LUMINOSITY SEGREGATION

IN GALAXY CLUSTERS

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as an indication of

DYNAMICAL EVOLUTION

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Theoretical models describing the dynamical evolution of self–gravitating systems predict a spatial mass segregation for more evolved systems, with the more massive objects concentrated toward the centre of the configuration. From the observational point of view, however, the existence of mass segregation in galaxy clusters seems to be a matter of controversy.

A special problem in this connection is the formation of cD galaxies in the centres of galaxy clusters. The most promising scenarios of their formation are galaxy cannibalism (merger scenario) (Hausmann and Ostriker 1978, Ostriker and Tremaine 1975, White 1976) and growing by cooling flows (Mushotsky et al. 1981, Silk 1976).

It seems to be plausible to consider the swallowing of smaller systems by a dominant galaxy as an important process in the evolution of a cD galaxy. The stage of the evolution of the dominant galaxy should be reflected by the surrounding galaxy population, especially by possible mass segregation effects.

Assuming that mass segregation is tantamount to luminosity segregation we analyzed luminosity segregation in roughly 40 cD galaxy clusters. Obviously there are three different groups of clusters: (i) clusters with luminosity segregation, (ii) clusters without luminosity segregation, and (iii) such objects exhibiting a phenomenon which we call antisegregation in luminosity, i.e. a deficiency of bright galaxies in the central regions of clusters. This result is interpreted in the sense of different degrees of mass segregation and as an indication for different evolution stages of these clusters. The clusters are arranged in the three segregation classes 2, 1, and 0 (S2 = strong mass segregation, S1 = moderate mass segregation, S0 = weak or absent mass segregation).

We assume that a galaxy cluster starts its dynamical evolution after virialization without any radial mass segregation. Energy exchange during encounters of cluster members as well as merger processes between cluster galaxies lead to an increasing radial mass segregation in the cluster (S1). If a certain degree of segregation (S2) has been established, an essential number of slow–moving and relative massive cluster members in the centre will be cannibalized by the initial brightest cluster galaxy. This process should lead to the growing of the predominate galaxy, which is accompanied by a diminution of the mass segregation (transition to S1 and S0, respectively) in the neighbourhood of the central very massive galaxy. An increase of the areal density of brighter galaxies towards the outer cluster regions (antisegregation of luminosity), i.e. an extreme low degree of mass segregation was estimated for a substantial percentage of cD clusters. This result favours the cannibalism scenario for the formation of cD galaxies.

Obviously, some relations between the estimated segregation classes and the properties of the dominant galaxies seem to exist which may express the connection between evolving cD galaxies and their environment. Malumuth (1992) discussed the question if cD galaxies with large peculiar velocities can be formed by mergers in a virialized cluster. He compiled peculiar velocities of cD galaxies. There are galaxy clusters with large peculiar cD velocities (more than 100 km/s) in our sample (A 1146, A 1795, A 2029, A 2634, and A 2670). According to the calculations of

Malumuth the growing of the cD galaxies in these clusters by merging should have been occured not long ago. Four of them (A 1795, A 2029, A 2634, and A 2670) show low or absent central mass segregation, i.e. a hint at a diminution of the number of bright galaxies in the central cluster region, which can be explained by merging and a preceding stripping of the cluster galaxies. On the other side strong mass segregation is observed for the clusters A 779 and A 2199 with peculiar velocities of 20 km/s and 57 km/s, respectively. We may conclude that these both clusters are in an early stage of evolution without any perceptible cannibalism.

The cD galaxies of the clusters A 85, A 426, A 1060, A 1795, A 1991, A 2029, and A 2052 – which have a large peculiar velocity and/or show a relative strong cannibalism effect (segregation classes 1 and 0) – have relative blue central colours in comparison with their envelopes from radial u–b profiles (McNamara and O'Connel 1991).

On the other hand the cD galaxies in A 496, A 779, and A 2199 in segregation class 2 with low peculiar velocities show opposite radial u–b colour gradients, i.e. with slightly red centres and blue envelopes or at least "neutral" radial colour distributions without any pronounced gradient. We consider objects in class 2 as in a very early evolutionary stage before any stripping and cannibalism. Abell 1413 with weak mass segregation and a colour gradient from a red centre to blue outer regions – but with a pronounced red envelope – seems to be in a medium evolutionary stage before the onset of cannibalism and later than A 496, A 779, and A 2199.

We looked for any correlation between mass segregation and the envelope luminosity of dominant cluster galaxies using the envelope luminosities given by Schombert (1988).

Three of the objects in segregation class 2 (A 779 and A 400, and A 2199) show low envelope luminosities. Three further clusters (A 426, A 2634, and A 1904) in segregation class 1 show moderate luminosity of the cD envelope. There is a colour profile only for the cD galaxy of A 426 with a distinct blue central u–b excess. This excess as well as its strong radio emission favour activity due to the onset of cannibalism. We assume that the cannibalism process in this early phase did not have enough time in order to build up a pronounced envelope already.

On the opposite the clusters with high envelope luminosities (A 1795, A 2670, A 2029, and A 1413) belong to groups 1 and 0 (moderate and high cannibalism properties). Therefore, we conclude that there seems to be a correlation between envelope luminosity and cannibalism properties.

If these relations will be confirmed they may contribute to understand the late stages of evolution of clusters and the cD galaxies therein.

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