THE ORIENTATION OF GALAXIES IN SUPERCLUSTERS

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The alignment of galaxies with the main plane of supercluster can contribute to recovering information on the structure origin. The positive result of the preliminary search for galaxy alignment in the Local Supercluster /Flin and Godlowski 1986, hereafter FG/ have stimulated further studies. Following Jaaniste and Saar /1977/, the both parameters, the position angle of the galaxy major axis p and the axial ratio b/a of the galaxy image, were used for the better determination of the actual spatial orientation of the galaxy disc. This approach also permit to consider "face-on" objects, whose discounting leads to obvious incompleteness of the analysed data. Each galaxy has two possible orientations and both were taken into account during calculations. The analysis is perfomed by transforming position angle p and coordinates α,δ of galaxies expressed in the equatorial coordinates into coordinate system connected with each parent supercluster separately, which gives parameters P, l and b respectively. The main supercluster plane should be determined, which resticts the present study to the three superclusters with a known spatial geometry, i.e. LSC /Tully 1982/, Perseus and Coma/A1367 /Chincarini et al. 1983/.

Only radial velocities of galaxies were used for determination of their membership to superclusters, and only disc galaxies, for which rotation axes are well determined, are considered. Galaxies with $V_r \leqslant 2600$ km s^{-1} belong to the LSC. The Coma/A1367 supercluster contains galaxies with V_r between 6000 and 8000 km s^{-1} having equatorial coordinates: $11^h.5 < \alpha < 13^h.3$ and $19^o < \delta < 32^o$ and brighter than $14^m.5$. The same brightness criterion was applied to the Perseus supercluster galaxies, which should be in the region $22^h < \alpha < 4^h$ and $21^o.5 < \delta < 45^o$ with $V_r \in (4000, 8500$ km s$^{-1})$. The galaxy coordinates, morphological types and position angles were taken from Nilson /1973, 1974/ and Lauberts /1982/. The Coma/A1367 sample is a complete one, while the completeness of the Perseus sample is 89 per cent. Beside the search of alignment in a supercluster as a whole an attempt was made to look for the effect separately in the main structure of a supercluster /the disc of the LSC, clusters A1656 and A1367 in the Coma supercluster and the main ridge of the Perseus supercluster/ and the remaining part of a

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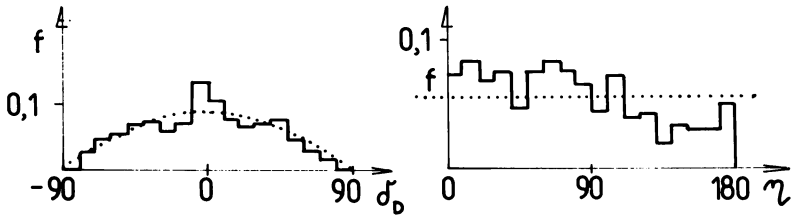

Fig.1 The frequency distribution of galaxy rotation axes in the Perseus supercluster /the dotted curve -isotropic distribution/

supercluster. Moreover the alignment of isolated and double galaxies in superclusters was investigated.

The isotropy of the distribution of two angles were studies: the polar angle δ_D between the direction normal to the galaxy plane/the direction of galaxy rotation axis/ and the main plane of a supercluster, as well as the azimuthal angle η between the projection of the rotation axis on the supercluster plane and the "zero meridian". The formulae for computing δ_D and η as given by FG are:

$$\sin \delta_D = - \cos i \sin b + \sin i \sin P \cos b$$

$$\sin \eta = (- \cos i \cos b \sin l + \sin i(\mp \sin P \sin b \sin l \mp \cos P \cos l))/ \cos \delta_D$$

The tilt angle i was derrived using Holmberg's formula. For "face-on" objects P≡0. The isotropy of of the angular distribution of the angles δ_D, η was checked performing statistical analysis in the manner proposed by Hawley and Peebles /1975/, as given in FG. It has been tested that the result does not depend either on the uncertainties in the measurements of both p and b/a or on the accepted value of the intrinsic axial ratio and the chosen "standard" system of photometric diameters.

The result of the analysis is given in Table 1. N denotes the number of galaxies, $P(>\chi^2)$ and $P(>\Delta)$ give probabilities that the departure from isotropy is due to random fluctuations /in χ^2 - test and the wave model/, the F-coefficient describes the direction of departure from isotropy /F>0- galaxy planes are aligned with the supercluster plane/ and σ_F is its standard deviation, C-the value of the autocorrelation test, the index $W = (N_{\parallel} - N_{\perp}) / (N_{\parallel} + N_{\perp})$ gives the excess of galaxies with rotation axes parallel or perpendicular to the supercluster plane.

Conclusions: /i/ the distribution of both angles δ_D and η is anisotropic, /ii/ within each supercluster galaxy planes tend to be perpendicular to the supercluster main plane, i.e. the galaxy rotation

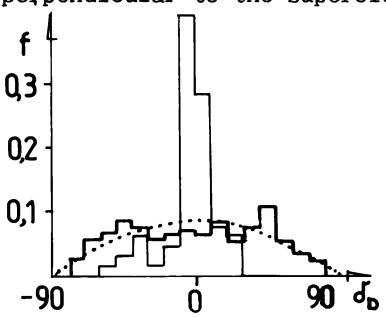

Fig.2 The distribution of the δ_D angle. The heavy histogram-galaxies with apparent axial ratio $b/a \leq 0.75$, the thin-with $b/a > 0.75$.
The resulting distribution is given in Fig.1. The dotted curve denotes isotropic distribution

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Table 1. The distribution of the investigated angles.

	the angle ϑ						the angle η		
	N	$P(>\chi^2)$	$P(>\Delta)$	F-coef	σ_F	C	W	$P(>\chi^2)$	$P(>\Delta)$	C
LSC	1565	0.19	0.10	−.0945	.0567	−5.0	0.00	0.16	0.01	5.2
disc	1096	0.00	0.00	+.0052	.0616	12.6	0.05	0.10	0.05	2.3
no disc	469	0.00	0.15	−.3142	.1991	14.2	−0.01	0.08	0.17	−3.7
double	34	0.00	0.08	+.2507	.2800	−22.8	−0.02	0.44	0.09	−6.0
isolated	75	0.11	0.36	−.0024	.1939	0.6	0.00	0.16	0.85	6.2
Coma	36	0.02	0.00	−.2696	.2893	12.0	0.31	0.00	0.00	22.0
$\alpha<11^h.8$ x	9	0.38	0.28	−.2293	.4303	−2.2	0.25	0.07	0.14	−3.0
$\alpha(11^h.8,12^h.7)$x	13	0.00	0.00	−1.3228	.4318	17.5	1.0	0.00	0.00	0.3
$\alpha>12^h.7$ x	9	0.99	0.94	+.2897	.2727	−0.5	0.14	0.80	0.99	0
Per	216	0.02	0.00	−.1590	.1246	33.6	0.17	0.00	0.00	33.0
main ridge x	88	0.67	0.13	−.1443	.1399	15.0	0.13	0.00	0.01	6.1
xx	67	0.17	0.00	−.1707	.2461	17.0	0.12	0.00	0.00	22.6
double	88	0.30	0.00	−.4207	.1193	19.1	0.33	0.52	0.59	−0.7
isolated	28	0.33	0.00	−.8383	.3060	2.6	0.56	0.17	0.48	−2.3

x supercluster latitude $|b|<3^o$; xx outside the main ridge and $|b|\geqslant 3^o$.

axes are aligned with the supercluster plane, /iii/ the alignment is observed both in the dispersed component and densely populated regions, /iv/ in the same supercluster particular substructures can have different orientation, /v/ the alignment of both isolated and double galaxies is similar to that of other objects placed in the same substructure, /vi/ the projections of galaxy rotation axes tend to point towards the main structures. In the LSC they are directed toward the Virgo cluster centre and in the Coma/A1367 supercluster they are grouped in the region corresponding to $\alpha \in (10^h, 15^h)$. In the Perseus supercluster the excess in the distribution of the η angle is observed well before studied region and extends till 7^h, encompassing the northern part of Gemini-Lynx supercluster.

The observed alignment of galaxy rotation axes with the main plane may be an artifact of the perpendicularity of galaxy planes with respect to the vectors toward the centres of superclusters. The present analysis does not allow for discriminating between these two possibilities. In the framework of conventional scenarios of galaxy origin the result is incompatible with the isothermal scenario,which predicts a null result. The alignment of rotation axes with the supercluster main plane is opposite to that expected in the turbulence theory and it is consistent with the dissipative models of galaxy formation. The evidence for the top-down scenario is however weakened by the presence of different kind of alignment in some substructures constituting supercluster.

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