АСТРОФИЗИКА

ТОМ 38 НОЯБРЬ, 1995 ВЫПУСК 4

BARRED SPIRALS AND DWARF GALAXIES IN THE VIRGO CLUSTER

A.T.KALLOGHLIAN

Byurakan Astrophysical Observatory

Using the extensive Catalog of Binggelli, Sandage and Tammann it is shown that dwarf galaxies in the Virgo cluster are more tightly connected with barred rather than with normal spirals. The number of dwarfs is as higher as greater the number of barreds in the given field. There is no preferential direction in the distribution of dwarfs around barred galaxies.

1. *Introduction.* Dwarf galaxies have been identified in nearby clusters of galaxies as Virgo, Coma and Fornax. It has been shown that there is a close connection of dwarf galaxies with bright galaxies [1,2]. The distribution of dwarf elliptical galaxies of type dE is similar to that of giant E + S0 galaxies . The late type dwarfs show a broader distribution than the giant galaxies.

Giovanardi and Binggeli [3] concluded that more than 95% of all dwarf ellipticals in Virgo cluster must be freely flying around in the cluster potential. Outside the clusters dE galaxies seem all bounded to giant galaxies [4]. Caldwell [5] found that dwarfs in Fornax cluster are less concentrated than the bright galaxies. The ratio of dwarfs to the bright ellipticals is significantly smaller than the ratio found in the Virgo cluster. On the other hand the ratio of dwarf ellipticals to the active star forming galaxies of S and Irr types is similar to that of in Virgo. This result seems to be very important.

In Coma cluster [6] the ratio of numbers of dwarf and bright galaxies is not higher than in the Virgo cluster. It means that this ratio does not rise with the richness of the cluster.

The connection of dwarf galaxies with spiral galaxies has been usually considered together for both barred and normal spirals. However the existence of bright bars gives rise to several inherent features in barred spirals. In particulary the nuclei of barred spirals are more active than that of normal spirals; it is well known that hot spots much more oftenly occur in the nuclear parts of barred spirals; according to [7] the radio emission in barred spirals is essentially more oftenly localized to the centers than that of in normal spirals; as it was shown by Martin and Roy [8] the O/H gradient is flatter in barred rather than in normal spirals which is consistent with recent models of radial flow. It is remarkable that active spectra established by Kinney et al [9] on the base of IUE observations are more oftenly observed in barred spirals.

In 1970 I have shown [10] that dwarf galaxies in Virgo cluster are more tightly connected with barred rather than with normal spirals.But at that time a few dwarf galaxies were known in Virgo cluster.

In this report the problem of connection of dwarf galaxies with barred and normal spirals is considered by using the extensive catalog published by Binggeli, Sandage and Tammann (hereafter catalog BST) [11].

2. *Description of the sample.* The Catalog BST covers 140 sq.degrees in the region of the Virgo cluster and contains 2096 galaxies.Of these galaxies 1277 are certain members of the cluster, 574 objects are possible members and 245 - field galaxies. According to the authors of the Catalog BST, all galaxies with $B_T \leq 18$ have been identified in the survey area. This limiting magnitude corresponds to an absolute magnitude M_{BT}= -13.7 if we take for distance modulus a value m-M=31.7 adopted in the Catalog BST. The Catalog, however, cotains many other objects fainter than this limit till to B_T = 20.0 or to M_{BT}= -11.7. Here we consider only certain members of the Virgo cluster including as all dwarf galaxies fainter than B_T= 16.7 (M_{BT} > -15.0) as well as bright spiral galaxies of both types with B_T < 14.7 (M_{BT} < -17.0). We call the latter galaxies as bright galaxies and the former ones - dwarf galaxies. The number of dwarf galaxies in the Catalog BST is 748. Up to accepted limit in the Catalog BST exist 175 bright spiral galaxies of both types. Of this 52 are barred spirals while 123 - normal spirals, i.e. the barreds are 30% of all spirals in the sample.

Fig. 1 shows the distribution of morphological types of bright spiral galaxies.Two peaks in the distributions of both type of spirals, namely at S0, SB0 and Sc, SBc are strongly pronounced.

Dwarf galaxies were counted in two concentric circles of radii 200 kpc and 100 kpc around every bright spiral galaxy.The obtained results show the same tendency for both radii. In this report we use the data refering to the radius of 200 kpc.

3. *Results.*The comparison of the counted number of dwarfs with the expected value in the case of random distribution is complicated by the fact of overlappings of various fields. For this reason the total number of counted dwarfs is essentially larger than their real number in the Catalog BST. Instead of this we compared the mean number of dwarf galaxies in one field for barred and for normal spirals. Beside of this

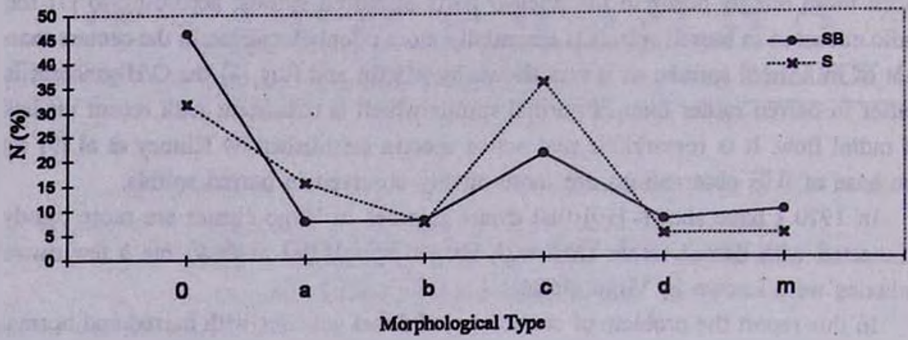

Fig. 1. Distribution of morphological types of bright spiral galaxies.

in the case of normal spirals we distinguish two kind of fields: one kind of fields contains at least one bright barred spiral, the others do not.The distribution of the fields according to this scheme is:

1) Number of fields with central SB-galaxies 52
2) Number of S-fields containing at least one SB-galaxy 60
(hereafter designated as S^{+SB})
3) Number of S-fields without any bright SB-galaxy 63
(hereafter desingnated as S^{-SB}).

Since the number of these three kind of fields is about the same we suggest that the overlapping factor for all of them is about the same. The results of counts of dwarf galaxies refering to one field with R=200 kpc for each of the three samples are presented in Fig. 2. The difference between SB, S^{+SB} fields on one side and S^{-SB} fields - on the other, is quite remarkable. Only at subtype "c" the results of SB and S^{-SB} fields are the same.In all other morphological types the curves for SB and S^{+SB} fields are significantly higher than for S^{-SB} fields.This means that dwarf galaxies appear more oftenly nearby barred spirals or in other words they are more tightly connected with barred galaxies.

Another result from the distributions given in Fig. 2 is that the mean number of dwarfs in one field decreases to the later types of bright central galaxies (from "0" to "d, m"). For "c" subtypes or later this number in the mean is about twice less than in the fields where the central galaxy is of "0" or "a" subtype.

Now we shall look if the number of dwarf galaxies depends on the number of bright SB-galaxies in the field. As well as according to Fig. 2 the SB and S^{+SB} fields show the same features concerning to the connection with dwarf galaxies, we consider

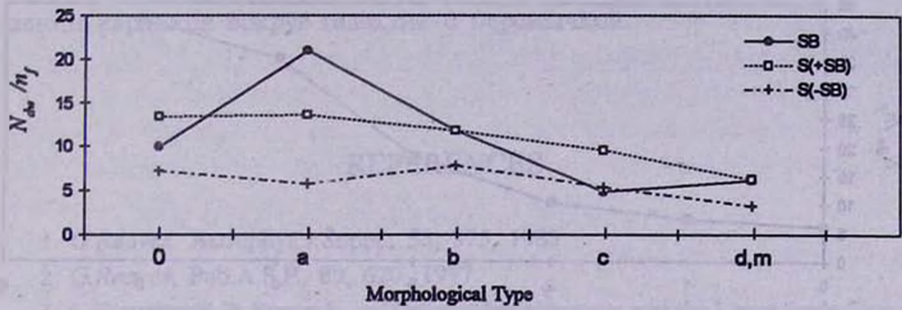

Fig. 2. The number of dwarfs in one field N_{dw}/n_f versus morphological type.Dots are for fields in the center of which are SB-galaxies, squares-for S^{+SB}-fields containing at least one SB-galaxy,crosses-for S^{-SB}-fields without any SB-galaxy.

both kind of fields together. The SB and S^{+SB} fields containing the same number of barred spirals have been combined and the mean number of dwarfs in corresponding fields has been calculated. The results are presented in Fig. 3. On absciss the so called "multiplicity" of barred galaxies in the field is given, on ordinates the number of dwarf galaxies refered to one field is shown. As it is seen the number N_{d}/n_f increases very steeply with increasing of the "multiplicity" of barred galaxies. It is remarkable that the lowest value of N_{d}/n_f is for fields without any SB-galaxy.

We considered also the distribution of dwarf galaxies around barred spirals with respect to the directions of bars. For this the position angles ϑ_p of the directions of bars of all bright SB-galaxies studied in this paper have been roughly estimated on the blue or red charts of Palomar Sky Survey. The dwarf galaxies were counted in slices of 30° wide. Every of four slices symmetricaly located with respect to the direction of the bar were binned together. As a result of these counts we have the following data:

ϑ_p	N_{dw}
0 - 30	143
30 - 60	155
60 - 90	131

We conclude from these results that no preferential direction exists in the distribution of dwarfs connected with barred spirals.

4. *Summary.* The main results of this investigation are:

1) Dwarf galaxies of all types with absolute magnitude M_{BT} >-15.0 more oftenly appear around bright barred spirals rather than around bright normal spirals.

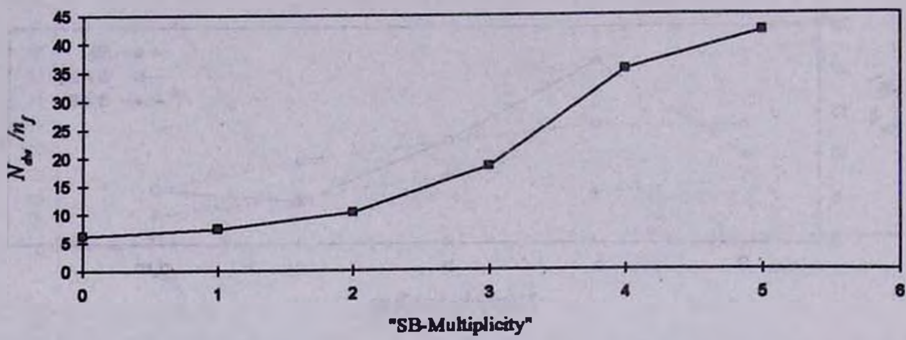

Fig. 3. The dependence of N_{dw}/n_f on the number of SB-galaxies in the field ("SB-multiplicity").

2) The number of dwarf galaxies increases rapidly with increasing of the number of bright barred spirals in the field.

3) The mean number of dwarf galaxies in one field decreases if the central bright spirals of both types are of later morphological types.

4) There is no excess in numbers of dwarf galaxies in the direction of bars.

The first two features apparently are caused by the existence of bar structure in the SB-galaxies. As it was suggested by Ambartsumian [12] the matter of bars may be ejected from the nuclea of galaxies during their activity. In frame of this suggestion it is possible to accept that at least a part of dwarf galaxies observed around SB-spirals,have been originated during nuclear activity of parent galaxies. The uniform distribution of dwarf galaxies around barred spirals does not contradict to this adoption.

ГАЛАКТИКИ С ПЕРЕМЫЧКОЙ И КАРЛИКОВЫЕ ГАЛАКТИКИ В СКОПЛЕНИИ VIRGO

А.Т.КАЛЛОГЛЯН

Используя обширный каталог Бингелли, Сандейджа и Таммана, показано, что карликовые галактики в скоплении Virgo более тесно связаны с галактиками с перемычкой, чем с нормальными спиралями. Число карликовых галактик увеличивается с числом галактик с пере-

мычкой в данной области. Нет примущественного направления в распределении карликов вокруг галактик с перемычкой.

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