The existence of Dark energy leaves no room for Dark matter

H.A. Harutyunian *

Byurakan Astrophysical Observatory, Armenia

Abstract

Dark matter was introduced into science to reconcile observational data with the dominant cosmogonic ideas. According to these ideas, all baryon configurations in our Universe are believed to be dynamically balanced, to which the virial theorem is applicable. However, the discovery of dark energy changed the situation drastically. Self-consistent application of physical laws to the process of interaction between baryon matter and the carrier of dark energy allows one to conclude that all baryon configurations are constantly gaining energy and cannot be balanced. Therefore, the need to introduce dark matter disappears, and the only inevitable conclusion is the rejection of dark matter, since it does not exist.

Keywords: *Dark energy, dark matter, baryon matter, interaction, energy exchange; virial theorem, expansion.*

1. Introduction

Dark matter, being the first cosmological "dark substance," hypothesized to interpret observational data, has a long history of ultimate recognition. The development of the idea of dark matter can be historically divided into two stages. Firstly, it was understood as ordinary matter that did not emit any radiation at all or did not have visible radiation. However, after some time, the physical properties of this hypothetical matter were changed: it became a non-baryonic substance with specific characteristics.

Currently, dark matter, as an introduced free parameter, which was invented to reconcile empirical data with theoretical results, is used in many situations. Like any other free parameter, dark matter is attributed precisely those properties that are needed to interpret the complicated situations. Two main characteristics, for example, which, according to researchers, dark matter should have, determine its capabilities for distribution and structure formation. It is believed that dark matter particles interact only gravitationally and are also deprived of the ability to free themselves from energy in any way. This excludes the formation of more complex "objects" from it, such as stars, planets, etc.

In this paper, we consider the question of the emergence of the hypothesis of the existence of dark energy. An analysis of the history of the emergence of this idea shows that the only reason for introducing dark matter into the arsenal of physics is the prevailing cosmogonic hypothesis, which states that all cosmic objects and their systems are formed as a result of the compression of a more rarefied substance, in which the resulting systems must be dynamically balanced. In this case, a contradiction arises between the observed velocity dispersions and the small mass of these systems, which is unable to ensure equilibrium.

On the other hand, we draw attention to the fact that in the presence of dark energy, equilibrium systems cannot exist in principle, since due to the interaction of the carrier of dark energy with baryon structures, the energy of the latter constantly increases. Therefore, even if at first they obeyed the requirements of the virial theorem, over time they increasingly move away from this and must expand, which is what observations show.

2. The brief history of dark matter

Many interesting and instructive facts have been presented in scientific literature devoted to the history of the concept of dark matter (see, for example, Bertone & Hooper (2018), de Swart et al. (2017)). We

*hhayk@bao.sci.am

doi: https://doi.org/10.52526/25792776-25.72.1-90

borrowed some important milestones related to the process of formation of the idea of dark matter from the first-mentioned paper, which we introduce in this part of the present paper.

First, Lord Kelvin was among the first scientists to attempt a dynamical estimate of the amount of unseen matter in the Milky Way. His argument was simple yet powerful: if stars in our Galaxy can be described as a gas of particles, acting under gravity, then one can establish a relationship between the system's size and its velocity dispersion. Of course, he was considering the Milky Way as a dynamically balanced system, obeying the virial theorem.

He concluded that within the sphere of radius one million light years, there might exist as many as one billion stars. But many of them, he suggested, might be extinct and dark. So, nine-tenths of them, though not all dark, may not be bright enough to be seen by us at their actual distance (Kelvin, 1904).

In 1906, Henri Poincaré explicitly mentioned the phrase "matière obscure" (dark matter) and argued that since the velocity dispersion predicted by Kelvin's estimate is of the same order of magnitude as that observed, the amount of dark matter was likely to be less than or similar to that of visible matter (Poincaré, 1906).

Later, in 1915, the Estonian astronomer Ernst Opik built a model of the motion of stars in the galaxy, also concluding that the presence of a large amount of unseen matter was unlikely (Opik, 1915). The next was Jacobus Kapteyn, who offered a quantitative model for the shape and size of the Galaxy. He then proceeded to establish a relationship between the motion of stars and their velocity dispersion, as Opik did a few years earlier. He concluded that "As matters stand at present, it appears at once that this mass cannot be excessive. If it were otherwise, the average mass, as derived from binary stars, would have been very much lower than what has been found for the effective mass" (Kapteyn, 1922).

In 1932, Kapteyn's pupil, Jan Oort, published an analysis of the vertical kinematics of stars in the solar neighborhood (Oort, 1932), writing "We may conclude that the total mass of nebulous or meteoric matter near the Sun... is probably less than the total mass of visible stars, possibly much less." Notably, up to this moment, all of the researchers meant ordinary matter, which did not radiate, and therefore remained unobservable or dark.

The next stage of introducing dark matter into the physics toolkit started due to the extragalactic research. In 1933, Fritz Zwicky studied redshifts of galaxies in several clusters, measured by Edwin Hubble and Milton Humason two years before. He applied the virial theorem to estimate the mass of the Coma cluster. He took the number of galaxies to be 800 and the average mass of a galaxy to be 1 billion solar masses, as suggested by Hubble. As the size of the cluster, he took 1 million light years, and found that the velocity dispersion should be around 80km/s. The average line of sight velocity dispersion, however, was 1000km/s (Zwicky, 1933, 1937). So, he concluded that for the dynamical stability of the cluster, the presence of dark matter should be much greater than that of luminous matter.

Over time, researchers increasingly came to believe that dark matter exists, which seemed to explain some of the discrepancies between observational data and theory. In the 1950s, Viktor Ambartsumian was the only famous astronomer who rejected the possibility that dark matter existed in clusters of galaxies and argued instead that they are unstable and rapidly expanding systems, to which the virial theorem cannot be applied (Ambartsumian, 1958).

In August 1961, a conference on the instability of galaxy clusters was held in Santa Barbara, and some of the most important astrophysicists active in that field of research were included as participants. Jerzy Neyman, Thornton Page, and Elizabeth Scott summarized the discussions around the mass discrepancy in galaxy clusters. Their verdict sounded as follows: "Several possible explanations of this mass discrepancy were discussed. Many of those present consider that it might be real and due to invisible intergalactic material in the clusters, totaling 90 to 99 percent of their mass. If these possibilities are excluded, however, the mass discrepancy indicates positive total energy and instability of the system involved" (Neyman et al., 1961).

So, dark matter was introduced into the astronomical toolkit as a free parameter to reconcile the observational data with the a priori hypothesis that all gravitational structures are dynamically balanced and obey the virial theorem.

3. Dark energy is the new reality

Everything mentioned above took place before the acceleration of the Universe's expansion was revealed and dark energy was discovered at the end of the last century (Perlmutter et al., 1999, Riess et al., 1998).

doi: https://doi.org/10.52526/25792776-25.72.1-90

Therefore, an important point must be made before proceeding to the next step of the argument. Namely, it must be taken into account that there is a regular exchange of energy between ordinary baryonic matter and the carrier of dark energy, whatever it may be.

This statement follows from the very fact of the dark energy discovery: If there were no interaction, there could be no acceleration of the Universe's expansion, and dark energy would not be discovered in the way it was revealed for the very beginning. Indeed, dark energy was introduced into modern science to interpret the acceleration of the Universe's expansion, i.e., the observed acceleration was considered to be the result of the interaction between unknown (dark) energy and baryonic matter (galaxies).

All structures in the baryonic universe are considered to have negative energy. This applies to structures of all hierarchical levels, from the microworld to galaxies and galaxy clusters. The absence of energy (negative energy) holds baryonic matter inside baryonic objects and their systems. Otherwise, structures bound by gravitational, molecular, atomic, or nuclear forces could not exist.

On the other hand, dark energy is positive by definition, since it continuously implements physical work, accelerating the expansion of the Universe. Applying the second law of thermodynamics, we inevitably conclude that baryonic objects continuously gain energy due to their interaction with the carrier of dark energy. If this interaction is continuous, one may conclude that all baryonic configurations obtain definite portions of energy over time.

Then the virial value will change by an amount $\Delta E > 0$ as a result of the interaction for the nonzero time $\Delta t > 0$. After a nonzero time, we will see that the virial theorem is breached and its value becomes positive:

$$W = \Delta E > 0, \tag{1}$$

As a physical quantity, energy has a cumulative nature. Therefore, no matter how low its exchange rate is. It accumulates over time and grows, yet the interaction goes on. On the other hand, the positive virial value indicates that the system should be expanding. It means that, thanks to the interaction between the carrier of dark energy and the baryonic world, all baryonic structures gain energy and continue expanding provided that the virial remains positive. Speaking figuratively, all systems of baryonic objects repeat the expansion movement of the Universe. This conclusion contradicts the widely adopted cosmogonic concept on the formation of cosmic structures, based on the Kant-Laplace hypothesis. One of these two suggestions is incorrect.

How can our conclusion be argued? First, one uses only known physical laws, which have been approved for many decades. Second, the accelerating expansion of the Universe is used as the key observational evidence. Nothing more! On the other hand, the accepted cosmogonic concept is backed only by a priori Kant-Laplace hypothesis.

Then, one can conclude that within the observable Universe, all processes are governed by dark energy, obeying the law of entropy growth. On the contrary, the accepted cosmogonic paradigm states that although the Universe is expanding as a whole, all other structures within it are formed by contraction and reached dynamical balance solely in this way, which does not allow their expansion.

A choice must be made between these two possibilities for further investigation. The most important question concerning this choice is the following: Do we observe compression or expansion processes on small scales? We know nothing about proven and verifiable compression processes. As for expansion, at least three cases are reliably known. Available data indicate that these phenomena occur at a rate of: 3.82 ± 0.07cm per year for the Earth-Moon pair (Dickey et al., 1994), 11.3 ± 2cm per year for the Saturn-Titan pair (Lainey et al., 2020), and 15 ± 4m per century for the Sun-Earth pair (Krasinsky & Brumberg, 2004).

Moreover, the measure expansion rates become more intriguing when one calculates the relative growth of orbital radii. It appeared the orbital radii of planet-moon systems approximately amount to: 9.94×10^{-11}, 9.42×10^{-11} for the first and second pairs. At the same time, the equivalent value, determined for the Hubble constant, is 6.71×10^{-11}. First, the relative rates for the two measured planet-moon systems are practically the same. Second, these values are of the same order as the Hubble constant, although they exceed it by 30 percent. This striking identity cannot be by chance. It can mean that the expansion rate is the same for all scales, but within the baryonic systems, other physical effects can accelerate or decelerate the expansion rate. The fact that the expansion rate for the pairs under consideration is larger than for the Hubble constant shows that the tidal mechanism contribution is added.

For the Astronomical Unit, the growth rate is about one hundred times smaller - $1. \times 10^{-12}$. We have discussed in detail a possible mechanism that reduces the expansion rate while remaining within the proposed

doi: https://doi.org/10.52526/25792776-25.72.1-90

paradigm and continuing to apply the laws of physics in a self-consistent manner. It turns out that such a discrepancy is easily explained when we consider dark energy's influence on the baryons within the atomic nuclei. This interaction reduces the nuclear binding energy, thereby increasing the mass of atomic nuclei, simultaneously making them less stable. The most massive multi-baryonic atomic nuclei gradually transform into a radioactive state, potentially ready to decay. Due to the decay, various types of daughter nuclei are formed, from free baryons to composite nuclei and electromagnetic radiation. This transformation leads to an increase in mass growth, always accompanied by radiation, which we observe for stars but not in the case of planets (Harutyunian & Grigoryan, 2018).

There is no longer any doubt that within our planetary system, we find examples of expansion. These observational facts fully confirm our conclusions about the expansion of systems of cosmic objects, which follow from the self-consistent application of the laws of physics. We conclude that with the improvement of observational methods in the future, new planet-satellite and Sun-planet pairs will be discovered in the solar system, which also obey this universal law of expansion. However, our conclusions do not depend on the scale of the system under consideration. Undoubtedly, the interaction with the carrier of dark energy constantly supplies energy to baryon structures. And this, in turn, prohibits the application of the virial theorem. Therefore, there can be only one conclusion: there was no need to introduce dark matter, since it does not exist and never has existed.

4. The main observational facts used for the "invention" of dark matter.

The modern concept of dark matter emerged largely due to Fritz Zwicky's conventional thinking. Influenced by his authority, the scientific community initiated the search for a non-baryonic substance that interacts with ordinary matter solely through gravity. This approach represents a classic example of introducing a free parameter to reconcile observational data with prevailing theoretical expectations. In this case, the prevailing assumption is that galaxy clusters are in a state of dynamic equilibrium.

However, it is important to note that this assumption does not arise from demonstrable physical principles subject to rigorous analysis. Instead, it stems from an earlier cosmogonic hypothesis suggesting that all cosmic structures and systems formed through the gravitational collapse of diffuse matter. Within this framework, the possibility that baryonic systems could undergo expansion is effectively ruled out, as they are presumed to have reached a dynamic equilibrium through gravitational compression.

Horace Babcock was the next to find some unusual properties of galaxies, which were later used to justify the existence of dark matter (Babcock, 1939). His measurement of the M31 galaxy's rotation curve showed that the mass-luminosity ratio of the galaxy increases with radius. The author attempted to explain this dependence by absorption effects in the galaxy, which prevented seeing the whole matter in the galaxy. In a year, Jan Oort revealed the same effect for the galaxy NGC 3115 and interpreted it as a gravitational influence of the massive halo (Oort, 1940).

At the end of the 1960s, Vera Rubin and Kent Ford measured the M31's rotation curve in detail (Rubin & Ford, 1970). Their results and observations in the 21 cm neutral hydrogen line showed that the galaxy's rotation curve does not obey Kepler's law. It does not decrease, as predicted, with distance from the galaxy's center. This result was later extended to other disk galaxies (Persic et al., 1996) and became another "firm" proof for the existence of dark matter.

Over time, new physical phenomena were involved to justify the introduction of dark matter into science. One of the most popular is the gravitational lensing of background galaxies or quasars by clusters of galaxies. Indeed, the phenomenon of gravitational lensing has long been beyond doubt, and several dozen images of objects formed due to this effect have already been discovered.

So, all the mentioned effects are real. The velocity dispersion in clusters of galaxies is very significant, which allows predicting the existence of vast masses if clusters are dynamically balanced. Similarly, the same approach can be applied to the velocity dispersion in elliptical galaxies, as well as when considering the rotation curves of spiral galaxies. Indeed, one finds huge masses for these galaxies if one hypothesizes that they are in dynamical equilibrium. On the other hand, no observational evidence is available to prove their stationary state, which allows the application of the virial theorem.

Moreover, the previous paragraph states that the presence of dark energy excludes the fulfillment of the virial theorem for these systems. We have concluded that these systems are constantly increasing their total energy at the expense of dark energy. It means, therefore, that they are expanding continuously. If we extrapolate the processes back into the past, we find that everything began on smaller scales. Hence, we

doi: https://doi.org/10.52526/25792776-25.72.1-90

conclude that in some sense, it repeats the larger-scale expansion of the Universe, as a result of which the baryonic matter itself evolves. However, this is a separate issue. We will dwell on this in more detail in the papers specially devoted to this problem.

The mechanism of gravitational lens, being physically justified, nevertheless depends on many parameters, some of which can be considered free. The presence of free parameters, being a convenient tool for fitting observational data to theory, is often used to justify ideas accepted by the scientific community at a certain stage of scientific development. Therefore, in the future, we will return to this mechanism in more detail.

5. Conclusion.

The formation of the idea of the existence of dark matter is considered. It is argued that there existed only one reason for introducing dark matter into science. That was the concept accepted by the scientific community, stating the dynamic equilibrium of baryonic objects and their systems, such as star clusters, galaxies, and clusters of galaxies. If the hypothesis about the existence of large masses in these systems had not been accepted, the conclusion that these systems are expanding would have been inevitable. But the expansion of these cosmic systems would contradict the basic cosmogonic concept about their formation by compression.

The discovery of the Universe's accelerating expansion and the introduction of the concept of dark energy radically changed the situation. Since dark energy was discovered due to its effect on galaxies, one can conclude that the carrier of dark energy interacts with baryonic matter. Under such circumstances, naturally, the well-known laws of thermodynamics should be used to describe this interaction. Based on this, one comes to the inevitable conclusion that due to interaction, all baryonic objects and their systems continuously receive non-zero portions of energy, thereby increasing their total energy. And this, in turn, means that even if during formation these systems obeyed the virial theorem and were dynamically balanced, under the influence of dark energy, they should have become re-expanding systems.

This conclusion is based on two key facts: a) the presence of dark energy and b) its obvious ability to interact with baryonic matter. And if the conclusion is true, the requirement for dynamic balance of the systems under consideration immediately disappears. As a consequence, the need for the existence of dark matter disappears. This is a transparent cause-and-effect chain. Then the conclusion that dark matter does not exist at all becomes inevitable. This hypothetical substance has been invented as a free parameter to explain the alleged stability of baryonic structures. However, after the discovery of dark energy, the question of the balance of these configurations loses its meaning.

References

Ambartsumian V. A., 1958, Stoops, R. (ed.) La structure et l'evolution de l'universe, Bruxelles

Babcock H. W., 1939, Lick Observatory Bulletin, 498, 41

Bertone G., Hooper D., 2018, Reviews of Modern Physics, 90, 045002

Dickey J. O., et al., 1994, Science, 265, 482

Harutyunian H. A., Grigoryan A. M., 2018, Communications of the Byurakan Astrophysical Observatory, 65, 268

Kapteyn J. C., 1922, Astrophys. J. , 55, 302

Kelvin L., 1904, Baltimore Lectures on Molecular Dynamics and the Wave Theory of Light, London, UK: C.J. Clay and Sons., p. p.274

Krasinsky G. A., Brumberg V. A., 2004, Celestial Mechanics and Dynamical Astronomy, 90, 267

Lainey V., et al., 2020, Nature Astronomy, 4, 1053

Neyman J., Page T., Scott E., 1961, Astron. J. , 66, 633

Oort J. H., 1932, Bull. Astron. Inst. Neth. , 6, 249

Oort J. H., 1940, Astrophys. J. , 91, 273

Opik E., 1915, Bull. de la Soc. Astr. de Russia, 21, 150

Perlmutter S., et al., 1999, Astrophys. J. , 517, 565

Persic M., Salucci P., Stel F., 1996, Mon. Not. R. Astron. Soc. , 281, 27

doi: https://doi.org/10.52526/25792776-25.72.1-90

Poincaré H., 1906, Bulletin de la Société astronomique de France, 20, 153–165

Riess A. G., et al., 1998, Astron. J. , 116, 1009

Rubin V. C., Ford Jr. W. K., 1970, Astrophys. J. , 159, 379

Zwicky F., 1933, Helvetica Physica Acta, 6, 110

Zwicky F., 1937, Astrophys. J. , 86, 217

de Swart J. G., Bertone G., van Dongen J., 2017, Nature Astronomy, 1, 0059

van den Bergh S., 1961, Astron. J. , 66, 566

doi: https://doi.org/10.52526/25792776-25.72.1-90