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MORPHOLOGICAL SEGREGATION OF GALAXIES IN NEARBY CLUSTERS

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Abstract – Quantitative morphological classification by analysis of CCD images is required if one wants to study the morphological segregation of galaxies in nearby clusters. We present our strategy and the first results of such a program.

key-words – galaxies – clusters – morphological segregation

1. GENERAL CONTEXT

The idea that there is a morphological segregation of galaxies in clusters seems to be well established: the inner regions of clusters are rich in elliptical and lenticular galaxies, whereàs the field and the outer regions of clusters are rich in spirals. Moreover, the morphological composition changes with cluster age (Butcher-Oemler effect).

These results rely on a *subjective* classification of galaxies by *visual inspection* of *large field* plates. Moreover, the samples studied are often *incomplete.* Finally, and paradoxically, the astronomical community has more detailed images for galaxies in distant clusters than in nearby ones, since distant clusters have been imaged with the Space Telescope and nearby ones with plates; the gain in resolution of the Space Telescope with respect to plates exceeds the effect of the larger distance of distant clusters. For all these reasons, the morphological composition and segregation found in the literature for nearby clusters cannot be representative of the real one and it is not comparable to the one found in distant clusters.

2. STRATEGY OF OUR WORK

We thus decided to take a different observation strategy and we began to observe and to classify galaxies in nearby cluster avoiding the above problems. We focus on the clusters Perseus, Coma, Abell 194 and Abell 754.

First of all we study only *volume and magnitude complete* samples of galaxies, thus avoiding all problems tied to selection biases. Also, all galaxies have to be observed in good enough conditions to detect possible faint spiral arms, disks or bars or other morphological details necessary for a *correct* classification. We make use of plates to classify galaxies whose morphological type is obvious (galaxies with large spiral arms or bars and irregular galaxies), and we collect CCD data for all the other galaxies in good seeing conditions, typically 1.0 arcsec. This allows a direct comparison of our data and Space Telescope ones since the rest-frame resolution of the observed galaxies is now the same (the better angular resolution of the Space Telescope is now counterbalanced by the larger distance of the distant clusters). Moreover, we do not use subjective methods to classify the galaxies but *quantitative* ones [6] based on the analysis of isophote shapes and surface brightness profiles. All personal classification biases are thus avoided. Finally, the significance of the observed segregation in *each* cluster is assessed *statistically* by Monte-Carlo simulations. In each cluster we determine the *fundamental* segregation and not only the presence of a density or cluster-centric segregation, as in previous works.

3. RESULTS

3.1 Results for the inner region of the Perseus cluster

We only sketch here the main interesting results found for this cluster (for details, see [2]). First of all, the inner region of Perseus is *rich* in spirals. Independent evidence shows that (most) nearby clusters are rich in spirals [1], making their morphological composition similar to the one of distant ($z \sim 0.4$) clusters. Moreover, the spatial distribution of Hubble types in the inner region is *not homogeneous* and different from the one expected for a relaxed cluster. Therefore the cluster is not relaxed. Rosat X-ray observations [8] confirm the young dynamical age of this cluster. We note that the Perseus cluster has been considered up to now as the prototype of the evolved clusters [5, 7]. Finally, the morphology-density and the morphology-radius relations are not the *fundamental* ones. A detailed analysis of the method used in the literature to compute these two relations shows that our conclusion could also be true for most nearby clusters. This means that, for Perseus, and perhaps for most other nearby clusters, the distance from the cluster center and the galaxy density have not (yet) played a fundamental role in determining the galaxy morphology, as previously considered.

3.2 Other clusters or cluster regions

The morphological composition of the central region of Coma does not differ

from the one of a small region in the outskirts of the cluster, the two regions being rich in elliptical and lenticular galaxies. Whereas a low spiral fraction is expected for the central region, such a low value (10 %) is totally unexpected for the peripheral region at ~ 4.5 Mpc ($H_0 = 75$ km s^{-1} Mpc^{-1}) from the cluster center. To confirm such a result, we are now studying another (randomly chosen) region in the outskirts of the cluster.

We are also studying the outer region of the Perseus cluster out to 4 Mpc from the cluster center (to better sample regions of low galaxies density) and the clusters Abell 194 and Abell 754. These latter two clusters are cannibalizing groups of galaxies, along and orthogonally, respectively, to the line of sight [3]. By comparing the morphological segregation of these clusters to the one in relaxed clusters, we will understand the effects of the cluster formation on the morphological segregation and composition of galaxies.

4. CONCLUSION

Little effort has been done by the scientific community to plan *good* observations of nearby clusters in recent years. We are trying to fill this gap. Our unexpected results show that *clusters of galaxies are not as well understood from the observational point of view as previously estimated* and that previous studies rely on an uncertain observational basis.

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