The evolution of nearby galaxy clusters

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ABSTRACT

On the basis of 377 Abell galaxy clusters with $z < 0.2$, constituting statistically uniform sample we determined the cluster ellipticity using three methods. We found weak correlation between cluster redshift and ellipticity. It is shown that this correlation is due to neither the assumed position of the cluster center nor method of the galaxy cluster ellipticity determination. This result is consistent with the reports of the recent evolution of galaxy clusters.

1. Observational data

In present study we check the ellipticity - redshift dependence using well determined sample of Abell galaxy clusters. We selected all Abell clusters with galactic latitude $|b| > 40°$ and Richness Class≥ 1. In such way we had 1238 clusters. Taking for these clusters redshifts (Struble & Rood 1999) we selected 377 Abell clusters with $z < 0.2$. Area covering 2Mpc x 2Mpc on the sky has been extracted from DSS ($h = 0.75$, $q_0 = 0.5$). Each cluster contains objects within the magnitude range m_3, $m_3 + 3$. The catalogues were obtained applying FOCAS package to DSS and visually verify. Each catalogue contains information about right ascension, declination, x and y position on the photographic plate, instrumental magnitude, area of object, ellipticity and galaxy position angle. The ellipticity and the orientation of each object were computed from the second - order momenta of the intensity distribution. The equatorial coordinates of galaxies for the epoch 2000 have been computed from the rectangular coordinates of DSS scans.

2. Method of analysis and result

It is well known that ellipticity depends also on the distance from the cluster center (e.g. Carter & Metcalfe 1980, Flin 1984, Trevese et al. 1992, Struble & Ftaclas 1994). Therefore,

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we calculated the ellipticity in circular rings for the distance range 0.5Mpc to 2Mpc with the step 0.25Mpc. We used four methods for cluster center determination: the mean position of all galaxies, the brightest galaxy in the cluster, the third brightest galaxy in the cluster and median of galaxy coordinates. For four methods of center determination we checked the ellipticity - radius dependence. The cluster ellipticity were computed using three methods: covariance ellipse (Carter & Metcalfe 1980), the tensor method based on the inertia tensor (Theije et al. 1995) and Plionis's method (Plionis 2002). For four galaxy cluster center determinations we calculated ellipticities at distances described above applying covariance and tensor method. Moreover we studied the distribution of cluster ellipticities obtained using these methods. The Kolmogorov - Smirnow test at significance level $\alpha = 0.01$ confirmed the similarity of the distribution in the cases of covariance and tensor methods. Fig.1 gives the investigated dependence of the cluster ellipticity on redshift when the tensor method was applied. Each plot gives the dependence for different distance from the cluster center R. The correlation between parameters was calculated and the result of the straight line fitting is located above the corresponding panel. For each cluster in the cases of covariance ellipse and tensor method we calculated also the mean values of the cluster ellipticity averaging individual values al all distances R from the cluster center. The result, together with statistical coefficient is depicted in Fig.2. Fig.3. shows the ellipticity - redshift relation when Plionis's method was used.

3. Discussion and Conclusions

1. It is clear that the ellipticity of galaxy cluster is not well defined parameter. It depends on the assumed cluster center, as well as it is changing with the radius. Going outside from the cluster center the ellipticity diminishes. Moreover, the run and ellipticity values are not the same for various centers.

2. The cluster ellipticity depends on the applied method too.

3. Because our main goal is to study redshift - ellipticity dependence we checked the influence of factors mentioned above. We show that in the case of individual galaxy clusters the two above mentioned factors are important, but the general trend of the increase of galaxy ellipticity with redshift is observed.

4. The mean evolution rate for three methods are: $de/dz = 0.22$ for covariance ellipse method, $de/dz = 0.58$ for tensor method and $de/dz = 0.53$ for Plionis method. The weakest evolution is observed for covariance ellipse method. This method is not very sensitive to the shape determination. The rate de/dz for other two methods is similar and we can find

stronger effect of redshift - cluster ellipticity relation. In the case of fixed values of the distance from the cluster center R (Fig.1) we also noted the evolution of ellipticity. The evolution coefficients are the highest for radius $R = 0.5$Mpc in both methods (covariance ellipse $de/dz = 0.32$, and $de/dz = 0.98$ for tensor method) and the smallest for $R = 1$Mpc and $R = 2$Mpc ($de/dz = 0.1$ and $de/dz = 0.48$ respectively).

5. This study confirms the dependence of galaxy cluster ellipticity on redshift, so it is in agreement with expectations of the low - Ω_m Universe.

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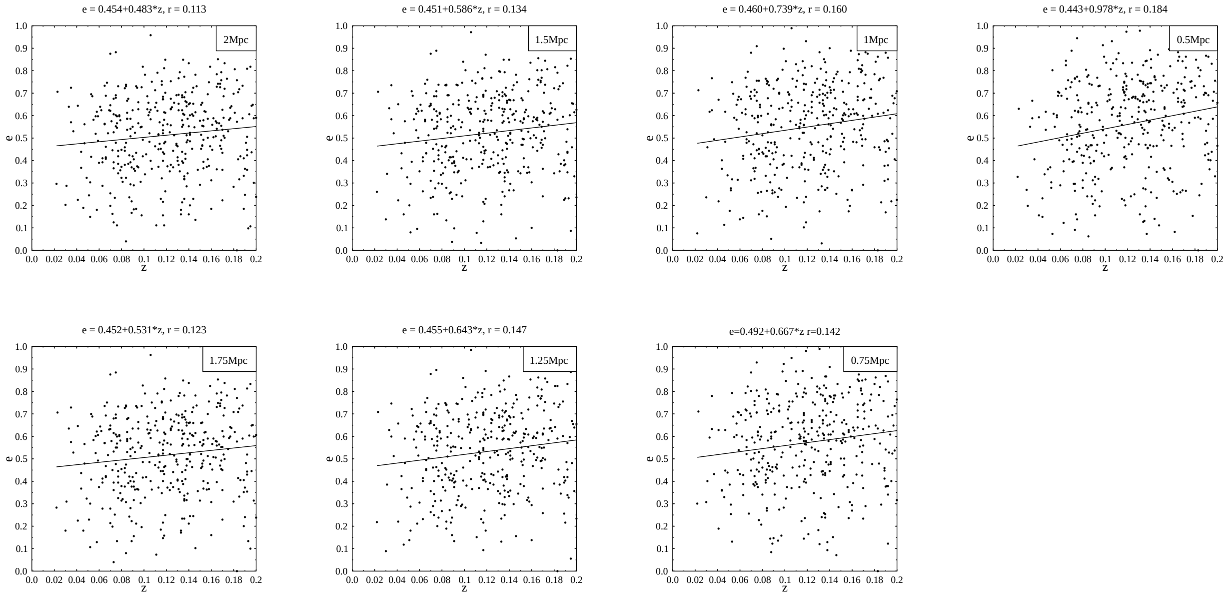

Fig. 1.— The dependence of the cluster ellipticity on redshift in the case of the tensor method for fixed values R from the cluster center

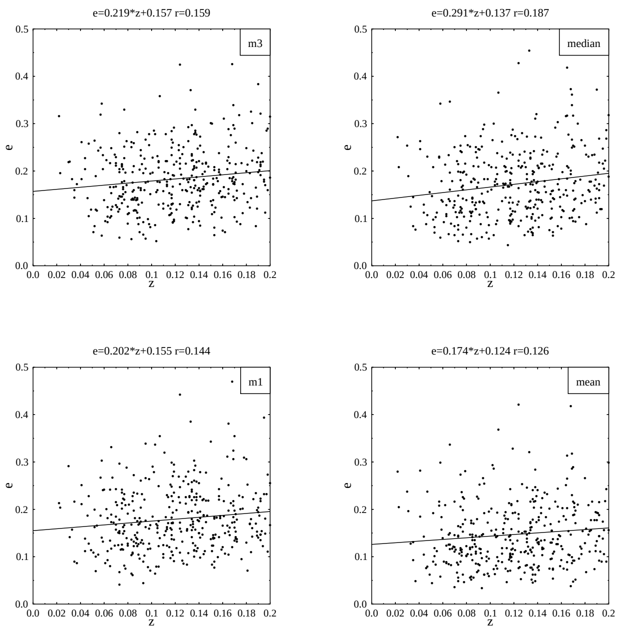

Fig. 2.— The relation between mean ellipticity and redshift for covariance and tensor methods calculated for four various centers

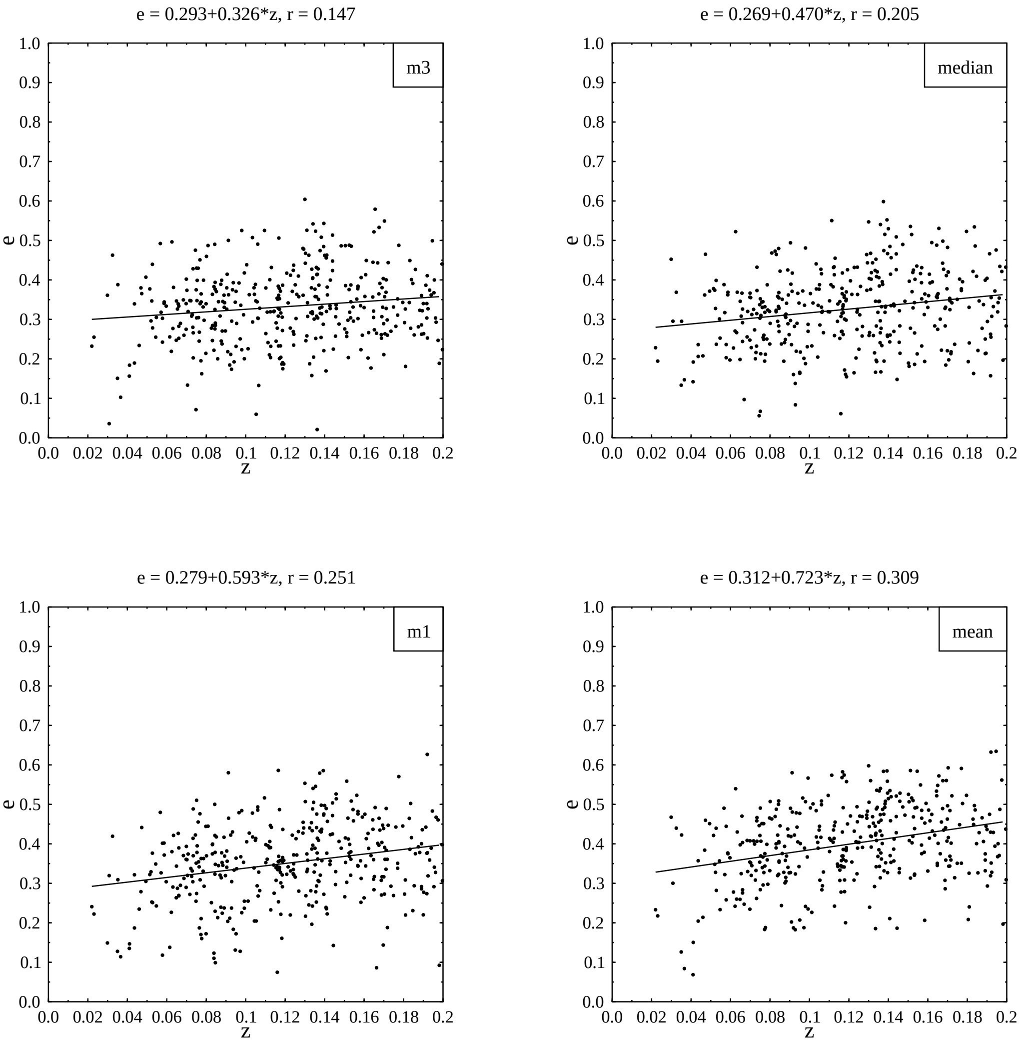

Fig. 3.— The relation between mean ellipticity and redshift for Plionis's method calculated for various centers