THE ELLIPTICITIES OF GALAXIES IN GALAXY CLUSTERS OF DIFFERENT MORPHOLOGICAL TYPE

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ABSTRACT. The distribution of galaxy ellipticities was analyzed for 207 rich PF galaxy clusters found in the Münster Red Sky Survey Galaxy Catalogue. Clusters with BM types from a comparison with the ACO catalogue were also classified on the new scheme. The new morphological types take into consideration concentration towards the cluster center, indications of a preferential direction or plane, and the role of the brightest cluster galaxies. Differences in the distribution of galaxy ellipticities for individual clusters are statistically significant, in contrast to the average distribution of ellipticities for galaxies belonging to clusters of different morphological type. Two types of galaxy ellipticity distribution were found: single-mode and bimodal. The distributions apparently reflect different contributions from spiral and elliptical galaxies. The shapes of galaxies in individual clusters appear to relate to local conditions.

Key words: Galaxies: clusters: morphological types, galaxies: ellipticities.

1. Introduction

Rich clusters of galaxies are the most massive virialized systems known, and provide a powerful tool for the study of galaxy formation. The morphology of clusters has been studied mainly relative to bright member galaxies, with the main classification schemes by Bautz & Morgan (1970, BM) and Rood & Sastry (1971, RS) describing the relative contrast between the brightest galaxy and other galaxies in the cluster, or to the geometrical distribution of the ten brightest members, respectively. Both schemes complement each other.

From studies of 122 rich Abell clusters, van Kampen & Rhee (1990) found an alignment of cD-galaxies with their surroundings, while López-Cruz & Gaztañaga (2001) showed that cD clusters and non-cD clusters are different dynamically. Sandage & Hardy (1973) found that BM types and the absolute magnitudes of Brightest Cluster Members (BCM) are independent of cluster richness; they therefore concluded that BM types were defined by initial conditions at the onset of cluster formation rather than by later evolution. Panko et al. (2009) analyzed the relative orientations of BCM and their parent clusters for 1056 PF clusters and found statistically significant alignments in BM I clusters. Godłowski et al. (2010), using data for 97 PF galaxy clusters, also found a weak dependence of galaxy velocity dispersion with BM type for the parent cluster.

In a survey paper, Bahcall (1996) collected common properties for clusters and superclusters of galaxies. In particular, she noted the difference between the typical galactic content of clusters and the different morphological types. In regular clusters (BM types I, I-II, and II) the galactic content E:S0:Sp is 3:4:2, for intermediate clusters (BM II and II–III) the E:S0:Sp content is 2:5:3, and for open clusters (BM II–III, III) the E:S0:Sp content is 1:2:3. The distribution of galaxy ellipticities was examined by us, since it can be an indicator of the galactic content in rich clusters.

2. Observational Basis

The Münster Red Sky Survey Galaxy Catalogue (Ungrue et al. 2003, hereafter MRSS) is a large scale galaxy catalogue in the red spectral region that covers an area of 5000 square degrees to a limit of $\sim 18^{\mathrm{m}}.3$. Various parameters were determined for each galaxy image, including ellipticity. The morphological types and redshifts of the galaxies were not established.

The Catalogue of Galaxy Clusters and Groups (Panko & Flin 2006, hereafter PF) was constructed from MRSS galaxies. By comparison with the ACO catalogue (Abell, Corwin & Olowin 1989) a list was created of PF clusters of different richness that have ACO analogues, and accordingly BM types. Only 247 rich PF clusters with $N_{\mathrm{g}} \geq 100$ were in the list. Panko (2013) proposed an integrated morphological scheme to study PF galaxy clusters. The primary designations are based on numerical criteria and take

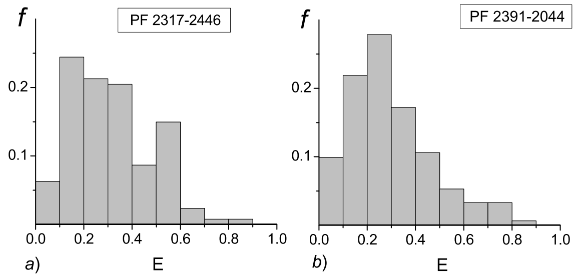

Figure 1: Bimodal and single-mode distribution of galaxy ellipticities in PF clusters of intermediate type.

into consideration the parameters: concentration to the cluster center (C = compact, I = intermediate, and O = open), the presence of a preferential direction or plane, hereafter flatness (L = line, F = flat, and no sign of flatness = without symbol), and the role of Bright Galaxies (cD and BG). Peculiarities are noted as P. Combined morphological types, such as CF, OFcD, IF, OF, etc., also exist. Such types were determined for 247 PF clusters by this scheme.

3. The Distribution of Galaxy Ellipticities

The distribution of galaxy image ellipticities was analyzed for individual rich PF clusters according to their morphology, excluding from the data set 40 clusters with peculiarities. An additional 207 clusters were divided into subsets containing both C, I, and O clusters of L and F type, with pure and combination types possible, such as CcD, OFBG, etc. An additional division into subsets according to BM type was also studied.

All subsets contain two kinds of ellipticity distributions: bimodal (Fig. 1a) and single-mode (Fig. 1b). Maximum frequency in single-mode clusters corresponds to bin 0.2–0.3. For bimodal clusters the main peak occurs in bin 0.1–0.2, with a secondary maximum in bins 0.4–0.6. The difference between distributions is statistically significant. The first case appears to occur in E-rich clusters, and the second in S-rich clusters. The same ellipticity distributions based on Galaxy Zoo classifications of galaxies were found by Hoyle et al. (2012); they note the difference between bulge-dominated and disk-dominated clusters. Fasano et al. (2000) found the trends in S0:E and S0:S indicated a morphological evolution; as redshift decreases, the S0 (lenticular) population tends to grow at the expense of regular spiral galaxies.

Weak signs of bimodality in the mean distributions are noted in O and IL types (Figs. 2a, 2b), but the global average distributions for all morphological types are identical (Fig. 2d). It seems that the E:S ratio in rich PF clusters does not depend on cluster morphology.

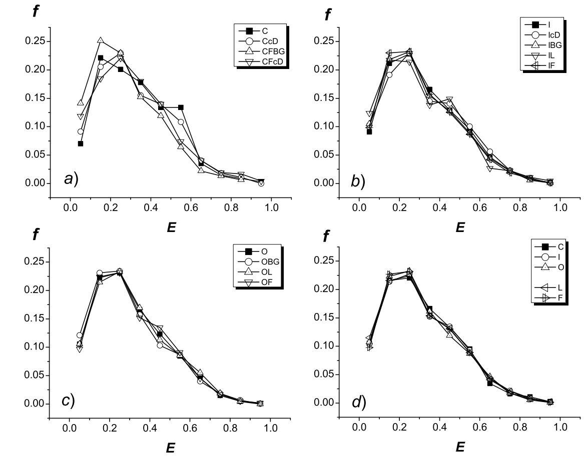

Figure 2: Median distributions of galaxy ellipticities in C, I, and O clusters of L and F type.

4. Conclusions

Two statistically significant types of distributions were found from analyses of galaxy ellipticities in rich galaxy clusters of different morphological type: single-mode and bimodal. The first type is present in E-rich clusters, while the second is found in S-rich clusters. Both distributions are present in all morphological types. The shapes of galaxies in individual clusters therefore appear to relate to local conditions.

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