Evolution, Structure and Rotation of the Milky Way Galaxy

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Abstract: Here we described the evolution and we determined the structure and rotation of the Milky Way. Our model is based on the Scale-Symmetric Theory (SST). We compared the theoretical results with observational data.

1. Evolution of the Milky Way

Our model of evolution, structure and rotation of the Milky Way is based on the SST cosmology [1] and the atom-like structure of baryons [2]. The SST is based on only seven initial parameters which can be replaced by the four physical constants and three masses [2]. But to determine the progress in the evolution of the Milky Way Galaxy, we need two additional parameters taken from observational data – they are as follows.

Today the mean rotation velocity of the Milky Way for the approximately flat part of the rotation curve is 238 ± 14 **km/s** [3]. This value is calculated with relatively high accuracy so the first additional parameter will be the central value of the observed rotational speed

$$v_{Rotation} = 238 \text{ km/s} . \quad (1)$$

The methods applied in the four publications between 1995 and 2000 lead to the mass of the central black hole in the Milky Way equal to about $3 \cdot 10^6$ **solar masses** [4]. On the other hand, in the nine papers published between 2002 and 2017, there appear values close to $4 \cdot 10^6$ **solar masses** [4]. The difference follows from the fact that in the earlier papers is considered star formation and velocity dispersion in smaller region (the central 0.5 parsec) [5]. In my opinion, such results are closer to the truth because the mass of surrounding matter is not included in the mass of the black hole. So the second additional parameter is as follows

$$M_{BH\text{-}actual} = 3.00 \cdot 10^6 \text{ solar masses} . \quad (2)$$

Inside the core of the Protoworld, there were two cosmological baryonic loops composed of the neutron black holes (NBHs) each with a baryon mass of 24.81 **solar masses** associated in protogalaxies each composed of 4^{16} NBHs so their baryon mass was $M_{Protogalaxy} = 1.0656 \cdot 10^{11}$ **solar masses** [1]. Each of the baryonic loops contained $2 \cdot 4^{16}$ protogalaxies [1]. Due to the four-object symmetry [1], the initial massive barred spiral protogalaxies (the barred quadrupoles) had a baryon mass equal to $M_{Barred\text{-}Quadrupole} = 4.2624 \cdot 10^{11}$ **solar masses**. But there were the two baryonic loops so there appeared the binary systems of the quadrupoles (the

double barred quadrupoles) – their initial baryon mass was $M_{Double\text{-}Barred\text{-}Quadrupole} = 8.5248 \cdot 10^{11}$ **solar masses**.

There were the inflows of dark matter into the protogalaxies [1]. In the SST cosmology, the total mass of dark matter relates to the mass of the charged core of baryons $H^+ = 727.440$ **MeV** while the total baryonic mass relates to the mass of the neutral pion $\pi^o = 134.977$ **MeV** [1] so we have

$$F = H^+ / \pi^o = 5.389 , \quad (3)$$

i.e. the total mass of dark matter is 5.389 times higher than the total mass of baryonic matter [1]. This value is consistent with observational data: $\sim 5.35(22)$ (CMB+lensing; 68% limits) [6].

We assume that initially the Milky Way was the barred quadrupole while the M31 galaxy was the double barred quadrupole.

The initial total mass of the barred quadrupole was

$$M_{Total\text{-}Barred\text{-}Quadrupole} = M_{Barred\text{-}Quadrupole} (1 + F) = 2.7232 \cdot 10^{12} \textbf{ solar masses}. \quad (4)$$

It was the black hole composed of NBHs. We define its equator as the circle with the spin speed equal to c – its initial radius, $R_{Barred\text{-}Quadrupole}$, was

$$R_{Barred\text{-}Quadrupole} = G M_{Total\text{-}Barred\text{-}Quadrupole} / c^2 = 4.0212 \cdot 10^{15} \textbf{ m} = 0.13032 \textbf{ pc} . \quad (5)$$

Initial spin speed of the cosmological baryonic loops was close to $c = 299{,}792{,}458$ **m/s** (see Paragraph **3**).

Due to the weak interactions (via leptonic pairs) of the dark-matter (DM) loops with baryonic matter (BM), there is the region of advection of the baryonic matter (the DM-BM advection region) [7]. In such a region we have [7]

$$v_{Rotation} = c (2\alpha_{w(electron\text{-}muon)} M_{BM\text{-}actual} / M_{Barred\text{-}Quadrupole})^{1/2} , \quad (6)$$

where $2\alpha_{w(electron\text{-}muon)} = 2 \cdot 0.951108 \cdot 10^{-6}$ is the coupling constant for the weak interactions via the leptonic pairs [2] – the factor 2 is because of the two particles in the leptonic pairs, and $M_{BM\text{-}actual}$ is the present-day baryonic mass inside the Milky Way, i.e. it is the sum of the masses of stars, of the invisible hot baryonic plasma, of the baryonic mass of the dwarf galaxies which have been rejected by the evolving Milky Way Galaxy, and of the black holes composed of NBHs. Formulae (1) and (6) lead to

$$M_{BM\text{-}actual} = 1.41 \cdot 10^{11} \textbf{ solar masses}. \quad (7)$$

The present-day total mass of the Milky Way (DM + BM) inside the sphere with a radius equal to the radius of the external edge of the halo is

$$M_{Total\text{-}actual} = M_{BM\text{-}actual} (1 + F) = 0.902 \cdot 10^{12} \textbf{ solar masses}. \quad (8)$$

It is about 33% of the initial total mass. The rest of the initial total mass is outside the Milky-Way halo.

Due to the explosions, the central baryonic mass decreased. From formula $GM = v_{Orbital}^2 r$, and from the invariance of spin of loop for a constant mass of the loop: $mv_{Orbital}r$ = **const.**, we obtain that radius of the loop/orbit is inversely proportional to central mass

$$M \sim 1 / r . \tag{9}$$

From (2) and (9) we have that the radius of the initial equator of the BH increased to

$$R_{Monoceros} = R_{Barred\text{-}Quadrupole} M_{Barred\text{-}Quadrupole} / M_{BH\text{-}actual} = 18.5 \textbf{ kpc} . \tag{10}$$

Such a radius is the radius of the Monoceros ring. For the Monoceros ring we have: above the Galactic plane is 18 ± 2 **kpc** while below it is 20 ± 2 **kpc** [8].

It is very important that the radius of the Monoceros ring, $R_{Monoceros} = 18.5$ **kpc, relates to both the radius of the fundamental gluon loop (FGL) in the baryons,** $R_{FGL} = 2A/3 = 0.465$ **fm where** $A = 0.6974425$ **fm is the equatorial radius of the core of baryons [2], and to the radius of the two cosmological loops,** $R_{Cosmological} = 0.1911$ **Gly, [1] because for both the spin speed is equal to** c. **Such relations allow us to determine the other characteristic radii for the Milky Way!**

Today rotation velocity should be maximal for an orbit with the radius 18.5 **kpc** – outside it the orbital velocity should decrease – we can see it in the rotation curve [9]. Moreover, the last orbit for the nuclear strong interactions in baryons has the radius $A + 4B = 2.7048$ **fm**, where $B = 0.5018395$ **fm** [2], so it is 3.88 times bigger than the equatorial radius of the core of baryons which here relates to the 18.5 **kpc**. This means that we should observe some increase in the rotational velocity for $18.5 \cdot 3.88 = 71.7$ **kpc** – it is consistent with observational data [9].

2. Galactic bulge, radius of the stellar disc, and the DM-halo radius

The DM halo consists of the DM loops [7]. Highest number density of such loops should be from the surface of the bulge to the Monoceros ring.

Height of the galactic bulge in the direction perpendicular to the disc for not barred galaxy should relate to the diameter of the central condensate in the baryons $L = 2R_{Condensate} = 1.742 \cdot 10^{-17}$ **m** – it is about 26.7 times smaller than the radius of the FGL that today relates to 18.5 **kpc**. So we obtain 0.693 **kpc**. The determined height of an intrinsic peanut is 0.65 ± 0.17 **kpc** [10]. Notice that the four Protogalaxies caused that the bulge in the plane of the galactic disc is more extended.

We can see that the DM plateau should extend from about $0.693 / 2 = 0.346$ **kpc** to 18.5 **kpc** – it is consistent with observational data [9].

Radius of the stellar disc, R_{Disc}, should relate to the equatorial radius of the core of baryons, i.e. to A

$$R_{Disc} = R_{Monoceros} A / R_{FGL} = 27.7 \textbf{ kpc} , \tag{11}$$

so diameter of the stellar disc is $181{,}000$ **light-years**.

The $A + B = 1.1993$ **fm** is the last state occupied in the nucleons [2]. The photon loops overlapping with such an orbit have the range 2π times bigger. The Monoceros ring relates to $R_{FGL} = 2A/3$ so radii of the DM loops can maximally increase to R_{Halo} equal to – it is the radius of the galactic halo

$$R_{Halo} = R_{Monoceros}\, 2\,\pi\,(A + B) / R_{FGL} = 300\ \textbf{kpc}\ . \tag{12}$$

3. The invariant period of spinning/rotation of galaxies

The initial state of the baryonic part of the Universe was the two cosmological loops with a radius $R_{Cosmological} = 0.1911$ **Gly** both built of the NBHs grouped in protogalaxies [1]. Collisions of the NBHs with DM and the mutual collisions of the NBHs caused that protogalaxies were embedded in a low-temperature baryonic-plasma ring (the NBHs are the cold objects). Such a ring, due to the nuclear strong interactions at low energy (the coupling constant for such interactions is $\alpha_S = 1$ [2]), had interacted with gluon loops that overlapped with the cosmological loops. It caused that the spin speed of the cosmological loops was close to c. So the period of rotation, $T_{cosmological}$, was

$$T_{cosmological} = 2\,\pi\,R_{Cosmological} = 1.201\ \textbf{Gyr}\ . \tag{13}$$

The tidal locking (or a mutual spin-orbit resonance) of the Moon and the Earth caused that the rotation and revolution periods of the Moon are the same. Similar processes caused that the period of rotation of protogalaxies (so of the present-day galaxies as well) was (and still is) equal to the period of spinning of the two cosmological loops composed of the protogalaxies.

Our exact result 1.201 **Gly** is close to the observational result ~1 **Gyr** [11].

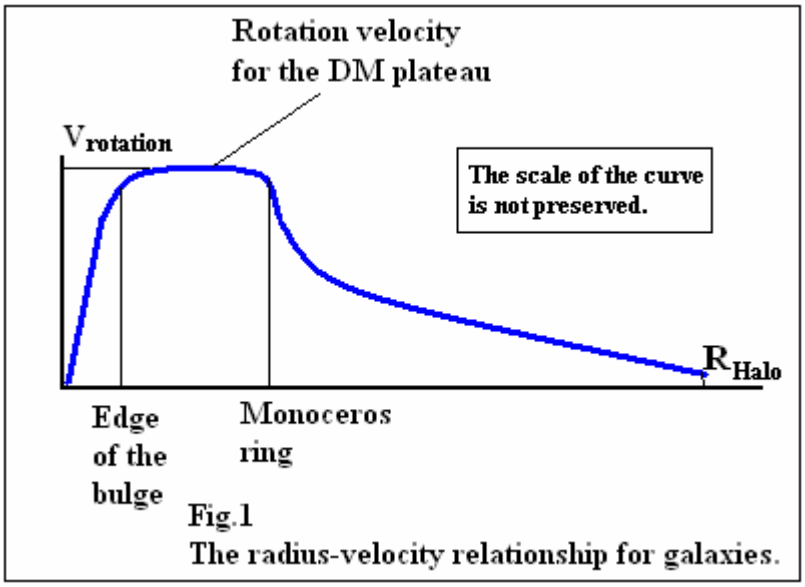

Fig.1
The radius-velocity relationship for galaxies.

4. Summary

In a dozen or so recent papers, I have shown how strong the links between astronomy and cosmology and particle physics are. The resulting great theoretical results are such that only ill-willed scientists fail to recognize that some parts of mainstream physics have been wrong for decades.

The great physicists made two key mistakes that cause all scientists today to suffer. Namely, at low energies, the atom-like structure of baryons dominates [2], not three crazy valence

quarks, and it is not true that the big bang was from nothing [1]. All proton spin comes from the carriers of gluons [2].

Table 1. *Galactic quantities for the Milky Way*

Quantity	Theory	Observational data **[paper]**
Initial baryon mass	**$4.2624 \cdot 10^{11}$ solar masses**	
Actual baryon mass	**$1.41 \cdot 10^{11}$ solar masses (33%)**	
Total mass (BM + DM)	**$0.902 \cdot 10^{12}$ solar masses**	**$0.89^{+0.10}_{-0.06} \cdot 10^{12}$ solar masses** [12]
DM / BM	**5.389**	**~5.35(22)** (CMB+lensing; 68% limits) [6].
Monoceros ring	**18.5 kpc**	Above the Galactic plane: **18 ± 2 kpc** Below: **20 ± 2 kpc** [8]
Height of galactic bulge	**0.693 kpc**	**0.65 ± 0.17 kpc** [10]
DM plateau	**0.346 kpc** to **18.5 kpc**	Consistent with [9]
Diameter of stellar disc	**181,000 ly** **Radius 27.7 kpc**	**> 163 ly** **Radius > 25 kpc** [13]
Radius of halo	**300 kpc**	**292 ± 61 kpc** [14]
Period of rotation	**1.201 Gyr**	**~1 Gyr** [11]

Here we have shown that the smallest scales (particle physics), through medium scales (astronomy) to the largest scales (cosmology), communicate with each other through very simple relationships – it results from the fact that Nature is not equipped with powerful computers that would tell Nature how to behave.

It really is time to reassess our views, or else future generations will mock our descriptions of interactions.

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