SEGREGATION OF GALAXIES BELONGING TO DIFFERENT MORPHOLOGICAL TYPES INTO GROUPS

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Groups of galaxies are studied to identify galaxies of different morphological type in terms of their position relative to the centers of the groups and in terms of their peculiar radial velocities within the groups. The following results are obtained: (1) The mean distances of the galaxies relative to the centers of the groups gradually increase in the transition from the elliptical to the lenticular and spiral galaxies. However, galaxies classified in the subtypes of early or late elliptical are not distinguishable on the basis of this parameter. (b) The peculiar radial velocities of the elliptical, lenticular, and spiral galaxies in the groups are statistically indistinguishable. However, spiral galaxies falling in the early and late subtypes are distinguishable in terms of this parameter. The former subtype exhibit a lesser mean peculiar radial velocity than the latter subtype.

1. Introduction. In [1] the dependence of the relative number of galaxies of different morphological type on such global characteristics of the environment in the galaxies as the number of galaxies in the system, the mean pair distance between the galaxies, the mean spatial density of the luminous mass, and the dispersion of the radial velocities of the galaxies was studied. It was found that the frequency at which galaxies of different morphological types come into contact is a function of the number of galaxies in the system, though it is independent of the other environment characteristics we have noted.

It is important to understand whether galaxies of different morphological type differ in terms of their position relative to the centers of the groups and in terms of their peculiar radial velocities within the groups.

The dependence of the relative number of galaxies of different morphological type on distance to the center in clusters has been investigated in numerous studies (e.g., [2-5]). In these studies it was established that the relative number of spiral galaxies increases with distance from the centers of clusters. Some researchers have found an analogous segregation also within a family of spiral galaxies both in clusters as well as in groups of galaxies (e.g., [6, 7]).

In the present note we study groups of galaxies to identify a segregation of galaxies belonging to different morphological types in terms of their position relative to the centers of the groups and in terms of their peculiar radial velocities within the groups. For this purpose we will use a list of groups of galaxies that have been identified by means of a new physically well-founded technique [8-10] based on a selection from the CfA red shift survey [11].

As in a previous note [12], in which segregations of galaxies of different luminosities and different masses in terms of their positions and in terms of their peculiar radial velocities within the groups were studied, here we will investigate groups of galaxies with from six to 18 members that are at distances of from 3 to 80 Mpc from the Earth. In each of the groups we are interested in the following transformations of the physical parameters of the galaxies:

(a) The peculiar radial velocities within the group are broken down into a dispersion of the velocities of the galaxies. The new parameter δV thus obtained will have in all the groups a distribution with identical unit dispersion.

(b) The distances (more properly, their projections on the celestial sphere) of the galaxies to the geometric center (henceforth, simply the center) of the group are broken down into their mean values with respect to each group. The new parameter δRc thus obtained will have in all the groups a mean value of one.

After these transformations, all the groups are collected together into a single unified group in which each galaxy occurs with its own new parameters δV and δRc. To simplify the discussion, these dimensionless parameters will henceforth be referred to as before as velocities and distances.
TABLE 1. Mean Moduli of Peculiar Radial Velocities and Distances from the Center of the Groups of Galaxies

<table>
<thead>
<tr>
<th>$T$</th>
<th>$n$</th>
<th>$\delta V_m$</th>
<th>$s(V)$</th>
<th>$\delta R_m$</th>
<th>$s(R)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-7$</td>
<td>47</td>
<td>0.783</td>
<td>0.559</td>
<td>0.710</td>
<td>0.473</td>
</tr>
<tr>
<td>$-3$</td>
<td>77</td>
<td>0.718</td>
<td>0.527</td>
<td>0.880</td>
<td>0.485</td>
</tr>
<tr>
<td>0</td>
<td>58</td>
<td>0.658</td>
<td>0.520</td>
<td>1.104</td>
<td>0.645</td>
</tr>
<tr>
<td>3</td>
<td>84</td>
<td>0.892</td>
<td>0.507</td>
<td>1.090</td>
<td>0.600</td>
</tr>
<tr>
<td>$-7$</td>
<td>124</td>
<td>0.743</td>
<td>0.539</td>
<td>0.816</td>
<td>0.486</td>
</tr>
<tr>
<td>0</td>
<td>166</td>
<td>0.800</td>
<td>0.522</td>
<td>1.119</td>
<td>0.642</td>
</tr>
</tbody>
</table>

The morphological types of the galaxies were borrowed from the CfA catalogue [11] in which they were coded using the technique developed by de Vaucouleurs [13] with some additions:

$-6 < T < -4$ elliptical galaxies
$-3 < T < -1$ lenticular galaxies
$0 < T < 9$ spiral galaxies
$T = 10$ irregular galaxies
$T = -7$ unclassified elliptical galaxies
$T = 20$ unclassified spiral galaxies
$T = 15$ peculiar or unclassified galaxies

2. Results. In order to study segregations of morphological types, the entire set of galaxies of the unified group were broken down into four parts defined by the following inequalities: $-7 \leq T \leq -4$ (elliptical galaxies); $-3 \leq T \leq -1$ (lenticular galaxies); $0 \leq T \leq 2$ (early spiral galaxies); and $3 \leq T \leq 10$ (late spiral galaxies plus the irregular galaxies). For these sets we found the mean value of the moduli of the peculiar radial velocities $\delta V_m$ and the mean value of the distances from the center of the group $\delta R_m$.

We also compared the sets with the two cases $T < 0$ and $T \geq 0$.

Table 1 presents the following quantities: the number of galaxies $n$, the mean values of the moduli of the peculiar radial velocities of the galaxies $\delta V_m$, their mean-square deviations $s(V)$, the mean distances (in projections on the celestial sphere) of the galaxies relative to the center of the group $\delta R_m$ and their mean-square deviations $s(R)$.

From Table 1 it is clear that, on average, the spiral galaxies have the same peculiar radial velocities as the lenticular and elliptical galaxies. However, it is important to note that at the significance level $\alpha < 0.01$ (the two means are compared in the terms of the Student t criterion), the mean peculiar radial velocities differ between the early and late (plus irregular) subtypes of the spiral galaxies.

It is also clear that the mean distances of the galaxies relative to the center of the groups increase in the transition from the elliptical to the spiral galaxies, which is in agreement with observations of large clusters. The mean distances for the spiral galaxies ($T$ in the range 0 to 10, 20) and the elliptical plus the lenticular galanes ($T$ in the range $-7$ to $-1$) differ at the significance level $\alpha < 0.001$. The mean distances of the lenticular and the spiral galaxies ($\alpha < 0.01$) as well as of the elliptical and lenticular galaxies ($\alpha < 0.06$) are also remarkable, whereas the two subtypes of spiral galaxies are at roughly the same mean distances from the center of the group. Note that the latter result is in contradiction with the the result of [7] according to which the early subtypes of the spiral galaxies are, on average, closer to the center than are the late subtypes. It is also interesting that, according to [14], there are virtually no segregations by morphological galaxy type in the groups.

3. Conclusion. Our investigation of a segregation of galaxies of different morphological types in terms of their position and peculiar radial velocities in the groups taken from the list published in [10] leads to the following conclusions:

(a) Elliptical galaxies are, on average, closer to the center of the group, while the spiral galaxies, are further. The lenticular galaxies occupy an intermediate position. The early and late subtypes of the spiral galaxies are found at roughly identical distances relative to the centers of the groups.