Communications of BAO, Vol. 67 Issue 2, 2020, pp 236-240

Observational Data Related to the Largest Galaxies of the Universe: What they Tell?

Harutyunian H. A*

Byurakan Astrophysical Observatory, Armenia

Abstract

The physical mechanism of interaction between dark energy and ordinary baryonic matter is used to show that Ambartsumian's cosmogonic paradigm on the galaxy formation gets new support. This mechanism is considered to compare the cD galaxies observational properties with the model predictions in the framework of the suggested paradigm.

Keywords: *Dark energy; evolution, baryonic matter, mass growth, cD galaxies*

1. Introduction

For construction of galaxy formation scenarios one should study galaxies together with their local environments. Two mutually exclusive hypotheses concerning the genetic links between a galaxy and its local environment are possible ways for their birth and evolution. First scenario, widely discussed and repeatedly studied by researchers,is the possible physical influence of the environment on the galaxy's formation process. Second possibility,remaining on the hypothesis level, is the contrary situation when the galaxy forms its environment.

The most luminous galaxies of the Universe or Brightest Cluster Members (BCMs) are unique ones and their formation history is not physically transparent. cD galaxies form the special high luminosity end of the BCMs. These objects have been classified and named in mid 60s of the last century (Matthews et al., 1964) to distinguish them from large elliptical galaxies. The morphological and other appearance features definition of cD galaxies done almost at the same time when these galaxies have been identified as a separate type remains unchanged (Morgan & Lesh, 1965) and have been modified slightly in course of time. These galaxies have the following common features.They are located exclusively in regular rich clusters of galaxies where they are the BCMs or the Second Brightest Cluster Galaxies (SBCGs) and they are never found as field galaxies.They are located in the center or very close to the center of the hosting cluster.They are never very oblate (see also, Beers & Geller, 1983, Oemler, 1976, White, 1978). They have bright elliptical core or "main body" which is imbeddedinto an amorphous envelope (see, for example, Hoessel & Schneider, 1985, Schombert, 1988, Tonry, 1985).

Schombert (1988) mentions that cD envelopes are found in a range of cluster environments, from regular, compact clusters to irregular, highly subclustered systems.It changes slightly the first item in the enumerated initially features characterizing cD galaxies. There is one more modification stating that cD envelopes can be found around non-first-ranked ellipticals such as NGC 4839 in Coma (Oemler, 1976) or NGC 6034 in Hercules (Schombert, 1984). However, all cD envelopes were found at local cluster density maxima (see Beers & Geller, 1983), but never discovered in the field.

It is evident that one should consider the scenario of galaxies formation in a cluster parallel with the cluster formation. The very fact that the existence of a central galaxy and its morphological type clearly correlates with the cluster type, lies at the base of cluster classification in which the type I designate systems containing cD galaxy (Bautz & Morgan, 1970). Clusters belonging to this type of

*hhayk@bao.sci.am

DOI: 10.52526/25792776-2020.67.2-236

systems are the most regular ones, exhibiting obvious concentration of members towards the cluster center and possessing of mainly early types of galaxies. For the cD galaxies has been revealed a sharp correlation between the luminosities of the galaxy halo L_k and cluster L_{cl} (Oemler, 1976). The latter correlation got a firm corroboration when appeared that BCMs in poor clusters do not possess of an envelope (Albert et al., 1977, Morgan et al., 1975).

cD galaxies differ markedly from other elliptical galaxies by their internal kinematical features as well. Usually as the main kinematical characteristic of elliptical galaxies, one uses the velocity dispersion. As a rule, this feature has its greatest value at the center of the galaxy disk (higher for the high luminosity galaxies) named Faber-Jackson relation (Faber & Jackson, 1976) serves as a good tool for determination of absolute luminosities of elliptical galaxies. It was shown that this relation is shallower for the supergiant cD galaxies than for ordinary ones (Efstathiou et al., 1980, Lauer et al., 2006, Malumuth & Kirshner, 1981, Oegerle & Hoessel, 1991). It was shown also that they have larger radii than predicted by Kormendy relation (Hoessel & Schneider, 1985, Oegerle & Hoessel, 1991, Schombert, 1987, Thuan & Romanishin, 1981).

Differences of cD physical features from other elliptical galaxies prompted researchers to create special scenarios for their formation mechanism. Indeed, at the beginning, BCGs were suggested to form due to the merging mechanism when the cluster galaxies sink to the bottom of the cluster gravitational potential well and merge (so called, galactic cannibalism Ostriker & Tremaine, 1975, White, 1976). Meanwhile, theoretical analyses (Merritt, 1976) showed that this mechanism is not providing with the requested masses for building the BCGs. Moreover, the "merger scenario" should change the color of galaxies – they should be bluer for their luminosities. No such color differences have been revealed (Gallagher et al., 1980, Schombert, 1988).

2. Evolution Scenario via Energy Injection and Active Decay

Ambartsumian (Ambartsumian, 1958) was the first to suggest a scenario describing the galaxy formation from the Galactic Active Nuclei (AGN) through the initial bare nucleusgradual decay physical process. According this hypothesis all the cosmic objects form from denser (superdense) matter due to ejection of smaller portions of it, which forms stars and interstellar gas.

This idea was a natural sequel of his preceding series of researches devoted to the stellar associations (Ambartsumian, 1947) for the higher level of cosmic objects hierarchy. Stellar associations, the author showed, evolve from a smaller volume and are nests of young stars. The discovery and further studies of stellar associations showed that star formation is an ongoing process in our Galaxy and that in any galaxy there can exist different generations of stars. Today this assertion does not seem strange as was about seventy years ago, and the scientific community adopted the fact of newborn stars existence.

The next stage of our understanding of the cosmic objects formation and their evolution, we believe, should be the recognition of the fact that in our observable Universe adjoin different generations of galaxies, including ones born very recently. In any galaxy, star formation takes place in star formation regions and further evolution continues in stellar associations until they dissolve in the common field of galaxies. Evidently, this process goes on in the direction of decreasing the space density of stars. That was the main reason for the appearance of the hypothesis concerning the existence of matter in superdense state. On the other hand, this kind of expansion and decay process somehow reiterates the process of the Universe expansion for the smaller scales.

Although the fact that the formation of stars in our cosmogonic era is no longer in doubt, the idea that they are the result of the decay of very dense matter was rejected. The reason of rejection was very practical. The modern theoretical physics does not permit the existence of any stable superdense configuration of baryonic matter exceeding several solar masses.Actually, the same reason ceased future discussions on the galaxy formation by means of decay of superdense pre-stellar baryonic nucleus, existing as pre-galactic configuration and not populated yet by stars, gaseous and dust clouds.

However, the scientific community carried out all these discussions and made the suitable conclusions about half a century ago. After that no serious studies in this field appeared. Nonetheless, researchers managed to discover some new physical effects, which could change our approaches to problems discussed above. Above all, the mentioned concerns the discovery of the accelerated expansion of the Universe and introducing the idea of dark energy into the scientific toolkit. Having even very obscure ideas concerning the dark energy, one should try to understand the physical consequences of real interaction between the new substance and baryonic matter. One needs to apply the adopted physical laws in a self-consistent way, keeping in mind that almost all the mass of baryonic objects is concentrated in their nuclei, which have very specific structural properties, called mass defect and binding energy.

The most important conclusionmade on the base of this hypothesisis one asserting the Universe total mass growth in the course of evolution. This growing is due to interaction of the baryonic matter with the carrier of dark energy, taking place according to the second law of thermodynamics. It appears that if one applies the physical laws in a self-consistent way, one should inevitably arrive at the conclusion that owing to the interaction with the carrier of dark energy, in the atomic nuclei gradually decreases the lack of energy and therefore grows their mass (Harutyunian, 2017, Harutyunian & Grigoryan, 2018). It does mean that in the distant past all same atomic nuclei could have been lighter and possessing much greater binding energy.

Moreover, one arrives at a conclusion that in the past there could have been existed atomic nuclei consisting of much more nucleons than we know at present.Evolution of cosmic objects goes on simultaneously making the mass of atomic nuclei larger consequently growing the mass of objects consisted of these atoms.Therefore, a successive decay of atomic nuclei and baryonic objects consisted of atoms should happen if those exceed the maximal mass permitted by physical lows for the given epoch of the matter evolution.

The long-lasting evolutionary growth of the Universe mass explains also a paradox why the Universe continues expanding although it should close with a bang after its birth through big bang. Indeed, if the baryonic mass of the Universe really appeared at once from a cosmic vacuum in a small area it should have been located within the Schwarzchild radius for rather long time. The modern gravitational theories accepted by the scientific community the black whole conditions existed obviously, provided that, such a physical phenomenon is possible at all.

Returning to the Ambartsumian hypothesis and keeping in mind these new ideas on the atomic nuclei evolution during the cosmological time, one should speak not about the mass of the baryonic matter but about the number of baryons. It seems more plausible that baryonic matter physical properties are directly depending on the general physical conditions and loss their mass in expense of binding energy if these conditions are like ones the Universe had long ago. In any cosmic object, consisted of baryonic matter, should show evolutionary gradient toward its center. The closer any given area is to the center of an object, the more matter there lags behind in the evolutionary path.

Therefore, it is also plausible that in the interior of massive objects (e.g. stars, galactic nuclei) exist a vast quantity of matter. However, the large quantity here deals with the baryons number, which could possess of a comparatively smaller mass. The mass should grow gradually accumulating the injected into atomic nuclei dark energy. In some moment of evolution when the growing mass exceeds the limit of stability the object gets into the class of non-stability or activity. Like the radioactive atomic nuclei, such object should decay or eject some part of its internal baryonic mass, which has all chances to become a new object belonging to the same hierarchical class or lower.

3. 3. Formation of Cluster of Galaxies via Matter Ejection from the First Central Body

If the evolution of the cosmic objects takes place according the decay/ejection scenario, at any stage of the Universe evolution there should exist cosmic objects of various sizes consisted of baryonic matter. These objects evolve due to influence of dark mater, continuously fitting their physical state to the external space properties of the given epoch of expansion. We assume that the baryonic matter of the object's surface layers, bordering with the free space evolves faster than its interior. However, the evolution process is going on in the internal arias as well and the object gets more massive and energetically instable. Due to the energy interactions,some clots of baryonic matter can acquire the required amount of energy and escape from the object. This process resembles evaporation mechanism or cluster type decay of atomic nuclei.

Depending on the mass (or, rather, number of baryonic embryos) of the object and its spin value, the further evolution can have various scenarios. The simplest dynamics has the nonrotating object, which is subject of the dark energy influence only. Therefore, all the ejections, if any, have isotropic distribution in space. Obviously, possessing of an axial rotation adds new dynamical effect provided by the centrifugal acceleration, which is maximal on the equator. It does mean that ejection in the equator plane becomes more probable and one can see more clots of matter in the equatorial plane than in other directions. The bigger is the rotational velocity, the more is differences between the populations in the equatorial and any other planes.

We consider here the simplest model of a nonrotating baryonic clot interacting with dark energy. Then the dark energy is the only factor affecting such an object and baryonic matter clumps ejected by the parental object should have more or less isotropic distribution around it. This process, on the other hand, goes on comparatively calmly and clamps' formation takes place closer to the surface layers. These clamps can consist of very different number of baryonic embryos if the parental object consists of sufficiently large number of these particles. If the parental clamp consists of a vast number baryonic embryo enough for producing hundreds of galaxies, it will eject not only smaller ones but also larger proto-galaxies.

Considering this scenario, one should keep in mind that every new daughter-clump interacts with the dark energy and experiences changes similar to the parental one taking into account the scale differences. Baryonic matter will continue to accumulate a part of the dark energy and transform a part of it into the baryonic mass, simultaneously making the proto-object more and more instable, until it will eject its own daughter clumps. The common property in this picture is that every such clump can form various cosmic objects belonging to the parental hierarchical level or lower.

Now, let us consider the particular case of largest clump, consisted of so huge number of baryonic embryo, which is enough to form several thousand galaxies.It does mean that this scenario could describe the formation process of various mass galaxies, stellar clusters, individual stars. The process of mass ejection goes on involving formation of the next level objects in the daughter clumps, which, in its turn, entails mass ejection process as well. If the clump gained enough impulse during the ejection to get the escape velocity, it will continue its retreat movement gradually decreasing the initial speed.

On the other hand, if the daughter proto-object ejects next level clumps, the parental object might capture some part of those, depending on direction of its motion. The captured debris will form some kind of halo around the parental object. The halo evidently will have as higher luminosity, as more daughter clumps (to become galaxies) ejects the central (parental) galaxy. It is impossible to find such galaxy outside of a cluster of galaxies. The cluster formed in this way will have a regular spherical shape inasmuch as the paternal objects ejects daughter clumps in all directions equally. Nearly all galaxies, formed owing to the described here mechanism, should belong to the earlier classes, since the nonrotating, parental galaxy could not provide them with ample rotational moment to form a disk galaxy. Moreover, the richer is the cluster of galaxies the closer to the center is the cD galaxy. Evidently, when the number ejections form the cluster galaxies is small, the statistics is not enough yet for constructing the real distribution following from the isotropic ejection of proto-galaxies in the cluster.

4. Conclusion

The newly suggested hypothesis on the interaction between the baryonic matter and dark energy opens new perspectives for the further development of Ambartsumian's cosmogonic paradigm. The biggest obstacle for applying his paradigm was the assertion on the impossible existence of superdense matter of high mass. The refusing of his idea, based on the modern physics laws and axioms about half a century ago, made it hopeless without any possible way for further progress.

Nevertheless, the discovery of dark energy changed the situation drastically. It opens new rooms for the better understanding of the Nature of the Universe. One of the most important conclusions linked to the existence of this new type of energy is one, stating that in the course of evolution the mass of baryonic universe grows up at the expense of dark energy injection. It is interesting that known laws and axioms of modern physics solely allow one of making these conclusions. Actually, one arrives at this conclusion simply employing the second law of thermodynamics.

References

Albert C. E., White R. A., Morgan W. W., 1977, ApJ, 211, 309

Ambartsumian V. A., 1947, The evolution of stars and astrophysics

Ambartsumian V. A., 1958, in La structure et l'évolution de l'universe. pp 241–249

Bautz L. P., Morgan W. W., 1970, ApJL, 162, L149

Beers T. C., Geller M. J., 1983, ApJ, 274, 491

Efstathiou G., Ellis R. S., Carter D., 1980, MNRAS, 193, 931

Faber S. M., Jackson R. E., 1976, ApJ, 204, 668

Gallagher J. S., Faber S. M., Burstein D., 1980, ApJ, 235, 743

Harutyunian H. A., 2017, Astrophysics, 60, 572

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

Hoessel J. G., Schneider D. P., 1985, AJ, 90, 1648

Hoessel J. G., Oegerle W. R., Schneider D. P., 1987, AJ, 94, 1111

Lauer T. R., Gebhardt K., Richstone D., Faber S. M., Tremaine S., 2006, The Most Massive Black Holes in the Local Universe, NOAO Proposal

Malumuth E. M., Kirshner R. P., 1981, ApJ, 251, 508

Matthews T. A., Morgan W. W., Schmidt M., 1964, ApJ, 140, 35

Merritt R., 1976, Instrum. Technol, 23, 27

Morgan W. W., Lesh J. R., 1965, ApJ, 142, 1364

Morgan W. W., Kayser S., White R. A., 1975, ApJ, 199, 545

Oegerle W. R., Hoessel J. G., 1991, ApJ, 375, 15

Oemler A. J., 1976, ApJ, 209, 693

Ostriker J. P., Tremaine S. D., 1975, ApJL, 202, L113

Schombert J. M., 1984, PhD thesis, Yale University., New Haven, CT.

Schombert J. M., 1987, ApJS, 64, 643

Schombert J. M., 1988, ApJ, 328, 475

Thuan T. X., Romanishin W., 1981, ApJ, 248, 439

Tonry J. L., 1985, AJ, 90, 2431

Von Der Linden A., Best P. N., Kauffmann G., White S. D. M., 2007, MNRAS, 379, 867

White S. D. M., 1976, MNRAS, 174, 19

White R. A., 1978, ApJ, 226, 591