АСТРОФИЗИКА

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AN ATTEMPT TO TEST THE AMBARTSUMIAN'S IDEA OF GALAXY ORIGIN I. GALAXY CLUSTERS' SHAPE

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We discuss the shape of 377 rich Abell clusters obtained through the application of FOCAS package to DSS. The covariance ellipse method is used for description of the clusters shape. We discuss the problem for two samples. The first one contains all galaxies in the considered magnitude range m_3, m_3+3. The second sample contains only 20 brightest galaxies. The Kolmogorov-Smirnov test is applied to show that these samples are taken from different populations. Such difference can be resulted due to different epoch origin of brighter and fainter galaxies in clusters, in accordance with Ambartsumian idea of galaxy formation through violent energetic phenomena in the nuclei of galaxies.

Key words: *galaxies:structure: properties:origin*

1. *Introduction*. In modern cosmology there are several theories, called scenarios of the large scale structures origin. The main difference among them is the mass of primeval proto-galaxy and the sequence of structure origin. In some scenarios it is assumed that very massive objects due to fragmentation gave rise to galaxy clusters, which are regarded as the greatest gravitationally bound systems. These are top-down scenarios. Fragmentation of primordial proto-structures due to anisotropic collapse giving the rise of shock waves producing after that flat structure, called pancake. In this Zeldovich [1-3] picture fragmentation of pancake produce galaxy structures.

In the hierarchical model (called also gravitational clustering model) smaller clusters are suggested to form larger ones due to aggregations [4]. This is bottom-up scenario of galaxy origin. In the frame of classic models also turbulence theory was considered, when the structures are formed from fragmentation of the primordial eddy [5].

None of these scenarios of galaxy structure origin describe correctly all properties of galaxy clusters. There are some other models of galaxy structures origin.

Some authors claimed that radio loud quasars were associated with active galaxies [6,7]. Series of evidences that these QSOs have been ejected from very energetic nuclei of galaxies were presented [8]. The proposed evolutionary scheme suggests that initially massive particles are generated which transform into quasars and later on companion galaxies [9-11]. The physical association of low redshift galaxies with high redshift quasars via filaments, for example, is regarded as one of the main argument in favour of this hypothesis. Moreover, the systematic differences of redshifts among companion galaxies [9] as well as quasar redshifts periodicity [12,13] also support this point of view [10]. Similar conclusions are made up analyzing distribution properties and apparent magnitudes of QSOs extracted from areas of rich clusters of galaxies [14].

The theoretical explanation of these processes was proposed too, involving the variability of particle mass [15]. The newly created matter is in the form of massive particle with mass increasing with time. This matter in the form of energy moves from the place of origin with a very high speed sometimes comparable to that of light. The mass of particle increases with time, diminishing gradually the speed. The process of matter ejection is quite similar to that proposed by Ambartsumian [16].

Ambartsumian was the first to point out the role of activity of galaxy nuclei [16,17]. He asserted that neither the structure of these objects, nor the physical processes occurring inside them are known. Therefore he preferred to point out that we observe only the external manifestation of unknown physical processes occurring inside these massive, dense objects, which can contain unknown matter. The standard examples of such activity were: the transformation of normal galaxies into radio galaxies, the ejection of gaseous masses from the nuclei and the existence of quasars.

The observed strong relation between morphology of galaxy clusters and their member galaxies give the foundation of his idea. The unknown matter ejected from a primordial galaxy nuclei lead to formation of galaxy clusters. He wrote that: "since we do not know the mechanism generating the activity of nuclei, we shall consider one after another the nuclear processes, which affect the overall properties and structure of galaxies, at purely empirical level" [18].

Therefore, we discuss the properties of the brightest 20 galaxies in rich galaxy clusters and compare them with overall properties of galaxies. The paper is devoted to the analysis of cluster shape, considering all member galaxies and the set of 20 brightest objects. The subsequent paper will present the analysis of position angles in these samples. We do not introduce theoretical explanation but present only the observed effects.

The paper is organized in the standard way, section 2 presents the observational data, while the section 3 is devoted to the description of the statistical method used in our investigations. Section 4 presents the result and its discussion.

2. *Observational data.* All the Abell [19] clusters with galactic latitude $|b| > 40°$ and richness class ≥ 1 were selected for analysis. Then, from the 1238 clusters selected we extracted the sample clusters with redshift $z < 0.2$ [20]. Therefore only 377 Abell clusters have been left to be analysed. This was our

observational basis. Around each cluster an area covering 2x2 Mpc (h=0.75, q_0=0.5) was extracted from DSS [21]. As a result of application of the FOCAS [22] packages to DSS we compiled the catalogues of galaxies to be analyzed, considering objects within the magnitude range m_3, m_3+3 in the studied area, where m_3 is the magnitude of the third brightest galaxy.

Afterwards, the automatically obtained catalogues were visually corrected to reduce the classification error caused by emulsion uncertainties and misclassification of diffraction images. Each catalogue contains information on the right ascension, declination of galaxies, coordinates x and y on the photographic plate, instrumental magnitude m, area of object, galaxy ellipticity and position angle of the major axis of the galaxy image. The equatorial coordinates of galaxies for the epoch 2000 have been computed from the rectangular coordinates of DSS scans [21].

At the same time in each galaxy cluster 20 brightest objects have been selected. We repeated the whole analysis of these subsamples. In such manner we have two subsamples, the first one containing all galaxies, denoted as A, and the second one with brightest galaxies denoted as B.

3. *Method of analysis.* The method used for ellipticity and position angle determination was covariance ellipse method described in Carter & Metcalfe [23]. The contour of an ellipse in two dimensional distribution of points is determined from the first five moments of the observed distribution:

$$M_{10}=\frac{1}{N}\sum_i x_i, \tag{1}$$

$$M_{01}=\frac{1}{N}\sum_i y_i, \tag{2}$$

$$M_{20}=\frac{1}{N}\sum_i x_i^2-\left(\frac{1}{N}\sum_i x_i\right)^2, \tag{3}$$

$$M_{02}=\frac{1}{N}\sum_i y_i^2-\left(\frac{1}{N}\sum_i y_i\right)^2, \tag{4}$$

$$M_{11}=\frac{1}{N}\sum_i x_i y_i-\frac{1}{N^2}\sum_i x_i\sum_i y_i, \tag{5}$$

where x_i and y_i denote the coordinates of i-th galaxy. The centroid of the contour is: $x_0=M_{10}$, $y_0=M_{01}$, this is the mean of galaxy coordinates. The semi-principal axes are the solution λ_u and λ_v of the quadratic equation:

$$\left(M_{20}-\lambda^2\right)\left(M_{02}-\lambda^2\right)-M_{11}^2=0 \tag{6}$$

- the eigenvalues of the matrix of moments of the distribution.

The cluster ellipticity is given by:

$$e=1-\sqrt{\frac{1-\varepsilon}{1+\varepsilon}}, \tag{7}$$

where

$$\varepsilon = \frac{\sqrt{(M_{20} - M_{02})^2 + 4M_{11}^2}}{M_{20} + M_{02}}. \quad (8)$$

The position angle of the major axis is defined as:

$$\mathrm{tg}2\theta = \frac{2M_{11}}{M_{20} - M_{02}}. \quad (9)$$

We fitted ellipse to individual galaxy cluster contained galaxies within magnitude range from m_3 to $m_3 + 3$. The analysis were done to the whole sample of 377 ACO clusters. Because the structure of ellipticity changes with distance from the cluster centre we calculate its value in circular rings having radii from 0.5 Mpc to 2 Mpc with the step of 0.25 Mpc. In the present investigation the points with mean coordinates of galaxies x_0, y_0 for each cluster were accepted as centre.

The same procedure was repeated for clusters' subsamples consisted of the 20 brightest galaxies. In order to compare with the corresponding "complete" sample (compiled for the case A) in each B sample the value of the greatest distance of a galaxy from the cluster centre has been determined and this value was used as a radius of a circle, inside which ellipticity has been calculated.

The similarity of the ellipticity distributions for samples A and B was checked applying Kolmogorov-Smirnov test.

4. *Results and discussions*. The maximal distances of galaxies from the cluster center in the samples B belong to the interval between 0.5 Mpc and 1.5 Mpc. Therefore, also in the case of samples A this distance range was considered. We distinguished four distance ranges, namely: 0.5 Mpc - 0.75 Mpc, 0.75 Mpc - 1.0 Mpc, 1.0 Mpc - 1.25 Mpc and 1.25 Mpc - 1.5 Mpc. The histograms presenting the number ellipticity relation for these samples are presented on the Fig.1 while Fig.2 presents this relation in the case of samples B.

We checked, using Kolmogorov-Smirnow test, if these distributions are extracted from the same population. At the significance level α=0.01 the critical value of the Kolmogorov-Smirnov test is λ_α=1.627. Table 1 presents the obtained λ values for independent comparisons of samples A and B in the case of four investigated distance ranges.

Comparing relevant histograms, as given in Fig.1 and Fig.2, it is easy to note that these distributions are different. The values of λ statistics confirm these observations. The statistical analysis shows that the distribution of all galaxies in the galaxy clusters is different from the distribution of brighter ones. The distribution of brighter objects is clearly more elongated than the distribution of all galaxies in the same regions. Undoubtedly the physical ground of this difference should be searched in the cluster formation mechanisms.

The fact that the distribution of 20 brighter galaxies in Abell clusters did not come from the same population as distribution of all galaxies in the considered area is surprising and it cannot be easily explained in the framework

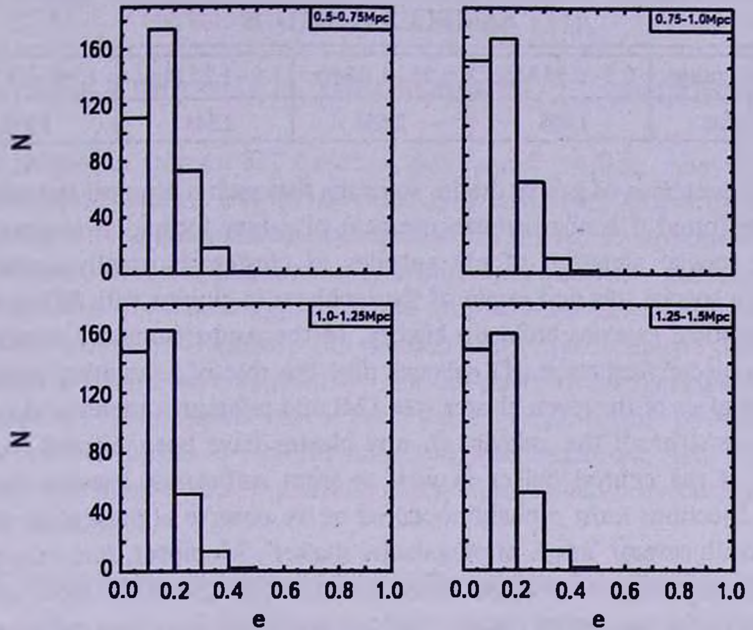

Fig.1. Ellipticity distribution of 377 ACO clusters at different distances from the cluster centre for galaxies in the sample A.

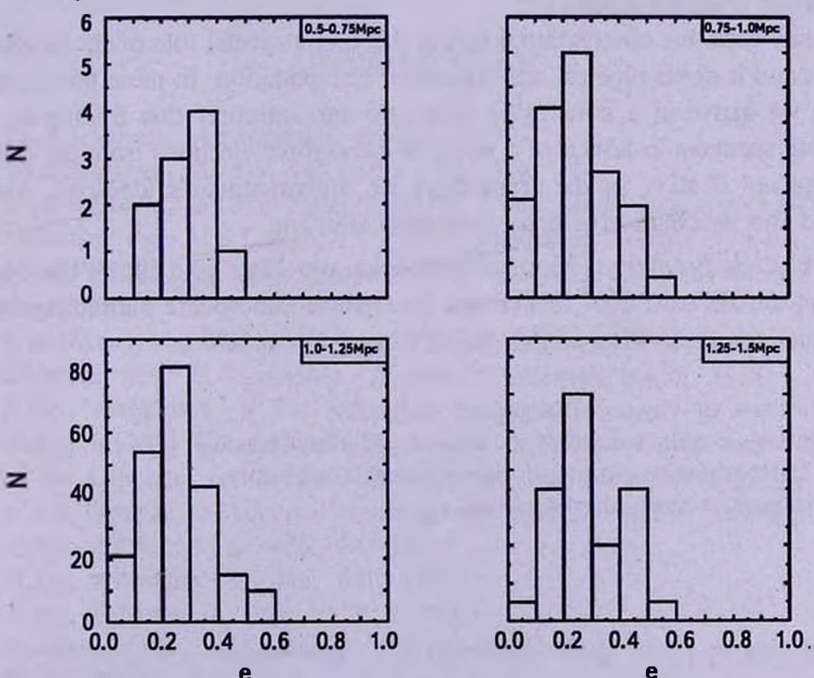

Fig.2. Ellipticity distribution of 377 ACO clusters at different distances from the cluster centre for galaxies in the sample B.

Table 1

THE VALUES OF λ STATISTICS FOR THE COMPARISON OF SAMPLES A AND B

distance range	0.5 - 0.75 Mpc	0.75 - 1.0 Mpc	1.0 - 1.25 Mpc	1.25 - 1.5 Mpc
λ value	1.405	2.556	3.544	1.977

of classic scenarios of galaxy origin. It seems that such a physical interpretation might be found if Ambartsumian concept of galaxy formation is considered.

The special situation of cD galaxies in clusters is usually regarded as showing a special role and origin of these objects in clusters with different from other elliptical galaxies build up history. In the Ambartsumian's paradigm of cosmic objects' formation cD galaxies play the role of generators originating all the galaxies of the given cluster (see [24] and references therein). According to this scenario all the galaxies in any cluster have been ejected from the nucleus of the central object as well as from sufficiently massive daughter objects. Ejections most probably occured as we observe at present in the case of M87 with several "knots of pregalactic matter". Moreover, one may suggest from physical viewpoint that first ejections statistically should be more powerful and could originate rather massive and consequently luminous galaxies. Thus we can conclude that among the first members of galaxy clusters should be formed the brightest ones.

In any case this observational fact is showing a special role of the brightest galaxies and it needs physical self-consistent interpretation. In these preliminary studies we arrive at a conclusion that one can interpret this finding as an argument speaking in favour of a series of anisotropic ejections from the initial proto-galaxy if stays in the framework of Ambartsumian's ideology. More detailed this mechanism will be described later on.

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ПОПЫТКА ПРОВЕРКИ ИДЕИ АМБАРЦУМЯНА О ПРОИСХОЖДЕНИИ ГАЛАКТИК. I. ФОРМА СКОПЛЕНИЙ ГАЛАКТИК

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Обсуждаются формы 377 богатых скоплений Эйбела, полученных с применением пакета FOCAS на DSS. Для описания форм скоплений использован метод ковариантных эллипсов. Проблема рассматривается для двух выборок. Первая выборка состоит из всех галактик со звездными величинами из интервала m_3, m_3+3. Во вторую выборку вошли двадцать ярчайших галактик каждого из скоплений. Применение критерия Колмогорова-Смирнова показало, что данные выборки принадлежат разным населениям. Такое различие может быть результатом разных эпох происхождения ярких и слабых галактик в скоплениях, что, согласно Амбарцумяну, происходит вследствие интенсивных энергетических явлений в ядрах галактик.

Ключевые слова: *галактики:структура:особенности:происхождение*

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