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ON ONE POSSIBLE TYPE OF STABLE PARTICLES IN THE METAGALAXY

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As M. Planck ([1,2]) showed, from the dimensional quantities $\hbar$, G, and c (where $\hbar$ is Planck' s constant, G is the gravitational constant, c is the speed of light) one can construct dimensional quantities

$$L = \sqrt{\frac{\hbar G}{c^3}} \simeq 1.3 \cdot 10^{-33} \text{ cm}, \quad m_L = \frac{1}{2}\sqrt{\frac{c\hbar}{G}} = \frac{\hbar}{2cL} \simeq 1.1 \cdot 10^{-5} \text{ g},$$

$$\tau_L = \frac{L}{c} = 10^{-43} \text{ sec.} \tag{1}$$

Let us note that in this case

$$L = 2Gm_L/c^2 = r_g, \tag{2}$$

where r_g is the gravitational radius of the mass m_L.

The density of a "particle" of mass m_L ([3])

$$\delta_L = \frac{3m_L}{4\pi L^3} = \frac{3}{4\pi}\frac{c^5}{2\hbar G^2} = 10^{95}\ \frac{\text{g}}{\text{cm}^3}. \tag{3}$$

It is remarkable, although also natural, that the radius of curvature a_L of the internal gravitational field of this "particle" turns out to be equal to L. Indeed, since the scalar curvature

$$R = \text{const} \cdot \frac{6}{a_L^2} = -\chi T = \frac{8\pi G\delta_L}{c^2} = \frac{8\pi \cdot 3c^3}{2 \cdot 4\pi\hbar G} = \frac{3}{L^2}, \tag{4}$$

whence indeed $a_L = L$ (const $= 1/2$).

It should now be noted that inside the particle we have as it were an "Einstein Universe" of "variable curvature," or, more precisely, an internal Schwarzschild field ([4]). Thus, such quasiparticles have dimensions equal to their gravitational radius and to their internal radius of curvature; moreover, these dimensions satisfy the uncertainty principle.

Having once "somehow" formed, perhaps as a consequence of rare fluctuations of energy or else at the initial stage of expansion of the Friedmann Universe, such particles will be stable and neutral in the sense of external radiation, both electromagnetic and gravitational. These particles, in contrast to Wheeler' s unstable geons, will be stable closed Einstein microuniverses. Their charge will be of the order of $\sqrt{\hbar c}/2 = \sqrt{137}/2\, e$, the field strength $E \simeq H \simeq e/L^2 \simeq 10^{56}$ oersted, but their total energy will correspond to a rest mass $\simeq 10^{-5}$ g.

Since the quantities L and m_L are associated with fluctuations of the gravitational field (gravitons), one may assume that the number of such particles $N_L = N_g^{1/2} = N_p^{3/4}$, where $N_g = 10^{120}$, $N_p = 10^{80}$ are the numbers of gravitons and nucleons in the Metagalaxy.

Thus, $N_L \simeq 10^{60}$. Then the total mass of the particles $M_L = N_{Lm}L \simeq 10^{55}$ g, which corresponds to the mass of the Metagalaxy. In other words, the energy of these particles is of the same order as other types of energy, as must be the case in a homogeneous model of the Universe. The number of collisions of these quasiparticles, which we shall now call planckeons (in honor of Planck), with nucleons, in order of magnitude, is determined by the relation

$$n_{\text{st}} = \pi r_0^2 c n\, n_p \simeq r_0^2 c N_p^{7/4} a^{-6}\ \text{sec}^{-1} \cdot \text{cm}^{-3}, \tag{5}$$

where $n_L = N_{La}^{-3}$, $n_p = N_{pa}^{-3}$ are the number densities of planckeons and nucleons, a is the radius of the Metagalaxy, and r_0 is the radius of nucleons.

Calculations show that $n_{\text{st}} \simeq 10^{-40}\ \text{cm}^{-3} \cdot \text{sec}^{-1}$. In this case energy will be released corresponding to a rest mass of $10^{-45}\ \text{g} \cdot \text{sec}^{-1} \cdot \text{cm}^{-3}$, which corresponds to the value of the mass necessary for the formation of new nucleons according to the Dirac-Hoyle theory, so that the law $N_p = T_m^2$ is satisfied, where $T_m = \omega_0 t_m$; ω_0 is the frequency of strong interactions, t_m is the age of our Universe (Metagalaxy) (T_m is the dimensionless age).

Indeed,

$$\Delta \dot{m} = \Delta \dot{N}_p m_p / \Delta t a^3 \simeq T_m \omega_0 m_p / a^3 \simeq 10^{-45}\ \text{g} \cdot \text{sec}^{-1} \cdot \text{cm}^{-3}. \tag{6}$$

Relation (5) gives

$$\Delta \dot{m} = n_{\text{st}} m_L = N_p^{7/4} r_0^2 c a^{-6} \sqrt{c\hbar/G}. \tag{7}$$

Since $\sqrt{c\hbar/G} = m_{pT} m^{1/2} = m_{pN} p^{1/4}$, comparing (6) and (7), we have $N_p^2 r_0^2 c a^{-3} = N_p^{1/2} \omega_0$; further, since $r_0 \omega_0 / c \simeq 1$, it follows that $N_p^{3/2} = a^3 / r_0^3$

and $a/r_0 = N_p^{1/2}$, which is in fact the case and proves the assertion. Further, it is just as easy to show that $\Delta\dot{m} = \alpha M_0/a^3$, where $M_0 = N_{pm}p$ is the mass of the Metagalaxy. Indeed, $\alpha \simeq 1/t = \omega_0/T_m$, therefore

$$\Delta\dot{m} = \omega_0 N_{pm} p/a^3 = \omega_0 N_p^{1/2} m_{pa}^{-3} = \omega_0 m_{pT_{ma}}^{-3},$$

which also gives (6).

According to Hoyle, matter was created from "nothing," which looked at least strange ([5]). At one time I put forward the hypothesis that the number of particles is replenished from the gravitational background owing to gravitational transmutations (according to D. D. Ivanenko) of "heavy gravitons" ([3]). Now we see that our points of view coincide to some extent. Hoyle' s "nothing" is our planckeon particles (if desired, "heavy" gravitons), whose energy is closed in on itself until, in interaction with some particle (or, in any case, with an elementary particle), the energy of a planckeon "breaks out" and a process of multiple birth of particles, $\simeq 10^{20}$ nucleons, occurs. Such is our hypothesis. Hoyle, however, still retains a contradiction with the law of conservation of energy, since for $G \sim T_m^{-1}$, $m_L \sim T_m^{1/2}$, i.e., it grows with time.

At the present time, thanks to the work of V. A. Ambartsumian ([6]) and modern observational data, it has become almost obvious that galaxies have an explosive origin; superstars, quasars, and a number of other objects of the Metagalaxy have the same origin. Our point of view concerning the possible origin of these objects is that ([3]) various superdense particles of very small size, which formed and are forming during the evolution of the Metagalaxy, could, in interactions, have given rise to both superstars and galaxies (considering that superstars are nascent galaxies). In this concept, what is essential is the evolution not only of matter, but also of the so-called world constants $(\hbar, G, m_p, e)$ of the "Universe," associated with the description of evolving matter. Now we again, but more substantiatedly, wish to confirm this point of view.

If we assume that $G \sim T_m$; $\hbar \sim m_p \sim e^2 \sim T_m^{-2}$; $c =$ const; $r_0 =$ const; $\omega_0 =$ const, then all conservation laws will be fulfilled and the relations $a = ct_m \sim T_m$; $Gm_p^2/e^2 \sim T_m^{-1}$; $N_p \simeq T_m^2$ will be satisfied. Then the quantities m_L at small T_m were enormous. Indeed,

$$m_L = \sqrt{\frac{c\hbar}{G}} = \sqrt{\frac{c\hbar_0}{G_0}}\, T_m^{-3/2} = M_0 T_m^{-3/2}. \tag{8}$$

For example, for $T_m = 10^8$, $m_L = 10^{44}$ g, which is the mass of the Galaxy. Some of these quasiparticles do not react immediately and replenish the "reserve" of galaxies. Interactions of planckeons with the nucleons of that time ($m_p \approx 10^{40}$ g) could have caused the formation of galaxies and their clusters. During the "aging" of particles, smaller galaxies, clusters of stars, and certain classes of stars could have formed. According to the hypothesis of I. D. Novikov (7), superstars are a later explosion of a part of "Friedmann dense matter" that was delayed during the main evolution of the Metagalaxy.

Our point of view is close to Novikov' s hypothesis; moreover, our mechanism for the "delay" in the evolution of this "Friedmann matter," whose density does indeed correspond to the initial density of the Metagalaxy ($\delta = 10^{95}$ g/cm^3), seems to be sufficiently reasonable.

The possible and very probable existence of planckeons leads one to think that the Metagalaxy is only a structural particle in a countable hierarchy of "particles" of an infinite Universe. In other systems similar to our Metagalaxy, there may be other reserves of energy, speeds of light, and particle sizes (on our scales). These systems may arise as a result of the interaction (collision) of "particles," or may be the result of fluctuations of still more grandiose structural formations. The "end" of these formations evidently consists in their expansion or compression and adaptation to external conditions.

Besides planckeons, other closed particles may evidently exist in the Metagalaxy as well. Table 1 gives the principal possible parameters of some particles.

Table 1

n	N	$N_\Phi = \sqrt{N}$	m, g	L, cm	δ, g/cm^3	$\hbar_n/\hbar_4$	V^*/V_0
1	1	1	10^{55}	$10^{28} \sim T_m$	$10^{-28} \sim T_m^{-3}$	$10^{120} \sim T_m^3$	1
2	$10^{40} \sim T_m$	$10^{20} \sim T_m^{1/2}$	$10^{35} \sim T_m^{-1/2}$	$10^7 \sim T_m^{1/2}$	$10^{14} \sim T_m^{-2}$	$10^{80} \sim T_m^2$	$10^{-40} \sim T_m^{-1}$
3	$10^{80} \sim T_m^2$	$10^{40} \sim T_m$	$10^{15} \sim T_m^{-1}$	10^{-13}	$10^{54} \sim T_m^{-1}$	$10^{40} \sim T_m$	$10^{-80} \sim T_m^{-2}$
4	$10^{120} \sim T_m^3$	$10^{60} \sim T_m^{3/2}$	$10^{-5} \sim T_m^{-3/2}$	$10^{-33} \sim T_m^{-1/2}$	10^{95}	1	$10^{-120} \sim T_m^{-3}$
...	...	...	...	...	...	...	...
5	$10^{160} \sim T_m^4$	$10^{80} \sim T_m^2$	$10^{-24} \sim T_m^{-2}$	$10^{-52} \sim T_m^{-1}$	$10^{135} \sim T_m$	$10^{-40} \sim T_m^{-1}$	$10^{-160} \sim T_m^{-4}$

Between $n = 4$ and $n = 5$ there may exist a large number of intermediate particles. Here N is the total number of "elementary" particles whose fluctuations give the number of stable fundamental particles $N_\Phi = \sqrt{N}$; m, L, δ are, respectively, the masses, sizes, and densities of the fundamental particles; $\hbar_n/\hbar_4$ are the effective relative values of the "Planck constants" for these particles (the table also gives the evolution of these quantities with time); V^*/V_0 is the relative volume lost in closed particles.

It is interesting to note, on the basis of an analysis of Table 1, that with time the probability of formation of large objects from particles with large n, such as clusters of galaxies and galaxies themselves (and quarks), will decrease, while the probability of formation of stellar objects from particles with small n, on the contrary, will increase. For $n = 4$ we have planckeons, and in this case $\hbar_4 = \hbar$. These stable particles may be called fundamental; as a result of their interaction (mainly with particles of neighboring classes), various "elementary" quasistable particles—stars, nucleons, and leptons—may arise. At the same time, in the Metagalaxy there is formed (at the present time), on the average, 10^{-45} g/cm$^3\cdot$ sec of "new" matter.

M. A. Markov suggests that planckeons (he calls these particles maximons) may perhaps be quarks as well (8). We are inclined to think that the particles of class $n = 5$ are more likely to be quarks.

The following scheme of interrelation between elementary and fundamental particles suggests itself. Owing to fluctuations of the fields of elementary particles, fundamental particles can be formed; from these, in interactions with elementary particles and with one another, elementary particles are again formed.

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Note: Figure translations are in progress. See original paper for figures.