On the Blueshift of the Andromeda Galaxy

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Abstract

The observed spectral shift of galaxies is usually interpreted using the Doppler effect. However, attention should be paid to other possible mechanisms of spectral shift. For example, suppose baryon matter evolves due to interaction with the carrier of dark energy. In that case, the objects that pass through longer evolutionary paths compared to our galaxy will be blue-shifted for us. Since the evolutionary spectral shift is a rather weak effect, it can only be detected at small cosmological distances, where the redshift due to the expansion of the Universe is not very large. From this point of view, the Andromeda Nebula is undoubtedly an appropriate example. It is one of the main members of the Local Group of galaxies and has a small blueshift. Here we review observational data and theoretical generalizations in favor of interpreting the blueshift of our neighboring galaxy as an evolutionary effect.

Keywords: *Dark energy, ordinary matter, interaction, evolution of matter; Andromeda galaxy: spectral blueshift, evolution path*

1. Introduction

Expansion is the preferred direction of motion in the Universe, at least on cosmological scales. This has become generally accepted since the relation between the distances of galaxies and their redshifts, discovered by Hubble, was officially recognized as the dependence of the speed of retreat of galaxies on their distances. Therefore, at present, only a few researchers doubt the real expansion of the Universe.

On the other hand, the same researchers always reject any idea associated with the existence of expansion on smaller scales like cosmological expansion. Smaller scales are the sizes of galaxy clusters and down to planetary systems. There is only one serious problem preventing the discussion of such ideas. Such a barrier is the dominant paradigm about the formation of space objects and their systems, which states that they all reach an equilibrium state through compression. In other words, the Universe, as a whole, is expanding, while all its parts were formed through compression.

This is why almost all interacting galaxies are considered "merging", although they could just as easily be interpreted as "separating". However, separation as a special case of expansion is inconsistent with the general idea of galaxy formation, and modern theories do not consider this possibility. Therefore, the observed blueshift of the famous Andromeda Galaxy is readily interpreted as an effect of its movement toward our Galaxy. Consequently, their collision and merger are predicted.

In this report, we consider another possibility for the observed blueshift, which is associated with the evolution of baryon matter under the influence of dark energy. Based on the analysis of observational data and known physical laws, this approach allows us to conclude that the observed blueshift may be a consequence of the baryon matter of the Andromeda Nebula has undergone a longer evolution than our Galaxy.

2. Interaction of baryonic matter with the carrier of dark energy.

After the discovery of dark energy ((Perlmutter et al., 1999, Riess et al., 1998)), the main content of the toolkit, used for cosmological and cosmogonical studies should change drastically. It did not happen. The significant point about the carrier of this energy should have always been mentioned, although we do not

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doi: https://doi.org/10.52526/25792776-24.71.1-68

know what it is. However, no energy form exists without a carrier. Therefore, the issue of the interaction of baryonic matter and the dark energy carrier has been repeatedly considered and substantiated in the works of one of the authors of this report (Harutyunian, 2022, Harutyunian & Grigoryan, 2018, Harutyunian et al., 2019). We will not dwell on this issue in detail, but will only note the following.

It has been shown that such an interaction inevitably leads to the transfer of dark energy to baryonic matter. It does not matter how much energy transfers to the baryonic matter. Energy is a cumulative substance, and it accumulates over time. This follows from two issues: These issues are the interaction between two substances and the application of the second law of thermodynamics. This conclusion is also consistent with the law of entropy growth.

Let's consider any baryonic object or system of objects interacting with a dark energy carrier. Due to this interaction, the baryon part of the interaction receives some energy ΔE. It doesn't matter how much energy the baryon structure receives. Energy is a cumulative substance and therefore it accumulates in the baryon structure. This means that the virial theorem for a given baryonic matter becomes positive, even if it was zero before the interaction. In turn, this leads to an increase in the size of baryon structures. Moreover, if the interaction continues, these structures continue to increase. And this is nothing more than an expansion.

There is another important issue to investigate more carefully. Let us introduce a parameter

$$\eta = \frac{|E_{gr}|}{E_{de}}, \tag{1}$$

where E_{gr} and E_{de} are the gravitational energy of the baryon structure and the dark energy in the volume of this baryon structure. This coefficient can be called the "measure of resistance" (MoR) of the gravitational baryon structure. Indeed, from general physical considerations, it follows that the baryon structure is more difficult to influence by dark energy, the larger the parameter introduced here.

It is well known that gravitational energy is proportional to the second power of mass and inversely proportional to the characteristic linear size. In other words, it is proportional to the square of the volume of the baryon structure, the square of the density of the baryon matter, and inversely proportional to the size. Taking into account the homogeneous distribution of dark energy in space, accepted by modern science, one can conclude that the parameter introduced above has the following dependence on size and density:

$$\eta \sim \frac{(R\rho_b)^2}{\rho_{de}} \tag{2}$$

whereρ_b andρ_{de} are the baryon mass and the dark energy density and $R$is the characteristic size of the baryon system. In the relation (2)ρ_{de} is constant according to the modern concepts of dark energy. Then the parameterη depends on the physical characteristics of the baryon structure only. It is easy to see that the relation (2) has the following form as well

$$\eta \sim \left(M\rho_b^2\right)^{2/3}. \tag{3}$$

Thus, if in a family of gravitational objects (systems), the value of d increases with increasing mass, then massive objects are less compliant to the influence of dark energy and more strongly resist any evolutionary changes, if any. Possible evolutionary changes under the influence of dark energy should be studied to test this conclusion. To check the conclusions made, we should clarify what we mean when baryon matter or baryon objects are considered. The concept of mass masks the properties of baryons. When solving problems about the formation of space objects, the main parameter is the mass of matter, and they rarely remember the structural features of this substance. However, the properties of any clump of matter are based on its structural features, the fact that baryon matter consists of atoms, the mass of which is concentrated in their nuclei. On the other hand, the atomic nucleus has one remarkable property, called mass defect, determining the nuclear binding energy. Without this property, atomic nuclei would not exist. This property is a universal mechanism for converting energy into mass and vice versa. Namely, this property of atomic nuclei will interest us as the main instrument for the absorption or emission of dark energy during the interaction of baryon matter with dark energy. Two key points must be considered while studying the interaction process between dark energy and baryon structures. We have already touched on one aspect above. This applies to the spatial scale where baryon structures physically feel the influence of dark energy. If, according to generally accepted modern concepts, thematic energy uniformly fills all space, from the microcosm to cosmological distances, then we inevitably conclude that baryon structures of any scale undergo such an

doi: https://doi.org/10.52526/25792776-24.71.1-68

influence. The second thing to note is that the baryon structures exist owing to different binding forces. On large scales, gravitational forces dominate, and binding energy is gravitational. The electric, weak, and nuclear forces dominate at much smaller scales. Therefore, understanding how dark energy affects the physical characteristics of structures that exist due to these forces is crucial. All the structures exist due to the negativity of energy, or rather, the lack of energy that could destroy these structures. As we have noted many times, dark energy is positive and therefore, when transferred to these structures, reduces their stability.

3. Spectral changes of the baryonic object due to the evolution process.

The interaction of atomic nuclei with the carrier of dark energy inevitably leads to a decrease in the nuclear binding energy. In turn, reduces the mass defect of the interacting nucleus, which leads to the mass growth of the nucleus. One can easily find that the greater the mass of the nucleus, the more the difference in energetic levels. It follows from the classical Rydberg relation. In other words, owing to such an interaction, spectral lines of the given atom should show some blueshift, determined by the mass-growth value. The blueshift value shows the difference between the evolution length for the emitter and observer systems. As the Doppler effect is based on the velocity difference, the evolutional spectral shift shows the difference between the evolutional paths of baryon structures. The length of the evolution path depends on the time of evolution as the first parameter. However, as it follows from the relation (3), the baryon structures of different mass will have different evolution lengths, dependent on their mass and density. For example, the lesser the mass of a galaxy the longer its evolution path for the same period. Interestingly, the evolution rate is higher also for the same mass and lesser density. This aspect is important for the study we implement in the next section of this report. Previously, we used the statistics of redshifts of galaxies of different masses belonging to individual galaxy clusters. Bearing in mind that clusters contain galaxies of different luminosities (mass), we studied the dependence of the average redshift on the stellar magnitudes of the galaxies of cluster members. Based on our findings about the evolutionary blueshift, we expected that the redshift of low-luminosity galaxies should have been smaller. These studies' results confirmed our expectations for the nearby clusters in Virgo and Fornax (), and the cluster in Coma (). Undoubtedly, studies in this area can provide much more information on the issue under consideration. Therefore, one should continue similar research to reach a higher significance of the results. One of the authors of the present report used this mechanism of the baryonic matter evolution to solve the paradox of the “Hubble tension” ((Harutyunian, 2021)). It was shown that the difference between Hubble constant values could be solved if the matter evolution process is considered. This effect increases the Hubble constant value. Moreover, this approach allows us to find the mass-growth rate in atomic nuclei. The mass-growth mechanism was also implemented in the growth of the Astronomical Unit (AU) and again a method was suggested for the mass change in such baryonic structures as stars (Harutyunian & Grigoryan, 2018, Harutyunian et al., 2019).

4. Andromeda galaxy's blueshift.

In the previous article of the authors (Harutyunian et al., 2023), we first formulated the problem of blueshift in the spectrum of the Andromeda nebula, which is interpreted as the approach of this galaxy to the Milky Way. Then we noticed that the blue shift may have a different mechanism, unrelated to the Doppler effect. Two reasons lead us to this conclusion. Firstly, it seems unnatural to us that, against the background of the general expansion of the Universe, a convergence of galaxies is occurring in the Local Group of galaxies. This would mean they first moved away from each other, as every material point in our Universe. Then, we should accept that this movement has been stopped at some distance, and the reversal movement began. The second point is related to the newfound mechanism of blueshift formation. That is the evolutionary mechanism, which does not deal with any mechanical movement. Moreover, this mechanism is better manifested at short distances.

However, on the other hand, one can ask what evidence there is that the Andromeda Nebula has gone through a longer evolutionary path than our galaxy. To answer this question thoroughly, many characteristics of the two galaxies must be examined and compared. Such describing parameters include mass, geometric size, metallicity, metallicity gradient, structural features, and much more.

Here we will only focus on discussing relation (3). According to new measurements, the mass of the Andromeda Nebula is approximately the same as that of our galaxy (see (Kafle et al., 2018) and references

doi: https://doi.org/10.52526/25792776-24.71.1-68

therein). But in terms of geometric dimensions, it is twice as large as the Milky Way ((Chapman et al., 2006)). With the same mass, twice the size indicates lower density. Moreover, the density of baryon matter will be four times less if we consider only the disk component and eight times less if the density is calculated over the entire volume.

In relation (3) the density of matter is included in the power of 4/3. Then we find that with equal mass and twice the size, the "Measure of Resistance" of the Andromeda Nebula is from 6.3 to 16 times less than that of our galaxy. If they formed at approximately the same time, then the Andromeda Nebula took much longer in the evolution of its baryon matter.

Thus, even a fairly simple analysis shows that the Andromeda Nebula has gone through a longer evolutionary path of baryon matter. Therefore, our cosmic neighbor may have a blueshift relative to our galaxy. We will do a more detailed analysis involving other characteristics of the two galaxies in the future.

5. Concluding remarks.

The blueshift of the Andromeda galaxy provides an excellent opportunity to test the hypothesis of the evolution of atomic nuclei under the influence of dark energy. The self-consistent application of the laws of physics suggests that the interaction of atomic nuclei and free baryons with the dark energy carrier should lead to a gradual increase of their mass. The nuclear mass increase, in turn, shifts the spectral lines of these atoms to the blue end of the spectrum. The more an object is evolved under the influence of dark energy, the greater its blueshift for an observer who is in an environment where the evolution of matter lags behind.

It is on the basis of these considerations that we approach the question of the spectral blueshift of the Andromeda nebula, which is usually interpreted as a result of Doppler effect, suggesting that the neighboring galaxy is approaching to the Milky Way. By studying all relevant features of the neighboring galaxy and comparing with the same characteristics of our own galaxy, we are going to find out whether it is ahead of our Galaxy in the sense of the evolution of matter itself. First of all we need to find the physical features, which show clear dependence on the matter evolution and compare them for two galaxies.

For this purpose, at the first stage of research, we are going to compare the stellar content of two galaxies, various manifestations of activity, the metallicity dependence on the galactocentric distances for all components of galaxies, the content and distribution of globular clusters, the content of gas and dust etc. All these physical characteristics which somehow depend on the age of galaxy should provide the necessary keys for the comparison we need.

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