On the orientation of galaxy clusters

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1. Short biased introduction

When we speak on orientation of structures this is the same as looking for either alignment or systematics among objects constituting structure or structures their selves. The main aim of such works is to study the angular momenta of galaxies. However, the number of galaxies with determined spins is small (see e.g. Aragon - Calvo poster). Therefore, the change of the investigated parameter is made. Instead of galaxy spin the position angle of galaxy major axis was considered, or after the works of Öpik (1970), and Jaaniste & Saar (1978) it was clear that galaxy planes are the better parameter (Flin & Godlowski 1986). It was shown that, due to different manner of the acquisition of angular momenta in various scenarios, the orientation of galaxy spins is different. In old, good days when Bernard wrote his paper "The origin of galaxies: A review of recent theoretical developments and their confrontation with observations" (1976) there were three scenarios of galaxy origin: hierarchical, adiabatic and turbulent. (Later on, it was shown that in explosive scenario the distribution of galaxy spins should be similar to that in the adiabatic one). This picture was valid for several years and Fig.1 presents schematically the expected alignment of galaxy spins is various scenarios (taken from: Iye & Sugai 1991). In the hierarchical scenario where angular momenta of galaxies are gain due to tidal torques the random distribution of galaxies in the whole structure is expected (Fig.1. c), while in the turbulence and adiabatic theories galaxy spins should be perpendicular (Fig.1. a) or parallel (Fig.1. b) to the main plane of the proto - structure respectively.

Several studies were performed in order to find observational arguments supporting one of this pictures.

Moreover, the position angle of a structure (galaxy group and cluster) was determined. The alignment among position angles of structures was checked, in order to see, if the neighbouring structures point to each other (Binggelli 1982, Rhee & Katgert 1988, Flin 1987, Plionis 1994).

The investigation of the possible relations among various parameters, which can be connected with the discussed problem were performed. These included the difference among:

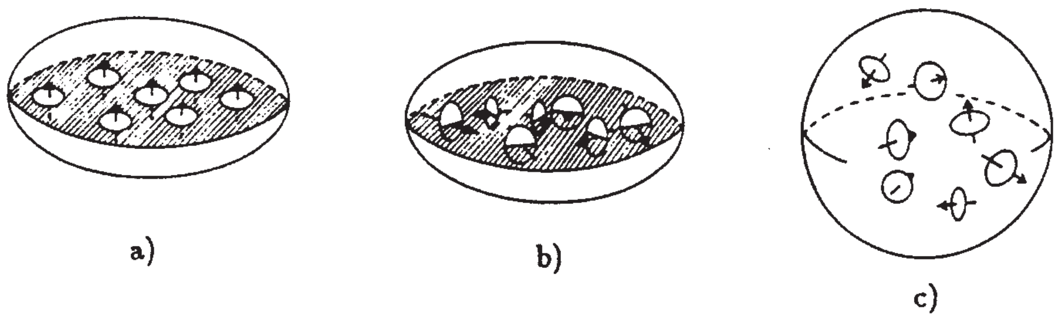

Fig. 1.— Schematic presentation of the distribution of galaxy spins in respect to the parent structure in the three classic scenarios of galaxy origin: turbulence, pancake, hierarchical clustering

the cluster position angle and the brightest cluster member,

the cluster position angle and the 2nd brightest galaxy,

the cluster position angle and the line joining the two brightest galaxy,

the position angle of a structure in respect to the special direction (e.g. Virgo cluster centre),

the line joining two brightest galaxies and the Virgo cluster centre.

Since old good days situation became much more complicated. Several theoretical studies showed that tidal interactions can introduce some weak general alignment of member galaxies situated in structures. Moreover, if shock waves acted at the early stage of structure formation the distribution of angular momenta can be non random. In addition, this subject is important because the study of weak lensing need know intrinsic alignment of galaxies (see e.g. Heavens talk). We should also remember about possible shear.

In the present paper we concentrate on the discussion of the Binggeli effect, this is the question whether great axes of structures tend to be directed toward other structures. Moreover, we discuss the distribution of galaxy planes in Tully's groups.

2. Observational data

There are two sets of data.

1. Tully's groups

From the Tully's Catalogue (1988) we investigated 61 structures, selected by him as galaxy groups, having at least 10 objects. We determined their ellipticity and position angle using the covariance ellipse method. The second sample contains 35 groups with at least 20 members.

2. The sample of 377 rich Abell clusters, $R \geq 1$, $z < 0.02$ (see: Biernacka & Flin poster) We use $H_0 = 75km * s^{-1} * Mpc^{-1}$ and $q_0 = 0.5$.

3. Results

We investigated the distribution of the acute angle $\Delta\theta$ between the position angle of the structure and the direction toward the centre of each structure. The analysis was performed separately for the sample containing the galaxy groups and galaxy clusters. The distributions of the $\Delta\theta$ angle are presented in Fig. 2 and Fig. 3. From figures follow that only in the case of nearby groups the Binggeli effect is observed. This visual impression is confirmed when the Kolmogorov - Smirnov test for randomness is applied. Also the excess of galaxies in the bins $(0° - 30°)$ is statistically significant. The distribution of the investigated angle in the remaining samples is random. In the case of galaxy clusters the observed excess in the first bin is in all cases greater than 3σ. In the sample of 35 galaxy groups we checked also the difference between the brightest galaxy in the group and the group position angle with null result. We analysed also both the distribution of position angles and planes of galaxies in 35 Tully's groups. The second approach involved two parameters, i.e. galaxy inclination and position angle as described in Flin & Godlowski (1986) and many subsequent papers. Only very weak alignment in two groups has been observed, and moreover when it appeared in position angle distribution it was absent in galaxy plane distribution, and vice versa. Moreover, as usually in our paper the isotropy of distributions were checked using three test: the chi square, the Fourier test and auto-correlation test (Hawley & Peebles 1975). There was no case that all three test pointed anisotropy of the galaxy plane distribution. Our conclusion is the lack of alignment of both position angle and galaxy planes in groups.

4. Discussion and conclusions

1. We show that the Binggeli effect is observed in our both samples. The extension of the effect depends on the size of the structure. It is small, till about 10 Mpc for groups while for clusters it extends till more than 60 Mpc. This is in good agreement with previous results. Moreover, it is in agreement with numerical simulations (Faltenbacher et al. 2002) "we find filamentary alignment out to scale of $100h^{-1}Mpc$, even for the projected data". The dependence on the structure size is obviously connected with the structure mass. So, for more massive structures the extension of the effect is greater.

2. We do not observed the alignment of the position angle of the brightest galaxy and the group position angle. Our groups are structures without a dominant galaxy. Our result confirm that this alignment is observed only for structures with such galaxy (BM class I, I-II) (Flin & Olowin 1989).

3. The lack of alignment of galaxy planes in respect to the main plane of the Local Supercluster for Tully's groups. Usually the alignment of galaxy rotation axes with the supercluster main plane was observed. However, in the LSC, as well as in the Shapley concentration in various part of the supercluster different types of alignment was observed. In some of these structures no alignment has been noted (Flin & Godlowski 1990, Aryal et al. 2006). So, the observed randomness of the distribution of galaxy planes is in agreement with these findings too.

4. If superclusters can be regarded as LSS then conclusion nr 1 of Trujillo talk (this conference) is incorrect. There are several dozen of papers (starting from 1977) showing the existence of galaxy alignment (of different morphological types) in superclusters: Local, Perseus, Hercules, Coma/A1367, Shapley.

We plan to study the alignment of galaxies belonging to structures, as well as the Binggeli effect. For this purpose we will be using the PF Catalogue of structures (Panko & Flin 2006). This catalogue contains 6517 structures, each having at least 10 members. The optical basis of the PF Catalogue is Münster Red Sky Survey (Ungruhe et al. 2003). MRSS contains the scans of 217 adjoining plates of the ESO Southern Sky Atlas R covering more that 5000 square degrees. The catalogue includes 5524245 galaxies and is complete till r_F 18m.3. The structures were found using 2D Voronoi tessellation technique.

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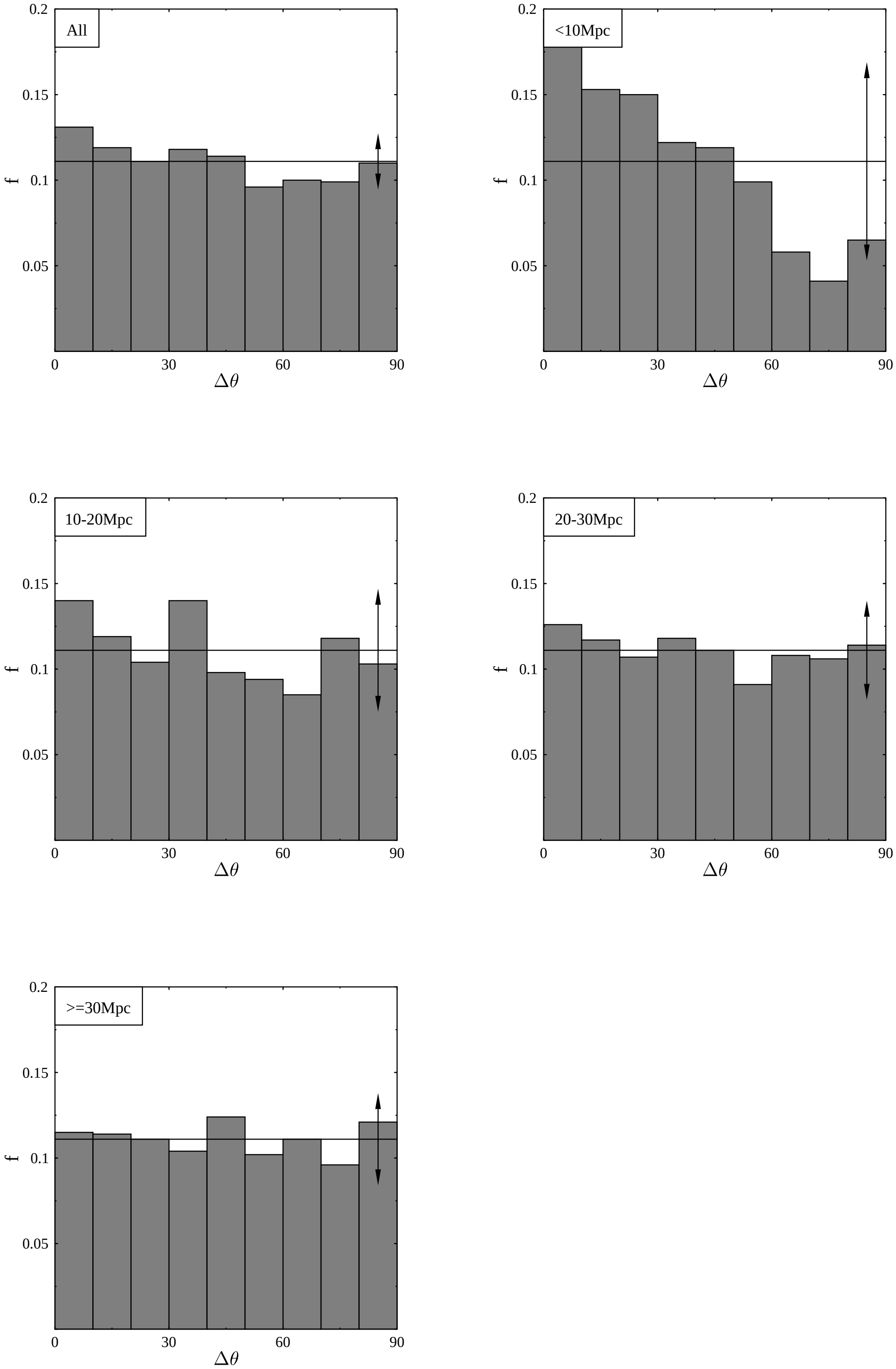

Fig. 2.— The distribution of the $\Delta\theta$ angle for 61 Tully's groups. The difference among group distances are given in the left upper corner of each panel. Arrows present 1σ error.

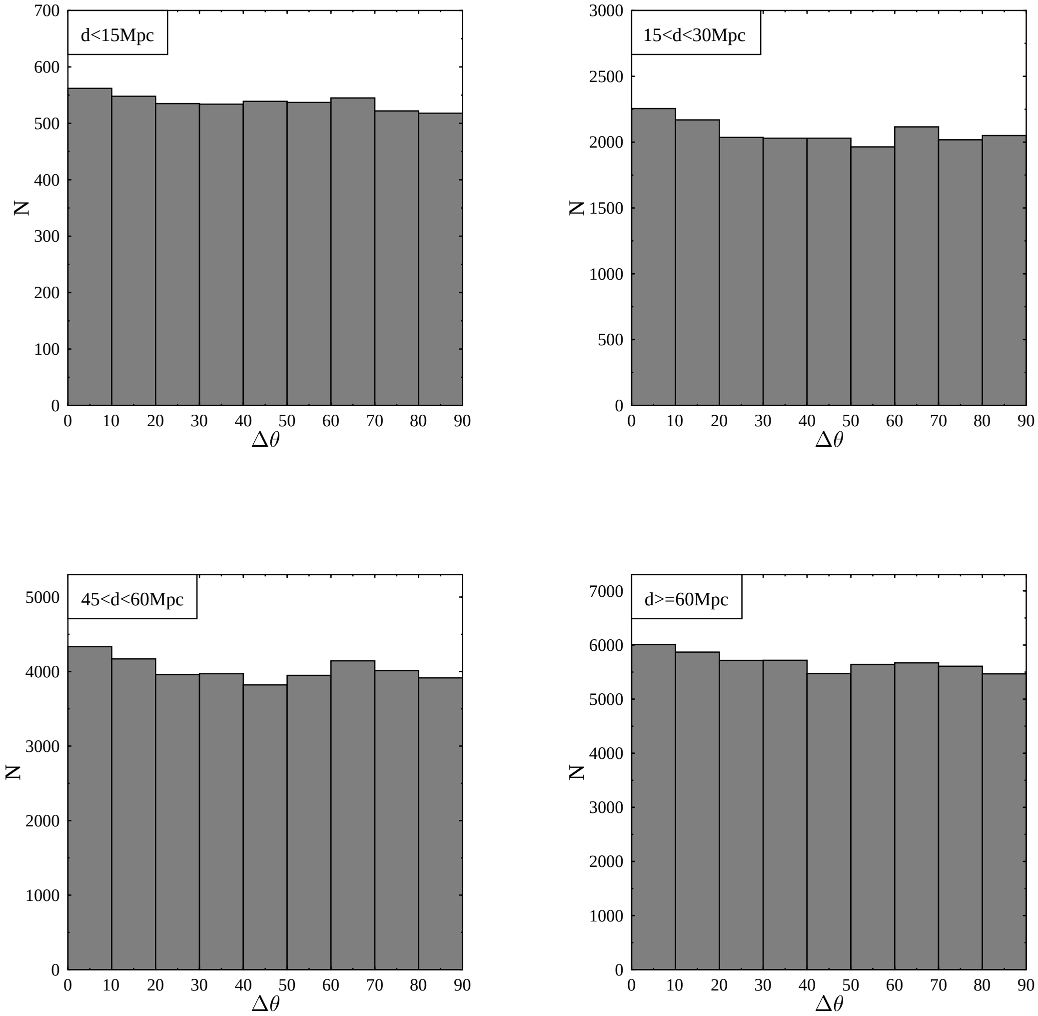

Fig. 3.— The distribution of the $\Delta\theta$ angle for 377 Abell clusters. The difference among group distances are given in the left upper corner of each panel.