

**LOW LEVELS OF LUMINOSITY SEGREGATION IN CLUSTERS OF GALAXIES:  
EVIDENCE FOR THEIR DYNAMICAL YOUTH?**

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**RESUMO.** Apresentamos resultados preliminares de um estudo da distribuição projetada de galáxias em uma amostra homogênea de 14 aglomerados ricos com fotometria feita por Colless (1989). Encontramos que mais da metade destes aglomerados estão segregados em luminosidade, ainda que com baixa significância. Comparamos estes resultados com aqueles provenientes de amostras da distribuição das galáxias em grandes escalas e sugerimos que estes aglomerados são dinamicamente jovens.

**ABSTRACT.** We present preliminary results of a study on the projected galaxy distribution of a homogeneous sample of 14 rich clusters for which the photometry was given by Colless (1989). We find that more than a half of these clusters are luminosity segregated at low levels. We compare our results with those coming from large scale samples to suggest that these clusters are dynamically young.

*Key words:* CLUSTERS-GALAXIES

**. INTRODUCTION**

The possibility of occurrence of luminosity segregation in rich clusters of galaxies has been associated to either, or both, of two processes: i) it may be originated at very initial epoch of cluster formation, as predicted by some biased galaxy formation scenarios in which the more luminous galaxies collapse and start their clustering evolution earlier than the fainter ones (Dekel and Silk, 1986); ii) it also may be due to the dynamical friction of the cluster dark matter substructure acting on the more massive (and therefore luminous) galaxies, causing them to spiral towards the cluster center (Lecar, 1975), therefore enhancing their central concentration. In this case the phenomena of luminosity segregation in clusters would much more reflect their dynamical aging rather than the initial conditions at formation. Clearly both processes should be playing a role in real clusters, with the dynamical friction acting towards the enhancement of a primordial luminosity segregation or even leading to the formation of central giant dominant galaxies.

It is therefore important to try to assess the relative importance of these two processes in the observed clusters. One possibility consists of estimating the level of the luminosity segregation displayed by a representative sample of rich clusters of galaxies and then compare it with similar results coming from the analysis of representative samples of the spatial distribution of galaxies at scales larger than cluster scales which we may suppose have suffered little dynamical evolution leading to luminosity segregation.

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## II. MEASURING THE LUMINOSITY SEGREGATION

In this work we have analysed the homogeneous sample of 14 southern clusters of galaxies given by Colless (1989) (see table 1). For each cluster the galaxies were grouped in 1 Mag bins, according to their  $B_J$  magnitudes and the clustering level in each bin was estimated using three distinct non-parametric estimators: (a) the arithmetic ( $\lambda_1$ ) and (b) the harmonic ( $\lambda_{-1}$ ) means of the projected separations of pairs of galaxies, as defined by Capelato et al. (1980) in their study of the luminosity segregation in the Coma cluster; (c) The mean ( $\langle\sigma\rangle$ ) of the local surface density of galaxies in each magnitude bin computed according to the prescription of Casertano and Hut (1985) using the distance to the 6th neighbour. These mean densities were normalised to the mean density of the cluster inside a  $1h_{100}$  Mpc circular region centered at the cluster center.

Table 1. The Cluster Sample

Cluster <sup>1</sup>	Type <sup>2</sup>	Redshift	$\sigma_v$ (km/s)
C02 A2717	I-II	0.04925	547
C03 A2721	II	0.11598	1011
C19 A3126	III	0.08588	1030
C20 DC0329-52	III	0.05938	854
C21 A458	I	0.10560	631
AC1 A3225	II-III	0.05489	1072
C30 A3334	I-II	0.09655	615
C31 A3360	III	0.08450	769
C37 A3705	III	0.08967	927
C39 A3716	III	0.04818	453
C52 A3854	II	0.14922	1180
C64 A2538	II-III	0.08291	821
C65 A2554	I-II	0.11094	797
C67 S1157	I-II	0.05846	726

- (1) Colless (1989) catalogue identification and other designations  
 (2) Bautz-Morgan type (from Colless 1989)

In order to avoid problems with the possible presence of sub-structures inside the clusters, we have restricted our analysis to galaxies within  $1h_{100}$  Mpc from the center of the clusters, which was calculated by simply averaging over the galaxy positions. Because of the small total number, galaxies brighter than  $M_B = -20$  were all grouped in the same magnitude bin. This magnitude is close to the value of the characteristic  $M_B^*$  of the Schechter luminosity function found by Colless (1989) for these clusters.

We found that 8 out of the 14 clusters do exhibit some degree of luminosity segregation: C02, AC1, C30, C31, C37, C52, C64, C65. However, the measured luminosity segregation level is weak, that is, with low statistical significance. In figure 1 we present the median profiles of our three measurements for these 8 clusters. This figure shows that the galaxies brighter than  $M_B^*$  are essentially the ones that appear to be segregated.

## III. DISCUSSION AND CONCLUSIONS

Our analysis of the projected galaxy distribution suggests that more than half of the clusters of Colless's sample show some level of luminosity segregation, although with low statistical significance for the majority of these clusters. These results are consistent with previous analyses (e.g., Quintana 1979, Capelato et al 1980) which have also found some level of luminosity segregation in some clusters.

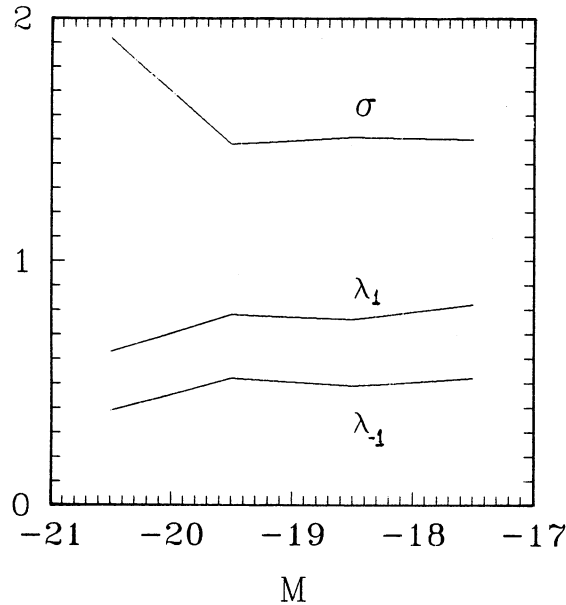


Fig. 1. Median profiles of luminosity segregation measures for 8 clusters

What is, on theoretical grounds, the expected level of luminosity segregation due to the dynamical processes (e.g. dynamical friction and two-body relaxation) occurring inside a rich cluster? The answer to this question depends essentially on the relative contribution to the cluster total mass of galaxies and dark matter. From one side, the analysis of White (1977) shows that if all the cluster mass, as estimated by the virial theorem, is attached to galaxies, one should observe a strong luminosity segregation. The simulations of Farouki and Salpeter (1982) and Farouki, Hoffman and Salpeter (1983, FHS) confirm this point. In fact, in these simulations, a strong mass segregation is established soon after the cluster collapse. On the other side, if the cluster mass is dominated by dark matter, the characteristic time scale for orbital decay of a  $m^*$  galaxy due to dynamical friction (Spitzer 1962) is close to or less than the Hubble time and thus only a mild segregation is expected, more in agreement with the results presented here.

From another side, we should also ask how much of the observed luminosity segregation may be attributed to the initial conditions prevailing at cluster formation epoch. A study of the two-point correlation function of galaxies in "fair samples of the Universe" shows in fact that there is an increase of the correlation length with the luminosity of galaxies, at least up to scales of  $5-10h_{100}$  Mpc (Davis et al. 1988, Boerner et al. 1989). Although part of this effect may be assigned to dynamically evolved structures with typical scales less than, say  $2h_{100}$  Mpc, for the larger scales it seems difficult to see how stellar dynamical processes could have erased the initial conditions of the distribution of galaxies. A direct comparison with our results can be made possible through the mean local surface density of galaxies. We find that for the 8 luminosity segregated clusters the median value of  $\lambda_1$  increases about 35% when going from the fainter than  $B_j = -20$  galaxies to the brighter ones (cf. Figure 1). Exactly the same amount of increase was found by Davis et al. (1989) for the mean of the normalized number of galaxy neighbors within a  $6h_{100}$  Mpc sphere (note that the rich magnitudes used by these authors almost coincide with those of Colless). Although the numerical coincidence should be regarded as fortuitous, it suggests that the level of the luminosity segregation measured in those clusters just reflects the initial conditions of cluster formation. We are led to conclude that as far as our cluster sample may be considered representative (an open question), the nearby rich clusters of galaxies do not seem to have suffered, in average, much dynamical evolution since their collapse and virialization. However, in view of all the uncertainties of this kind of analysis, this conclusion must be regarded with caution, waiting a more extensive study to be done.

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