SUBCLUSTERING IN CLUSTERS

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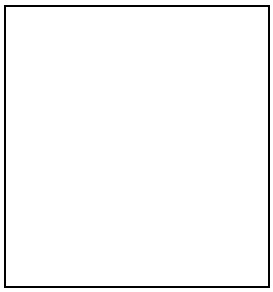

We investigated three rich clusters: Abell A14, A754 and A3667 on the base the Edinburgh Catalogue of clusters of galaxies. The aim of our investigation was to check up the existence of substructures in clusters. We compared old method used up to now with the result obtain from analysing alignments of galaxies. In our investigation of galaxy alignments we used two methods: classical method based on analysing the observed distribution of the position angles of galaxies and improved method based on analising normal to galaxy planes which takes into account both galaxy position angles and inclinations. We found rather good evidence for alignment and some evidence for subclustering within clusters. Separately we check our method on the "empty cluster" of galaxies in field and found no alignment in this cases.

1 Introduction

We analysed sample of galaxies in a region with three rich cluster of galaxies, namely A3667, A754 and Abell A14 on the base of the Edinburgh Catalogue of the cluster. At first we prerformed a general inspection of the cluster taking into account various proofs for subclustering. Afterwards we analyses the distribution the angular momenta of galaxies. The aim of our investigation was to use the method of analysing alignments of galaxies in connection with the existence of substructures in clusters. In our investigation of galaxy alignments we used two methods based on analising the observed distribution of position angles of galaxies and an improved method which takes into account both galaxy position angles and inclinations, respectively. We found some evidence for alignment and some evidence for subclustering within those clusters. For comparison we analyzed a nearby to A3667 "empty cluster" where we did not found any evidence for clustering.

2 Observational data and general description of the cluster

We analysed sample of galaxies in the field of three rich clusters. The data was taken from the COSMOS/UKTS Southern Sky Objects Catalogue (Yentis et al. 1991). We presented general view of the clusters on the Figures 1, 2 and 3. First, we divided the whole cluster area into different parts according to some assumed subclusters. In our dividing we also took into account results of the previous works based both on result going from galaxy distribution and from X-ray radiation. We obtained a division of the clusters into particular subclusters from analysis of the density profiles using Voronoi-tessellation method. Afterwards, from the known distribution of the galaxies we could find the position angles of cluster and subclusters using orthogonal regression method.

From our investigation we found that the Cluster Abell 754 (927 galaxies, Fig. 1.) are subsequently split into two main different parts. We founded that the position angle for the whole structure and most prominent substructure is roughly $\Theta \sim 117^{o}$ while the position angle for the second structure is $\Theta \sim 158^{o}$. Cluster Abell 14 (974 galaxies, Fig. 2.) could be divided into two main areas — inter and outer region. In all three cases (the whole cluster and both substructures) we obtained that position angles are very near to 170^{o}. For Cluster A3667 (447 galaxies, Fig. 3.) we try to divide the whole cluster for more prominent (and we divided it for two) subclusters. However, the visible structure of the cluster suggests that it is in fact a compact cluster with a large number of small subclusters. We could find the position angles of cluster and subclusters. In the cases of the whole cluster we obtained that position angles are very near to 150° while the position angles of the substructures are near to 170^{o}. However, because of complex structure of the cluster the detailed analysis of subclusters and its position angles requires further detailed studies.

3 Testing the galactic orientations in clusters

Secondly, we analyzed the distribution of the position angle of galaxies. From the cluster Abell 754 we selected 491 galaxies with the axial ratio less then 0.75. We found a very strong alignment of position angles in the whole cluster and within the subclusters. The preferred position angles of galaxies are perpendicular to the position angle of the cluster. This suggests that galaxy planes are oriented perpendicularly to the main plane of the cluster. From the cluster Abell 14 we selected 585 galaxies with axial ratio less then 0.75. The most important is that we found a very strong alignment of the positions angles in the whole cluster and within the subclusters. The value $\Theta \sim 170^{\circ}$ for the cluster position angle is in a good agreement with the maximum of this distribution of the position angles. It means that position angles of galaxies tend to be nearly parallel to the cluster position angles. This result is similar to that obtained by Hawley and Peebles (1976) but in clearly highest level. It should be stressed out that this results is quite opposite to that found for the Local Supercluster galaxies by Jaanistte & Saar, (1978) Flin & Godłowski (1986), Godłowski (1993, 1994) confirmed by Parnowsky (1994). We also (Godłowski, Baier and McGillivray (1998) found for the cluster A754 that position angles of galaxies are perpendicular to position angles of the whole cluster. For the cluster Abell 3667 we selected 270 galaxies with axial ratio less then 0.75. During our analysis we found aligment of the positions angles but the final picture is very complex. We observed a few peaks in the distribution of position angles. It is natural to suppose that this could be connected with the structure of the cluster, ie the existence of the large number of small subclusters. We also decided to analyse an “empty cluster” situated not far from Abell 3667. During this analysis of the position angles we found no significant alignments in the whole cluster and also within possible “subclusters” selected according to density profile.

4 Janniste & Saar methods

Further, we will discuss the method of analysis of the angular momenta of galaxies originally developed by Jaaniste & Saar. However, such investigation could be difficult because of our incomplete knowledge of true galactic shapes in the case of elliptical galaxies (Godłowski & Ostrowski 1999) Despite of that problem the results found with the help of such methods could give us important information about the alignment of galaxies and possible subclustering. We analised parameter Δ_{11} which gives an information about excess of angular momentum of galaxies with respect to analised cluster pole. For the considered clusters we mapped the ratio of Δ_{11} divided by its formal error $\sigma(\Delta_{11})$ for different possible cluster pole directions along the whole celestial sphere. According to our opinion it is important that the observed positive maximum of this ratio has a highly compact nature in the case of the clusters Abell 14 and Abell 754. This is possibly an indication of the fact that there is substructure with a different kind of alignment. For the cluster Abell 3667 and the "empty cluster" we observed in a positive extreme a very clear single structure. This could be explained in two ways — either we cannot observe any substructures (sugested for "empty cluster"), or the observed shape stems from a large number of small substructures. In this case the number of substructures are so high that any possible effect of "compact maximum" is randomized and as a result we observed single structures. Moreover, we observed strong negative extreme connected with the deficit of galaxies with angular momentum pointed towards that direction. This could be interpreted as a sign of real alignment of angular momentum of galaxies in the selected clusters. Results from J-S method are in agreement with those obtained from analysis of the position angles.

5 Final remarks

We found an evidence for existence of substructures in the analized clusters. During analisis of the position angles of galaxies we found that the distribution of the major axis of galaxies is not random. For the cluster A754 position angles of galaxies tend to be perpendicular to direction of the position angle of the cluster. For the cluster A14 position angles of galaxies tend to be parallel to the direction of the position angle of the cluster. For the cluster A3667 we obtained more complicated picture — non random. distribution with no definite preferred direction. This could sugest that alignment of galaxies in the clusters could have different shapes. From the analysis of the position angles we also have some evidence for existing of subclustering. This result is confirmed by the investigation of the distribution of the normals to galactic planes.

References

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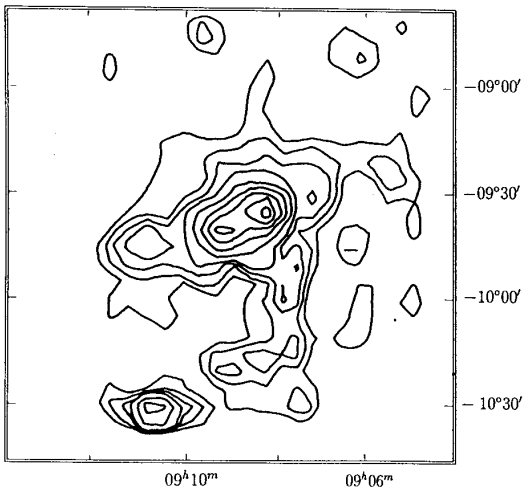

Figure 1: The galaxy distribution in the cluster A754 determined from the Edinburgh–catalog by Baier & MacGillivray (1996)

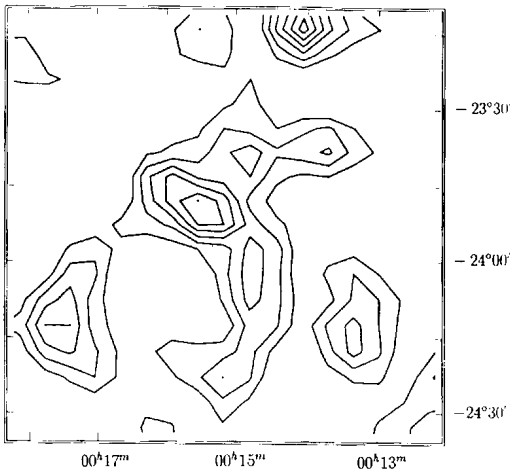

Figure 2: The galaxy distribution in the cluster A14 determined from the Edinburgh–catalog by Baier & MacGillivray (1996)

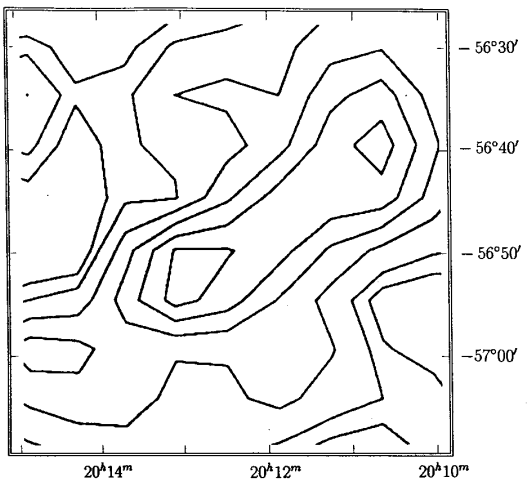

Figure 3: The galaxy distribution in the cluster A3667 determined from the Edinburgh–catalog by Baier & MacGillivray (1996)