ISOLATED CLUSTERS OF PF CATALOGUE

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ABSTRACT. The properties of isolated galaxy clusters are discussed. The clusters were found among 1746 PF clusters inclusive 50 and more galaxies in structure field. For 19 clusters with distances to the nearest neighbour larger than 68.5 h^{-1} Mpc we assigned the morphological types of these clusters according to Abell and Bauts & Morgan. The existence of preferential planes and angular momenta of isolated clusters was assumed. We connect evolution of isolated clusters with common large-scale characteristics.

Key words: large-scale structure: galaxy clusters

1. Introduction

The distribution of galaxy clusters, the largest virialized structures in the Universe, reflects the initial density perturbations. The characteristics of galaxy clusters both placed in rich regions and isolated ones can be used for better understanding of the formation of the large-scale structure.

Although considerable quantity of clusters belong to the larger-scale structures (Wray et al. 2006, Einasto et al. 2007, Panko 2011), there exist isolated clusters without neighbours. Lee (2012) investigated their relative abundance in connection with the dark energy equation of state. Godlowsky et al. (2012) compared the orientations of galaxies in clusters placed in and out of superclusters and found an influence on large scale structures formation both from nearest clusters and Supergalaxy.

The present study investigates the features of isolated galaxy clusters of PF catalogue (Panko & Flin 2006).

2. Observational data

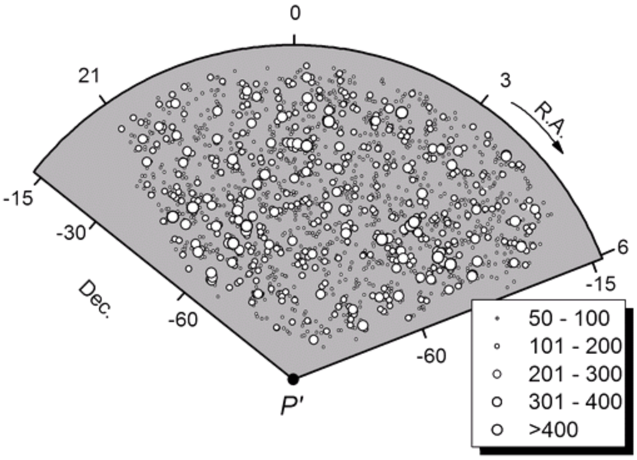

Figure 1: The distribution of PF clusters on the celestial sphere, symbol size correlates with the galaxy cluster richness.

The Catalogue of Galaxy Clusters and Groups (Panko & Flin 2006) was used as the input data for this investigation. The catalogue was created using data from the Muenster Red Sky Survey (Ungruhe et al. 2003), which is a large-scale homogeneous galaxy catalogue covering an area of about 5000 square degrees with galactic latitudes $b < -45°$. It is complete to a magnitude limit of $r_F = 18^m.3$. The same r_F magnitude limit defines the completeness limit for galaxies in the PF structures.

For each of 6188 structures, were found the richness, area, major and minor semiaxes, and ellipticity parameter of the best ellipse.

Kolmogorov-Smirnov test applied to distribution of ellipticities in sets of PF objects with different richness indicates that structures containing more than 50 members in the structure field belong to some population, but others are members of another population (Biernacka et al. 2009*a*). First population was attributed as normal and rich galaxy clusters. Second population contains groups of galaxies and poor galaxy clusters. The distribution of

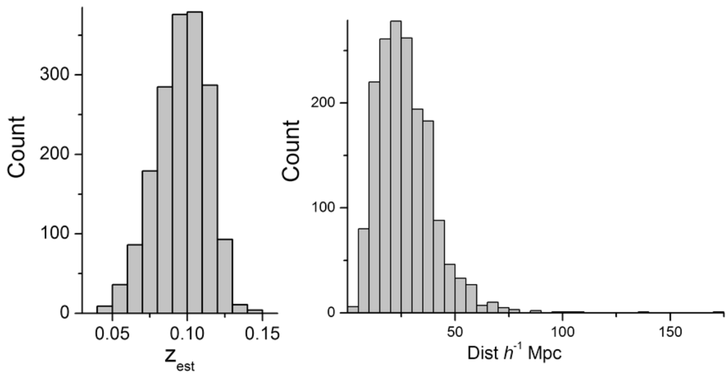

Figure 2: The distributions of redshifts (left panel) and distanced for nearest neighbours of PF clusters input list.

clusters from first population describes global large-scale features and second one detailed it (Panko 2008).

The positions on the celestial sphere of 1746 PF clusters input list is shown on Fig. 1 and rich and poor regions are clearly seen. The list of these PF clusters we shall name input list hereinafter. Galaxies of Muenster Red Sky Survey have no redshifts, so PF structures, have no redshifts too. In order to estimate distances for the PF structures, we calibrated the $\log z - m$ relation following Dalton et al. (1997), using the magnitude of the tenth brightness galaxy m_{10} as m in the calibration. We used dependence:

$$\log z_{\rm est} = -3.771+0.1660\, m_{10}\,, \qquad (1)$$

based upon 455 data points from the ACO (Abell, Corwin & Olowin 1989) comparison and 374 from the APM (Dalton et al. 1997) comparison (Biernacka et al. 2009b). The distribution of estimated redshifts of PF clusters input list is shows in Fig. 2, so the detected isolated clusters are not remote objects.

For the search of superclusters, the *Friend-of-Friend* method (*FoF*) was applied (Panko 2009), and for each cluster from input list the distances to the nearest neighbours were calculated. They lie within 4.6 and 173.7 h^{-1} Mpc (Fig. 2, right panel). Although Lee (2012) in his analysis took into consideration as isolated all clusters placed out of the superclusters, we assigned minimal distance to the nearest neighbour for isolated clusters as 68.5 h^{-1} Mpc. This limit was formally obtained using mean value and standard deviation of all distances. It is rigid criterion, and we assumed that the formation of these clusters was defined by a global distribution of the matter.

This condition is met for only 20 clusters from input list.

3. The properties of isolated PF clusters

Taking into account the richness limit for the input data, we checked the positions of poor PF structures in environs of the 20 detected clusters. One cluster, PF 0540-5764, was excluded from further analysis. Its nearest neighbour distance – 173.7 h^{-1} Mpc – is the largest for all input PF clusters, but it places close by bound of the Muenster Red Sky Survey.

We compared the positions of 19 isolated clusters on the celestial sphere with the positions of the ACO clusters. Common information about isolated PF clusters is given in Appendix A. The estimated redshifts of isolated clusters are in the range from 0.041 to 0.144, and we found no correlation between parameters of clusters. Three clusters belong to the rich cluster population, while others contain from 50 to 88 galaxies in the cluster field with a mean value of 60. Only 8 PF isolated clusters correspond with those in the ACO, and only 4 of them have measured redshifts.

We assigned morphological types to isolated clusters using the Abell (1958), Bauts & Morgan (1970), and Rood & Sastry (1971) classifications (Appendix A, second column). Abell types were R – regular, I – irregular and intermediate types RI and IR. Bauts & Morgan (BM) types are defined by the positions of several brightest galaxies, and BM I is a cluster containing a c*D* galaxy. For all isolated clusters we plotted their maps, with positions of the brightest galaxies taken into account. Two such cluster maps are shown in Fig. 4.

Our morphological types agree with the types from the ACO catalogue for three clusters: PF 0381-1789 (ACO 464), PF 2380-3628 (ACO 4039), and PF 2380-3628 (ACO 2877); two of them are of BM type I. Two clusters clearly correspond to the Rood & Sastry L-type. The common distribution of isolated clusters by Abell and BM types is given in Table 1.

Table 1: Morphological type's distribution of isolated clusters.

Abell types		BM types	
R	5	I	4
RI	11	I-II	–
IR	3	II	5
I	–	II-III	3
		III	7

In a comparison of counts for BM types of all ACO clusters corresponding to PF clusters (Panko et al. 2009) with similar richness we note an excess of BM type III clusters. There is no dominant galaxy in clusters of this type. Along with an ellipticity range from 0.11 to 0.39, the excess is evidence of the influence of more distant

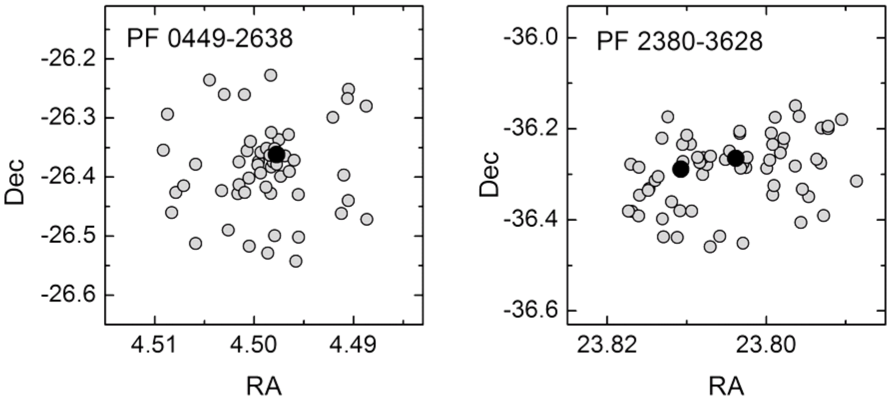

Figure 3: The BM I (left panel) and II clusters.

objects on the evolution of clusters, or a connection of cluster shape with common large-scale characteristics.

Values for the ellipticities argue for the existence of a preferential plane and angular momentum for clusters. The mean ellipticity of isolated clusters of $E_{\rm isol}$=0.20 is equal to the mean ellipticity of PF structures containing 50 or more galaxies in the structure field. We assume the existence of a mean residual ellipticity for galaxy clusters independent of neighbours. Moreover, a preferential plane of clusters confirms Gamow's (1946) idea of a common Universe rotating (see, for example, Birch P. 1982, Flin et al. 2007).

4. Conclusion

We analyzed the nearest neighbour for 1746 PF clusters containing 50 or more galaxies in the structure field. The critical distance separating isolated clusters from others was formally defined using the mean value and standard deviation of all distances. We selected this sharp criterion with the result that it connects the properties of isolated clusters with those for global large-scale characteristics.

We found 19 isolated PF clusters and assigned morphological types to the clusters according to the Abell and Bauts & Morgan schemes. Features of the distribution of morphological types and mean value of ellipticities show the existence of preferential planes and angular momenta for isolated clusters.

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NED: The NASA/IPAC Extragalactic Database: http://ned.ipac.caltech.edu/

Appendix A.

Parameters of PF isolated clusters.

The columns of the Table contain the following information:

Ident – structure identification, based on the first digits of R.A. and Dec.;

Classification – our classification according to Abel and Boutz & Morgan (as L marked clusters with clear L-type Rood & Sastry);

R.A., Dec. – Right Ascension and Declination for 2000.0;

N – the number of all galaxies in the cluster field;

a – semi-major axis of the fitted ellipse;

E – ellipticity of the cluster;

PA – the position angle of the semi-major axis of cluster,

z_{est} – estimated redshift according to relation 1;

$D_{nearest}$ – distance to the nearest neighbour in h^{-1}Mpc,

ACO – corresponding cluster in ACO Catalogue;

Klass A and BM – Abell and Boutz & Morgan types from ACO catalogue.

Ident	Classifications			R.A.	Dec.	N	*a*	*E*	PA	z_{est}	$D_{nearest}$	ACO	Klass A	BM
0016-5711		IR	II-III	0.167074	-57.107367	88	907	0.32	117.4	0.053	68.9	2731	I	III:
0024-2431		IR	III	0.247237	-24.300611	52	639	0.39	43.7	0.129	78.5			
0096-3921		RI	III	0.962162	-39.205838	52	655	0.11	69.8	0.142	136.9			
0115-4600	L	R	I	1.156725	-45.996573	260	1251	0.17	178.9	0.041	105.4	2877	R	I
0200-2252		RI	III	2.003679	-22.519040	52	690	0.12	105.5	0.133	73.0	S 213	R	I-II
0240-4218		R	II	2.402386	-42.175194	56	608	0.11	14.6	0.140	98.3	3014	I	III
0358-6952		RI	II	3.587338	-69.511811	53	1045	0.19	67.0	0.126	68.8			
0381-1789		R	I	3.817120	-17.885726	308	1688	0.24	38.9	0.069	73.5	464	R:	I
0397-6046		IR	III	3.973661	-60.450522	75	912	0.12	178.8	0.115	71.4			
0413-3091		RI	II	4.133604	-30.907580	271	1129	0.11	170.5	0.064	77.0	3223	RI	I
0444-3673	L	RI	II	4.446484	-36.724150	56	749	0.14	18.8	0.133	101.0			
0449-2638		R	I	4.498747	-26.377217	54	548	0.14	12.4	0.124	68.9	495	R	III
0450-6452		RI	III	4.501420	-64.516471	59	705	0.25	178.9	0.118	71.4			
0501-3610		R	II	5.017765	-36.090484	61	621	0.13	30.8	0.123	78.0			
2114-3750		RI	III	21.143841	-37.493762	55	748	0.25	45.7	0.127	69.0			
2175-1751		RI	III	21.750021	-17.503100	79	656	0.11	44.6	0.125	87.4			
2190-6118		RI	II-III	21.909741	-61.171245	58	681	0.28	34.3	0.119	73.1			
2195-7771		RI	I	21.956714	-77.709296	50	872	0.28	11.0	0.144	89.1			
2380-3628		RI	II	23.804412	-36.274714	65	734	0.35	61.3	0.126	69.7	4039	R:	II: