АКАДЕМИЯ НАУК АРМЯНСКОЙ ССР

АСТРОФИЗИКА

ТОМ 3 НОЯБРЬ, 1967 ВЫПУСК 4

BLUE COMPACT GALAXIES IN THE LEO A AND B CLUSTERS

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Received 27 September 1967

Clusters of galaxies are classified in seven categories depending on the relative numbers of spiral, elliptical, irregular and compact member galaxies. With respect to the preceding paper those clusters are of particular interest which contain both normal and very compact galaxies. For the latter greater redshifts should be observed thus furnishing a proof for the existence of Einstein gravitational redshifts. As examples of clusters suitable for decisive tests the Leo A and B clusters which contain many blue quasistellar like objects are discussed.

A. *Classification of clusters of galaxies.* Rich clusters of galaxies may be classified in a preliminary way in the following categories [1]:

1. Clusters which contain only irregular galaxies. These are very rare.

2. Clusters with a great variety of spirals and irregular systems.

3. Clusters with all types of objects except that few very compact systems are in evidence.

4. Clusters of the type 3 which also contain many compact objects.

5. Clusters which are composed mainly of elliptical galaxies, but few compact objects.

6. Clusters of the type 5 which also contain many compact galaxies as well as ellipticals with giant compact cores.

7. Clusters of compact galaxies. Although numerous groups of compact galaxies have been found, rich clusters consisting of only compact galaxies are rare, at least at distances at which the symbolic velocity of recession V_s is less than 50 000 *km/sec.*

The local group, although it is not a rich cluster would be described as being of the class 3.

Any of these clusters may be compact, medium compact or open as they were defined for inclusion in the Catalogue of Galaxies and Clusters of Galaxies [2—5], called the Catalogue in the following.

In view of the issue raised in the preceding paper [6] the thorough investigation of clusters of the type 6 is of importance. The clusters Leo A and B discussed in the following are suitable objects for our purpose [7]. With increasing compactness the member galaxies of a cluster of this type should show increasing Einstein redshifts. The magnitude of these, if large compared with the dispersion of radial velocities within the cluster could readily be distinguished from the average cosmological redshift of the cluster. Probability of identification of cluster membership depends of course on the density distribution of stellar like galaxies within the cluster. This probability can be most easily estimated if the investigation is limited to decidedly blue objects.

B. *Cl 1105.3+2835 (Leo A).* This cluster in the *Catalogue* is listed as Near, with 1090 member galaxies, brightest photographic magnitude about $m_p = 14.5$ and average symbolic velocity of recession about $V_s = 8700$ *km/sec.* The most interesting formation is associated with the double galaxy NGC 3561 from which a pencil jet extends to the south while a very large elongated faintly luminous and highly disrupted cloud is located to the north. The pencil jet passes through three blue compact galaxies of which the most southern, the Ambartsumian knot is recognizable as such. The other two blue knots found by Zwicky in 1956 are the first galaxies discovered which are stellar when photographed with the 200-inch telescope. Their spectra in the blue show λ3727 in emission and a very weak continuum [8].

On the accompanying photograph, Figure 1, other blue objects are marked which on 48-inch Schmidt plates are stellar in appearance and which will be investigated for the purpose stated above.

C. *Cl 1115.2×3013 (Leo B).* This cluster in the *Catalogue* is listed as Near, population 950, brightest galaxies about $m_p = 15.2$ and $\overline{V}_s \sim 14000$ *km/sec.*

A blue spiral (2 in the Fig. 2) and a blue spherical object (1) discovered by Ambartsumian and Shahbazian [9] ten years ago are near the region of greatest concentration. The spectrum of (1) shows λ3727 and other lines in emission indicating a symbolic velocity of recession of about 12500 *km/sec.* (Spectra were obtained at

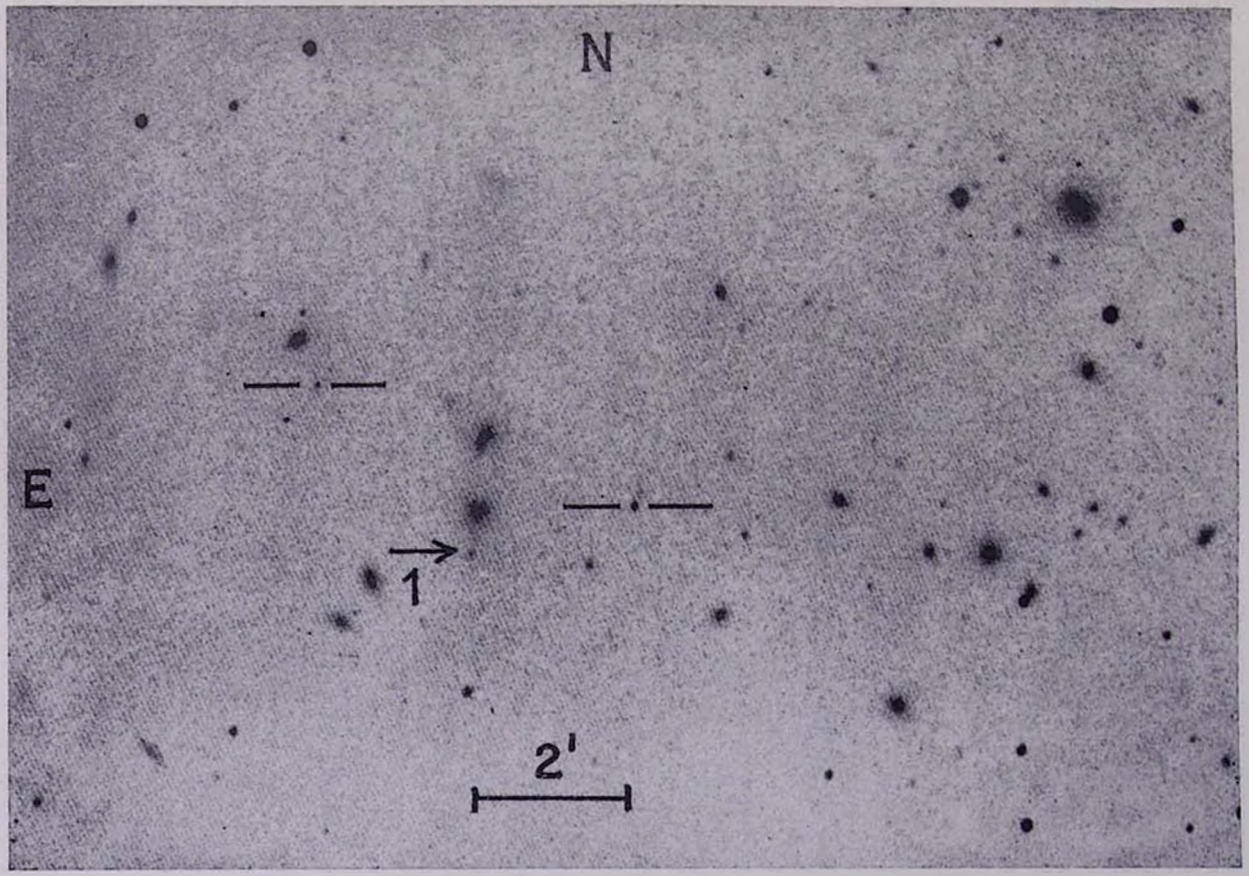

Fig. 1. Central part of the cluster of galaxies Cl 1105.3+2835 (Leo A) photographed with the 48-inch Schmidt telescope. 1 marks the blue Ambartsumian knot. The two stellar blue compact galaxies just north of it are not visible. Other bracketed images are those of stellar like blue objects. Scale as indicated.

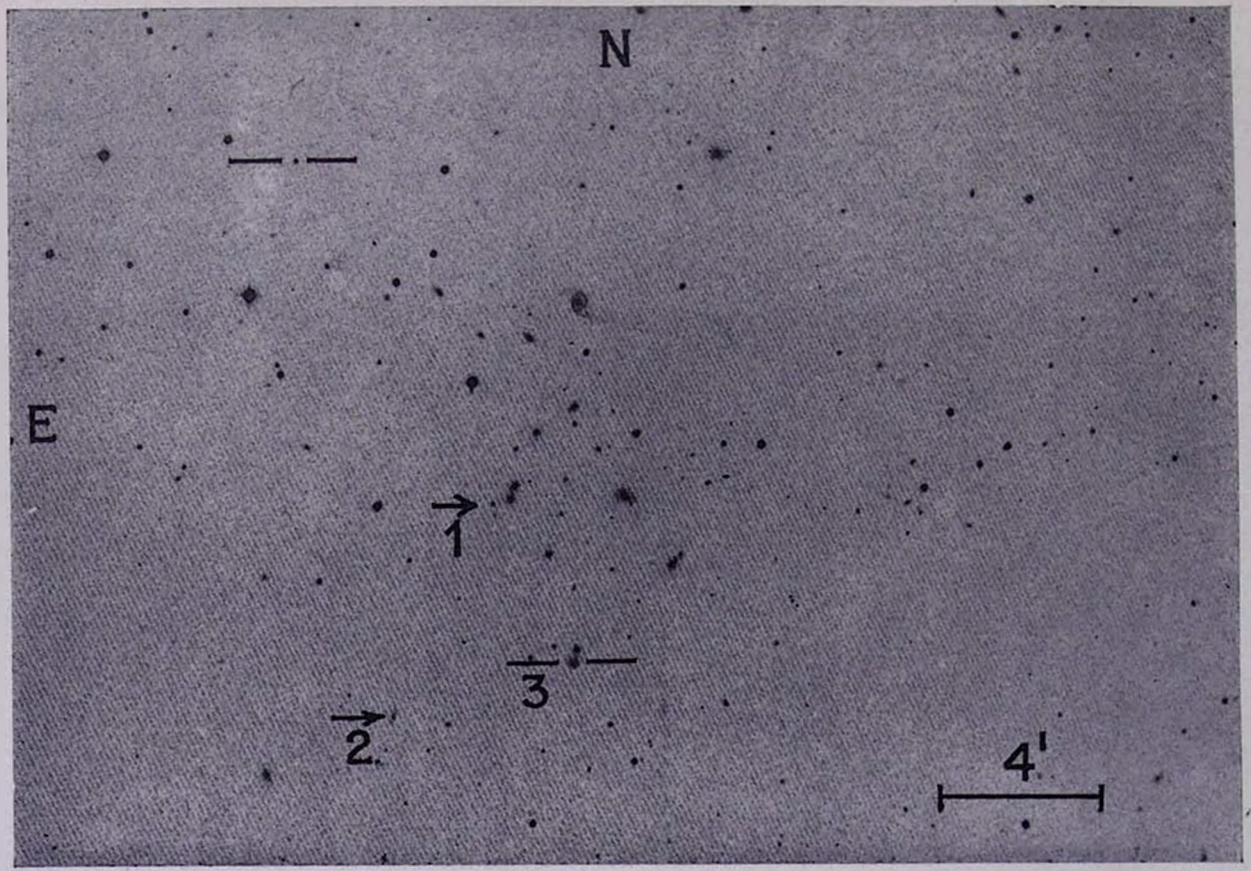

Fig. 2. Central part of Cl 1115.2+3013 (Leo B). Objects 1 and 2 and 3 are respectively a blue compact galaxy, a blue spiral and a blue spherical galaxy while the other shown is a blue stellar like object. Object 1 is at R. A. $11^h13.^m9$; Decl. $+29°31'$ (1950). Scale as indicated.

Kitt Peak independently by R. Barbon working with the author and A. Stockton working with C. R. Lynds). A supernova which appeared on an intergalactic bridge between two compact galaxies in the cluster has been reported on recently [10]. Most interesting is a possible intergalactic supernova at R. A. 11^h13^m5, Decl. $+29°38'$ (1950) recently discovered by Mrs. J. H. Anderson [11] which at maximum seems to have been very blue. Dr. H. C. Arp with the 200-inch telescope kindly obtained a plate of the region which shows no galaxy in the location of the Anderson star, which, however might be a member of the far outskirts of the galaxy directly north of it.

One of many blue stellar like objects is marked on the photograph shown in Figure 2 (NE corner) as well as a fairly blue spherical galaxy 3.

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ГОЛУБЫЕ КОМПАКТНЫЕ ГАЛАКТИКИ В СКОПЛЕНИЯХ LEO A и B

Ф. ЦВИККИ

Скопления галактик делятся на семь классов в зависимости от относительного числа спиральных, эллиптических, иррегулярных и компактных членов — галактик. Согласно предыдущей статье, представляют особый интерес те скопления, которые содержат одновременно нормальные и очень компактные галактики. Для последних должны наблюдаться большие красные смещения, таким образом доставляя доказательство существования эйнштейновского гравитационного красного смещения. Как примеры скоплений, подходящих для контрольной проверки, рассматриваются скопления Leo A и B, которые содержат много голубых объектов, подобных квазизвездным.

REFERENCES

1. *F. Zwicky*, Report to Commission 28, I. A. U., 1967 (to appear in the Draft Report for the Assembly in Prague, Aug. 1967).
2. *F. Zwicky, E. Herzog*, Catalogue of Galaxies and Clusters of Galaxies. Vol. I, Calif. Inst. of Technology, 1961.
3. *F. Zwicky, E. Herzog, P. Wild*, ibid., Vol. II, Calif. Inst. of Technology, 1963.

4. *F. Zwicky, E. Herzog*, ibid., Vol. III, Calif. Inst. of Technology, 1966.
5. *F. Zwicky, M. Karpowicz, C. Kowal*, ibid., Vol. V, Calif. Inst. of Technology, 1965.
6. *F. Zwicky*, Publ. A. S. P., 1967, (to be published).
7. *F. Zwicky*, Director's Report Mount Wilson and Palomer Observatories, Carnegie Institution of Washington Yearbook 65, 1966.
8. *F. Zwicky*, l'Astronomie, 72, 285, 1958.
9. *V. A. Ambartsumian, R. K. Shahbazian*, Doklady Akademy Nauk Armyanskoi SSR, 25, 185, 197.
10. *K. Rudnicki, F. Zwicky*, A. J., 72, 407, 1967.
11. *J. N. Anderson, W. J. Luyten, A. R. Sandage*, I. A. U., Circular № 2011, April 25, 1967.