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Cluster Cartography: Mapping and Tests

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Abstract

We created the program "Clusters Cartography" (CC set) for study of morphology of galaxy clusters. The CC set reconstructs the 2D-distribution of galaxies in the cluster field in the rectangular coordinates, taking into account the magnitude and shape of each galaxy. The next analysis allows to determine the galaxy clusters morphological types in concordance with concentration to the center, flatness signs and the role of brightest galaxies. The morphological types for certain clusters can be established using two basic analysis blocks: for concentration (C-I-O) and for anisotropy signs (L-F) with numerical criteria for the classification, and graph mode for clarity.

Using the CC set we determined the morphological types of 19 isolated galaxy clusters. The results are discussed.

Key words: clusters of galaxies: morphological types

Introduction

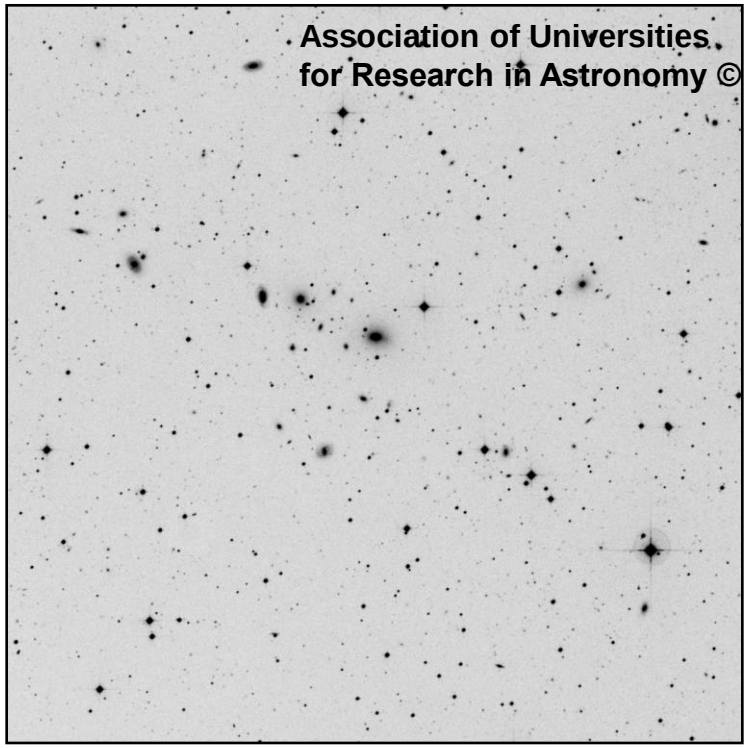
The morphological types of galaxy clusters resulting from their outward appearance is physically related to the clusters and their member galaxies. The classification of galaxy clusters at optical wavelengths is carried out using several different parameters: cluster richness (number of galaxies within a specific limiting magnitude), the central concentration, the presence of bright galaxies in the center of the cluster, the presence of peculiar galaxies, etc. Panko (2013) created the adapted scheme of morphology classification of galaxy clusters basing on the classical Zwicky et al. (1961-1968), Boutz & Morgan (1970, BM scheme), Rood & Sastry (1971) and revised version Struble and Rood (1982, 1985), and Lòpez-Cruz et al.(1997, 2001) systems.

The observational data, PF catalogue (Panko & Flin, 2006), allows to estimate the galactic content of clusters basing on distribution of ellipticity of galaxies (Panko & Flin, 2014). The difference in the galactic content of clusters (that is, the fraction of cluster galaxies which are spirals (Sps), disk galaxies without spiral structure (S0s), or elliptical (Es)) was studied by Morgan (1961) and Oemler (1974).

The determination of the morphological types for galaxy clusters, like to galaxies (Galaxy Zoo Project reasons), requires the visual control. We create the first version of "Cluster Cartography" program (Panko & Yemelianov, 2015, hereafter CC) for visualization if PG galaxy clusters. The new version of the "Cluster Cartography" program allows to determinate the morphological types of clusters in concordance with concentration to the center, flatness signs, the role of brightest galaxies, and to estimate the galactic content**.**

Observational data

Input data we obtained from PF catalogue (Panko & Flin, 2006). Panko & Andrievsky (2012) selected Isolated clusters were from PF catalogue using hard criterion and determined their morphological types according to BM scheme.



The input data we have in the format:

Cluster data

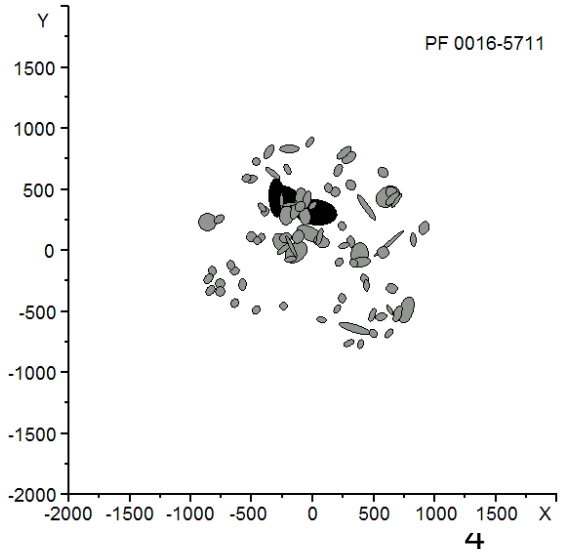
0016-5711 0.1670739 -57.107367 940 2130600 88 31 48 907 617 0.32
117.4 13.02 13.72 15.05 97.4 0.41 22.8

Galaxies data

149-40043	59	2.75	5.30	3.85	0.31	24.0	16.56	16.53	0.136070	-57.054264
149-39501	21	2.15	4.26	2.51	0.49	178.0	17.98	17.95	0.139043	-57.081429
111-51504	394	6.14	12.73	7.33	0.51	16.5	14.81	14.77	0.140979	-57.240734
111-50854	111	4.09	7.88	4.37	0.54	19.1	16.35	16.32	0.143299	-57.250084
149-38602	36	3.27	7.23	2.99	0.72	34.9	17.53	17.50	0.143872	-56.993507
149-38414	59	2.79	5.74	3.06	0.56	48.4	16.63	16.60	0.144886	-56.988529
111-50278	52	2.69	4.73	4.11	0.14	105.6	16.95	16.91	0.145107	-57.191956

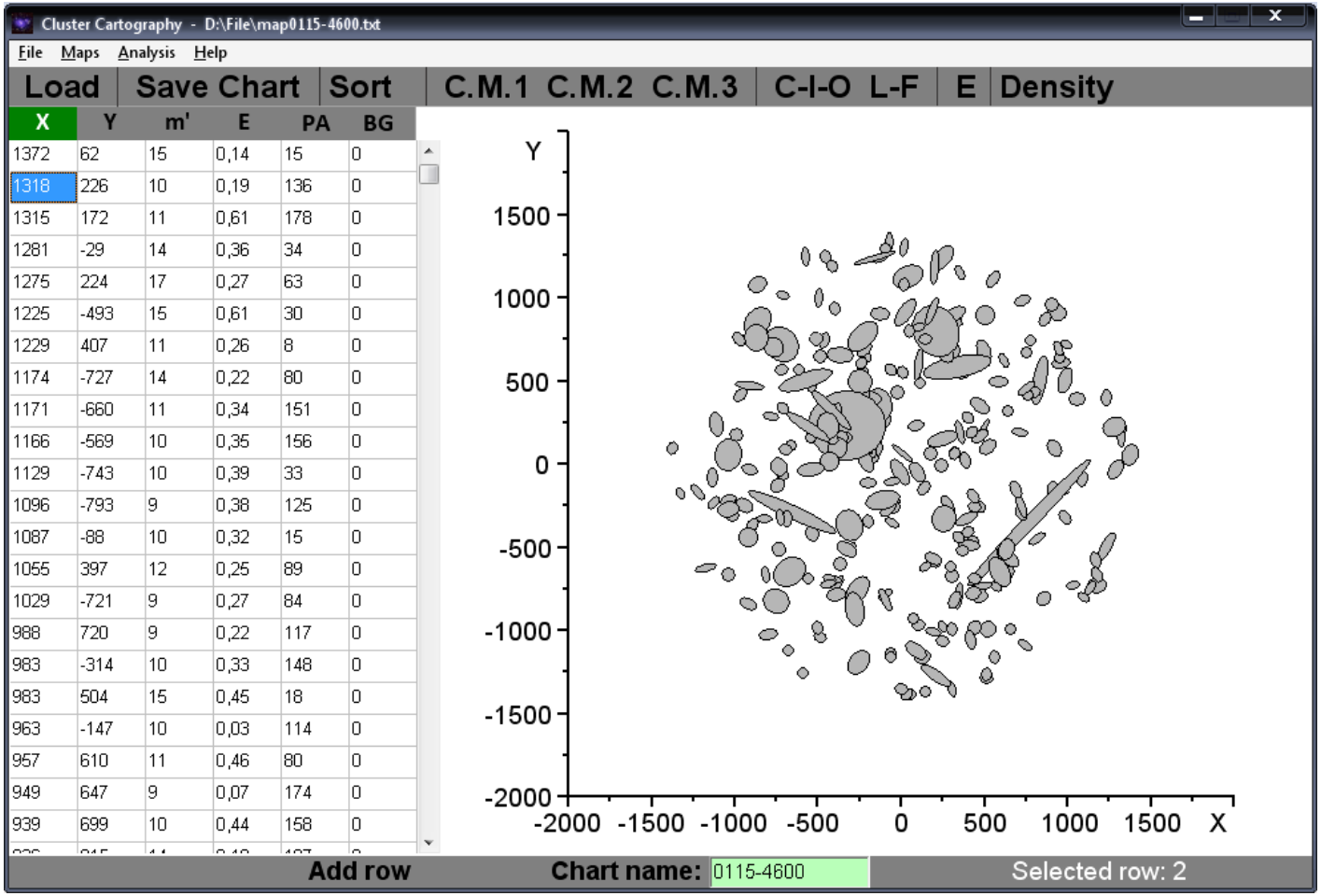
We used the same input data for our work.

On the right we show the real 4200"×4200" field of PF 0381-1789 cluster from DSS-R and our map 4000"×4000" size. The background stars are present on the real frame. Weak galaxies on the frame are not visible.



"Cluster Cartography" using

Step 1. Visualization of the cluster field. The positions of galaxies we recalculate into rectangular coordinates by standard procedure. The real magnitudes ***m*** are recalculated to adapted ones ***m′*** as $m' = 3 \cdot 2^{0.6(18.5-m)} + 6.$ On our map ***m′*** corresponds to diameter of the symbol with ellipticity *E*=0.



The shape of galaxy in ellipse fit with *A* and *B* axes we determine from the ***m′*** and *E*.

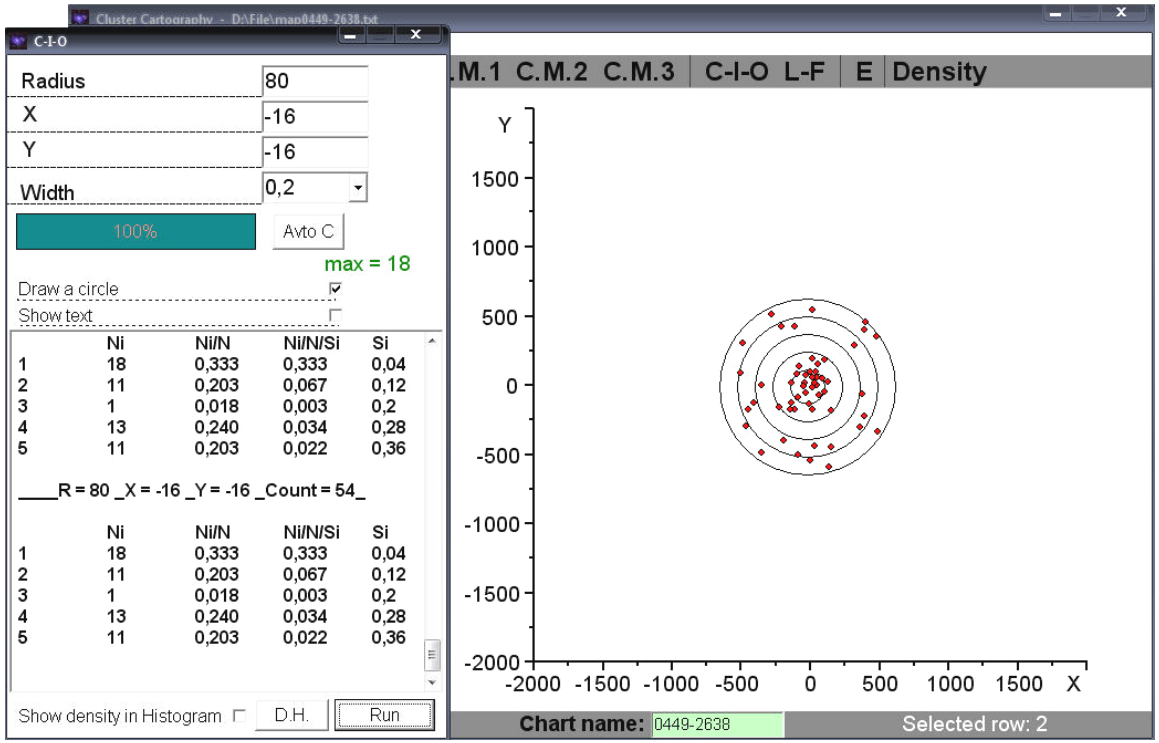
$$A = \frac{m'}{\sqrt[4]{1 - 2E + E^2}}$$

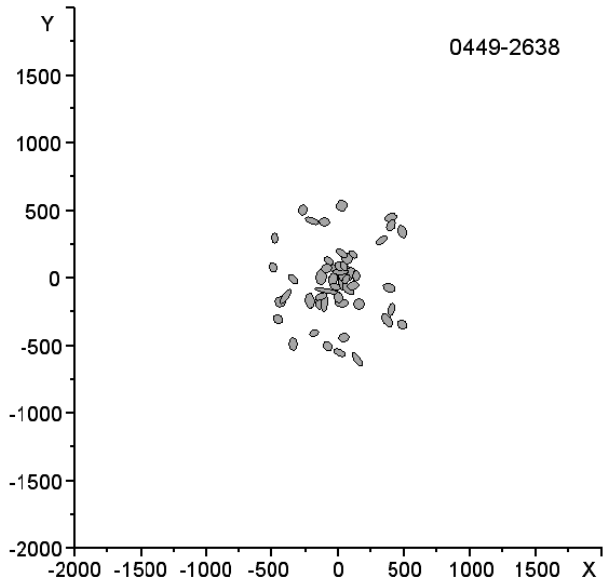
$$B = \frac{(m')^2}{A}$$

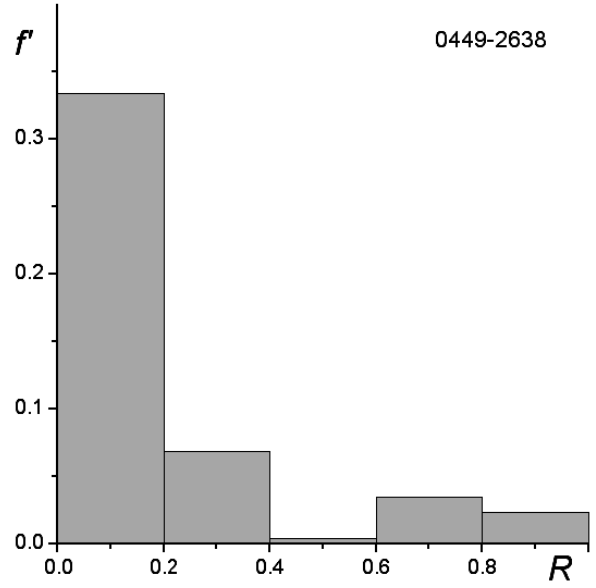
The equations were obtained in assuming

$$S = \pi \frac{(m')^2}{4} = \pi \frac{A \cdot B}{4}$$

"Cluster Cartography" using

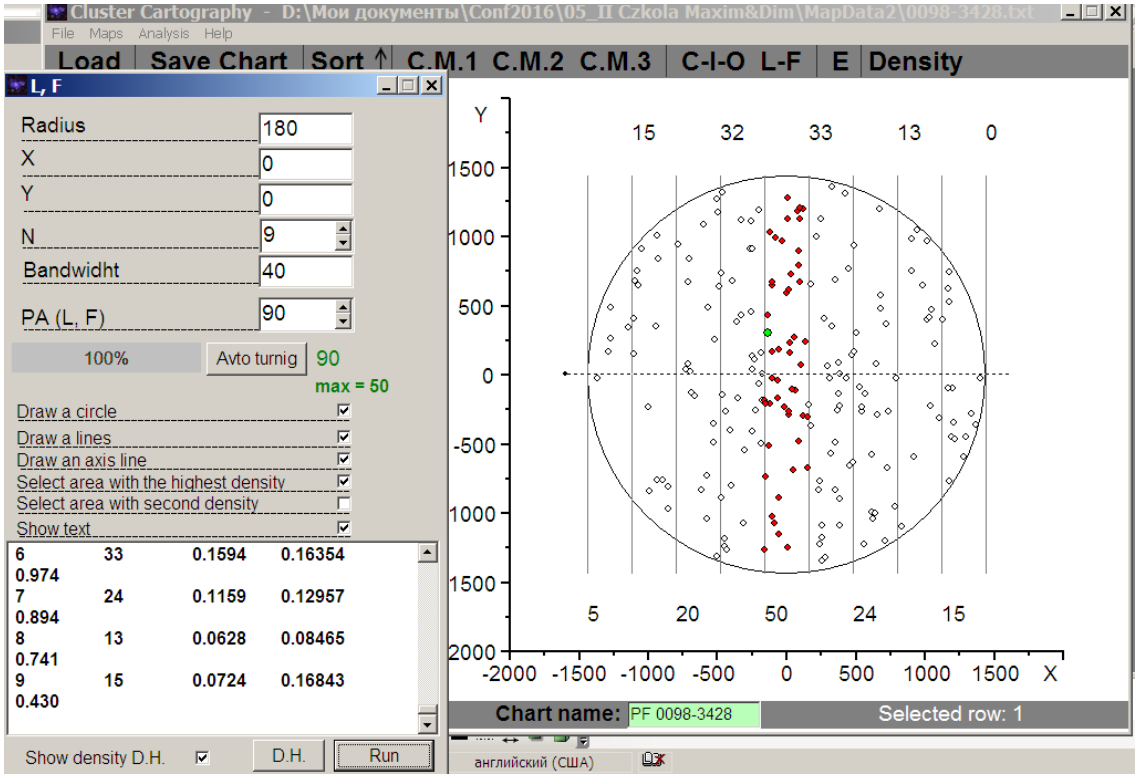


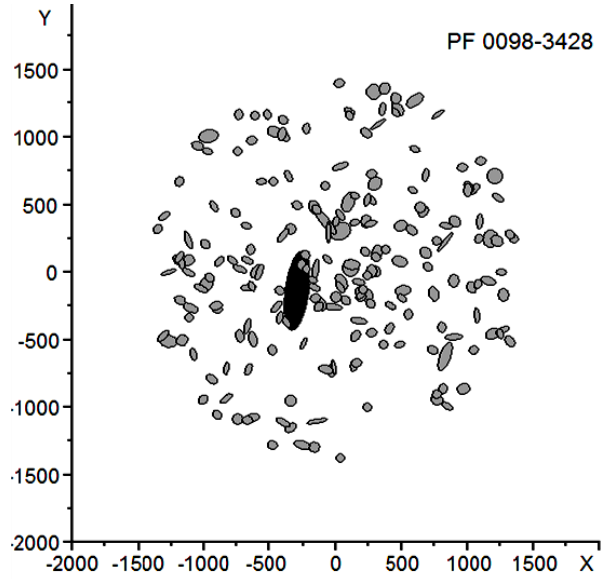


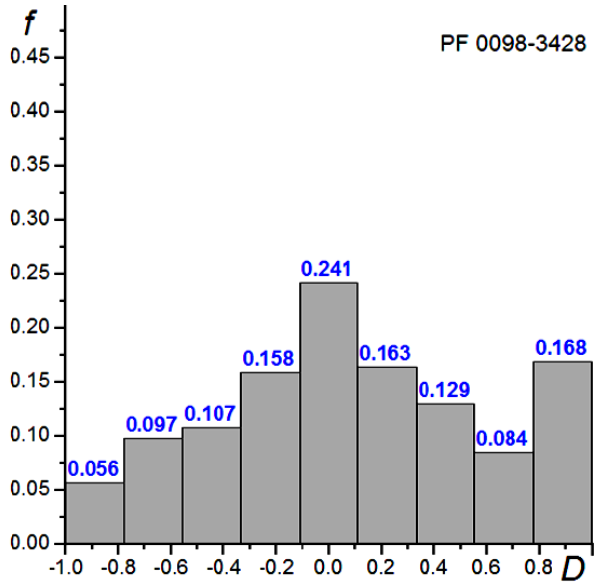


Step 2. C-I-O mode is intended for the determination of the concentration type from concentrated C to open O. The mode analyses the concentration towards the center or another point (automatically). It uses three main components: equivalent radius of the cluster, coordinates of the center X and Y, and the width of zone in parts of radius. The weighted density is calculated taking into account the area of zone and the number of galaxies in the cluster (***f'*** on histogram).

"Cluster Cartography" using







Step 3. L-F mode allows to find automatically the preference line/belt (if it is present). It uses equivalent radius of the cluster, coordinates of the center X and Y, the number of bands (bandwidth in parts of radius). The weighted density on each band is calculated taking into account the area of band and the number of galaxies in the cluster (***f'*** on histogram).

Brightest galaxies are shown as green circle in C-I-O and L-F frames and dark symbols in the cluster map.

The morphology types of 19 isolated PF galaxy clusters

Table 1.

Ident	R.A.	Dec.	N	*a*	*E*	PA	z_{est}	Classifications	
								Abell	Panko
0016-5711	0.167074	-57.107367	88	907	0.32	117.0	0.053	IR	I
0024-2431	0.247237	-24.300611	52	639	0.39	43.7	0.129	IR	I
0096-3921	0.962162	-39.205838	52	655	0.11	69.8	0.142	RI	O
0115-4600	1.156725	-45.996573	260	1251	0.17	179.0	0.041	R	O
0200-2252	2.003679	-22.519040	52	690	0.12	106.0	0.133	RI	O
0240-4218	2.402386	-42.175194	56	608	0.11	14.6	0.140	R	OF
0358-6952	3.587338	-69.511811	53	1045	0.19	67.0	0.126	RI	O
0381-1789	3.817120	-17.885726	308	1688	0.24	38.9	0.069	R	O
0397-6046	3.973661	-60.450522	75	912	0.12	179.0	0.115	IR	O
0413-3091	4.133604	-30.907580	271	1129	0.11	171.0	0.064	RI	IFP
0444-3673	4.446484	-36.724150	56	749	0.14	18.8	0.133	RI	OF
0449-2638	4.498747	-26.377217	54	548	0.14	12.4	0.124	R	C
0450-6452	4.501420	-64.516471	59	705	0.25	179.0	0.118	RI	OF
0501-3610	5.017765	-36.090484	61	621	0.13	30.8	0.123	R	I
2114-3750	21.143841	-37.493762	55	748	0.25	45.7	0.127	RI	OL
2175-1751	21.750021	-17.503100	79	656	0.11	44.6	0.125	RI	OL
2190-6118	21.909741	-61.171245	58	681	0.28	34.3	0.119	RI	OF
2195-7771	21.956714	-77.709296	50	872	0.28	11.0	0.144	RI	O
2380-3628	23.804412	-36.274714	65	734	0.35	61.3	0.126	RI	OF

Using the CC program we determined the typed of 19 isolated PF galaxy clusters according to Panko (2013) scheme. The information is present in the Table 1. The distribution according the types for isolated PF clusters is present in the Table 2. In contrary to Panko et al. (2016) paper in a present work we found the excess of open clusters.

Table 2.

Type		*L*	*F*	*BG*	*P*	Sum
Concentration ⇧	*C*	–	–	1		1
⇧	*I*	–	1	3	1	4
	O	2	5	7		14

Conclusion

We showed how useful our "Clusters Cartography" program is for detail study of galaxy clusters (see also Maksym Huzei, Dmytro Maleta et al. poster). The morphological types for certain clusters are established using of two basic analyze modes of the program. Types for concentration (C-I-O) and for anisotropy signs (L-F) can be obtained with numerical criteria for the classification, and graph mode for clarity.

We determined the morphological typed for 19 isolated PF galaxy clusters.

We found the significant difference with distribution on types for isolated and rich PF clusters studied by Panko et al. (2016). It is possible the difference can be connected with different density in corresponding areas.

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