MARKARIAN GALAXIES AND ZWICKY CLUSTERS

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ABSTRACT. From 1344 Markarian galaxies lying in the same area covered by Markarian survey and CGCG,592 are positioned within the contours of Zwicky clusters.On the basis of these data statistical investigation of the relation of Markarian galaxies with Zwicky clusters is carried out. Markarian galaxies take part in the tendency of clustering of galaxies and they lie in any type of Zwicky clusters. Markarian galaxies coincide with greater probability with medium compact clusters than with open ones where they follow the distribution of normal galaxies.In medium compact and compact clusters they appear near the centres of concentration of galaxies but probably not in their dense cores.

1.INTRODUCTION

The first investigation on the relation of Markarian galaxies (MG) with clusters was carried out by Komberg(1976). In a review paper he pointed out a possible deficiency in the number of MG in clusters.Later on,similar result was obtained by Gisler(1978).Let us note that both conclusions are tentative because of the small statistics of the objects.

New observational data for MG favour their association with clusters (Arakelian,1978;Joeveer et al.,1979;Thompson,1983).

After Gisler's paper another statistical investigation was done for these objects (Arakelian and Terebizh,1982). It is concluded that MG show tendency,like other galaxies, to lie in the clusters.

E. Ye. Khachikian et al. (eds.), Observational Evidence of Activity in Galaxies, 87–94.

In this paper the results of statistical investigation of the relation of MG with Zwicky clusters based on data of Petrosian and Turatto(1986,PT1) are developed.

2. EXPECTED AND OBSERVED CASES OF COINCIDENCE OF MARKARIAN GALAXIES WITH CLUSTERS.

The sky area covered both by Markarian and Zwicky surveys is about 12 500 sq.degree. In this area 1344 MG were identified and about 1080 of them have redshift. If we restrict the space by redshift to consider only objects with $z \leq 0.05$ (near distance class of Zwicky), 980 (91%) UV galaxies of 1080 remain in it. In this space there are 229 open Zwicky's clusters with 1289 sq.degrees common surface, 185 medium compact clusters with 921 sq.degrees common surface and 24 compact clusters with 69 sq.degrees common surface (CGCG, Zwicky et al., 1961 - 1968).

In assumption that their appearance is due to Poisson law the expected chance numbers of coincidences of MG in the common surface of clusters were calculated. In Table 1 the numbers of expected chance and observed coincidences of MG with different type and all near Zwicky clusters and with field, regardless of their redshifts, are presented.

TABLE 1

System type	Number of galaxies	
	Expected chance	Observed
Open	101 ± 10	186
Medium compact	72 ± 8	165
Compact	5 ± 2	17
All near clusters	179 ± 13	368
Field	801 ± 28	610

As seen from Table 1 observed numbers of coincidences are in average about twice larger then expected chance numbers. This means that in bi-dimensional case Markarian galaxies do not avoid any type of Zwicky clusters.

3. OBSERVATIONAL RELATION OF MARKARIAN GALAXIES TO ZWICKY CLUSTERS.

We assigned a UV galaxy to a Zwicky cluster if it lay within the contour boundary of a cluster and if the difference between its velocity and that of the cluster was ≤ 2000 km/s (Abell, 1978; Beers et al 1983). If the difference between galaxy and cluster velocities was in the range of $2000 < V \leq 4000$ km/s MG as probable member of the

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cluster was accepted. When V > 4000 km/s we considered this as projection case.

597 MG from the selected 1344 (45%) are positioned within the contours of Zwicky clusters. The radial velocities for 499 of 597 are available, most of them are collected in the catalogue of Palumbo et al (1983). From these 597 MG 438 (more than 70%) are projected on 176 near Zwicky clusters, 68 on 60 medium distant (VD) and 33 on 30 enormously distant (ED) clusters. In 27 cases the same MG is projected on two or three clusters simultaneously.

The radial velocities for the clusters are taken from the catalogues of Baiesi-Pillastrini et al (1984), Fetisova (1981), Noonan (1981), Sarazin et al (1982).

In PT1 we assembled in different tables all possible cases of MG - cluster relation. Following that in Table 2 numbers of MG observed in each case are presented.

TABLE 2

	Open	Med. Compact	Compact
MG as the members of the clusters with only one z value	82	87	11
MG as the members of the clusters with two or more values of z	35	27	2
MG as the members of the foreground or background groups	30	26	1
MG is the only object with measured z in the cluster	7	11	2
MG as probable members of clusters	7	5	1
Projection cases	29	20	3

As seen from Table 2 in three dimensional case about 85 - 90% of MG are real or probable members of clusters and groups of galaxies. This means that MG participate in the tendency of clustering of galaxies.

Let draw also attention to some facts. MG with greater

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probability coincide with medium compact clusters than open ones (Table 1),in analogy to results obtained for the sample of Seyfert galaxies (Petrosian,1982).Since from 17 MG coincident with compact clusters 8 are members of Coma whose compactness is discussed now (e.g.Baier,1984) the large difference between expected chance and observed number of coincidences of MG with compact clusters is to be approached with care.

4.MARKARIAN GALAXIES AS MEMBERS OF A CLUSTER.

To consider the properties of MG members of the clusters, the sample of Zwicky clusters containing MG as real members and with only one value of redshift is used (see Table 1 of PT1).The sample contains 55 open clusters with 82 MG,36 medium compact clusters with 87 galaxies and 4 compact clusters with 11 galaxies.In all there are 95 clusters with 180 MG.

The first and more important question is the distribution of MG in clusters.For these MG were assembled in 3 groups,inner,intermediate and outer,according to their relative distances from the nearest centre of concentration of galaxies to the cluster boundary.

In Table 3 the observed numbers of galaxies in three groups respectively are compared with the expected numbers which are calculated for the same sample of MG assuming constant space density of these galaxies versus condensation radius for open,medium compact,compact and for all clusters.

TABLE 3

System type	Observed numbers	N	Expected numbers
Open	11:17:54	82	9:27:46
Med.compact	24:27:36	87	10:29:48
Compact	8:0:3	11	1:4:6
All clusters	43:44:93	180	20:60:100

The data of Table 3 show that the excess of MG in the central regions of medium compact (see also communication of Moss and Whitte,1984) and compact (see also Arakelian, 1978) clusters is real.

Since the radial velocities for all MG and clusters in the sample are known,it is possible to have the distribu-

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tion ($V_{cl} - V_{Mrk}$) for open and medium compact clusters (Figures 1 and 2). The numbers of galaxies in each column, divided accordingly to their distances from the centres of concentration (three mentioned above groups), are given in the upper panels of these figures.

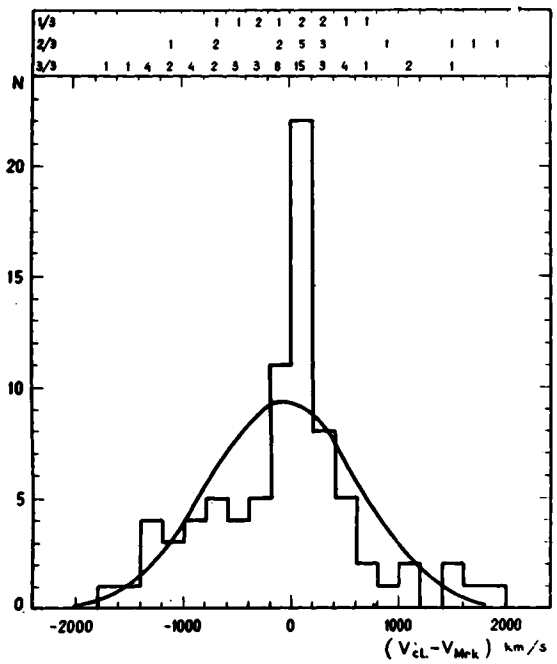

Figure 1. ($V_{cl} - V_{Mrk}$) histogram for MG in open Zwicky clusters. Bins are 200 km/s. Bell-shaped curve is a Gaussian with mean and standard deviation of the observed sample.

The distribution of ($V_{cl} - V_{Mrk}$) of the sample of 82 MG in open clusters (Fig. 1) has an average - 77 km/s value and a standard deviation of 696 km/s. χ^2 - test shows that the observed distribution in Figure 1 is inconsistent with a Gaussian curve, constructed with these parameters.

More then half of MG in open clusters have velocities near the clusters mean ($\pm$400 km/s). There are central and extreme objects with the same frequency among them. The galaxies with big difference of velocities are mostly extreme objects and some of them can be field galaxies.

The same distribution of the sample of 87 MG in medium compact clusters (Fig-2) has an average - 142 km/s value and a standard deviation of 760 km/s. This observed distribution also is inconsistent (χ^2 - test) with a Gaussian curve constructed with these parameters.

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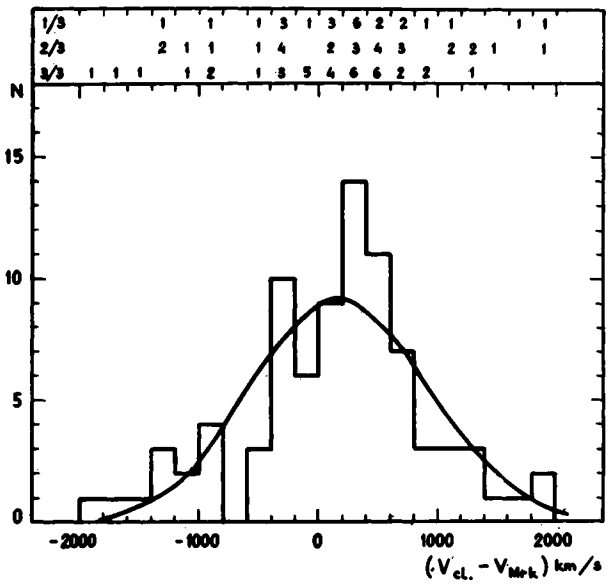

Figure 2. (V_{cl} - V_{Mrk}) histogram for MG in medium -compact ciusters. Bins are 200 km/s. Bell-shaped curve is a Gaussian with mean and standard deviation of the observed sample.

Here is more interesting a shortage of MG in the central range ±200 km/s on the whole conditioned by the central and intermediate objects.

Since some of medium compact clusters have more than one centre of galaxies concentration and the above values of V_{cl} are usually radial velocities for the clusters as a single whole, an examination of relation between the positions of MG with the respect to centres of concentration in clusters and the values of (V_{cl} - V_{Mrk}) may be incorrect. Nevertheless, we must not disregard the possible interpretation that MG lying in the centres of concentration of galaxies avoid their cores.

Most probably this is true for compact clusters. In Coma, for instance, all 6 central MG have high values of (V_{cl} - V_{Mrk}), or in three-dimensional sense MG probably avoid its core..

Relations between absolute magnitudes of MG, their positions in the clusters and the values of (V_{cl} - V_{Mrk}) were considered. Significant correlations between these parameters were not found.

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5. CONCLUSIONS.

The conclusion of this work can be summarized as follows:

1. MG participate in the tendency of clustering of galaxies and do not avoid any type of Zwicky clusters.

2. MG coincide with medium compact clusters with greater probability than with open ones.

3. The distribution of MG in Zwicky's open clusters probably follows the distribution of normal galaxies.

4. MG as members of medium compact and compact clusters show the tendency to appear near the centres of concentrations of galaxies in clusters, but probably not in their dense cores.

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DISCUSSION

TERLEVICH: Do you find any relation between percentage of Markarian galaxies and the spiral percentage?

PETROSIAN: We didn't make the special study of this relation. But from our point of view in clusters must be positive correlation between percentage of AGN's and the percentage of spiral.

MELNICK: You find Markarian galaxies projected against the core of the Coma cluster that have a small velocity difference with the cluster mean. How close to the core of Coma do you think they are or may be? Is it consistent with what we know about the density of the intergalactic medium of Coma?

PETROSIAN: In Coma all 6 central Markarian galaxies have high values of $(V_{Cl}-V_{Mrk})$, or in three-dimensional sense Markarian galaxies probably avoid its core.

TREVESE: You mentioned earlier results indicating that AGN tend to "avoid" cluster. How do you explain the difference with your results? Is it related to the effect, that you also find, indicating that MG avoid the very centre of clusters?

PETROSIAN: The probability to find AGN's in cluster depends strongly on cluster structure and mean morphological class of galaxies in cluster.

PISMIS: Have you looked into the distribution of the luminosity of galaxies from the centre outwards in the different clusters you have discussed? Are there clusters with more numerous membership, more centrally condensed as the ones with fewer members? The more massive galaxies being located at the central region.

PETROSIAN: Relations between absolute magnitude of Markarian galaxies, their positions in the clusters and the values of $(V_{Cl}-V_{Mrk})$ were considered. Significant correlations between these parameters were not found.

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