The Evolution of the System of Gravitating Bodies

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Abstract

A natural physical approach to the analysis of the structure of closed gravitating systems has been formulated in the scope of classical mechanics. The approach relies on the interrelation between densities of nested spheres inscribed in the circular orbits of the system bodies. An empirical law has been defined for the evolution of closed gravitating systems differing in mass, time scale and distance from the ground-based Observer. The gravitating systems undergo modifications and evolve from their initial state, namely, a gas-and-dust formation of almost constant density over the entire volume, to a certain terminal phase of the process when the system structure becomes similar to the planetary system (like the Solar system) where almost all the gravitating mass is concentrated in the vicinity of the system center of gravity. Using the proposed method of nested spheres, it is possible to reveal for the gravitating system the character of radial distribution of matter density in the system symmetry plane, quantitatively evaluate the density of medium containing the gravitating system under consideration, and assess the current phase of the system evolution. The research results have led us to a conclusion that introduction into the scientific practice of such an entity as "dark matter" has no physical background since it is based on a wrong interpretation of an "unordinary" distribution of star orbital velocities in galaxies.

1. Definition of the problem

Let us consider as the study object a galaxy that is a closed system of material bodies of various nature and size interacting purely by gravity. Assume that the system under consideration is dynamically quasi-stable. The galaxy time scale and distance from the Observer restrict significantly the methods and techniques for studying the dynamics and nature of these systems of gravitating bodies.

The visible galaxy structures allow us to suggest the existence of rotation motion about the dominant center of gravitational attraction since the straight-line motion is impossible in the system of gravitating bodies. The instrumentally observable galaxy structures are nothing but manifestation of the current stage of gravitational compaction. This is only an instant at the time scale of evolution from a conditionally static gas-and-dust "cloud" to a quasi-stable rotating system of gravitating bodies.

The only available observation data are the Doppler[1] measurements of radial velocities[2] of some stars in the galaxy rotation plane. Hereinafter we assume that all the stars and other material objects move in the galaxy rotation plane along a circular trajectory about the dominant center of attraction.

Let us define the problem as follows: using linear velocities of a limited number of stars located in the galaxy rotation plane, construct the radial distribution of the matter density ignoring the star formation processes and non-gravitational interaction effects.

2. System of nested spheres

A galaxy is a quasi-stable cluster of material objects, such as stars, gas-and-dust formations, nearly invisible and absolutely invisible objects. The total galaxy matter as a whole participates in the complicated rotation about its dominant center of attraction. As known from classical mechanics, the very possibility of a material body motion in the gravity field along a circular orbit, i.e., with a constant radius and constant orbital velocity, is due to the total gravitating mass enveloped by a sphere inscribed in the circular orbit of the body under consideration.

Why it should be a sphere? Why not another rotary figure with the symmetry axis coinciding with the galaxy rotation axis? It is of note here that the probe mass[3] located in the galaxy rotation plane makes no difference (from the gravitational point of view) between the gravitating mass of a sphere and another rotary body inscribed in its orbit. We have chosen a sphere because parameters of other rotary figures can hardly be quantitatively described due to multiple conditionalities and uncertainties in the visible configuration of the galaxy.

Thus, the observed star belonging to the galaxy under consideration plays the role of a probe mass by observing which it is possible to assess the gravitating mass keeping it in the orbit (a circular orbit in our case).

Designate the dominant attraction center of the galaxy as O . Bring the xOy Cartesian system into coincidence with the galaxy rotation plane (Fig. 1).

Assume that all the A_i stars, as well as the remaining matter, move about the attraction center O in the xOy plane counterclockwise along circular orbits[4]. Based on the Doppler shift of star spectrum lines, Observers determine the stars' relative radial velocities which are further used to calculate star orbital velocities $\underline{v}_i$.

Let us write down an expression for the gravitating mass of matter located in a sphere whose radius is equal to that of the star A_i (a probe mass) circular orbit. Taking into account that any selected star A_i with gravitating mass m_i moves in

[1]The Doppler effect is the shift of spectral lines of a moving radiation source.

[2]The body velocity along the line connecting the Observer and radiation source.

[3]The "probe mass" is a material body (a research tool) that does not significantly distort the studied gravity field of the system of gravitating bodies.

[4]Generally, trajectories of stars and other bodies are continuously evolving open spatial curves.

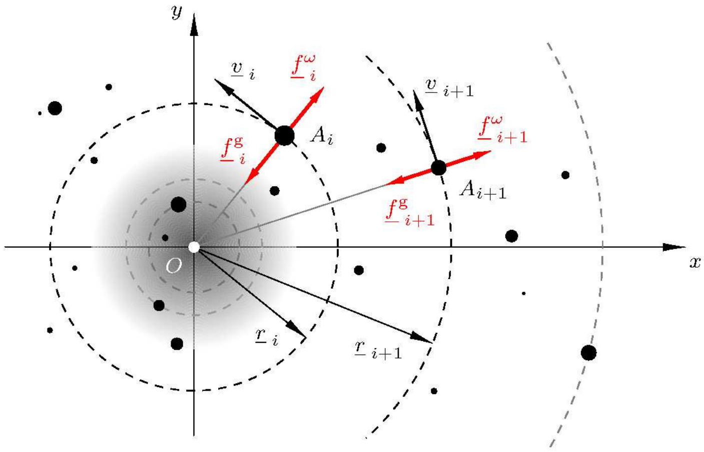

Figure 1: Galaxy rotation plane xOy.

the galaxy symmetry plane along a circular orbit of radius $\underline{r}$ (hereinafter we omit index i), the force balance equation for the gravity $\underline{f}^{\mathbf{g}}$ and centrifugal $\underline{f}^{\omega}$ forces may be written as:

$$\underline{f}^{\mathbf{g}} + \underline{f}^{\omega} = 0 \,, \tag{1}$$

where

$$|\underline{f}^{\mathbf{g}}| = \tilde{m}\, \overbrace{\frac{\mathbf{G}\widetilde{M}}{r^2}}^{\mathbf{g}} \,, \qquad \tilde{m} = m\left(1 - \frac{\rho_0}{\rho_{prob}}\right) \tag{2}$$

and

$$|\underline{f}^{\omega}| = m\, r\omega^2 \,, \qquad v = \omega r \,. \tag{3}$$

Here $\mathbf{G}$ is the gravitation constant; $\widetilde{M}$ is the gravitating mass of the sphere inscribed into the star orbit of radius r; m, $\tilde{m}$ are the star inertia and gravitating masses[5]; ρ_0 is the density of medium containing the galaxy; ρ_{prob} is the probe mass (star A) density; $\mathbf{g}$ is the gravity field intensity at distance r from the attraction center O; ω is the angular velocity of the star rotating about attraction center O.

Therefore, based on the star A velocity and distance from the attraction center O, we can find gravitating mass $\widetilde{M}$ of the matter enclosed in the sphere inscribed in the star A orbit of radius r. Using the force balance equation (1) and taking into account (2) and (3), obtain the expression for gravitating mass $\widetilde{M}$

$$\widetilde{M}(r,v) = \frac{1}{\mathbf{G}k_\rho}\, rv^2 \,, \quad k_\rho = \left(1 - \frac{\rho_0}{\rho_{prob}}\right) \tag{4}$$

and density of the gravitating mass enclosed in the sphere of radius r

$$\rho(r,v) = \frac{\widetilde{M}(r,v)}{V(r)} = \frac{1}{\frac{4}{3}\pi\mathbf{G}k_\rho}\, \left(\frac{v}{r}\right)^2 \,, \tag{5}$$

[5]Interrelation between the inertial and gravitating masses is described in detail in paper [7, 8].

where $V(r)$ is the volume of the sphere inscribed into the star A circular orbit.

Here we should emphasize that the assumption on the star orbit circularity stipulates that the star is gravity-neutral to all the gravitating objects beyond the sphere inscribed into its orbit and interacts only with all the averaged gravitating matter located in the sphere. The orbit circularity also means that there is no friction with the material medium ρ_0 in density which is external to the star.

Now consider a group of n probe masses (stars) belonging to the galaxy under study and lying in its rotation plane xOy. In the scope of the defined task, our goal is to reveal how the gravitating matter is distributed in the galaxy rotation plane. Let us assign a gravitating sphere of radius r_i to each probe mass A_i moving along a circular orbit of radius r_i with velocity v_i. As a result, a sequence of n nested spheres with common symmetry center O was obtained. Designate the gravitating mass of the sphere inscribed in the star A_i orbit as $\widetilde{M}_i$. Assume that the matter is uniformly distributed over the sphere volumes. The sequence of uniform spheres nested in each other allows us to speak about a sequence of spherical layers, their masses and densities. Assume also that the spherical layer index is equal to the lesser of two orbit radii: $r_i < r_{i+1}$. Gravitating mass $\Delta\widetilde{M}_i$ of each i-th spherical layer $(r_{i+1} - r_i)$ in thickness is equal to the total gravitating mass of all the material bodies included in the considered spherical layer volume ΔV_i. Thus, we can define the volume and mass of the i-th spherical layer as

$$\Delta\widetilde{M}_i = \widetilde{M}_{i+1} - \widetilde{M}_i = \frac{1}{\mathbf{G}} \left(r_{i+1} v_{i+1}^2 - r_i v_i^2 \right) , \tag{6}$$

$$\Delta V_i = V_{i+1} - V_i = \frac{4}{3}\pi \left(r_{i+1}^3 - r_i^3 \right) , \tag{7}$$

and use the obtained spherical layer volume and mass to derive the expression for the density increment:

$$\Delta\rho_i = \Delta\widetilde{M}_i \,/\, \Delta V_i = \frac{1}{\frac{4}{3}\pi\mathbf{G}} \frac{r_{i+1} v_{i+1}^2 - r_i v_i^2}{r_{i+1}^3 - r_i^3} . \tag{8}$$

Thus we have obtained the radial distribution for mass increment $\Delta\widetilde{M}(r, v)$ and density increment $\Delta\rho(r, v)$ of a sequence of spherical layers for the galaxy which we regard as a system of nested spheres with respective gravitating masses that in the first approximation make the stars moving circularly with velocities known from observations.

In summary, we have defined in the scope of classical mechanics and based on the classical law of gravitational interaction between two point masses a method of nested spheres enabling deriving the radial mass (density) distribution from observations only of the star radial velocities and distances to the dominant galaxy attraction center O without refining the observed configuration of the galaxy. The method of nested spheres allows the transition from the real gravitating system characterized by a high extent of uncertainty in geometry and matter distribution to its centrosymmetric gravitational model.

Let us show that the approach suggested provides reliable and significant results in analyzing closed gravitating systems of various sizes and configurations. Let us test it by the example of such a relatively well studied system as the Solar System.

Solar system. Let us construct a gravitationally equivalent model of the Solar system in the form of a sequence of uniform nested spheres with the Sun as a dominant center of attraction.

Generally, all the planet trajectories are perturbed orbits, i.e., open spatial curves elliptic in the first approximation. We will rely upon the fact that we know only the planet velocities in the *pericenter* and *apocenter* and also the distances from these points of the elliptic orbit to the attraction center. Physical characteristics of the planets are listed in Table 3 (appendix A).

Assume that all the planets orbit in circular orbits with constant velocities, which *a priori* excludes from consideration their gravitational interactions. Each planet is associated with a sphere of a radius equal to that of its orbit. Let us take as the planet-to-Sun distance the elliptic orbit semiaxis and assume the planet velocity (Table 3) to be the arithmetic mean of velocities in the orbit *pericenter* and *apocenter*:

$$\bar{r} = 1/2\,(r_{min} + r_{max}) \,, \qquad \bar{v} = 1/2\,(v_{min} + v_{max}) \,. \tag{9}$$

The fact that we consider averaged velocities and orbit radii means that formally we have turned to circular orbits. However, in switching from elliptic orbits to circular ones, we should not lose the gravitational interconsistency of planet masses which breaks immediately after averaging the orbit radii and velocities. What does it mean? The planet gravitating masses should comply with the commonly accepted and many times verified values, namely, the spherical layer masses should be equal to the known planet masses. Gravitating mass of the sphere enclosing the Solar system matter should monotonically grow with its radius, while densities of the spheres inscribed in the planet orbits should form a decreasing sequence according to formula (5).

The sequence of spheres inscribed in the planet orbits makes it possible to estimate gravitating masses of these planets via the spherical layer masses (6). The order of the layer sequence depends on the planet distance from the Solar system attraction center. The mass of the sphere inscribed in the orbit of Mercury, the first planet, appears to be equal to the mass of the Sun and all the remaining matter of the near-Sun space inside the Mercury orbit. Then, the difference between the masses of spheres inscribed in the Mercury and Venus orbits is equal to the Mercury gravitating mass. Cycling through the orbits, we can calculate masses of all the planets except for Pluto since such calculation needs knowing orbital parameters of the next planet[6]

As the quantity to be corrected in order to ensure physical interconsistency of the system, the mean orbital velocity $\bar{v}$ of the planets was chosen; it is defined by (9). Designate the velocity $\bar{v}$ matching correction as Δv:

$$v = \bar{v} + \Delta v \,. \tag{10}$$

Strictly speaking, we might take as a corrected quantity the planet orbit radius and fix the velocity, but we have chosen the velocity as a quantity to be corrected.

[6]Probably, here planet **X** is meant, whose existence has been justified in paper [1].

Correction Δv was derived from the condition of constancy of the planet gravitating masses given in Table 3 (appendix A).

As a result, we have obtained a gravitationally balanced and centrally symmetric model for the Solar system whose characteristics are presented in Table 1.

	r, *min	v, km/s	ρ, kg/m^3	$m/M_\oplus$	$\widetilde{M}/M_\odot$
Sun	—	—	—	332937.079	1.000000000
Mercury	3.21945	47.87273 *2.14%*	0.0395751	0.055	1.000000166
Venus	6.01583	35.02123 *0.01%*	0.0113343	0.815	1.000002614
Earth	8.31659	29.78565 *0.02%*	0.0059305	1.012	1.000005654
Mars	12.67127	24.13072 *0.43%*	0.0025547	0.107	1.000005977
Jupiter	43.28383	13.05622 *0.18%*	0.0002189	317.901	1.000960814
Saturn	79.69541	9.62656 *0.09%*	0.0000646	95.184	1.001246705
Uranus	159.69159	6.80156 *0.02%*	0.0000161	14.536	1.001290364
Neptune	249.89844	5.43722 *0.04%*	0.0000065	17.152	1.001341881
Pluto	328.35911	4.74346 *3.29%*	0.0000038	0.002	1.001341888
X	583.75857	3.55757 *7.38%*	0.0000012	—	—

Table 1: Interconsistent parameters of the centrally symmetric gravitational model of the Solar system. Here m is the planet gravitating mass (including its satellites); r is the radius of the planet circular orbit expressed in light minutes; $\widetilde{M}$ is the gravitating mass of the sphere inscribed in the planet orbit; $M_\odot$ and $M_\oplus$ are the Sun and Earth masses (the values are taken from Table 3).

You can see that corrections Δv to circular velocity v are quite insignificant in percentage terms (see Table 1, the third column, italic type). However, just these minor corrections helped the centrally symmetric gravitational model of the Solar system to remain physically interconsistent with respect to the planet masses.

Fig. 2 represents the densities of nested spheres versus their radii, i.e., versus the planet distance from the dominant center of attraction (Sun).

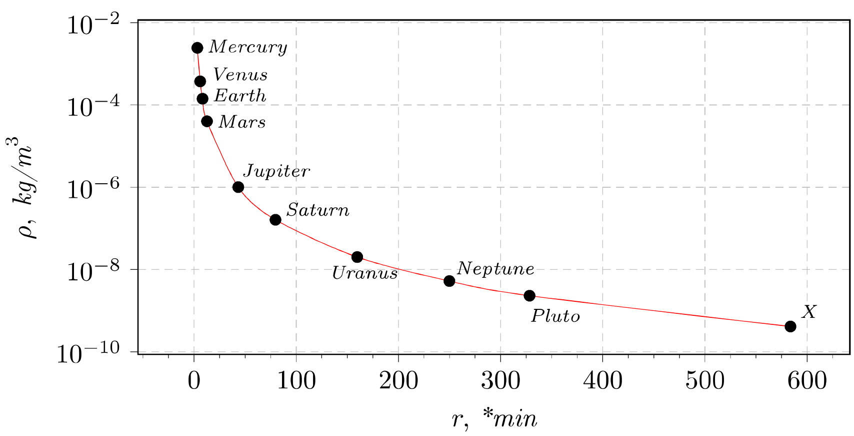

Figure 2: Distribution $\rho(r, v)$ of densities of nested spheres inscribed in respective circular orbits of the planets. The ordinate scale is logarithmic. Distance r is expressed in light minutes.

Analysis of the spheres' density ρ dependence on their radii r has shown that the dependence is well fittable by an power function with the correlation of almost 1 :

$$\rho(r) = ar^{-3\beta} + \rho_0 \ , \quad \beta = 0.999999789 \ ^{*)} \tag{11}$$

where

$$\begin{aligned} a &= 4.7471194762 \cdot 10^{29} \quad [kg/m^{3(1-\beta)}] \ , \\ \rho_0 &= 7.6646813633 \cdot 10^{-11} \quad [kg/m^3] \ . \end{aligned} \tag{12}$$

Hence, the density of gravitating spheres keeping the Solar system planets orbiting circularly with constant orbital velocities varies according to a power law with the power coefficient of -3β. Fig. 2 clearly demonstrates that any already known or yet unrevealed material body (e.g., planet **X**), its velocity and orbit radius should not contradict the power law of density distribution in the sequence of nested gravitating spheres. This means that, using formula (11) for the supposed average radius of the planet **X** circular orbit, it is possible to find the gravitating mass of the sphere inscribed in this orbit and then determine its circular velocity and respective period of revolution about the Sun.

Galaxies. After making sure that the above-described method of the nested sphere sequence is effective, let us apply this approach to spiral galaxies using their "rotation curves" obtained from measured Doppler shifts of star spectral lines. Let us consider the orbital velocity distribution for stars of the following galaxies: `NGC6503`, `NGC3198`, `NGC2403` [2]; `NGC598(M33)` [3]; `NGC7331`, `Milky Way` [4].

Assume that the observed stars of each galaxy move within the galaxy rotation planes along circular orbits about dominant centers of attraction with constant velocities. Fig. 3 represents "rotation curves" of the above-mentioned galaxies in one and the same scale.

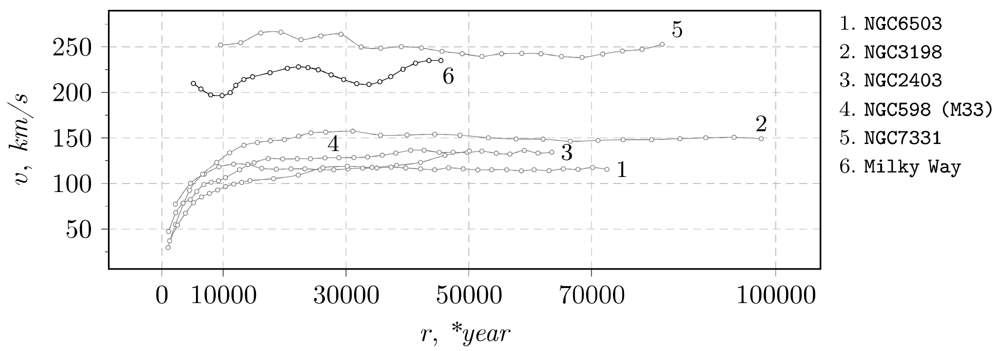

Figure 3: Galaxy "rotation curves".

These velocities were obtained from the measurements of spectral line Doppler shifts for stars lying predominantly in the galaxy rotation planes.

Substituting data on the radial distribution of orbital velocities (Fig. 3) into relations (4) and (5), construct for the sequence of nested spheres distributions of the gravitating masses (Fig. 4) and densities (Fig. 5).

The character of these plots lets us suggest mutual adequacy of kinematic and physical parameters of the galaxies as well as similarity of their evolution processes.

*) The coefficient β proximity to 1 is not a calculation error. Inaccessibility of $\lim_{t\to\infty} \beta(t) = 1$ is determined by physical processes occurring in our Universe. This idea is described in more details in para. 3.

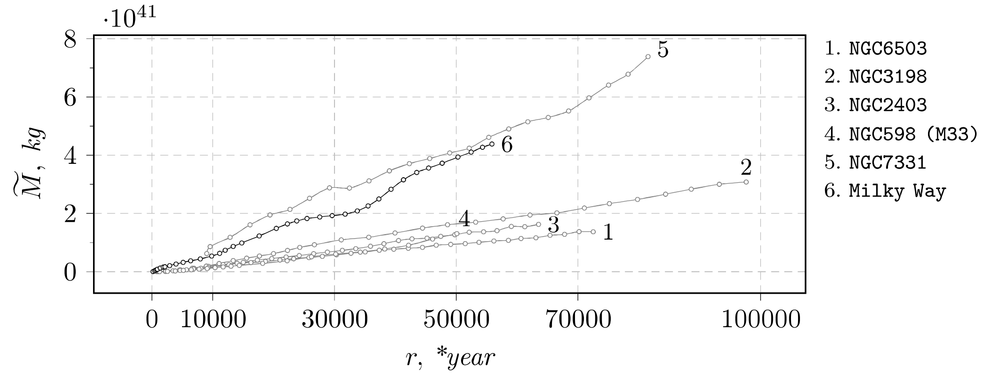

Figure 4: Increase in the sphere gravitating mass $\widetilde{M}$ with increasing radius of the sphere enclosing the galaxy matter.

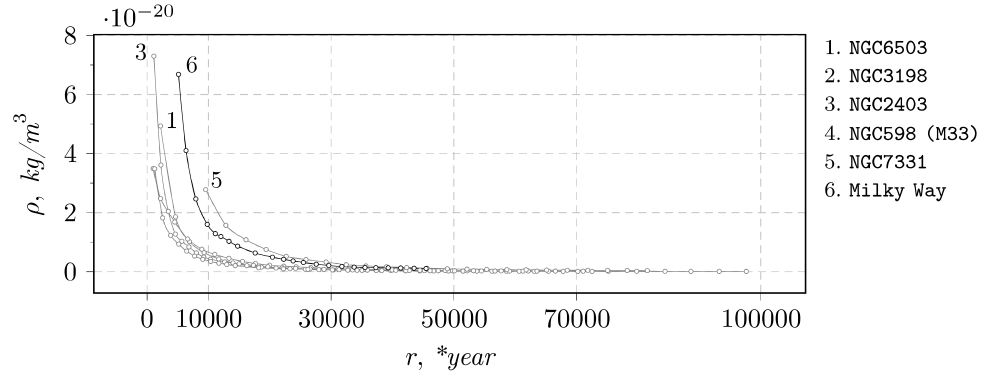

Figure 5: Radial distribution of the nested sphere densities.

Based on the velocity of the farthest star, we can quantitatively estimate the galaxy matter gravitating mass and calculate the galaxy mass. Hence, theoretically it is not difficult to estimate the galaxy mass; for this purpose one should merely select the galaxy star outermost from the galaxy center of attraction and measure the Doppler effect. However, here some technical difficulties arise, namely, the farther is the star, the lower is its angular and, hence, radial velocity, which manifests itself in the fact that the shift of the star spectral line is hardly detectable.

An important specific feature of falling sections of the plots representing a sequence of sphere densities shown in Fig. 5 is good fittability by a power function. Parameters of power function (11) approximating the falling sections of the sphere density plots are listed in Table 2. The results, including data on the Solar system, are arranged according to the increase in dimensionless coefficient β. One can see a regularity allowing an assumption that, as parameter β grows, the gravitation compaction intensity decreases, and the gravitating mass concentrates near the dominant center of attraction.

The obtained densities ρ_0 of the background medium (Table 2) do not contradict the estimates of densities of interstar space and Solar system interplanet matter.

Note. This concerns the comparison of two radial distributions of densities and their possible interchangeability. Here we mean the density expressions (5) and (8). For instance, Fig. 6 presents three curves constructed for galaxy `NGC3198`: the galaxy

	β	a	ρ_0 , kg/m^3	correlation
NGC598(M33)	0.5557725	$7.4682219{\cdot}10^{12}$	$1.9966367{\cdot}10^{-23}$	0.99973
NGC2403	0.6658555	$5.0648252{\cdot}10^{19}$	$3.4107570{\cdot}10^{-23}$	0.99969
NGC3198	0.7029228	$1.4582120{\cdot}10^{22}$	$4.6049746{\cdot}10^{-25}$	0.99972
NGC6503	0.7263460	$2.0268896{\cdot}10^{23}$	$3.3736620{\cdot}10^{-23}$	0.99976
NGC7331	0.7282799	$1.3999389{\cdot}10^{24}$	$2.0675915{\cdot}10^{-23}$	0.99938
Milky Way	0.7640299	$8.5863233{\cdot}10^{25}$	$1.2554146{\cdot}10^{-21}$	0.99996
Solar System	0.9999997	$4.7471194{\cdot}10^{29}$	$7.6646813{\cdot}10^{-11}$	1.00000

Table 2: Parameters of power function (11) fitting the falling sections of plots presenting densities of nested spheres.

"rotation curve", distribution of the spherical layer densities, and distribution of the nested sphere densities. The Fig. 6 curves show that it is quite possible to replace

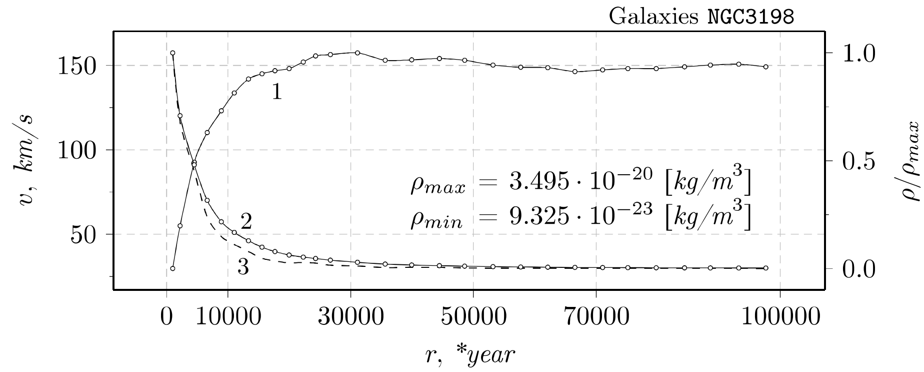

Figure 6: Comparison of density distributions for the sequence of nested spheres and spherical layers for galaxy NGC3198. 1 – the galaxy "rotation curve"; 2 – density distribution for the sequence of nested spheres, equation (5); 3 – density distribution for the sequence of spherical layers, equation (8).

the actual distribution of spherical layer densities with a smoother distribution of the nested sphere densities without losing physical sense. I.e., we may replace the sequence of nested spheres with only one sphere with the radial density distribution (5). We can assert that this sphere characterized by a nonlinear radial distribution of density is fully gravitationally consistent (via the probe mass) with the real galaxy, because orbital velocity of the probe mass (star) located at the preset distance from the center of attraction is consistent with observations.

3. Evolution of gravitating systems

The above-revealed power-like character of the nested sphere density distribution for the Solar system (Fig. 2) and family of galaxies (Fig. 5) allows generalization and makes it possible to formulate a law that functionally interrelates radius r of the sphere inscribed in the probe mass (star) circular orbit and density ρ of this sphere:

$$\boxed{\rho(r,\beta) = ar^{-3\beta} + \rho_0}\,, \qquad r > 0\,, \quad 0 < \beta < 1\,, \quad \rho_0 > 0\,. \tag{13}$$

Here β is the dimensionless coefficient characterizing the evolution stage of the gravitating bodies system, which may be interpreted as, e.g., the ratio between the current time and total time of existence of the system under study; ρ_0 is the density of medium containing the gravitating system. The dimension-matching factor a in (13) may be derived from boundary condition

$$\rho(r,\beta)\Big|_{r=r_{max}} = \rho_{min} \, . \tag{14}$$

Condition (14) is valid for any value from the $0 < \beta < 1$ range and may be regarded as the law of the gravitating mass constancy in the process of evolution of the closed gravitating system. Regardless of the way of the system gravitating matter redistribution with respect to the dominant center of attraction, the total gravitating mass remains constant at all the stages of the system gravitational compaction. All this also follows from the initial condition stating that the gravitating system is closed.

Substituting (14) into (13), define coefficient a as follows:

$$a = (\rho_{min} - \rho_0)\, r_{max}^{3\beta} \, , \qquad \rho_{min} > \rho_0 > 0 \, , \tag{15}$$

where ρ_{min} is the density of matter enclosed by the sphere inscribed in the orbit of the outermost observed object (probe mass) of the system under consideration; r_{max} is the radius of this outermost object (probe mass) orbit.

Thus, the densities of nested spheres inscribed in the probe mass circular orbits may be expressed as follows:

$$\rho(r,\beta) = \begin{cases} \rho(r_{min},\beta) & , \quad 0 < r \leqslant r_{min} \, , \\ \rho(r,\beta) & , \quad r_{min} < r \leqslant r_{max} \, . \end{cases} \tag{16}$$

Then, let us express the gravitating mass in terms of density and the circular velocity in terms of mass by using the empiric density distribution law:

$$\widetilde{M}(r,\beta) = \overbrace{\frac{4}{3}\pi r^3}^{\text{volume}} \rho(r,\beta) \, , \qquad v(r,\beta) = \sqrt{\frac{\mathbf{G}\widetilde{M}(r,\beta)}{r}\left(1 - \frac{\rho_0}{\rho_{prob}}\right)} \, , \tag{17}$$

where ρ_{prob} is the density of a probe mass that is a body moving with velocity v along a circular orbit of radius r about the center of attraction. The probe mass circular velocity depends only on the gravitating mass of the sphere inscribed in its orbit.

Choosing a few values of dimensionless parameter β successively growing from 0 to 1 and using (16) and (17), construct three curves for each fixed β: distributions of density $\rho(r)$, gravitating mass $\widetilde{M}(r)$, and orbital velocity $v(r)$. The obtained plots are presented in Fig. 7.

The Fig. 7 plots illustrate the unidirectional process of gravitational compaction at the constant total gravitating mass. What is meant here is the density redistribution within the system. This process is characterized by dimensionless parameter β from (13). Stating the empiric character of the inscribed spheres' density distribution and using the classical law of gravitational interaction between two point

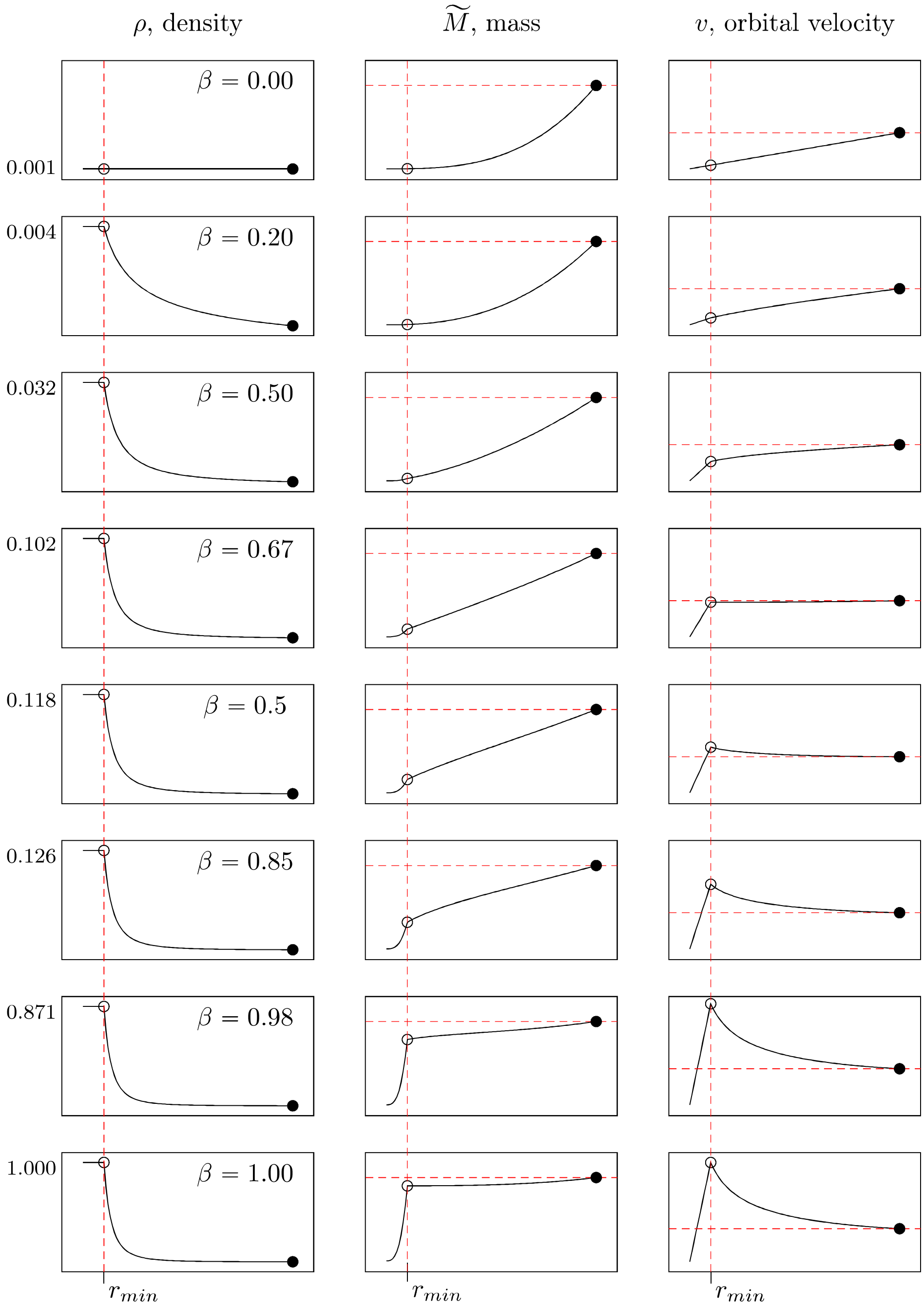

Figure 7: Here ρ is the density of a sphere from a sequence of nested spheres inscribed in the probe mass circular orbits; v is the probe-mass orbital velocity; $\widetilde{M}$ is the total gravitating mass. Black dots indicate the densities, masses and velocities at distance r_{max} from the center of attraction which remain invariant during the entire period of the system evolution.

masses (17), we have obtained a structured sequence of rotation curves (orbital velocity distribution). For instance, $\beta = 0.67$ relates to the orbital velocity distribution having a plateau-like section, which is characteristic of spiral galaxies, while $\beta = 0.98$ correspond to the velocity distribution in the Solar system.

Thus, dimensionless parameter β of the power function characterizes the current ratio between the densities of the nested spheres for a closed system of gravitating bodies, which, in its turn, determines the "rotation curve" character.

Note that the range limits $\beta = 0$ and $\beta = 1$ should be regarded as singular points since they correspond to purely theoretical realizations of the physical systems. For instance, parameter $\beta = 0$ corresponds to the initial stage of evolution, namely, a motionless gas-and-dust "cloud" whose components then begin rotate regularly about the dominant center of attraction due to the internal gravitational interaction. The limiting but not accessible state will be that of total completion of gravitational compaction when all the gravitating mass concentrates in a finite volume with a complete absence of matter outside it. This phase is characterized by $\beta = 1$.

Actually, parameter β is a dimensionless time parameter characterizing the current state of natural gravitational self-compaction of a closed gravitating system. "Life times" of each closed gravitating system are different and depend on various initial conditions of the matter distribution and its characteristics, as well as, to a lower extent, on accompanying internal non-gravitational processes. The only feature common for all closed gravitating systems is the power-like character of the gravitational compaction (13).

"Dark matter". Based on the results of systematic observations of spiral galaxy 21 and empiric method for estimating the gravitating mass from star luminosity, Rubin V.C. [5] has concluded that characteristic radial distribution of the circular velocity with a plateau cannot be achieved in the absence of instrumentally observable material gravitating mass. The presence of the plateau in the "rotation curve" is out of the researchers' evident expectations. The dependence was assumed to be similar to the orbital velocity distribution in the Solar system since the planet orbital velocities decrease with increasing distance from the Sun. Therefore, in addition to the classical matter, a hypothetical invisible matter referred to as "dark matter" was introduced, its physical properties being very obscure.

For instance, Fig. 8 taken from the paper by Yang Y. and Yeung W.B. [2] presents a characteristic plot demonstrating, in their opinion, a qualitative discrepancy between the observed linear velocities of the spiral galaxy stars and those calculated in the scope of classical mechanics upon the condition that the main part of the galaxy gravitating mass is concentrated in the center of attraction. The anomalousness of the galaxies' "rotation curves" 3, namely, the presence of plateaus, disappears if the family of distributions of star angular velocities 9 in rotating about respective dominant attraction centers of the galaxies is constructed. These curves are quite ordinary. The angular velocities decrease towards the gravitating system periphery, the character of the decrease being consistent with that of the Solar system, i.e., everything remains in the frame of classical mechanic. This is just the base for further analysis. Everything located within the sphere inscribed in the star orbit, including objects instrumentally invisible at present, is material and has a gravitating mass dictating the star orbital velocity.

The existence of a plateau in the galaxy "rotation curve" can be explained only by the current matter distribution in the galaxy depending on its gravitational compaction. The rotation curve plateau is merely a reflection of the current distribution of the gravitating matter over the system, which corresponds to a certain stage of the gravitational compaction of matter in its classical sense. The example of the

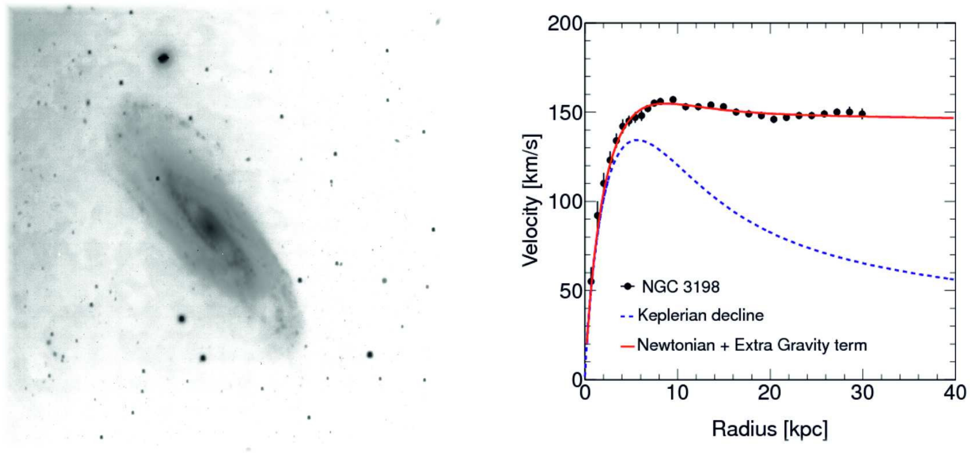

Figure 8: Characteristic distribution of the observed and calculated linear velocities of the stars over their distances from the Galaxy `NGC3198` center [2].

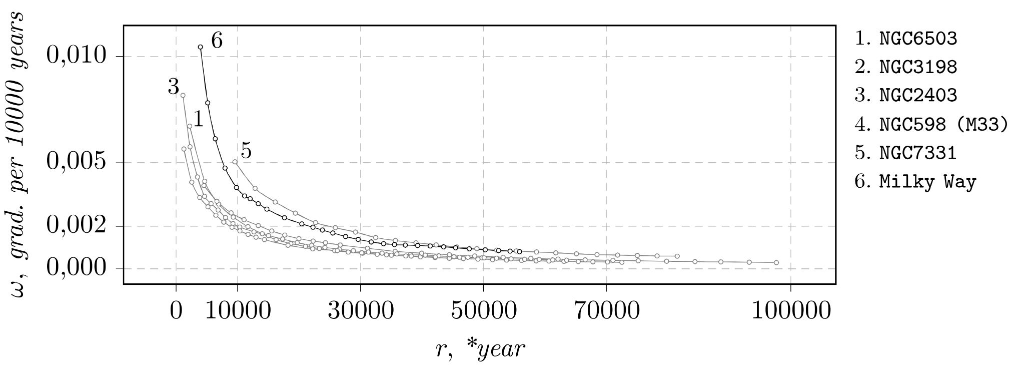

Figure 9: Angular velocities of rotation of stars about attraction centers of galaxies.

Solar system shows unambiguously that no additional gravitating mass with mystic properties is needed.

The revealed empiric dependence (13) valid both for the Solar system and galaxies leads to an unambiguous conclusion that the hypothetical "dark matter" does not physically exist as a gravitating substance.

4. Conclusions

Evolution of the gravitating system. The method of *a sequence of nested spheres* applied to real gravitating systems enabled us to reveal an empiric law describing the nonstationary process of gravitational compaction. A nonlinear mathematical model of the matter density distribution over a closed gravitating system has been created. Using the Doppler measurements of star velocities and the galaxy "rotation curve", it is possible to construct the density distribution of the gravitating matter and calculate the respective evolution parameter β. Dimensionless parameter β allows estimation of the system relative age and its comparison with that of other systems. Gravitating systems evolve from the initial state (a dust-and-gas formation with the initial density distribution) to a final state when almost all the system matter is concentrated in the vicinity of the dominant center of attraction of the system. Essentially, the obtained empiric law of natural gravitational self-compaction of the system is a variant of solution of the n -body gravitational interaction problem.

Universality of gravitational interaction. Due to the fact that the falling section of distribution of nested sphere densities in the Solar system and spiral galaxies can be described by a power function, we can speak about universality of the Gravity Law in its classical interpretation within the instrumentally observable Universe.

Vacuum density. Using the power function to describe the falling part of the nested sphere density distribution, we succeeded in quantitative estimation of the vacuum density, i.e., density of the inter-star and inter-galaxy medium containing the system of gravitating bodies. The results obtained do not contradict the currently known quantitative estimates of densities of different Universe regions.

"Dark matter". The analysis of "rotation curves" of galaxies belonging to the instrumentally observable Universe has shown unambiguously the sufficiency of existence of a sole gravitating mass perceived through classical physical experiments.

The horizontal section (plateau) of the distribution of star orbital velocities is merely a consequence of the current (by the moment of observation) distribution of the matter density in the evolving galaxy. The use of such an entity as "dark matter" for interpreting a "mystic" radial distribution of star orbital velocities in galaxies should be regarded as one of misconceptions that, unfortunately, sometimes occur in science[7] and always lead away from the truth.

In summary, we can recommend you the following:

Entering an unknown room and seeing nothing but darkness, do not hurry to create new entities – just switch on the light.

Here words "switch on the light" mean improvement of the physical experiment technology and development of new physical principles and approaches to measuring the Doppler effect.

[7]It so happened that, in interpreting the observed time variations in the Polar Star altitude, astronomers have missed the fact that the star latitude variations are detected in the rotating frame of reference with a period equal to a solar day [6]. Theoretical physics has postulated the equality of the inertial and gravitating masses, however, time showed that this is valid only for a material medium with zero density which does not exist in our Universe [7, 8].

Appendix A. Solar System

planets	pericenter		apocenter		mass	radius
	r_p, *min	v_p, km/s	r_a, *min	v_a, km/s	$m_i/m_{\oplus}$	$r_i/r_{\oplus}$
☿ – Mercury	2.55732	58.98	3.88157	38.86	0.05526	0.38293
♀ – Venus	5.97524	35.26	6.05641	34.79	0.81498	0.94989
⊕ – Earth	8.17732	30.29	8.45584	29.29	1.00000	1.00000
♂ – Mars	11.48683	26.50	13.85569	21.97	0.10744	0.53202
♃ – Jupiter	41.16848	13.72	45.39918	12.44	317.83477	10.97331
♄ – Saturn	75.19368	10.18	84.19713	9.09	95.16123	9.14016
⛢ – Uranus	152.39987	7.11	166.98329	6.49	14.53571	3.98085
Ψ – Neptune	247.08482	5.50	252.71205	5.37	17.14831	3.86469
♇ – Pluto	246.66064	6.10	410.05756	3.71	0.00218	0.18631
– X	583.73716	3.84	583.77997	3.84	10.00000	

Table 3: Parameters of the Solar System planets[8]. The constants used are: $r_{\oplus} = 6371$ km is the Earth's average radius; $m_{\oplus} = 5.9726 \times 10^{24}$ kg is the Earth's mass. *min is the light minute (distance expressed in time units). During one minute, light covers a distance of 17987547.4 km.

[8] `http://nssdc.gsfc.nasa.gov/planetary/planetfact.html`.

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