LUMINOSITY SEGREGATION IN DISTANT GALAXY CLUSTERS

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ABSTRACT : Angular separation-magnitude plots drawn from deep photometry of galaxies in distant clusters show evidence for luminosity segregation which cannot be accounted for by field contamination. This segregation, interpreted in terms of dynamical friction, allows one to determine $(M/L)_g$, the mass-to-light ratio of galaxies from their velocity dispersion. In A370 (z=0.37) more than 30 velocities have been measured by multi-aperture spectroscopy, leading to $(M/L)_g \backsim 70$. Values greater than 100 are found in 5 other distant clusters by deriving the velocity dispersion from the richness. The luminosity segregation, observed even inside each of the clumps of 3C299, could result either from dynamical friction inside the clumps or from some early environmental influence .

A few years ago, we started a program of deep photometry and multi-aperture spectroscopy of distant clusters involving many collaborators : A. Bijaoui (Nice), B. Fort and J.P. Picat (Toulouse), D. Gerbal (Meudon), R. Pello and E. Salvador-Solé (Barcelona). For the clusters A992, 1305+2952, 3C299 and 0016+16 electronographic BV photometry was first obtained at Canada-France-Hawaii 3.60 m Telescope prime focus and then VRI CCD photometry was made at the focal reducer of the Pic du Midi 2m Telescope (Le fèvre et al. 1986 a,b). For A370, CCD BVR photometry and then multi-aperture spectroscopy with the PUMA system was made at the CFHT Cassegrain focal reducer (Soucail et al. 1986). We would like here to focus on the somewhat surprising **luminosity segregation** found in each of these distant clusters (z=0.25 to 0.55) and on its implications on cluster dynamics.

Observational evidences for luminosity segregation, obtained in nearby clusters by various technics, were first very controversial. In distant clusters, we used the method of Capelato et al. (1980) of comparing the mean angular separations $\langle R_{ij} \rangle$, a characteristic of the point distribution in various magnitude bins. This method does not need any hypothesis on the cluster symmetry, but the price to pay is a major difficulty encountered in the field correction.

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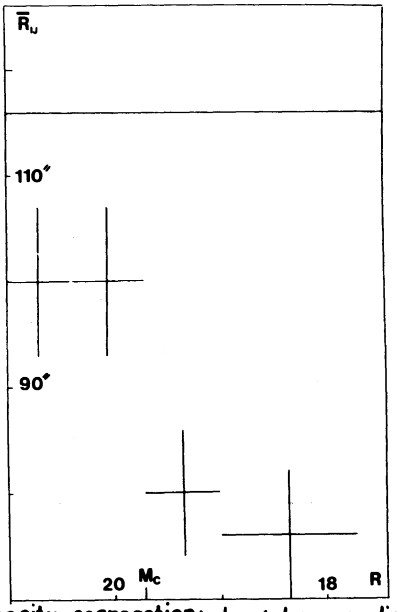
In all distant clusters for which we obtained photometric data, the brighter the galaxies, the smaller are their $\langle R_{ij} \rangle$ hence the more concentrated their distribution (Fig. 1). Verified for the brightest galaxies only, such a property indicates some luminosity segregation above a critical luminosity L_c. This result, obtained as well in the photographic data of Mathieu and Spinrad for 3C295 as in the electronographic and CCD data on 5 distant clusters, is independent of the telescope and of the receptor.

Fig. 1



luminosity segregation: galaxy/galaxy mean distance in bins by R mag. The more luminous are the galaxies the more concentrated is their distribution. The horizontal line corresponds to an uniform distribution.

Similar results were (at least partially) attributed to contamination in nearby clusters. Since the mean angular separation is greater between field galaxies than between cluster galaxies, field contamination, supposed to increase with increasing magnitude, will mimic luminosity segregation. This is in general the case in nearby clusters, but not in distant ones. Two other arguments are in order : i) the luminosity segregation found in the Coma cluster from photometric data only is still observed among galaxies with Coma redshift (Mellier et al. 1986) and ii) the luminosity segregation found in the distant cluster A370 (Mellier et al. in preparation) from the photographic data of Butcher, Oemler and Wells (1983) vanishes in a composite frame consisting of data on the cluster plus its comparison field.

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To look for dynamical implications, consider T_{df}, the characteristic time for dynamical friction (Chandrasekhar 1943), inversely proportional to the mass density ρ and to the particle mass m. It is then natural to interpret our finding of a critical luminosity L_c by assuming that the cluster age T(z) is around the time necessary to achieve dynamical friction for particles of mass M_c (corresponding to the luminosity L_c), which writes :

$$T(z) \ \alpha \ \frac{v^3}{\rho \ M_c} \ \alpha \ \frac{v^3}{(M/L)_g^2 \ \rho_L \ L_c} \quad (1)$$

denoting by v the velocity dispersion, $(M/L)_g$ the mean galactic mass-to-light ratio and ρ_L the luminosity density. Once a T(z) relation is determined from the choice of a cosmological model, eq. (1) expresses $(M/L)_g$ in terms of the observable quantities v, L_c and z.

Let us illustrate the method on **the distant cluster** A370 (z=0.374) by using our photometric and **spectroscopic data**, namely the total luminosity $L_V = 1.7 \ 10^{13} \ h_{50}^{-2} \ L_0$, **the virial radius** $r_{vir} = 0.5 \ h_{50}^{-1}$ Mpc and the velocity dispersion v = **1380 km/s**. It leads to a **cluster** mass-to-light ratio of 120 h_{50} solar units (without evolution correction to the luminosity). The plot in Fig. 1 gives $L_c = 4 \ 10^9 \ h_{50}^{-2} \ L_0$ then a **galactic** $(M/L)_g = 70 \ h_{50}$, about half the cluster M/L, which seems to indicate that **half of the dark matter lies outside galaxies**. However,the things are less simple. For the other distant clusters, the photometric data, combined with a value of the velocity dispersion guessed from the richness $N_{0.5}$, lead to unacceptably high values $(M/L)_g$>100 (Le fèvre et al. 1986c). The segregation observed inside the clumps of the cluster 3C299 rather indicates that either the dynamical friction occurs within the clumps before their merging or that the luminosity segregation results from some environmental influence undergone at galaxy formation.

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