_u = m_u \omega_u \tau_u^2 \qquad (41)$$

we take $\tau_u \approx 1.86 \times 10^{28}$ cm, $m_u \approx 10^{56}$ g, and use the value of (40) for $\mathcal{J}_u$ we obtain the following estimate for the angular velocity of the Universe:

$$\omega_u \approx 1.6 \times 10^{-20} \text{ rad s}^{-1} \qquad (42)$$

or

$$\omega_u \approx 5 \times 10^{-13} \text{ rad year}^{-1} \qquad (43)$$

If we take the age of the Universe equal to 2×10^{10} years, the angular velocity of rotation in this unit of measurement of

* If we substitute this quantity for $\mathcal{J}_u$ and the value given by the Eddington number $m_u = 10^{80} m_p$ into the expression for "the Compton wavelength of the Universe" $\tau_u = \mathcal{J}_u / m_u c$ we obtain the value τ_u expressed via the Compton wavelength of proton $\tau_u = 10^{40} \lambda_p$ (cf discussion of formula (26)).

time is

$$\omega_u \approx 10^{-2} \text{ rad (age of the Universe)}^{-1} \qquad (44)$$

i.e. for all its lifetime the Universe has managed to do a revolution of 10^{-2} rad. The time for one complete revolution

$$T_u = \frac{2\pi}{\omega_u} \qquad (45)$$

is 10^{13} years, which is approximately 3 orders greater than the age of the Universe, a huge time interval even in cosmological scale.

Note that in recent paper [41] the author has presented observational data suggesting the possible rotation of the Universe (see, however, ref. [42]). They are based on the study of the geometric shape of magnetic fields in radio galaxies, and the obtained value of the angular velocity $\omega_u \approx$ $\approx 10^{-13}$ rad year^{-1} does not contradict our prediction (43).

Of certain interest is the estimate of the maximum possible velocity of rotation of the Universe on the basis of classical mechanics laws. There are, at least, three independent estimation methods leading to the same result:

1. It follows from the Newton theory, that the rotating Universe not to be disrupted, the condition

$$\omega_{max}^2 \tau \leqslant \frac{Gm}{\tau^2} \qquad (46)$$

should be fulfilled, which implies that the centrifugal acceleration should be smaller than the gravitational one. From this follows a constraint on the maximum angular velocity of the Universe:

$$\omega_{max} \leqslant 1 \times 10^{-18} \text{ rad s}^{-1} \qquad (47)$$

2. The second independent constraint follows from the consideration of Hubble's relation $v = H_0 \tau$ with the condition $v \leqslant c$, dictated by the special theory of relativity. Hence

$$\omega_{max} \leqslant \frac{c}{\tau_u} \leqslant H_0 \qquad (48)$$

For the presently accepted value of $H_0 = 50$ km s^{-1} Mps^{-1} = 1.6 x 10^{-18} s^{-1} we obtain the constraint

$$\omega_{max} \leqslant 1.6 \times 10^{-18} \text{ rad s}^{-1} \qquad (49)$$

3. The third method is based on the use of the classical formula (17) for the angular momentum of the Universe, which results in the estimate $J_u \approx 8.84 \times 10^{94}$ g cm^2 s^{-1}. The use of this value of the momentum results in the value

$$\omega_{max} \leqslant 2.5 \times 10^{-18} \text{ rad s}^{-1} \qquad (50)$$

All three classical constraints on the maximum possible angular velocity of the Universe are in a good agreement with each other and are two orders of magnitude greater than the value $\omega_u = 1.6 \times 10^{-20}$ rad s^{-1} presented in (42) and obtained due to the use of the value $J_u = 5 \times 10^{92}$ g cm^2 s^{-1} that results from the formula (38) which is quantum-mechanical in its nature.

In some sense this implies that the Universe rotates slowly. Mach's principle, forbidding the rotation of the Universe, is violated but not in a maximum possible way.

Note also that the predicted velocity of rotation (42) does not contradict the constraint imposed by the search for the quadrupole anisotropy of the microwave background [43].

7. Conclusion

The proposed approach allows one, in a self-consistent manner, to theoretically obtain reasonable values for rotational momenta of cosmic objects, beginning with planets and ending with the astronomical Universe as a whole, with an extremely wide mass interval, corresponding to 30 orders of magnitude (from 10^{26} g for planets to 10^{56} g for the Universe), being overlapped. The appropriate interval for angular momenta overlaps 56 orders of magnitude (from 10^{36} to 10^{92} g cm^{2}s^{-1}). It should be emphasized that this is achieved without any arbitrary parameters, using the formulae containing as parameters the fundamental constants of nature only.

The basic difference between the approach based on the superhadron hypothesis, and other cosmological theories is that our approach includes quite naturally the quantum-mechanical parameters $\hbar$ and m_p along with the classical parameters G and c. Apparently, this condition should necessarily be satisfied in any future more fundamental theory of the origin of celestial bodies. It is quite possible that this future theory will be a substantially quantum theory, unifying strong interactions with electromagnetism and gravitation. In our opinion, one should understand Ambartsumian's well known statement about the need of new physics for a more detailed explanation of the origin and evolution of cosmic objects just in this sense.

The arguments presented here and in [4-8] make probable the possibility of the cosmic objects origin due to the decay of macroscopic quantum bodies such as superhadrons. The formation of galaxies from the viewpoint of cosmological hadronic fireball was considered by R.F.Sistero [44]. In ref. [45], basing on other arguments, the author has discussed the possibility of the fact that sometime in the past the Universe has had an extremely anisotropic planar configuration, which is in agreement with our deduction.

It is easy to see that our approach has some common features both with the Big Bang model and the hierarchical cosmological model advocated by G.de Vaucouleurs [37,38].

At any rate, any further development of the considered approach will help to shed light on this outstanding problem: has the astronomical Universe really originated due to the decay and fragmentation of one superheavy hadron with pancake shape ? Or, in other words, isn't the observed Universe with all the diversity of its structural parts - galaxies, stars, planets and diffuse matter - a relict of one "Primeval hadron" with the pancake shape, mass $10^{80} m_p$ and spin $10^{120}\hbar$?

Figure Captions

Fig. 1 Chew-Frautschi plots for mesons and baryons.

a) Mesonic Regge trajectory

b) Nucleonic and Δ-Regge trajectories.

Fig. 2 The angular momentum-mass distribution for cosmic objects. Straight lines correspond to the Regge-like relations (4) and (6):

$$J = \hbar \left(\frac{m}{m_p}\right)^{4/3} = 5.31 \times 10^4 \, m^{4/3}$$

$$J = \hbar \left(\frac{m}{m_p}\right)^{3/2} = 4.87 \times 10^8 \, m^{3/2}$$

Observational data are taken from [4,7,13-16].

Fig. 3 Three straight lines are drawn on the $\log J / \log m$ plane

$$J = \begin{cases} \dfrac{Gm^2}{c} & \text{I.} \\ \hbar\left(\dfrac{m}{m_p}\right)^{4/3} & \text{II.} \\ \hbar\left(\dfrac{m}{m_p}\right)^{3/2} & \text{III.} \end{cases}$$

The intersection point of I and II has the coordinates

$$\left\{ m_p\left(\frac{\hbar c}{G m_p^2}\right)^{3/2}, \ \hbar\left(\frac{\hbar c}{G m_p^2}\right)^2 \right\}$$

which corresponds to the limiting values of mass and angular momentum of stars. The intersection point of I and III has the coordinates

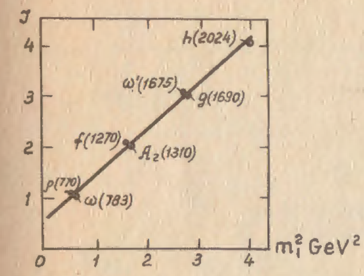
$$\left\{ m_p\left(\frac{\hbar c}{G m_p^2}\right)^2, \ \hbar\left(\frac{\hbar c}{G m_p^2}\right)^3 \right\}$$

corresponding to the mass and angular momentum of the Universe.

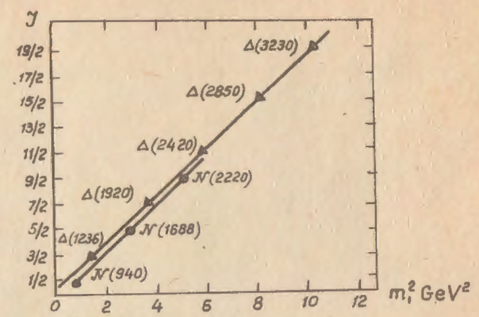
Fig. 4 On the origin of the structure of the magnetic field of spiral galaxies.

a) Dipole magnetic field of superhadron-protogalaxy.

b) The matter ejected due to the superhadron decay, carries with it the magnetic lines of force of the magnetic dipole, that are stretched out along the spiral arms. As a result, there arises a deformed dipole magnetic field of typical spiral galaxy.



a)



b)

Fig. 1

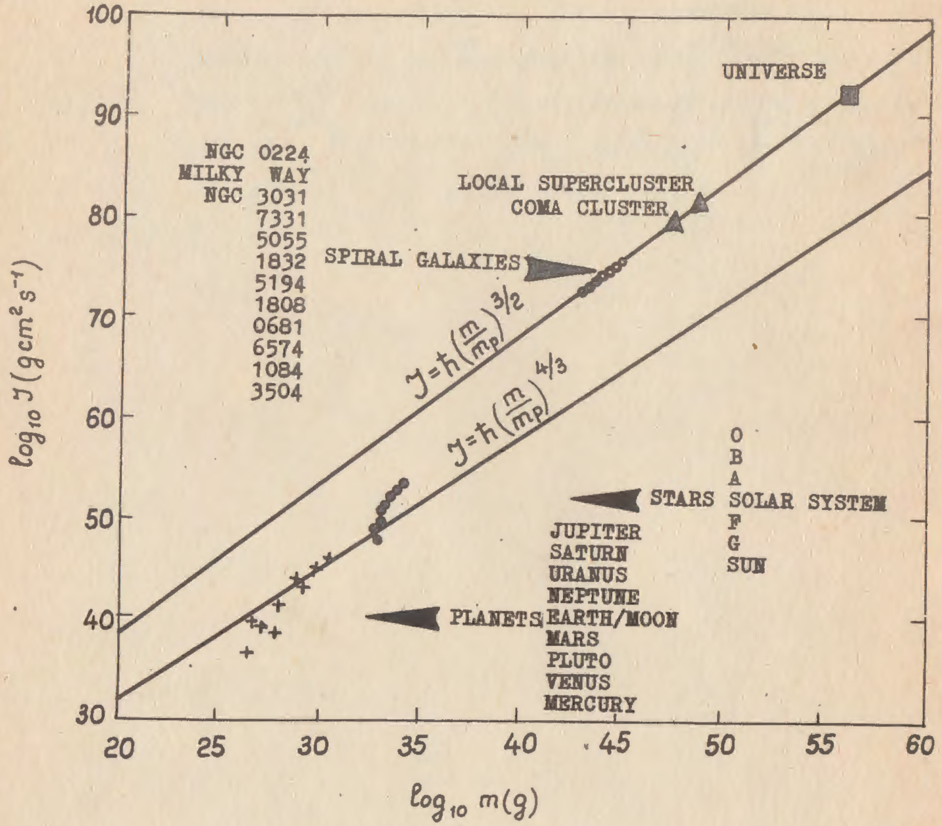

UNIVERSE
LOCAL SUPERCLUSTER
COMA CLUSTER
NGC 0224
MILKY WAY
NGC 3031
7331
5055
1832
5194
1808
0681
6574
1084
3504
SPIRAL GALAXIES
STARS
O
B
A
SOLAR SYSTEM
F
G
SUN
JUPITER
SATURN
URANUS
NEPTUNE
PLANETS
EARTH/MOON
MARS
PLUTO
VENUS
MERCURY
$J = \hbar\left(\frac{m}{m_p}\right)^{3/2}$
$J = \hbar\left(\frac{m}{m_p}\right)^{4/3}$
$\log_{10} J\,(g\,cm^2\,s^{-1})$
$\log_{10} m\,(g)$
100
90
80
70
60
50
40
30
20
25
30
35
40
45
50
55
60

Fig. 2

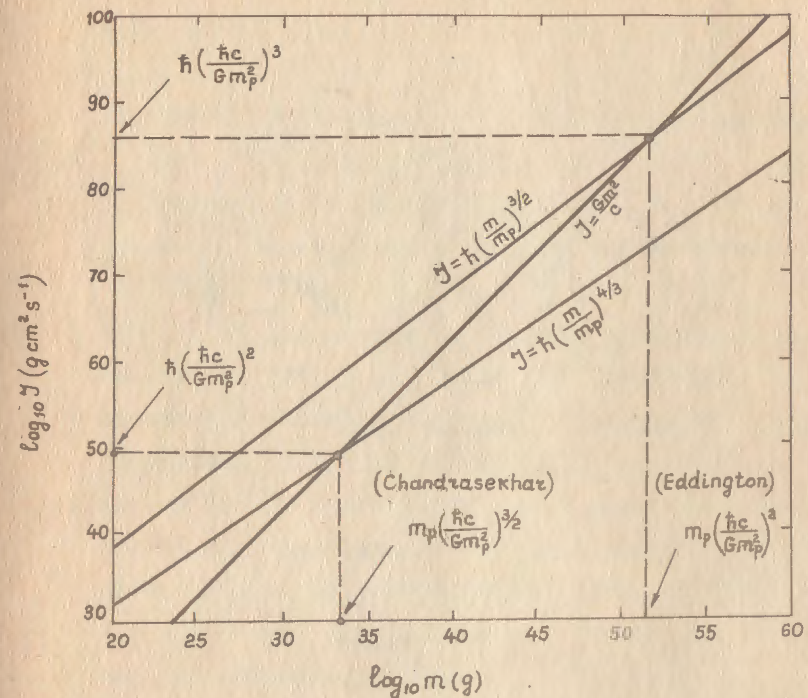

$\hbar\left(\frac{\hbar c}{G m_p^2}\right)^3$
$\hbar\left(\frac{\hbar c}{G m_p^2}\right)^2$
$J = \hbar\left(\frac{m}{m_p}\right)^{3/2}$
$J = \frac{G m^2}{c}$
$J = \hbar\left(\frac{m}{m_p}\right)^{4/3}$
(Chandrasekhar)
$m_p\left(\frac{\hbar c}{G m_p^2}\right)^{3/2}$
(Eddington)
$m_p\left(\frac{\hbar c}{G m_p^2}\right)^2$
$\log_{10} J\,(g\,cm^2\,s^{-1})$
$\log_{10} m\,(g)$
100
90
80
70
60
50
40
30
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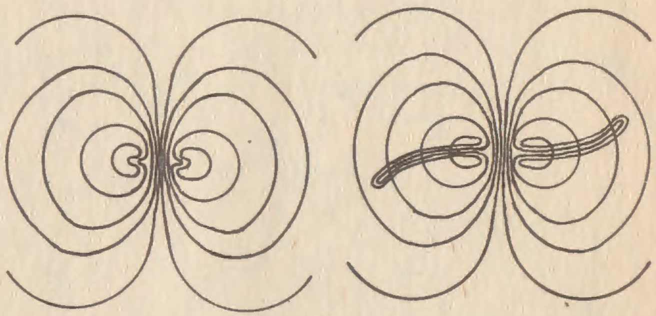
Fig. 3



a) b)

Fig. 4

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