The Universal Rotation Curve of Dwarf Disc Galaxies Created by the Most Massive Disc Galaxies

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Abstract: According to the Scale-Symmetric Theory (SST), visible mass (or baryonic mass) of most massive disc galaxies is about 0.85 multiplied by both 12 powers of ten and the solar mass. Calculated within SST the mean baryonic mass of discs of dwarf galaxies produced by such massive galaxies is 5.2 multiplied by both 7 powers of ten and the solar mass. The calculated within SST mean orbital speed of stars in such dwarf galaxies, which results from the interactions of stars with the dark-matter (DM) structures, is about 37 km/s. SST shows that the total number of dwarf galaxies in the early Universe should be about 2.2 multiplied by 12 powers of ten and should decrease with time because of their mergers and due to their absorption by the nearby massive galaxies (massive galaxies have mass higher than about 11 powers of ten multiplied by the solar mass and there should be a massive black hole in their centre). In the early Universe there should be about 1000 times more the dwarf galaxies than the massive galaxies. Contrary to the mainstream cosmology, SST shows that number of massive galaxies in the observed Universe should not depend on time i.e. it is an invariant. SST shows that we should not observe a smooth field of first stars or smooth field of first dwarf galaxies free from the massive galaxies. Moreover, reionization is an illusory phenomenon which follows from the "transition" of galaxies from the unseen period of evolution to the observed period - it took place in the time distance about 13.8 Gyr. All theoretical results obtained in this paper are consistent with observational facts.

1.1 Introduction

The Scale-Symmetric Theory (SST) [1] shows that the succeeding phase transitions of the superluminal non-gravitating Higgs field (HF) during its inflation (the initial big bang) had led to the different mass/energy scales and size scales (bigger structures consist of smaller structures) [1A]. Due to a few new symmetries and 7 parameters only, there appear the superluminal binary systems of closed strings (the spin-1 entanglons) which are responsible for the quantum entanglement (it is the quantum-entanglement scale), neutrinos and the very stable spin-1 neutrino-antineutrino pairs (NAPs) moving with the speed of light in "vacuum", c, which are the components of the gravitating Einstein spacetime (ES) (it is the Planck scale;

mass of lightest neutrino is the smallest gravitational mass; neutrinos acquire their gravitational masses due to their interactions with the Higgs field [1A]; as for electrons, we can define two different masses of a neutrino i.e. particle mass and wave mass (or their geometric mean) [2]), cores of baryons (it is the proton/electric-charge scale), and the cosmic-structure/Protoworld (it is the cosmological scale; Protoworld created the early Universe [1B]) that evolution leads to the dark-matter (DM) structures (they are built of entangled non-rotating-spin NAPs), dark energy (it consists of the additional non-rotating-spin NAPs interacting gravitationally only i.e. they are not entangled i.e. the dark energy is an infinitesimal part of the ground state of ES) and the expanding Universe (the "soft" big bang due to the inflows of the dark energy into the Protoworld) [1A], [1B]. The proton scale leads to the atom-like structure of baryons [1A].

During the inflation almost whole the non-gravitating Higgs field composed of tachyons transformed into the gravitating Einstein spacetime. The residual Higgs field causes that the ES components acquire their gravitational mass. All hadronic matter and the charged leptons consist of the ES components [1A]. The collapse of the front layer of the expanding ES created the return shock wave that created in the centre of the Cosmos both the Protoworld and the very early Universe inside it [1B], [1A]. Due to the evolution of the Protoworld, there appeared the expanding Universe [1B]. The very early Universe was the binary system of loops composed of the identical disc protogalaxies already grouped in larger structures [1B].

Disc protogalaxies were built of the neutron black holes (NBHs). Mass of NBH is f = 24.81 times greater than the Sun i.e. $M_{NBH} = f\, M_{Sun}$ [1B]. Mass of each disc protogalaxy – it is the lower limit (LL) for mass of massive galaxy $M_{LL\text{-}MG}$ – was [1B]

$$M_{LL\text{-}MG} = M_{Disc\text{-}protogalaxy} = 4^{16}\, M_{NBH} = 4^{16}\, f\, M_{Sun} \approx 1.066 \cdot 10^{11}\, M_{Sun}\,. \qquad (1)$$

Due to the four-object symmetry, disc protogalaxies were grouped in larger structures [1B].

Number of entangled objects in a system is quantized [1B]

$$D_{n,S} = 4^{d} \text{ (for single objects)}, \qquad (2a)$$

$$D_{n,B} = 2 \cdot 4^{d} \text{ (for binary systems)}, \qquad (2b)$$

where for flat/disc-like structures is d = 0, 1, 2, 4, 8, 16… = 0, 2^n, where n = 0, 1, 2, 3, 4, 5,… whereas for chains is d = 3, 6, 12.

SST shows that we should not observe a smooth field of first stars or smooth field of first dwarf galaxies free from the massive galaxies [1B]. Moreover, reionization is an illusory phenomenon which follows from the "transition" of galaxies with redshift higher or very close to 0.64 (they are already 7.75 Gyr old and we cannot see the initial period 7.75 Gyr of their evolution but we can see all baryonic matter) from the unseen period of evolution to the observed period – it took place in the time distance about 13.8 Gyr [1B].

Within SST we present two curves showing the dependence of the relative recession velocity of galaxies on redshift: for the early Universe and present-day Universe [3]. The mean curve of the two SST curves is close to the General-Relativity (GR) curve. It means that the GR is the theory of observer, not of the real Universe. Moreover, there are the small differences, for example, SST shows that the acceleration in the expansion of the Universe is an illusion [4], [3].

According to SST, the dark-matter (DM) structures consist, first of all, of the cosmological-scale circles built of entangled ES components with spins tangent to the circles. Such orientation of spins causes that the ES components cannot rotate i.e. cannot acquire electromagnetic energy or other energy – it is the reason that detection of the DM structures is such difficult. The DM structures can interact gravitationally and due to the confinement with the ES condensates in the centres of electrically charged fermions (it is the weak interactions). Notice that the spins of carriers of photons and gluons, i.e. of the ES components, rotate in plane perpendicular to their velocity – such orientation of spins causes that photons contrary to the DM structures can change their rotational energies.

1.2 Upper limit for mass of massive disc galaxies

When gravity dominates then the associations containing smallest number of objects (of course apart from the trivial case $d = 0$) appear most often. Since pairing of cosmological objects is common so very important are objects containing four binary systems – from (2b) we obtain $D_{n,B,Typical} = 2 \cdot 4^1 = 8$ constituents. For example, in the CMB we observe an octopole [5].

The above remarks suggest that the upper limit (UL) for mass of massive disc galaxy should be

$$M_{UL\text{-}MG} = 8\, M_{Disc\text{-}protogalaxy} \approx 0.8525 \cdot 10^{12}\, M_{Sun}\,. \quad (3)$$

1.3 Number of massive galaxies in the Universe

Sometimes in the early Universe, the associations composed of 8 disc protogalaxies had decayed to smaller massive disc galaxies – such processes increased number of massive galaxies. On the other hand, observational facts suggest that more numerous associations of disc protogalaxies (more than 8 disc protogalaxies) had collapsed to massive elliptical galaxies – such processes decreased number of massive galaxies. We assume that the all initial decays and mergers of the most massive disc galaxies did not change number of massive galaxies i.e. we assume that the number of all massive galaxies is an invariant.

SST shows that initial number of the disc protogalaxies was $N = 4^{17} = 1.718 \cdot 10^{10}$ (two loops each composed of $2 \cdot 4^{16}$ NBHs [1B]. It means that the invariant number of massive galaxies, $N_{Invariant\text{-}MG}$, is

$$N_{Invariant\text{-}MG} = N / 8 \approx 2.15 \cdot 10^9\,. \quad (4)$$

1.4 The universal rotation curve of massive disc galaxies

We already described orbital motions of stars in massive disc galaxies [6]. The universal rotation curve of massive disc galaxies that follows from the interactions of stars with the dark-matter (DM) structures via leptons describes formula

$$v_{advection,orbital} = c\, (2\alpha_{w(electron\text{-}muon)}\, m_{actual} / m_{o,initial})^{1/2}, \quad (5)$$

where $v_{advection,orbital}$ is the orbital speed of a star in a region in which the interactions with the dark-matter structures dominate over the gravitational interactions, c is the speed of light in "vacuum", $\alpha_{w(electron\text{-}muon)} = 9.511082 \cdot 10^{-7}$ is the coupling constant for weak interactions of the charged leptons, m_{actual} is the baryonic mass of a massive galaxy, whereas $m_{o,initial} \approx 0.8525 \cdot 10^{12} M_{Sun}$ is the mass of the most massive disc galaxy which initially was a black hole – each massive galaxy evolved from a most massive disc galaxy because of the inflows of dark matter and dark energy [6], [1B]. Obtained results are consistent with observational data [6].

2. The mean baryonic mass of discs of dwarf galaxies

According to SST, the dwarf galaxies were created due to explosions of the massive galaxies because of the inflows of dark energy and dark matter.

Calculate the mean baryonic mass of dwarf disc galaxies. Initially, most numerous were the most massive disc galaxies. They transformed into quasars so there appeared plasma composed of electrically charged baryons and leptons. We can calculate the electromagnetic mass of such galaxies from formula $m_{em,o,initial} = \alpha_{em}\, m_{o,initial}$ where $\alpha_{em} = 1 / 137.036$ is the fine-structure constant. But structure of the most massive disc galaxies was grainy (initially there were the NBHs) so separation of the electromagnetic mass was impossible – just there dominated structures defined by formulae (2a) and (2b). Notice that α_{em} is close to $1 / 128 = 1 / 2 \cdot 4^3$ that follows from formula (2b). It means that probability of separation of mass

$$M^*_{em,o,initial} = m_{o,initial} / 2 \cdot 4^3 = 8\ (2 \cdot 4^{12})\ M_{NBH} = 0.666 \cdot 10^{10}\ M_{Sun} \qquad (6)$$

instead the electromagnetic mass is very high. From formula (2b) follows that the initial baryonic mass for dwarf disc galaxies was built of 8 binary systems of megachains of NBHs (for megachains is $d = 12$ [1B]). From such initial baryonic mass evolved the dwarf disc galaxies i.e. in formula (5) instead $m_{o,initial}$ should be $M^*_{em,o,initial}$. Moreover, such initial mass is built of 128 parts so there is very high probability that due to evolution of the Universe, it should decay, first of all, to 128 parts. It leads to conclusion that most often the actual baryonic mass of the dwarf disc galaxies should be 128 times lower than $M^*_{em,o,initial}$. It means that the mean baryonic mass of dwarf disc galaxies should be

$$M_{actual,dwarf} = M^*_{em,o,initial} / 2 \cdot 4^3 = 5.203 \cdot 10^7\ M_{Sun}\ . \qquad (7)$$

From observational facts follows that mean baryonic mass of discs of dwarf galaxies is about $6 \cdot 10^7\ M_{Sun}$ [7] (see Table 3 in [7]) – but due to the observational uncertainties we can say that our result is very close to observational data.

3. The universal rotation curve of dwarf disc galaxies

Applying results obtained in Paragraph 2, we can rewrite formula (5) for dwarf disc galaxies as follows

$$v_{DM\text{-}stars,orbital} = c\ (2\alpha_{w(electron\text{-}muon)} / 128)^{1/2} = 36.546\ \text{km/s}. \qquad (8)$$

Such should be the most often orbital speed of stars in the dwarf disc galaxies in the regions where the interactions of stars with DM structures dominate over the gravitational interactions of stars with the all baryonic matter of the dwarf galaxies i.e. for $v_{DM\text{-}stars,orbital}^{\ 2} >> v_{gravitational}^{\ 2} = G\ M_{baryon} / r$, where M_{baryon} is the baryonic mass of a galaxy.

Notice as well that due to the fact that the initial mass is grainy, it can decay to 64 parts, not to 128 parts, so from formula (8) we obtain about 52 km/s, or can decay to 256 parts or 512 parts – then we obtain respectively about 26 km/s and 18 km/s. We can compare it with observational data [7] (see V_{opt} in Table 1 in [7]). But there appears some problem because, generally, orbital speeds of stars in the region where the interactions with DM structures dominate change. What distance from centre of dwarf galaxies we should consider? We showed that the initial mass for dwarf disc galaxies was built of 8 binary systems of megachains (for megachains is $d = 12$). It suggests that initially there was an orbit for single binary system of megachains on which the gravitational orbital velocity was equal to the orbital velocity forced by the interactions with the DM loops i.e. was equal to $v_{DM\text{-}stars,orbital}$. We can calculate radius of such orbit, R_{best}, – on such orbit, the orbital speed $v_{DM\text{-}stars,orbital}$ should be still best fitted to formula (8)

$$R_{best} = G\, M_{megachain} / v_{DM\text{-}stars,orbital}{}^2 =$$

$$= G\, (2 \cdot 4^{12})\, M_{NBH} / v_{DM\text{-}stars,orbital}{}^2 \approx 2.69 \text{ kpc} . \quad (9)$$

It means that for galactic halo, for distance 2.69 kpc we obtain the orbital speed equal to 36.546 km/s. Of course, it is a statistical result. This result is consistent with the other models [7] (see Figure 7 in [7]).

4. Number of dwarf galaxies in the early Universe

We can see that initially each most massive disc galaxy was composed of 8 protogalaxies – such number is universal so we can assume that each such galaxy produced 8 separated the initial masses for dwarf galaxies (i.e. total ejected mass by one most massive galaxy was $8 \cdot M^*_{em,o,initial}$) and each mass $M^*_{em,o,initial}$ decayed to 128 dwarf disc galaxies i.e. each most massive disc galaxy (initially there were only such galaxies) created $8 \cdot 128 = 1024$ dwarf disc galaxies. Of course, it is a statistical picture. Applying formula (4) we can find that total number of dwarf galaxies in the early Universe was

$$N_{Initial,Dwarf} = 1024\, N / 8 \approx 2.2 \cdot 10^{12} . \quad (10)$$

This result is consistent with observational facts [8].

With time, because of mergers of the dwarf galaxies and due to their absorption by the nearby massive galaxies, number of dwarf galaxies decreases.

On the other hand, emphasize that contrary to the mainstream cosmology, SST shows that number of massive galaxies in the observed Universe should not depend on time i.e. the number of massive galaxies is an invariant.

5. Summary

Here we calculated the upper limit for mass of massive disc galaxies and showed that total number of massive galaxies is an invariant i.e. does not depend on time, we calculated the lower limit for mass of massive galaxies, the mean baryonic mass of the dwarf disc galaxies, we derived the universal rotation curve of dwarf disc galaxies, and we showed that there should be about 1000 times more the dwarf galaxies in the early Universe than the massive galaxies. Obtained results are consistent with observational facts.

Within SST we calculated the total mass of the dark-matter structures in the Universe – it is about 5.4 times greater than the total baryonic mass of the Universe [1B]. But it is not true that in each galaxy there is 5.4 times more DM than baryonic matter so why we obtain the universal rotation curves for massive galaxies and dwarf galaxies? It follows from the almost perfect symmetry for the initial conditions that are responsible for the observed behaviour of stars in the galactic regions defined by $v_{DM\text{-}stars,orbital}{}^2 >> v_{gravitational}{}^2 = G\, M_{baryon} / r$, where M_{baryon} is the baryonic mass of a galaxy. Just the DM circles created at the beginning of expansion of the Universe are the very stable structures – due to their interactions with “visible” matter, they can change their size.

References

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