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Ten Arguments Against the Proclaimed Amount of Dark Matter

M. Křížek*

Institute of Mathematics, Czech Academy of Sciences, Žitná 25, 115 67 Prague 1, Czech Republic

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Abstract—According to the Standard cosmological model, our universe needs a significant amount of dark matter (DM), about six times that of the usual baryonic matter, besides an even larger amount of dark energy. But to date, both DM and dark energy have remained conceptually delusive, without concrete evidence based on direct physical measurements. In this survey paper, we present ten counterarguments showing that such a claimed amount of DM can be a result of vast overestimation and does not conform to reality. Some of those counterarguments can be convincingly verified even by simple hand calculations.

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Dedicated to Professor Lawrence Somer on his 70th birthday

The term DM (*dunkle Materie* in German) can be found in Zwicky's 1933 paper [51, p. 125] and stands for astronomic matter that could not be accounted for from estimated luminous mass. It was also briefly mentioned in Oort's earlier 1932 paper [38, p. 285], again for mass that was not visible. None of those authors claimed that DM must be nonbaryonic other than just optically invisible. But in modern terms, DM stands for the nonbaryonic DM, it does not include baryonic matter that is not luminous.

The idea that the universe could have "zero radius" in the very distant past was first stated by A. Friedmann in 1922 [13]. In 1927, Belgian cosmologist G.H. Lemaître came up with the claim that the expansion speed of the universe is 625 km/(s Mpc), see [32, p. 56]. Two years later, the expansion of the Universe was independently confirmed by E. Hubble. In [16], he published a chart showing that the radial component of velocity of a galaxy depends approximately linearly on its distance from us, and the expansion speed is about 500 km/(s Mpc). Current measuring technologies lead, however, to a much smaller value of approximately 70 km/(s Mpc), see [40].

DM should decelerate the expansion of the universe. Nevertheless, according to the standard ΛCDM cosmological model (i.e., Λ-Cold Dark Matter), an accelerating expansion of the universe is observed due to *dark energy*. This proposition is based on the fact that the expansion function (scale factor) seems to have been strictly convex over the last 5 Gyr, see, e.g., [20, 24]. From Fig. 1 we may deduce that

$$\text{the ratio of masses of dark matter to baryonic matter} \approx 6:1. \tag{1}$$

The aim of this paper is to collect arguments showing that this ratio is exaggerated. We do not claim that DM does not exist. However, we do claim that the ratio on the left-hand side of (1) is smaller and can even be zero.

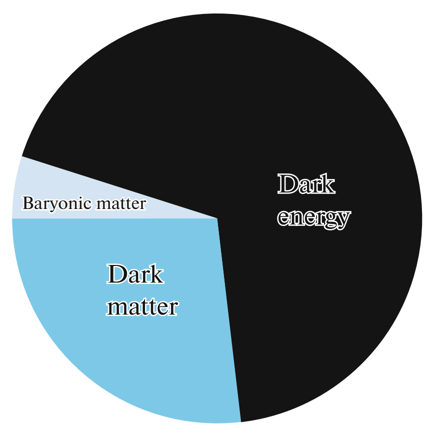

Fig. 1. According to the scientific results of the Planck satellite [40], our Universe is composed of about 68% of dark energy (DE), 27% of DM, and less than 5% of baryonic matter. However, these data were obtained from the ΛCDM cosmological model which is based on excessive extrapolations (cf. Section 2). It is said that dark and baryonic matter should slow down the expansion of the universe, while DE should cause its acceleration.

*E-mail: krizek@cesnet.cz

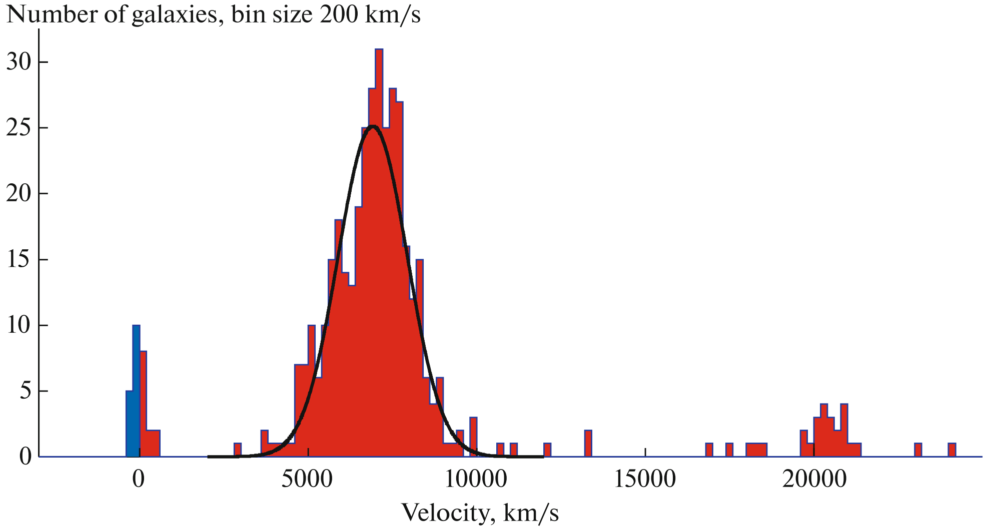

Fig. 2. Histogram of radial velocities less than 25 000 km/s of galaxies projected to the Coma cluster region. Here we consider only those galaxies whose magnitude does not exceed 20. These data are available in [1, 6, 10]. Galaxies possessing blueshift are on the left. The dark line represents the Gaussian curve fitted to data that correspond to galaxies belonging to the Comma cluster. Other galaxies are not contained in this cluster since their velocities with respect to the cluster's center of gravity are too large. They should not be used to calculate the virial mass (3), because they do not form a bound system.

1. ANALYSIS OF ZWICKY'S METHOD

In 1933 Fritz Zwicky predicted the existence of some hypothetic DM which holds together the Coma galaxy cluster A1656. Using the Virial Theorem

$$V + 2T = 0, \tag{2}$$

he estimated its mass M by the formula

$$M = \frac{5R\overline{v}^2}{3G}, \tag{3}$$

where $V = -\frac{3}{5}GM^2/R$ is the total potential energy of the cluster, $T = \frac{1}{2}M\overline{v}^2$ is the kinetic energy, R is the cluster radius, and $\overline{v}$ is the mean quadratic speed with respect to the center of gravity of the cluster. In [51], Zwicky stated that to explain the fast motion of galaxies for which $\overline{v} > 1000$ km/s in the Coma cluster, he had to assume the existence of a 400 times larger amount of nonluminous than luminous matter to keep the cluster gravitationally bound together. In [52], he reduced this ratio to 150. However, he used very imprecise data and made many simplifying assumptions. Thus, he was mistaken by an order when estimating the distance of the cluster, and by two orders when calculating the masses of galaxies from their luminosity, he replaced galaxies by point masses, he used Newtonian classical mechanics in flat Euclidean space, he measured the recession velocities with an accuracy of ≈100 km/s, he assumed that the Virial Theorem (2) holds absolutely exactly, etc. Therefore, the DM to baryonic matter mass ratio later reduced to (1).

If the *virial parameter* is $Q := T/|V| = 0.5$, then the virial mass M is given by (3). However, it seems that $Q > 0.5$ (i.e., the cluster dissolves), and then from (2) we get

$$M < \frac{5R\overline{v}^2}{3G}.$$

Considering a nonuniform mass distribution, the factor 5/3 in (3) can be made smaller (see [23, pp. 112–115] for details). Also, Sinclair Smith [47] assumes that this factor is only 1/2 or 1 for the Virgo cluster. Taking into account the relativistic effects of high velocities, gravitational redshift, gravitational lensing in a curved space, the decreasing Hubble parameter, intergalactic baryonic matter, gravitational aberration, etc., the proclaimed virial mass M and also the ratio (1) can be essentially reduced by means of actual data (see Fig. 2). These arguments are not accounted for in Zwicky's method, see [21] for details.

Finally note that the Coma cluster is located near the north Galactic pole. Therefore, its recession speed from the Sun is practically equal to that of a Coma cluster galaxy from the Milky way, even though the orbital speed $v_\odot = 230$ km/s of the Sun about the Galactic center is relatively high. The mean recession speed can be established by Pogson's equation, for details see [23, p. 111].

2. EXCESSIVE COSMOLOGICAL EXTRAPOLATIONS

Each equation of mathematical physics has certain ranges of the size of investigated objects where

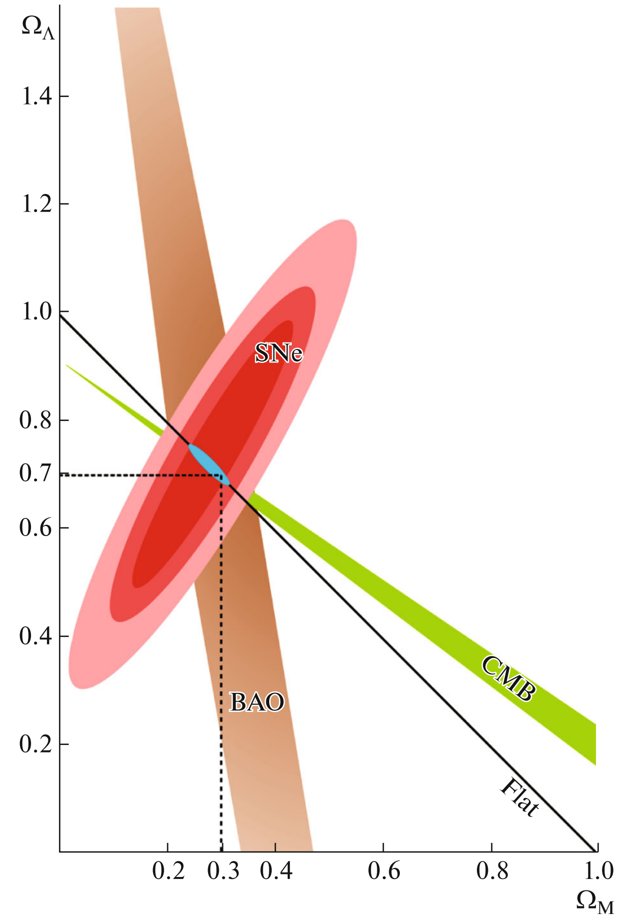

Fig. 3. Admissible values of the cosmological parameters (4) and (5) obtained by three different methods: BAO, CMB, and SNe, intersect in a small region containing the proposed parameters $\Omega_M \approx 0.3$ and $\Omega_\Lambda \approx 0.7$. However, these methods are not independent, because they are all based on the normalized Friedmann equation derived by questionable extrapolations.

reality is modeled well and where its description fails, i.e., the modeling error essentially depends on the size of these objects, see [25]. At present, the ΛCDM model, based on the Friedmann equation, is preferred. Alexander Friedmann [13] derived it in 1922, and he applied the scale non-invariant Einstein's equations to the whole Universe, even though they are formulated only locally. In this way he committed a questionable extrapolation since these equations "are verified" (cf. [19]) on scales of the Solar system while the universe is at least 15 orders of magnitude larger.

The current cosmological model is based on the normalized Friedmann equation

$$\Omega_M + \Omega_\Lambda = 1,$$

which is assumed to be valid for any time, and the spatial curvature is supposed to be close to zero. Here the so-called *mass density parameter* is defined by

$$\Omega_M(t) := \frac{8\pi G\rho(t)}{3H^2(t)}, \qquad (4)$$

where $\rho(t)$ is the mass density, $H(t) := \dot{a}/a$ is the *Hubble parameter*, $a = a(t)$ is the scale factor of the Universe, and the dot denotes a time derivative. The *vacuum energy density* is defined by

$$\Omega_\Lambda(t) := \frac{\Lambda c^2}{3H^2(t)}, \qquad (5)$$

where Λ is the cosmological constant and c the speed of light in vacuum.

A tiny intersection of admissible sets of cosmological parameters determined by three different methods of Baryonic Acoustic Oscillations (BAO), Cosmic Microwave Background (CMB), and Supernovae type Ia explosions (SNe) should demonstrate that the Universe consists of approximately 70% of dark energy and 30% of dark and baryonic matter, see Fig. 3. However, these methods are not independent since they are all based on the same Friedmann equation, derived by questionable extrapolations, see [26]. In truth, it is more likely that the measured data sketched in Fig. 3 just indicate that the extrapolation is wrong since it requires introduction of some exotic DM and DE. Consequently, it seems that the real dynamics of the Universe cannot be described by the simple Friedmann equation, which is an autonomous ordinary differential equation[1] with time-independent coefficients (see [26, p. 274]). From such a simple equation, far-reaching conclusions on the deep past and far future are made in [3, 40], ...

In the vicinity of our Galaxy, up to a distance of 400 Mpc, we observe that the mean mass density is lower than elsewhere, see, e.g., [30, p. 172]. However, from a statistical point of view, it is very unlikely that we could be located just in the middle of such an underdensity bubble. This also indicates that the Friedmann equation should not be applied to cosmological distances.

Another reason is that the difference between the measured and theoretically derived density of vacuum energy is 120 orders of magnitude (see, e.g., [3, pp. 3, 109]). It makes evident that the present cosmological model cannot be correct.

[1] The behavior of many dynamical systems essentially depends on history, i.e., on the way in which the system got into its present state. The Friedmann equation does not have this property, since it is an ordinary differential equation.

Distribution of stars in our Galaxy by spectral classes. The second row shows the mass of a typical star in solar mass units, $M_\odot = 2 \times 10^{30}$ kg. The third row shows the number of stars of a particular spectral class divided by 10^9. The last row presents the calculated mass of all stars in a particular spectral class in billions of solar masses. The last column corresponds to white dwarfs (WD) which belong to luminosity class V

Spectral class	O	B	A	F	G	K	M	WD
Mass in $M_\odot$	25	5	1.7	1.2	0.9	0.5	0.25	0.7
Number in billions	10^{-5}	0.3	3	12	26	52	**270**	35
Product	≈0	1.5	5.1	14.4	23.4	26	**67.5**	24.5

3. RED DWARFS

In 1960 Jan Oort [39] showed that the observed oscillations of stars perpendicularly to the galactic plane require double mass density of the galactic disk. At the end of the 20th century it was thought that red dwarfs of spectral class M form only 3% of the total number of stars, see [5, p. 93]. However, at present it is estimated that red dwarfs are in vast majority, about 70% (see Table 1). To support this statement we point out that among 20 nearest stars to our Sun, 13 red dwarfs are currently known. The mass of a red dwarf ranges from 0.08 $M_\odot$ to 0.45 $M_\odot$. The observed motion of stars perpendicularly to the galactic plane can thus be explained by a large amount of red dwarfs without DM.

Table 1 is based on Hipparcos' data taken from our close neighborhood up to a distance of a few hundred parsecs. The Harvard Spectral Classification [54] shows a similar relative representation of stars. Also, the observational HR diagram by the Gaia satellite is almost the same as that of the Hipparcos satellite [14]. Furthermore, Gaia is able to look at the center of our Galaxy and in the opposite direction at the galactic edge.

In the last century, astronomers, of course, could not know about the existence of so many red dwarfs of spectral class M. This growth is due to the continual sensitivity improvements of space telescopes. In this way, the estimated mass of baryonic matter in our Galaxy has considerably increased. Summing up the numbers in the last row of Table 1, we get

$$\mathcal{M}(r_{\rm G}) \geq 162.4 \times 10^9\ M_\odot = 3.25 \times 10^{41}\ \text{kg},$$

where $\mathcal{M}(r)$ is the *mass of baryonic matter* in a ball of radius r, centered in the middle of our Galaxy, and the radius of the visible part of our galactic disk is estimated as

$$r_{\rm G} = 16\ \text{kpc} = 4.938 \times 10^{20}\ \text{m}. \quad (6)$$

Unfortunately, we cannot so far reliably determine the contribution to the total mass of our Galaxy from black holes, neutron stars,[2] infrared dwarfs,[3] etc., whose luminosities are small. According to [35, p. 393], the mass of baryonic matter of all stars in the Galaxy is about

$$175 \times 10^9\ M_\odot = 3.5 \times 10^{41}\ \text{kg}, \quad (7)$$

including further stars of luminosity classes I–IV (i.e., supergiants, giants, and subgiants). The disk and bulge contain also a large amount of nonluminous baryonic matter in the form of dust, gas, and plasma. In [35, p. 353], the amount of interstellar matter (without hypothetic DM) is estimated at about 10% of the total mass of Milky Way's stars, i.e., by (7) we obtain

$$\mathcal{M}(r_{\rm G}) \geq 3.85 \times 10^{41}\ \text{kg}. \quad (8)$$

It is a much larger value than that predicted in the 20th century. Thus the ratio (1) should be smaller.

4. ANALYSIS OF ROTATION CURVES BY VERA RUBIN

Vera Rubin's greatest discovery was the fact that spiral galaxies have "flat" rotation curves (see Fig. 4 and [41]). On that basis, in the 1970s she developed her own theory of rotation curves of galaxies. From the high orbital speed of stars she concluded that galaxies should contain much more nonluminous than luminous matter to be kept together by gravity, see, e.g,. her review articles [42, 44, 45].

Now let us look more closely at her hypothesis. Consider a test particle of mass m (typically this will be a star) and let $M \gg m$ be the mass of a body generating the central force field. Assume that the

[2] The amount of stars in the left part of Table 1 is so small because they live very briefly. On the other hand, there may exist many invisible superdense compact remnants left by these stars in the Galaxy.

[3] Three new spectral classes for small cold dim stars were introduced quite recently: L (red-brown dwarfs), T (brown dwarfs), and Y (black dwarfs). For instance, in 2013 Kevin Luhman discovered a pair of brown dwarfs only 6.5 ly from the Sun. Another brown dwarf WISE J085510.83-071442.5 is located 7.2 ly from us. It seems that there exist over 10^{11} brown dwarfs i n the Milky Way.

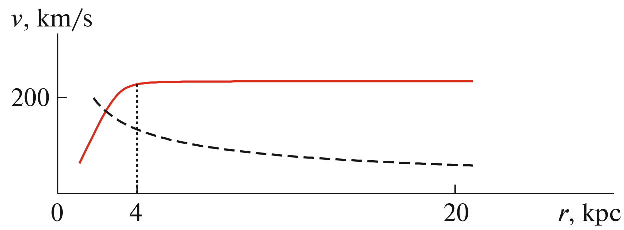

Fig. 4. The solid line shows an idealized rotational curve whose shape was derived by Rubin from a variety of measurements. It is flat for $r > r_0 \approx 4$ kpc. The dashed line shows a decrease of velocities for Keplerian orbits depending on the distance r from the center of a spiral galaxy.

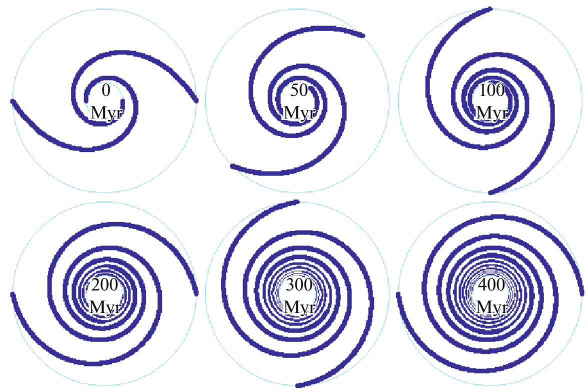

Fig. 5. The flat rotational curve from Fig. 4 causes very quick tightening of spiral arms after one revolution of the most external stars. This takes approximately 400 Myr for a typical spiral galaxy (note that the age of the Sun is more than 10 times larger). Here, stars at the galactic edge revolved about the angles: 0 (an idealized initial state), $\pi/4$, $\pi/2$, π, $3\pi/2$, and 2π. After a relatively short time period of 100 Myr we would not get a shape similar to Fig. 10. After a few hundreds million years the spiral arms would be highly twisted. After 1 Gyr they would be completely wrapped up. However, observed spiral galaxies exist for many Gyr.

test particle revolves about the center along a circular orbit with radius r and speed v. Then from Newton's law of gravity and the relation for a centripetal force, Rubin easily obtained that [42, 43]

$$G\frac{Mm}{r^2} = \frac{mv^2}{r}, \quad \text{i.e.,} \quad v = \sqrt{\frac{GM}{r}}. \tag{9}$$

The velocity v of a particle in a circular orbit is thus proportional to $r^{-1/2}$. Such orbits are called *Keplerian* (see Fig. 4).

In 1962, Rubin et al. in [41, p. 491] stated: ... *the stellar curve does not decrease as is expected for Keplerian orbits*. To explain this discrepancy, we note that spiral galaxies do not have a typical central force field. For instance, the mass of the central black hole is only 0.01% of the total mass of our Galaxy; while in the Solar system 99.85% of the mass is concentrated in the Sun. The planets barely interact gravitationally among themselves, and their motion is determined mainly by the central force of the Sun. Unlike that, trajectories of stars in a galactic disk are substantially influenced by neighboring stars since the central bulge contains only about 10% of the total mass of a galaxy. Therefore, the speed v of stars in circular orbits in a spiral galaxy should be higher than for Keplerian orbits (cf. Fig. 4). For details see [22].

Noteworthy, the stars of spiral galaxies are measured to move at almost constant speed [45, p. 7], but these galaxies are not winding up and surprisingly do not show an expected tightening of arms as shown in Fig. 5. Therefore, their shape cannot be stable if they have gone through many revolutions.

To see this, consider a spiral galaxy as in the upper left part of Fig. 5. Assume that the outer radius is 20 kpc, and the inner radius $r_0 = 4$ kpc (see Fig. 4). Then after one revolution of a star in the outer orbit, a star in the inner orbit makes $20 : 4 = 5$ revolutions if it has the same speed. This contradicts observations (e.g., Fig. 10).

With difficulty it can also be assumed that the arms of, e.g., type Sbc galaxies are formed by some kind of density waves, as suggested in [5, p. 544]. Such barred spiral galaxies resemble an open letter S. Therefore, many astronomers did not become convinced of the need for DM halos in spiral galaxies.

5. ORBITAL SPEED OF STARS

Our Sun orbits the center of the Milky Way with the speed[4]

$$v_\odot = 230 \text{ km/s} \tag{10}$$

in a path of radius $r_\odot = 8$ kpc, i.e., it stays about halfway (cf. (6)) out from the center O of the Galaxy. Stars orbiting the center of our Galaxy at any distance $r > r_0 \approx 4$ kpc should have a speed similar to $v_\odot$ due to the expected flat rotation curve (Fig. 4).

Denote the mass of all baryonic matter contained inside the ball of radius (6) centered at O by $\mathcal{M}(r_G)$. Further, we shall proceed in two steps:

1. First, let us concentrate all baryonic matter contained in this ball at the central point O. Then from (6), (8), (9), the velocity of a test particle in the orbit of radius r_G is

$$v = \sqrt{\frac{G\mathcal{M}(r_G)}{r_G}} \geq \sqrt{\frac{6.674 \times 10^{-11} \times 3.85 \times 10^{41}}{4.938 \times 10^{20}}} = 228 \times 10^3 \text{ (m/s)}. \tag{11}$$

[4] Most sources give the solar speed $v_\odot$ in the range of 220 to 240 km/s.

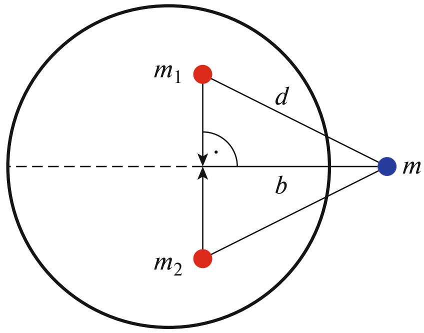

Fig. 6. A ball with symmetrically distributed mass with respect to the horizontal plane acts on a test particle with a smaller force than the mass projected perpendicularly to the horizontal plane of the disk—dashed.

Fig. 7. The Antennae Galaxies, also known as NGC 4038/NGC 4039, are a pair of interacting galaxies in the constellation Corvus.

By this simple "back of the envelope" calculation, we see that v is indeed comparable to the measured speed (10). Although these relations are only approximate, to postulate the existence of six times more DM than baryonic matter (see (1)) to hold the Galaxy together by gravity seems to be highly overestimated.

2. Second, we claim that the orbital velocity around a flat disk of the same mass is even higher than that in (11). This results from the following theorem proved in [23, pp. 131–134].

Theorem. *A particle orbiting a central mass point along a circular trajectory of radius R has a smaller speed than if it were to orbit a flat disk of radius R and the same mass with an arbitrary rotationally symmetric density distribution.*

To explain the main idea of the proof, consider the situation in Fig. 6. Let two point masses $m_1 = m_2$ be located inside a ball placed symmetrically with respect to the horizontal plane. Let a test particle of mass m be in this plane. Then the total force F of both point masses acting on the test particle of mass m will be smaller than the force $\overline{F}$ of both point masses projected perpendicularly to the disk and acting on m. Let d be the distance between m_1 and m. Denoting by b its orthogonal projection on the horizontal plane, we find that

$$F = G\frac{2m_1 m}{d^2} \cdot \frac{b}{d}, \quad \text{and} \quad \overline{F} = G\frac{2m_1 m}{b^2}.$$

Thus the ratio of forces $\overline{F}$ and F is equal to a cube of the fraction d/b,

$$\overline{F} = \left(\frac{d}{b}\right)^3 F \geq F.$$

This cubic nonlinearity causes a larger attractive gravitational force from the disk than from the ball (cf. (9)), hence also a higher orbital speed around the disk. For instance, $(5/4)^3 \approx 2$. The above theorem thus explains the large orbital velocities of stars in our Galaxy, even though spiral galaxies do not have a rotationally symmetric distribution of mass. It also indicates why (1) is overestimated and why Newton's law of gravity on galactic scales could be still a fairly good approximation of reality.

Finally, note that for a spherically symmetric mass distribution of the halo may be neglected due to the Shell Theorem [23]:[5] it concerns dark and baryonic matter outside a ball that contains the galactic disk. For simplicity, assume that the areal baryonic mass density $\sigma(r)$ of the galactic disk decreases[6] as r^{-1}. Then the total mass of the disk inside the circle of radius r is

$$\mathcal{M}(r) = 2\pi \int_0^r \sigma(s) s \, \mathrm{d}s = Cr,$$

where s is the Jacobian of the polar coordinates, and $C > 0$ is a proportionality. factor: Substituting $\mathcal{M}(r)$ into (11), we find that

$$v = \sqrt{\frac{G\mathcal{M}(r)}{r}} = \text{const.}$$

This is of course only a very rough estimate, but it suggests why the real velocities are almost constant at $r > r_0$ (see Fig. 4) without DM.

6. TIDAL TAILS

Figure 7 presents a collision of two galaxies called *Antennae*. Behind each galaxy there is a clear "tidal

[5] The Shell Theorem states that a spherical layer with a spherically symmetric mass density distribution exerts no force on a point mass located inside.

[6] Rubin in [43, p. 1340] and [44, p. 29] assumed spherical symmetry of the whole galaxy and that the density $\mathcal{M}(r)/r^3$ decreases as r^{-2}, much faster than r^{-1}. Then from the relation $G\mathcal{M}(r)m/r^2 = mv^2(r)/r$ (cf. (9)) she got $v(r) \equiv$ const.

tail" showing their original trajectories. If there were to be six times more DM than baryonic matter (see (1)) around this pair, there would not be such nice almost elliptic Keplerian orbits as in the classical two-body problem.

7. COLLISION OF GALAXY CLUSTERS

Douglas Clowe et al. [9] proposed a collision of two galaxy clusters, where the intergalactic gas is stopped while the galaxies continue in an unchanged direction together with presumed DM. The title of this paper ("A direct empirical proof of the existence of DM") should impress that DM was finally found. Nevertheless, we are unable to measure tangential components of velocities of these clusters to prove that the collision really happens. The authors neglect dynamical friction of particular galaxies and suppose quite an unrealistic mutual infall velocity (see [9, p. L112])

$$v \approx 4700 \text{ km/s} > 0.01c$$

of these clusters to guarantee that the collision does not last more than a few billion years. The expected tidal tails are not visible as in Fig. 7. Moreover, the proposed infall velocity v has the opposite sign to the overall Hubble expansion speed of the universe. How could these two clusters get such unlikely high velocities several Gyr ago? This would produce an extremely large kinetic energy proportional to v^2 in an almost isotropic and homogeneous Universe, where the local peculiar speed of galaxies is usually only a few hundred km/s.

The regions with DM are artificially colored in blue [9] by some numerical simulations based on gravitational lensing. In the case of light bending near our Sun at total eclipses, we know exactly the bending angle. However, for hypothetic DM regions we have to apply only some inexact heuristic algorithms and interpolation techniques between galaxies, since galaxies are represented only by several pixels in photos.

8. REVOLUTION OF TWO GIANT GALAXIES IN THE COMA CLUSTER

Now we shall present another "back of the envelope" calculation illustrating whether it is necessary to assume some extragalactic DM at the center of the Coma cluster, satisfying (1). Each of the two supergiant elliptic galaxies NGC 4889 and NGC 4874 in the middle of Fig. 8 has a mass 10 times as large as that of the Milky Way (see, e.g., [53]). Hence,

$$m = 10M_{\text{G}} = 10^{13}\ M_\odot = 2 \times 10^{43} \text{ kg}, \qquad (12)$$

Fig. 8. Giant galaxy cluster Abell 1656 in the constellation Coma Berenices. In the middle there are two supergiant elliptic galaxies NGC 4889 and NGC 4874 (photo NASA).

where the total mass of our Galaxy is $M_{\text{G}} = 10^{12}\ M_\odot = 2 \times 10^{42}$ kg as given in [31, p. 127]. This mass M_{G} is, of course, larger than the lower bound for $\mathcal{M}(r_{\text{G}})$ in (8), where r_{G} is the radius of the visible part of the galactic disk only. Assume that both giant galaxies[7] orbit along a circular trajectory with center O, radius r, and velocity v.

By the Shell Theorem [23, p. 45], the gravitational potential inside a homogeneous spherical layer is constant. External galaxies and possible DM outside the sphere with center O and radius r have almost no effect on this motion. From Newton's laws and the relation for a centripetal force we get

$$\frac{Gm^2}{4r^2} = \frac{mv^2}{r}. \qquad (13)$$

The galaxies' distance on the celestial sphere is 8.15′, which, projected on the distance of 100 Mpc, gives 7.32×10^{21} m. Thus for the radius r we have

$$r \geq 3.66 \times 10^{21} \text{ m}. \qquad (14)$$

According to [1, p. 19], the measured radial velocities of the two supergiant galaxies are 6472 km/s and 7189 km/s. Their average velocity $\tilde{v} = 6830.5$ km/s nicely corresponds to the mean recession speed of the whole cluster (Fig. 2). For the radial velocity v_{radial} with respect to O we get by (12)–(14)

$$3.585 \times 10^5 = \frac{7\,189\,000 - 6\,472\,000}{2} = v_{\text{radial}} \leq v$$
$$= \sqrt{\frac{Gm}{4r}} \leq \sqrt{\frac{6.673 \times 10^{-11} \times 2 \times 10^{43}}{4 \times 3.66 \times 10^{21}}}$$

[7] If one of these two galaxies were smaller, it would orbit the larger one with a higher velocity and at a longer path. Then it would absorb more additional galaxies than the larger one. By this mechanism the masses of the two galaxies are well balanced, see (12).

$$= 3.02 \times 10^5\ (\text{m/s}). \qquad (15)$$

Comparing the left-hand and right-hand sides, we find a small discrepancy. However, by the Shell Theorem, the velocity of the two giant galaxies is mainly affected by matter located inside the sphere of radius r and center O. Thus, considering the gravitational influence of other matter (small galaxies, large amount of solitary stars, and hot gas) inside this sphere, the right-hand side of (15) should be much larger. For instance, by [49], the intracluster medium contains 30–50% of stars from all stars of the cluster. Inside galaxy clusters there is at least five times more baryonic matter in the form of hot gas emitting X-rays than baryonic matter contained in the galaxies [2, 7, 17, 50].

Assume, for simplicity, that this additional baryonic matter of mass M has a spherically symmetric distribution. Concentrating the mass M at the center O, the speed v in (15) can be, using the First Newton Theorem [23, p. 43], replaced by

$$\overline{v} = \sqrt{\frac{G(m + 4M)}{4r}} \gg v.$$

To see that, it is sufficient to consider the relation

$$\frac{Gm^2}{4r^2} + \frac{4}{4} \times \frac{GmM}{r^2} = \frac{m\overline{v}^2}{r}$$

instead of (13). Zwicky's paradox of large observed velocities thus vanishes since it has quite a natural explanation without DM (cf. (1)).

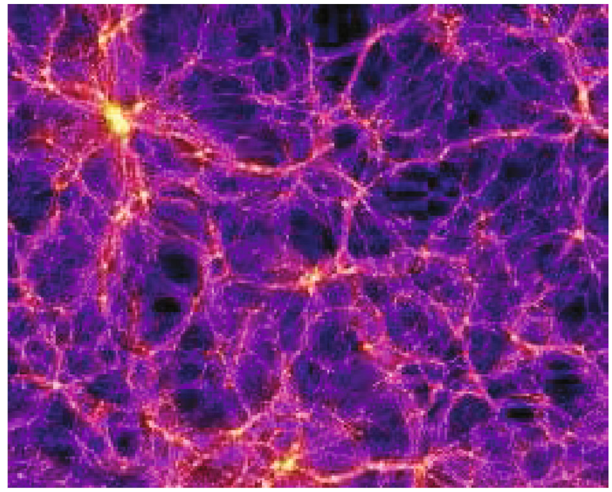

Fig. 9. Millenium simulation.

Fig. 10. Spiral galaxies could not have such a large symmetry if there were to be six times as much of uniformly distributed DM than as structured baryonic matter.

9. MILLENNIUM SIMULATION

The Millennium simulation [8] seeks to prove that without DM galaxies could not form after the Big Bang. However, this simulation is based on a Newtonian model with unclear definition of initial and boundary conditions. This model possesses several classical drawbacks, for instance, the mirror image of Fig. 9 should also be a solution of this problem. The modeling error of the N-body simulation with 10^{10} DM particles as presented in [48] is ignored. It is also not evident whether Newtonian mechanics can be applied to the early superdense Universe. Moreover, the Millennium simulation assumes an infinite speed of gravitational interaction which obviously contradicts causality. Therefore, any conclusion on the existence of a large amount of DM is questionable.

10. HIGH SYMMETRY OF SPIRAL GALAXIES

Gravity is the only interaction that rules our universe on galactic scales. Dark matter should only interact gravitationally (and perhaps also weakly). Most of the observed galaxies have a spiral structure. If these galaxies were to contain six times as much of more uniformly distributed DM as baryonic matter, they could not exhibit such a high symmetry of structured baryonic matter as seen in Fig. 10, since they would be governed by DM halo. Although non-discovery of DM does not mean that it does not exist, the ratio (1) seems to be again overestimated.

11. FINAL REMARKS

In the previous sections we have introduced 10 arguments showing that the amount of DM as given in (1) seems to be considerably overestimated. It then follows that the amount of DE shown in Fig. 1 is also mistakenly determined, or that DE does not exist at all.

It is very probable that Newton's law of gravity and GR on the large cosmological scales approximate the reality only very roughly, and thus the proclaimed DM is nothing else than a modeling error. Pavel Kroupa in [27, 28] states other arguments that point at the absence of DM around our Galaxy and M31. A number of other papers [4, 11, 12, 15, 18, 29, 33, 36, 37, 46] also confirm that on the scales of galactic disks it is not necessary to assume the existence of DM. The main arguments are as follows:

• The influence of DM in the Solar system has not been observed, even though our Sun is a large gravitational attractor [36].

• The ratio between the virial mass and luminous mass in globular clusters is smaller than two [34].

• The cosmic microwave background corresponds to a redshift $z \approx 1089$ [40]. The most typical diameter in fluctuations of the temperature angular power spectrum is about 1°. Since the radius of the universe is about 10^{27} m, the size of these fluctuations is about 10^{21} m, which is comparable with the present diameter of 100 000 ly of our Galaxy. However, there is no physical process that could produce, e.g., polarization of the CMB or BAO on such a large scale during a period of only 10 000 years when the CMB was created. At that time, the mean mass density was $(z+1)^3 \approx 10^9$ times larger than now. Hence, it is difficult to state any reliable conclusions on the present value of the mass density parameter (4) from the CMB map.

• Also, weak gravitational lensing essentially deforms CMB for $z \gg 1$ (see [26, p. 277]).

• Several modifications of Newtonian theory, e.g., MOND (Modified Newtonian Dynamics) and its relativistic generalization TeVeS (Tensor-Vector-Scalar), are at present being developed and studied. Effects that are attributed to DM are explained by a different form of the gravitational law on large scales. However, MOND contradicts causality since it assumes an infinite speed of gravitational interaction.

Remark. In the standard model of particles and their interactions, there is no place for axions, neutralinos, WIMPs, etc. Also the LHC at CERN has not found any signs of new physics that could explain DM.

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