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QO‘SHALOQ GALAKTIYALARNING JAMLANMA KATALOGI HAQIDA VA ULARNING STATISTIK TAHLILI

Annotation

Bu ishda qo‘shaloq galaktikalarning mavjud kataloglari va zamonaviy kuzatuv ma’lumotlarini o‘rganish asosida 613 ta juft ob’yektdan iborat jamlanma katalog yaratildi. Statistik tahlil o‘tkazildi: juftliklar orasidagi burchak va chiziqli masofalar hisoblab chiqildi, galaktikalarning umumiy va individual massalari hisoblandi, gistogrammalar chizilad va korrelyatsiya koeffitsientlari hisoblab chiqildi.

Kalit so‘zlar: qo‘shaloq galaktikalar kataloglari, statistik tahlil.

О СВОДНОМ КАТАЛОГЕ ДВОЙНЫХ ГАЛАКТИК И ИХ СТАТИСТИЧЕСКОМ АНАЛИЗЕ

Аннотация

В данной работе на основе изучения существующих до настоящего времени каталогов двойных галактик и современных наблюдательных данных создан их сводный каталог, состоящий из 613 пар объектов. Проведен статистический анализ: вычислены угловые и линейные расстояние между парами, оценены суммарная и отдельные массы галактик, построены гистограммы, вычислены корреляционные коэффициенты.

Ключевые слова: каталоги двойных галактик, статистический анализ.

ABOUT THE CONSOLIDATED CATALOG OF BINARY GALAXIES AND THEIR STATISTICAL ANALYSIS

Annotation

In this work, based on the study of existing catalogs of binary galaxies and modern observational data, a consolidated catalog consisting of 613 pairs of objects was created. A statistical analysis was carried out: angular and linear distances between pairs were calculated, the total and individual masses of galaxies were estimated, histograms were constructed, correlation coefficients were calculated.

Keywords: catalogs of binary galaxies, statistical analysis.

Introduction. It’s not hard to understand that if two objects occupy a mutually close distance to each other in the sky, it doesn’t always mean they form a binary system. They can be quite far apart and not gravitationally connected to each other.

In binary galaxies, the proper motions of the components are so small that they are difficult to determine even after many years of observation. This is where difficulties arise in determining whether it is an optical or physical double. Therefore, a statistical method of selecting binary stars is used to determine binary galaxies. One has to rely on a certain criterion, the fulfillment of which makes the physicality of a binary galaxy quite likely. However, it is difficult to find a generally accepted formulation of the definition of binary galaxies in modern literature.

In astrophysics, the birth, life, and evolution of binary stars have been studied in detail and their theory has been developed. However, the physics of binary galaxies has not been resolved to this day. For example, the following questions remain open:

1. How are binary galaxies born?
2. What types of binary galaxies exist?
3. What is the distribution of these types of galaxies by distance and physical parameters?
4. Do binary galaxies influence the development process of large systems, for example, clusters and superclusters of galaxies as a whole?
5. It is clear that due to tidal forces and dynamic friction, star formation in close binary systems and evolution there occur more intensively than in single galaxies, but this question is not fully studied.
6. Do pairs of galaxies have a common origin or is it a result of mutual capture?
7. One of the main tasks of extragalactic astronomy - determining the mass of components by rotation curves or by the virial theorem (which is directly related to the problem of dark matter) is still waiting for its solution and others.

To date, some of these problems have been studied by a number of authors and catalogs and atlases of binary galaxies have been compiled. For example, the catalogs of Holmberg, Zwicky, Karachentsev, Turner, 1976, Tully, etc. [1-7]. In addition to these catalogs, there are atlases and catalogs of Arp and Vorontsov-Velyaminov, where you can also find binary

galaxies [8, 9]. The aforementioned catalogs differ from each other in the number of objects, the physical and geometric quantities of pairs, and overall their approach to the problem and purpose. Our tasks in this work are:

- conducting a review and studying the existing catalogs and atlases of binary systems to date;
- based on observational data from recent years, compiling a consolidated catalog of binary galaxies, conducting its statistical analysis;
- determining the angular and linear distances between components;
- estimating the total mass and mass of individual components of binary galaxies using formulas proposed in the work by Heisler and Tremaine [10].

Brief review of catalogs and atlas. Arp’s work “Atlas of Peculiar Galaxies” contains information about various peculiar structures found in neighboring galaxies [8]. Arp emphasized that the process of forming elliptical and spiral galaxies is not well studied. The atlas has little information about the physical processes that affect the shape of galaxies, and therefore galaxies are classified based on their appearance. Objects from 1 to 101 represent individual peculiar spiral galaxies with small components. Objects from 102 to 145 - elliptical galaxies. Spiral and non-elliptical individual galaxies or groups of galaxies have numbers 146-268. However, in this atlas we are interested in objects from 269 to 327 - binary galaxies. And finally, objects not related to the above categories are listed under numbers 332-338. Interacting galaxies (colliding galaxies) are galaxies whose gravitational fields cause each other to collide. Examples of secondary interacting objects include a galaxy’s moon or spiral arms. A major interaction can be called a galaxy collision, which can lead to the merger of galaxies. The morphological catalog of interacting galaxies compiled by Vorontsov-Velyaminov et al., includes 2014 pairs [9]. This catalog includes objects with declination more than -45 degrees and up to 15 stellar magnitudes. The first statistical study of binary galaxies was conducted by Swedish astronomer Holmberg in the work “Study of Binary and Multiple Galaxies” [1], who first compiled a catalog of 695 pairs. The catalog lists all pairs of galaxies, the distance to the components of which is less than twice the sum of their diameters. It can be assured that most of this catalog represents a physical binary galaxy. Karachentsev’s catalog “Binary Galaxies in the Place of Supercluster and its Vicinity” is the most complete catalog of binary galaxies available today and contains 509 pairs selected from 10403 local galaxies with a radial velocity less than 3500 km/s, [3]. Physical binary galaxies are distinguished by the fact that their total energy is negative, and their components lie within the surface of zero velocity. Individual masses of galaxies are considered proportional to their total luminosity in the K-filter. The catalog contains information about stellar magnitude, morphological type, orbital mass and isolation index of galaxies. There is also Turner’s catalog “Binary Galaxies”, where 156 pairs are given [5, 6]. Turner extracted a sample of 156 binary systems of galaxies from Zwicky’s catalog of galaxies and clusters of galaxies [2], using certain identification criteria. Stellar magnitude, morphological type, radial velocity, angular distance and other parameters of objects are given. Radial velocity was measured for both components of 66 pairs.

Tully compiled a catalog of nearby binary galaxies with a radial velocity of less than 3000 km/s [7]. This catalog contains 2367 galaxies with a diameter of 82 Mpc, which is comparable to the size of the cosmological homogeneity of the Universe. Using the hierarchical dendrogram method, Tully identified 179 groups in this catalog, comprising 69% of the studied galaxies. The study of binary galaxies is of great interest in considering the issue of their formation and evolution, and can also be widely used in studying the distribution of light and dark matter in pairs of galaxies. In his work [3], Karachentsev considered the problem of the distribution of light and dark matter in the volume of the Local Supercluster and its surroundings, which is comparable to a cosmological cell of homogeneity. It is known that gravitational lenses can also reveal concentrations of dark matter with sizes on the order of galaxy clusters. Work has already begun in this direction and their results suggest that in the future, when enough information about binary galaxies and gravitational lenses has been accumulated, it will be possible to build maps of galaxy clusters. It will also be possible to determine the angle of deviation of a light beam, which occurs according to the effect of gravitational lensing when passing around pairs of galaxies.

Consolidated catalog and statistical analysis of data. When compiling the consolidated catalog, we relied on the catalogs of the authors mentioned above and observational data from recent years. This resulted in the creation of the “Consolidated Catalog of Binary Galaxies”, consisting of 613 pairs, which will be published separately. Below are some histograms, correlation coefficients, and empirical formulas.

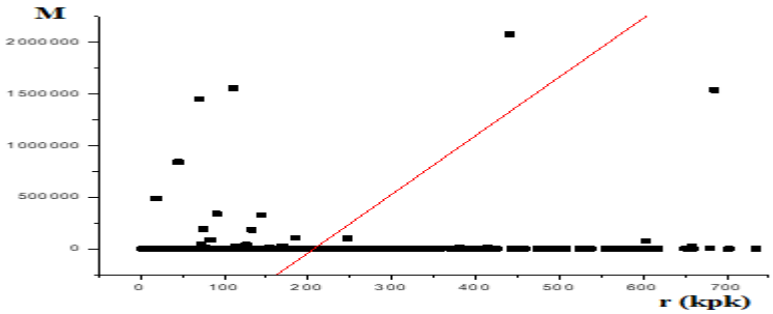

Fig.1. Dependence of the total mass M (109 solar masses)on the distance between the components r.

You can see the dependence $M = a+b\cdot r$. We determined the coefficients a and b by the method of least squares: a = -1.18± 59.41, b =57.86±24.67. The correlation coefficient K = 0.69 suggests that there is the indicated dependence between M and r.

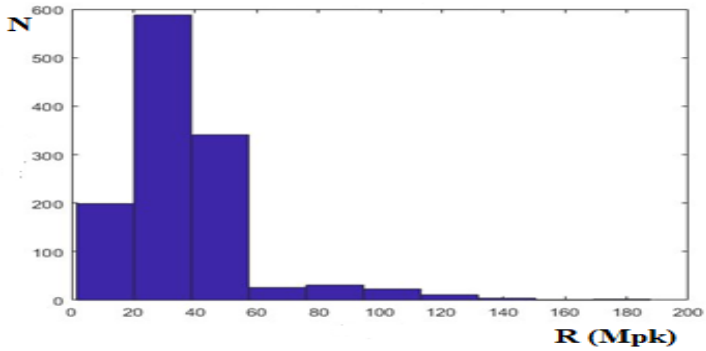

Fig. 2. Distribution of galaxy pairs by distances. Most pairs of galaxies are within 20 to 60 Mpc. V_r (km/s)

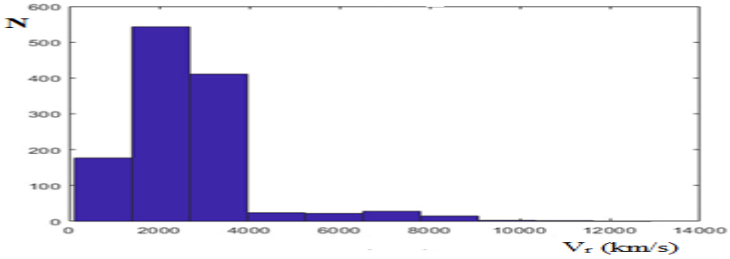

Fig. 3. Dependence of radial velocity V_r on the total number of galaxies N.

You can see a linear dependence $V_r = a+b \cdot R$, with coefficients $a = 225.23 \pm 24.92$, $b = 65.52 \pm 0.59$, and a correlation coefficient $K = 0.95$.

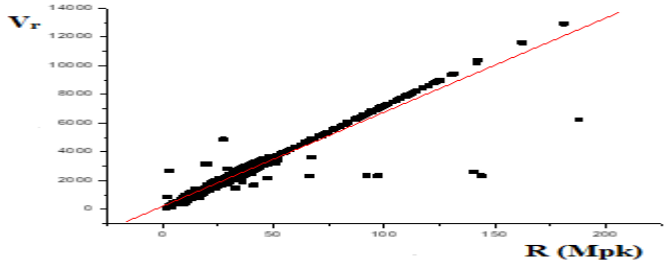

Fig.3. Dependence of radial velocity V_r on distance R.

The analysis of the obtained data on the types of binary galaxies, in percentage terms, is presented in Table 1. As can be seen from the table, binary galaxies are mainly composed of spiral galaxies.

Table 1. Types of Binary Galaxies.

№	Pair	Number	Percent (%)
1	**E ÷ E**	**5**	**0,8**
2	**E ÷ S**	**29**	**4,7**
3	**E ÷ SO**	**8**	**1,3**
4	**E ÷ Ir**	**2**	**0,3**
5	**S ÷ S**	**340**	**55,5**
6	**S ÷ SO**	**81**	**13,2**
7	**S ÷ Ir**	**101**	**16,5**
8	**SO ÷ SO**	**20**	**3,3**
9	**SO ÷ Ir**	**14**	**2,3**
10	**Ir ÷ Ir**	**13**	**2,1**

Conclusion. Let’s list the main results: A review of the catalogs and atlases of binary, as well as interacting galaxies of Zwicky, Holmberg, Tully, Arp, Vorontsov-Velyaminov, Turner, Karachentsev and others available to date has been conducted. From these, binary galaxies were specifically identified; Angular and linear distances between pairs of galaxies were calculated and refined; • The total mass of galaxy pairs was calculated using formulas [Heisler and Tremaine, 1985], as well as the masses of each component; A consolidated catalog of binary galaxies consisting of 613 pairs was created, with radial velocities less than 13500 km/s, in a volume with a diameter of 200 Mpc. The catalog includes the ordinal number, name, equatorial coordinates RA (h m s) and RD (° ’ ”), type T, radial velocities Vr (km/s), mutual distance r(Kpc), apparent stellar magnitude m(mag), redshift z, distances to galaxies R(Mpc), total mass M and masses of each pair $M_{1,2}$ in units of solar mass; Correlations of quantities *(V_r ; r), (V_r; m), (V_r; z), (V_r; R), (V_r; M), (V_r; $M_{1,2}$), (r; m), (r; z), (r; R), (r; M), (r;*

M1,2), (m; z), (m; R), (m; M), (m; $M_{1,2}$), (z; R), (z; M), (z; $M_{1,2}$), (R; M), (R; $M_{1,2}$), (M; $M_{1,2}$) were calculated; a statistical analysis was carried out, histograms of the above quantities were constructed, some empirical formulas were found.

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LITERATURE

1. Holmberg E. A Study of Double and Multiple Galaxies //Annals of the Observ. Of Lund., V.6.- P.5, 1937
2. Zwicky F., et al. VizieR Online Catalog: Galaxies and Clusters of Galaxies, 1968
3. Караченцев И. Д., Макаров Д.И., Астрофиз. бюллетень, т.63, №4, 2008
4. Karachentsev I.D., Astronom. J. 129, 2005
5. Turner E.L. Binary Galaxies. I. //Ap.J. 208: P.20-29, 1976
6. Turner E.L. Binary Galaxies. II. //Ap.J. 208: P.304-316, 1976
7. Tully B. B., Nearby Galaxies Catalog, Astrophys. J. 132, 729, 2006
8. Arp H., Astrophys. J. 256, 54, 1982
9. Vorontsov-Velyaminov B. A., et al. Astr. & Astrophys. Trans., 11 Dec.2007
10. Heisler J. and Tremaine S., The Astrophysical Journal, 298:8-17, 1985