Is the Andromeda galaxy approaching our galaxy Milky Way?

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Abstract

No doubt that the dark energy carrier interacts with the baryonic matter. Due to this interaction some portions of energy are transferring gradually to all baryonic objects and their systems without any exception at all hierarchical levels of the baryonic world. The consequences of the energy transfer are quite dramatic for all objects. The most dramatic changes take place at the nuclear level. Objects of this particular level have the universal property of converting energy into mass, which ultimately affects the cosmic objects of all levels and the baryonic Universe as whole. Hear we consider the side effect of growing mass of nuclei. That is the inevitable blueshift of spectral lines of atoms possessing higher mass nuclei compared with the atoms having nuclei of lesser mass. We hypothesize here that the Andromeda galaxy spectral blueshift can be resulted by Doppler effect as accepted but due to the more advanced evolution compared with our galaxy but not by its approaching velocity.

Keywords: *dark energy, baryon matter, interaction, energy exchange: Andromeda galaxy, spectral blueshift*

1. Introduction

Measurements show that the galactocentric spectral shift of the Andromeda galaxy is about -0.00037. Its interpretation as a result of the Doppler effect gives an approach speed of 110 km/s. And therefore, it is believed by astronomers and physicists that in the distant future the Andromeda galaxy will collide with our Galaxy. The scenario of the huge merger of these two giant galaxies has been repeatedly discussed not only in scientific articles, but even more intensely in popular literature.

However, it is clear that there is only one indisputable issue, and that is the observed spectral shift of the neighboring galaxy. Doppler mechanism for its interpretation is chosen a priori as a granted one. Therefore, while discussing this observational fact no other spectral blueshift mechanisms have been even considered. On the other hand, the discovery of dark energy provides a new possible way for interpretation of the blueshift in spectra of cosmic objects without involving the Doppler effect and the corresponding velocity. In a series of papers, one of the authors of the present report explored the consequences of the interaction between the dark energy carrier and baryonic matter. The fact of such an interaction is obvious, since dark energy was discovered and brought into consideration solely due to the acceleration of the Universe expansion (Perlmutter et al., 1999, Riess et al., 1998). Indeed, no physical mechanism is known to accelerate galaxies expansion velocities without interaction with them. Therefore, we accept from the very beginning that if the phenomenon of the dark energy is real, we should inevitably arrive at a conclusion that its carrier interacts with the ordinary baryonic matter.

In this paper we are going to discuss the physical mechanism leading to formation of a blueshift effect not connected with velocity. Perhaps, we might call it an evolutionary effect since such a spectral shift arises due to energetic changes in atomic nuclei as a result of long lasting interaction with the dark energy carrier (DEC). It seems obvious that if the dark energy is added into the toolkit of the modern physics, one should consider all the consequences to which leads the usage of this newfound tool.

Although we do not know the real physical essence of the dark energy carrier, the scientific community has accepted that dark energy fills all the three-dimensional space absolutely homogeneously. Moreover, that

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doi: https://doi.org/10.52526/25792776-23.70.2-165

statement is correct for at all scales. Therefore, one should consider the physical picture self-consistently taking account at least mentioned two issues, namely, obvious interaction between the carrier of dark energy and baryonic matter, as well as, the existence of DEC at all scales from the microcosm up to the mega world. If one of these these features is not taken into account, the picture cannot be correct.

2. Does dark energy influence the baryonic matter?

We already have considered several physical consequences of interaction between the DEC and baryonic matter (Harutyunian & Grigoryan, 2018, Harutyunian et al., 2019). As it was shown in previous papers, at the level of the gravitationally configurated objects and systems, such an interaction affects baryonic objects and their systems injecting some portions of dark energy into them. Due to this process the baryonic world gains energy which inevitably should destabilize them. The energy transferred to the baryonic objects and their systems by DEC can be responsible for the variety of non-stable phenomena at all the levels of baryonic world hierarchical structure (Harutyunian, 2023).

However, this is not the only physical consequence of the interaction between mentioned two substances. This effect has different manifestations at various hierarchical levels. In the microworld where the objects' stability is provided by residual strong forces, the situation is absolutely different than in larger structures, where the electric or gravitational forces are responsible for integrity of baryonic objects. Only in the microcosm acts one of the most essential laws of baryonic matter – transformation between mass and energy.

Note also that almost all mass of baryonic matter is concentrated in the atomic nuclei, and atomic nuclei themselves exist as separate integrites exceptionally owing to the mass defect or energy lack in them. In atomic nuclei all baryons possess of mass which is lower than one they should have being outside of nuclei. Every physicist can easily recall the standard diagram showing the mass defect depending on the atomic number. All baryons loss some part of their mass for fitting themselves to the physical conditions inside the nuclei.

The nuclear feature, called mass defect, is very important for more comprehensive understanding of global properties of our baryonic world. This feature provides very essential fingerprints of how was originated the baryonic world. But much more essential conclusion one can make is the following. The such quantum objects as baryons, which are considered to be unchangeable, have smaller masses being parts of any atomic nucleus. Moreover, in different nuclei they have different masses. So, we can conclude that these baryons change their mass depending on the physical conditions they are involved and can show quite different mass-losses. An essential question is arising therefore: can this fitting conditions change in the course of time following to some evolutionary path? And also, what we can say about the free baryons which also have complex structure and exist because of the same strong forces?

Interaction of atomic nuclei with DEC decreases the absolute value of their (negative) nuclear binding energy. In other words, this interaction decreases the lack of energy which could decay the atomic nuclei and split it into the separated free baryons with their known masses. Since the nuclear binding energy simply is the lack of mass in energetic terms, its decreasing leads to the growth of nuclear mass.

These predicted phenomena have been considered in the previous papers of one of the authors. In more detail it is discussed in association with the, so called, "Hubble tension" (Harutyunian, 2021), the problem of the growth of the Astronomical Unit (Harutyunian & Grigoryan, 2018), and while considering the galaxy redshift dependence on the luminosity in the clusters of galaxies (Harutyunian et al., 2019). In all the mentioned papers the phenomenon of atomic nuclear mass increase is considered for interpretation of observational paradoxes. The nuclear mass growth has a particular manifestation which is evident when one uses the Rydberg relation for spectral lines frequencies, which has the following form for the hydrogen like atoms:

$$\frac{1}{\lambda_{ij}} = Ry\frac{1}{hc}\frac{M_n}{M_n + m_e}\left(\frac{1}{i^2} - \frac{1}{j^2}\right) \tag{1}$$

where

$$Ry = \frac{m_e e^4}{8\varepsilon_0^2 h^2} \tag{2}$$

is the Rydberg constant. We see that the wavelengths of spectral lines depend inversely on the reduced

doi: https://doi.org/10.52526/25792776-23.70.2-165

mass of nucleus and electron

$$m_r = \frac{M_n m_e}{M_n + m_e}. \tag{3}$$

Obviously, when the masses of the nucleus and electron increase, spectral lines get blueshifted.

It is clear that the spectrum of any object should be blue-shifted relative to another if it has been more influenced by dark energy. A greater influence is determined either by a longer duration of exposure or by a greater intensity of the process of this influence. Therefore, it is necessary to clearly determine which objects are easily susceptible to this influence and which are more stable.

For this purpose, we introduced into consideration a coefficient showing the ratio of the gravitational energy of a given object to the amount of dark energy in the volume of the same object. Gravitational or any other energy that is responsible for preserving a given object as an integrity, is the only tool for a given object preventing any changes caused by dark energy. Therefore, the coefficient introduced in this way can serve as a kind of "resistance index". The higher this index, the more difficult it is for dark energy to make changes in an object and, therefore, the slower evolutionary changes take place under the influence of dark energy.

It is known that the gravitational energy of any object is proportional to the second power of its mass and inversely proportional to the size (radius) of the object. Considering that the mass is proportional to the third power of the radius, we come to the conclusion that gravitational energy is proportional to the fifth power of the radius. On the other hand, with a uniform distribution of dark energy, its amount in the volume occupied by the object is proportional to the third order of magnitude. This means that the ratio of an object's gravitational energy to dark energy increases as the second power of the object's size.

This simple qualitative analysis shows that the more massive objects belonging to the same hierarchical class cosmic objects are more resistive against the evolutionary changes caused by dark energy. In other words, all the changes resulted from the interaction between baryonic matter and DEC easier exhibit the objects of lesser mass. All the changes predicted on the base of analysis of the interaction process, if any, take place easier and sooner, for example, in dwarf galaxies than in giant ones.

Taking into account the above conclusion we may say that evolutionary time for dwarf objects is shorter than for giants, provided that average density of matter is approximately the same. Density dependence makes considerable changes and, of course, should be studied in detail for any particular case. Hear, for the rough qualitative estimates, we consider a simpler situation when the density does not depend on the size of the object.

There are two main observable features very sensitive to the dark energy influence. One is the metallicity of the object. The longer is the evolutionary time the higher should be the metallicity, since it lasts longer to decrease the nuclear binding energy and decay the heavier nuclei through radioactivity. It means that the relative amount of light elements, including the hydrogen, grows more slowly and metallicity remains higher. This effect is known already for a half of century, namely, since the last quarter of the last century. Indeed, in a series of papers on the base of a huge observational data was approved the result stating that the metallicity of faint galaxies is lower comping with giant ones.

The second feature, which can also be easily detected during observations, in our opinion, should be a noticeable blue shift in the spectra of more evolved objects. Therefore, we statistically studied the dependence of the redshift of galaxies in clusters on their apparent magnitude. For the two closest clusters in Virgo and Fornax, we obtained a clear relationship with a very high correlation coefficient (Harutyunian et al., 2019). A fairly significant dependence was also obtained for the galaxies of the Coma cluster. In all the cases considered, with a decrease in the luminosity of galaxies, a decrease in redshift is observed, which can be explained by the faster evolution of objects with lower masses.

3. The blueshift of the Andromeda galaxy

The Andromeda Galaxy is located at the distance of about 770 kpc (2.5 million light years). This means that what all observable information we have today is obtained from the light, which was emitted by this galaxy about 2.5 million years ago. And the most intriguing question is the following: was really at that time the Andromeda Galaxy ahead of our Galaxy on the evolutionary path of baryonic matter. In the other words, was the evolution of the matter belonging to the Andromeda galaxy longer, was it more evolved than the matter of our galaxy today?

The question formulated above is very essential for the problem under consideration. Indeed, if the neighboring galaxy is ahead in evolutionary path, then according to our conclusion made on the base of the

doi: https://doi.org/10.52526/25792776-23.70.2-165

known physical laws, it should be blueshifted relative to us. Although we will never be able to check in any other way, the similar self-consistent argumentation and calculations, on the other hand, suggest that for an observer, living somewhere in the Andromeda nebula, our Galaxy should be redshifted. So, a spectral shift of any type exhibited by an object has a sense, if determined relative to some other system, which can be tied to some object. If the Doppler shift is symmetrical for two objects, the evolutionary shift is not. In one of the upcoming papers we will dwell on this issue in more detail.

Obviously, for a more solid argumentation of the proposed idea, and simultaneously as a necessary condition for maintaining this idea at the level of provable truth, one needs to find reliable observational facts showing that the Andromeda galaxy is really ahead of the Milky Way on its evolutionary path. It is obvious that in reality this is by no means an easy task. For such a conclusion one should analyse in detail many different physical features of both objects.

The modern astronomical data argues that Andromeda galaxy is approximately 2-2.5 times more massive than the Milky Way, which makes it more "resistant" to the changing influence of dark energy. The only possible way to achieve the necessary arguments for its longer evolutionary path can serve an unshakable proof that our neighboring giant galaxy is significantly older than ours. Therefore, the correct galaxy aging "fingerprints" should be used. The more such "fingerprints" there are, the more confidently we can talk about this issue.

However, the adopted by astronomers estimates give for the Andromeda galaxy a surprisingly small age. One should check the methods used for obtaining these estimates. If this estimates are correct, Andromeda galaxy appears to be much younger than our Milky Way. And if it is so, we should admit that there is incorrectness in our argumentation and search for an explanation of obvious inconsistency between observational data and physical conclusion made on their base. Therefore, we are going to compare as many as possible physical characteristics of these two giant inhabitants of the Local Group.

Within the paradigm we follow here, the main evolutionary processes occur in the microcosm, although their manifestation is better visible at cosmological scales. It is in the microcosm that the universal mechanism of converting portions of dark energy into mass operates, gradually reducing the nuclear binding energy in multi-baryon atomic nuclei and converting it into a mass of baryons without changing their total number. This process increases the mass of the atomic nuclei, and, as a result, growing the mass of all cosmic objects and the Universe itself.

Constructing this hypothesis on the base of observational data, we inevitably arrive at a conclusion that in the past all baryons should have been possessing of a much smaller masses. One can call them "baryonic embryos", which could join together and build atomic nuclei consisting of vast number of baryons. Moreover, such embryonic baryons and nuclei should exist at present in the cores of very massive objects (stars, galactic nuclei). These huge numbers of embryos, which continue to survive at present owing to the supporting physical conditions with a high high "resistant index", potentially contain masses able to originate new stars and even new galaxies.

On the other hand, a decrease of the nuclear binding energy and an increase of the mass of the nucleus gradually destabilize the nucleus itself, which at a certain moment of time moves from the class of stable nuclei into the class of radioactive ones and necessarily should eject the excessive mass and energy through decay. At present, we see some distribution of stable and unstable nuclei, which corresponds to the baryon/DEC going on interaction present situation in our galaxy. If the hypothesis is correct, in the future this distribution will change in favour of unstable and lighter nuclei.

The same process is observed at higher hierarchical levels as well, namely, gravitationally bound objects and their systems gradually increase their masses and energy, simultaneously exhibiting various phenomena of instability. It seems rather plausible that all instability phenomena are manifestations of the mentioned interaction and energy transfer into the baryonic world, The most obvious manifestation of this effect is observed in clusters of galaxies and in the Universe itself as a whole formation. As is known, under the dictates of the dominant Kant-Laplacian hypothesis, Zwicky introduced the concept of dark matter into astrophysical research (Zwicky, 1933, 1937), which is not revealed up to nowadays.

It is clear that the blueshift of the spectrum, due to a larger "evolutionary age," can only be detected in relatively closer galaxies. In the spectra of distant galaxies, the "evolutionary lag" adds its contribution to the value of the cosmological redshift and decreases it, but cannot make it negative and therefore is not noticeable without special research approach. We considered this issue in connection with the, so called, "Hubble tension" (Harutyunian, 2021), and it allowed explain the new-born paradox in a natural way. It was useful also for interpretation of lesser redshift of the fainter galaxies in the clusters of galaxies (Harutyunian et al., 2019). Therefore, we consider the Andromeda nebula with its blueshift as a good "laboratory" for

doi: https://doi.org/10.52526/25792776-23.70.2-165

testing the idea.

4. 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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