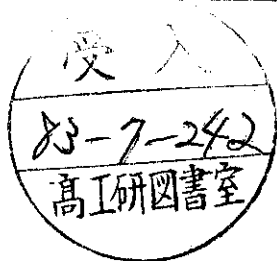


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R.M.MURADIAN

ON THE ROTATION OF ASTRONOMICAL UNIVERSE

ԵՐԵՎԱՆ 1983 ԵՐԵՎԱՆ

Р.М.МУРАДЯН

О ВРАЩЕНИИ АСТРОНОМИЧЕСКОЙ ВСЕЛЕННОЙ

В недавнем сообщении П.Берча [1] утверждается, что Вселенная вращается с угловой скоростью $\omega_u \simeq 10^{-13}$ рад.год $^{-1}$. Этот вывод находится в приближенном согласии с нашим теоретическим предсказанием для углового момента Вселенной $J_u = \hbar \left(\frac{m_u}{m_p}\right)^{3/2}$. В единицах постоянной Планка это предсказание выглядит как "Большое число" $J_u \simeq 10^{120} \hbar$ или в системе СГС $J_u \simeq 5 \times 10^{92} \text{гсм}^2 \text{с}^{-1}$. Это совпадение может рассматриваться как наблюдательное подтверждение нашего подхода, согласно которому вращение космических тел объясняется реджеподобной связью между угловым моментом и массой объекта, по аналогии с физикой элементарных частиц (адронов).

Ереванский физический институт

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ON THE ROTATION OF ASTRONOMICAL UNIVERSE

In a recent letter to "Nature" P.Birch [1] claimed that Universe is rotating with an angular velocity $\omega_u \approx 10^{-13} \text{ rad yr}^{-1}$. This conclusion is in an approximate agreement with our theoretical prediction for the angular momentum of the Universe $J_u = \hbar \left(\frac{m_u}{m_p} \right)^{3/2}$ which in Plank's constant units reads as "Large number" $J_u \approx 10^{120} \hbar$, or in CGS units $J_u \approx 5 \times 10^{92} \text{ g cm}^2 \text{ s}^{-1}$. This coincidence can be considered as an observational support for our approach, which explains rotation of cosmic objects by Regge-like connection between angular momenta and masses in a manner known from elementary particle (hadron) physics.

Yerevan Physics Institute

Yerevan 1983

Y E R E V A N P H Y S I C S I N S T I T U T E

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R.M.MURADIAN

ON THE ROTATION OF ASTRONOMICAL UNIVERSE

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In 1958 V.A.Ambartsumian [2] formulated his ideas on the fundamental role of very condensed prestellar matter in the origin and evolution of cosmic objects.

Several years ago the present author [3-6] proposed, that Ambartsumian's primeval matter has a hadronic nature. It turns out that many basic properties of astronomical objects, such as angular momentum, magnetic fields etc. can be understood in this way not only qualitatively, but in some cases they can be calculated theoretically by means of several fundamental constants.

The starting point of our approach is the basic Regge-like relation between angular momentum J and mass m for a heavy hadron proposed in ref. [3]

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

where $\hbar = 1.06 \times 10^{-27} \text{ g cm}^2 \text{ s}^{-1}$ is Planck's constant; $m_p = 1.67 \times 10^{-24} \text{ g}$ is the proton mass, and the parameter $n = 1, 2, 3$ describes the spatial shape of particle ($n = 1$ corresponds to one-dimensional or string-like particles; $n = 2$ to two-dimensional or disk-like particles and $n = 3$ to spherical ones).

The usual hadrons and hadronic resonances, known from elementary particle physics, correspond to the case $n = 1$ and lie on the straight line Regge trajectory on the famous Chew-Frautschi [7] plot. This is a basic fact in our understanding of hadronic or strong interactions and it confirms the deep interconnection between the angular momentum and the mass of an elementary particle.

The analysis of observational data on the rotation and masses of astronomical objects demonstrated that eq.(1) in the disk-like case $n = 2$

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

describes well enough the galaxies, their clusters and superclusters and, perhaps, the Metagalaxy or observable Universe as a whole.

In the case $n = 3$ (spherical superparticles)

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

the angular momenta of stars and planets are described by means of the same fundamental constants.

Currently available observational data on the rotation of different cosmic objects (excluding asteroids) are presented in the figure.

The theoretical relations are confirmed reasonably well by observational data, and in a certain sense, figure represents the generalized Chew-Frautschi plot for astronomical objects. Note that theoretical straight lines in this log/log plot describe in a right manner not only the slope, but also the abso-

lute values in a very large interval of masses and spins. The cosmogonic deductions from these facts for the origin of astronomical objects are considered in detail in refs. [3-6]. In this paper we shall consider mainly the problems related to the possible rotation of the Universe as a whole in connection with a recent paper [1]. Substituting in eq.(2) the currently accepted mass of the observable Universe $m_u \approx 10^{56} g$ we obtain [4]

$$J_u \approx 10^{120} \hbar$$

or, a little more correctly [6]

$$J_u \approx 5 \times 10^{92} g \text{ cm}^2 \text{ s}^{-1}$$

To calculate the angular velocity of the Universe we use this number for J_u together with the relation $J_u = m_u \omega_u r_u^2$. This implies the following order-by-magnitude estimate $\omega_u \approx 1,6 \times 10^{-20} \text{ rad s}^{-1}$, if we accept $r_u \approx 1,86 \times 10^{28} \text{ cm}$. The agreement with the value $10^{-13} \text{ rad yr}^{-1} = 0,3 \times 10^{-20} \text{ rad s}^{-1}$, quoted in ref. 1 is reasonable good*. This coincidence represents, in our opinion, some evidence for the validity of our cosmogonic picture, which proceeds from disk-like "Primeval hadron" [6] with the mass $m_u \approx 10^{56} g$ and spin $J_u \approx 5 \times 10^{92} g \text{ cm}^2 \text{ s}^{-1}$. The conserved spin of this proto-Universe now manifests as an angular momentum of the whole astronomical Universe.

The constraints on the maximum universal angular velocity

* Note that the extrapolation of $J \sim m^3$ relation from refs. [8,9] gives $J_u \approx 10^{97} g \text{ cm}^2 \text{ s}^{-1}$, which is larger than even the classical constraint allows.

can be obtained at least in two simple ways.

First, from Newtonian theory the gravitational acceleration must be larger than the maximum centrifugal one, for a rotating Universe not to be disrupted: $\frac{Gm_u}{r_u^2} \geq \omega_u^2 r_u$ where G is Newton's gravitational constant. This implies that

$$\omega_u \lesssim 1 \times 10^{-18} \text{ rad s}^{-1}.$$

Second independent constraint follows from the combination of Hubble's law $V = H_0 r$ with a special relativity condition $V < C$. It then follows, that $\omega_u \lesssim \frac{C}{r_u} = H_0$. For the presently accepted value $H_0 = 50 \text{ km s}^{-1} \text{ Mpc}^{-1} = 1.6 \cdot 10^{-18} \text{ s}^{-1}$ it follows that $\omega_u \lesssim 1.6 \times 10^{-18} \text{ rad s}^{-1}$. But these constraints are by two orders of magnitude larger than that predicted by the present author from "Primeval hadron" hypothesis [4,6] and the observed value claimed by P. Birch [1]. In some sense this implies that the Universe rotates slowly*. The Mach principle is violated but not in the maximum allowed way.

Let us note for completeness, that there is a third method for obtaining a constraint on the angular momentum of the Universe in the frame of classified relativistic physics. Using generalized dimensional analysis with different units of length which take account of the anisotropy of the problem due to the rotation, we obtain** (see refs. [4,6] for detail):

* The observed rotation is close to the microwave background limit [10]. An attempt is undertaken to explain this fact from a different viewpoint [11].

** It is interesting to note that the same relation follows from the solution of Einstein-Cartan equation for gravitational theory with a spin [12]. It seems that the Einstein-Cartan gravitational theory is more appropriate for describing rotation than general relativity.

$$J_u \approx \sqrt{\frac{m_u c^4 z_u^3}{G}} = \frac{G m_u^2}{c} \left(\frac{z_u c^2}{G m_u} \right)^{3/2} \approx 8.84 \times 10^{34} \text{ g cm}^2 \text{ s}^{-1} \quad (4)$$

This constraint too is by two orders of magnitude larger than our predicted number $5 \times 10^{32} \text{ g cm}^2 \text{ s}^{-1}$.

Our approach gains more theoretical support from the following derivation of the well-known Eddington-Dirac [13] and Chandrasekhar's [14] relations for limiting masses through fundamental constants G, c, \hbar, m_p . Consider the so-called maximal Kerr or gravitational angular momentum $J = \frac{G m^2}{c}$ and equate it to the relations (2) and (3) as $\frac{G m^2}{c} = \hbar \left(\frac{m}{m_p} \right)^{3/2}$ and $\frac{G m^2}{c} = \hbar \left(\frac{m}{m_p} \right)^{4/3}$. Solving these simple equations for the masses we obtain [3,4]

$$m_u = m_p \left(\frac{\hbar c}{G m_p^2} \right)^2 \quad \text{in the first case}$$

$$m_\odot = m_p \left(\frac{\hbar c}{G m_p^2} \right)^{3/2} \quad \text{in the second one [6,15].}$$

Substituting the Eddington-Dirac relation in our equation (2), we obtain the angular momentum of the astronomical Universe by means of fundamental constants [4,6]

$$J_u = \hbar \left(\frac{\hbar c}{G m_p^2} \right)^3 \quad (5)$$

In the same way, substituting Chandrasekhar's limiting mass in our equation (3) we obtain [6]

$$J_\odot = \hbar \left(\frac{\hbar c}{G m_p^2} \right)^2 \quad (6)$$

These results are listed in table.

Table

The masses and spins of astronomical objects expressed as a combination of fundamental constants

object	mass , m	spin , J
Star	$m_p \left(\frac{\hbar c}{G m_p^2} \right)^{3/2}$ (a)	$\hbar \left(\frac{\hbar c}{G m_p^2} \right)^2$ (c)
Universe	$m_p \left(\frac{\hbar c}{G m_p^2} \right)^2$ (b)	$\hbar \left(\frac{\hbar c}{G m_p^2} \right)^3$ (d)

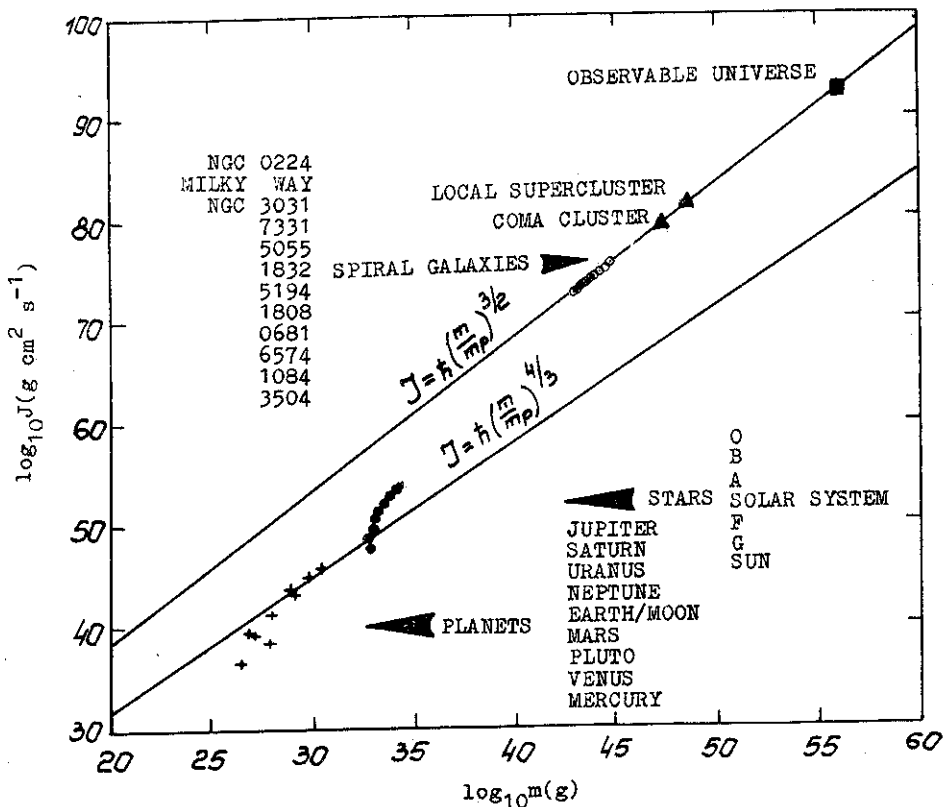
a) ref. [14] b) ref. [13] c) ref. [6] d) ref. [4]

From table we see that our approach incorporates, in a natural way, fundamental quantum-mechanical parameters \hbar and m_p along with the classical parameters G and C . Perhaps, the relations obtained here and the proposed explanation for the origin of the rotation in cosmic scale reflect some deep-rooted connection between particle physics and gravitation. And in some sense, all this looks like a fragment of a more complete future physical theory unifying strong interactions with gravitation in a new and radical way.

Current standard theories on the origin of celestial systems rotation are unsatisfactory because they do not give any numerical predictions, i.e. are entirely post_hoc.

On the other hand, the arguments presented here and in refs. [3-6] made plausible the possibility for the origin of cosmic objects from the decay of macroscopic quantum bodies, such as superheavy hadrons. And, if this is true, the present approach can yield some insight into the outstanding problem: has the astronomical Universe really started from a superheavy hadron? Or, in other words, is the observable Universe a remnant of the "Primeval hadron" with a mass $10^{80} m_p$ and spin $10^{120} \hbar$?

I am grateful to Academician V.A. Ambartsumian for stimulating discussions.



The angular momentum J of astronomical objects versus their masses m . The data taken from refs. [3,6] lie in this log/log plot on two straight lines defined by Regge-like relations:

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

for planets and stars;

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

for galaxies, their clusters and superclusters and perhaps for the observable Universe as a whole.

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