The Origin of Masses of Old Globular Clusters

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Abstract: The Scale-Symmetric Theory (SST) shows that the Chandrasekhar limits indeed concern the neutron stars but they are not a Fermi gas that obeys Fermi-Dirac statistics - they are a crystal that behaves as a ferromagnetic. Due to the atom-like structure of baryons, the binding energy for all neutrons has the same value so the factors which appear in the Chandrasekhar limit are incorrect. There are at least two Chandrasekhar limits i.e. about 11.2 solar masses and 1.394 solar masses which is the mass of the Type Ia supernovae. The clouds, that later transform into the globular clusters, are produced on Schwarzschild surface of the quasars and are carried by the relativistic jets. Calculated here the upper limit for the initial mass of the old globular clusters in the halo of the Milky-Way Galaxy is 155,200 solar masses. Quasars with greater mass produce more massive globular clusters. The obtained theoretical upper limit for the mass is consistent with observational facts.

1. Introduction

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [1A]. On the other hand, the Scale-Symmetric Theory (SST) shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes/energies [1A]. Due to the saturation of interactions via the Higgs field and due to the law of conservation of the half-integral spin that is obligatory for all scales, there consequently appear the superluminal binary systems of closed strings (entanglons) responsible for the quantum entanglement (it is the quantum-entanglement scale), stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal Einstein spacetime (it is the Planck scale), cores of baryons (it is the electric-charges scale), and the cosmic structures (protoworlds; it is the cosmological scale) that evolution leads to the dark matter, dark energy and expanding universes (the “soft” big bangs) [1A], [1B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguishes particles from their antiparticles [1A]. SST shows that a fundamental theory should start from infinite nothingness and pieces of space [1A]. Sizes of pieces of space depend on their velocities [1A]. The inflation field started as the liquid-like field composed of non-gravitating pieces of space [1A]. Cosmoses composed of universes are created because of collisions of big pieces of space [1A], [1B]. During the inflation, the liquid-like inflation field (the non-gravitating superluminal Higgs field) transformed partially into the luminal Einstein spacetime (the big bang) [1A], [1B]. In our Cosmos, the two-component spacetime is surrounded by timeless wall – it causes that the fundamental constants are invariant [1A], [1B].

Due to the symmetrical decays of bosons on the equator of the core of baryons, there appears the atom-like structure of baryons described by the Titius-Bode orbits for the nuclear strong interactions [1A].

Applying 7 parameters only and a few new symmetries we calculated a thousand of basic physical (and mathematical) quantities (there are derived the physical and mathematical constants as well) consistent or very close to experimental data and observational facts (http://vixra.org/author/sylwester_kornowski). In SST there do not appear approximations, mathematical tricks, and free parameters which are characteristic for the mainstream particle physics and mainstream cosmology.

The Scale-Symmetric Theory shows that the very early Universe was the cosmic double loop composed of protogalaxies grouped in larger cosmic structures [1B]. Each protogalaxy was built from the modified neutron black holes (MNBHs; according to SST, there is not a central singularity in centres of modified black holes but there is a circle with spin speed equal to the speed of light in "vacuum" c) [1B]. Mass of MNBH is 24.81 solar masses and its radius is $R_{MNBH} = 3.664 \cdot 10^4$ m [1B] – it is inconsistent with the mainstream theory of neutron stars.

The Scale-Symmetric Theory (SST) shows that the Chandrasekhar limits indeed concern the neutron stars but they are not a Fermi gas that obeys Fermi-Dirac statistics – they are a crystal that behaves as a ferromagnetic. The Fermi-Dirac statistics determines the energy distribution of fermions in a Fermi gas in thermal equilibrium. In reality, the SST leads to the atom-like structure of baryons. There appears the shells and radius of the last shell is $R_S = 2.7048$ fm [1A]. The distances between the nucleons in atomic nuclei are mostly equal to $R_S / sqrt(2)$ and R_S. Such model leads to perfect results for nuclear binding energies [2]. In a neutron star there is a lattice with the side equal to $R_S / sqrt(2)$, i.e. the diagonal of a net mesh is R_S. It is true that the neutrons in a neutron star behave as a non-interacting Fermi gas but due to the shells which result from the nuclear strong interactions, the neutrons are in strictly determined mean distance for which the nuclear binding energy is not equal to zero but this energy is confined in the strong fields. The binding energy for all neutrons has the same value so the factors which appear in the Chandrasekhar limit are incorrect. It concerns the term $\omega_3^o sqrt(3)/(2\mu_e^2)$, where $\omega_3^o \approx 2.018236$ is a constant connected with the solution of the Lane-Emden equation whereas μ_e is the average molecular weight/mass per electron. The same concerns the relativistic many-particle Schrödinger equation.

Knowing the side of the lattice and knowing that neutrons behave as "non-interacting" fermions, it is very easy to calculate the maximum mass of neutron star (of MNBH) and its radius [1B].

There is not only one Chandrasekhar limit but a few threshold masses for stars which explode as the supernovae without a neutron-star remnant. The transport of energy from interior to exterior of the MNBHs is due to the neutrons, i.e. the mass of neutron (*mass* = 939.565 MeV [1A], leads to star with mass equal to 24.81 solar masses. When energy is carried by less massive objects then mass of supernova is lower. For example, if energy is carried by the condensates in centre of the core of baryons ([1A]: *mass* = 424.124 MeV) then mass of supernova is $24.8 \cdot 424.124 / 939.565 = 11.2$ solar masses – such mass had the supernova SN 1987A so we should not observe a neutron-star remnant. If energy is carried by the condensates in the centre of muons ([1A]: *mass* = 105.656/2 = 52.828 MeV) then mass of supernova is $24.8 \cdot 52.828 / 939.565 = 1.394$ solar masses and it is the mass of the Type Ia supernovae. The condensates in centre of the baryons and muons are the black holes in respect of the weak interactions [1A].

Within SST, we can as well correctly calculate the mass density of the MNBHs: $2.394 \cdot 10^{17}$ kg/m^3.

Due to the succeeding inflows of the dark matter (the additional Einstein-spacetime components entangled with visible matter [1B]) and of the dark energy (the additional "free" Einstein-spacetime components – they interact gravitationally only [1B]), there was the exit of the double cosmic loop from its black-hole state. The protogalaxies transformed into quasars whereas most of the modified neutron black holes transformed into the big stars.

2. Calculations

For radiation energy density, ρ_r, we obtain

$$p = \rho_r = E / V = h \nu / V = h c / (\lambda V), \qquad (1)$$

where p is the negative pressure created in the Einstein spacetime by virtual or real loop that circumference is equal to the length of wave λ, h is the Planck constant, c is the speed of light in "vacuum" whereas V is volume. We can see that negative pressure is inversely proportional to radius of loop.

The black holes in centre of quasars are built of neutron black holes. The MNBHs produce jets. The mechanism is as follows. On their equators are produced loops. They are moving to poles of MNBHs so their radius decreases whereas energy increases – it follows from the conservation of their angular momentum ($E r / c = const$). On the poles their radius is the reduced Compton wave of bare electron $r_e = \lambda\!\!\!^{-}_{C,bare\text{-}electron} = 3.8661 \cdot 10^{-13}$ m [1A].

Applying formula (1), we obtain

$$p_{flow} = (R_{MNBH} / r_e)\, p_{dyn,E}, \qquad (2)$$

where $p_{dyn,E} = \rho_E c^2 / 2$ is the mean dynamic pressure of the Einstein spacetime whereas $\rho_E = 1.10220 \cdot 10^{28}$ kg/m^3 is the density of the Einstein spacetime [1A].

Due to the four-particle symmetry, the maximum number of entangled electron loops that appear on a pole of a MNBH is $N = 2 \cdot 4^{32} = 3.7 \cdot 10^{19}$, [1B], so the maximum initial energy of an electron in the jets produced by the modified neutron black holes a quasar consists of is about $1.9 \cdot 10^{19}$ MeV.

Due to the negative pressure in the jets that follows from the flows of the Einstein spacetime along the jets, on the electrons is exerted force opposite to the gravitational attraction

$$F_{flow,electron} / (\pi r_e^2) = (R_{MNBH} / r_e)\, p_{dyn,E}, \qquad (3)$$

$$F_{flow,electron} = \pi R_{MNBH} r_e \rho_E c^2 / 2. \qquad (4)$$

The clouds, which later transformed into the old globular clusters in the halos of galaxies, are produced on Schwarzschild surface of a quasar. The initial gravitational force acting on a cloud (the cloud, due to the advection, is carried by the jets) is

$$F_{gr,cloud} = G M_{quasar} m_{cloud} / R_{Sch,quasar}^2 = c^4 m_{cloud} / (4 G M_{quasar}). \qquad (5)$$

From following condition we can calculate the upper limit for initial mass of a cloud

$$F_{flow,electron} = F_{gr,cloud}. \tag{6}$$

From formulae (4) – (6), we obtain

$$m_{cloud} \leq \pi\, R_{MNBH}\, r_e\, \rho_E\, 2\, G\, M_{quasar} / c^2 = 155{,}200 \text{ solar masses}, \tag{7}$$

where $M_{quasar} = 2.13 \cdot 10^{11}$ solar masses is the typical mass of quasars which transform into the massive spiral galaxies (the merger of two protogalaxies) [3]. The next typical mass of quasars is $8M_{quasar}$ – they transformed into the massive elliptical galaxies [3]. There as well were the barred quasars and quasars with non-typical masses. The mass $m_{cloud} \leq 155{,}200$ solar masses, is for the Milky-Way Galaxy.

From formula (7) follows that quasars with greater mass produce more massive globular clusters.

The today masses of the old globular clusters in the halos of the Milky Way are, roughly, from about 10^4 to 10^5 solar masses so the obtained theoretical upper limit for the mass is consistent with observational facts.

3. Summary

The Scale-Symmetric Theory (SST) shows that the Chandrasekhar limits indeed concern the neutron stars but they are not a Fermi gas that obeys Fermi-Dirac statistics – they are a crystal that behaves as a ferromagnetic. Due to the atom-like structure of baryons, the binding energy for all neutrons has the same value so the factors which appear in the Chandrasekhar limit are incorrect.

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The obtained theoretical upper limit for the mass is consistent with observational facts.

References

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