The Fundamental Plane and Other Scaling Relations of Groups and Clusters of Galaxies

F.G. Kopylova[1], A.I. Kopylov[1]

E-mail: *flera@sao.ru*

We present the scaling relations of galaxy groups and clusters derived by using archival data from SDSS and 2MASX catalogs. We applied a new method for determining the size of the galaxy clusters [1] and their effective radius as the radius enclosing half of the galaxies (not half of the luminosity), since the luminosity of the brightest galaxies in groups can exceed 50% of the total luminosity of the group. The characteristics $\log L_K$, $\log R_e$ and $\log \sigma_{200}$ obtained for 94 systems of galaxies ($0.012 < z < 0.09$ and Virgo) define the Fundamental Plane (FP) relation with the scatter of 0.15 that is similar in slope to the FP of clusters of galaxies measured in [2, 3] by other methods and in other bands. We find that the FP of the stellar population of the systems of galaxies in the near-infrared has the slope $L_K \propto R_e^{0.70\pm0.13}\sigma^{1.34\pm0.13}$ and the FP of the hot gas does $L_X \propto R_e^{1.15\pm0.39}\sigma^{2.56\pm0.40}$ or $L_K \propto R_e^{0.81\pm0.21} \log L_X^{0.30\pm0.05}$.

Dynamical and photometric parameters of the early-type galaxies (central stellar velocity dispersion σ, effective radius R_e, mean surface brightness $\langle I_e \rangle$) form the so-called Fundamental Plane [4, 5]. The FP of the galaxies has a significantly lower scatter compared with the earlier obtained Faber–Jackson relation between luminosity and velocity dispersion and the Kormendy relation between surface brightness and radius. Originally, the FP of clusters of galaxies was constructed using observational characteristics of a sample of 16 rich clusters of galaxies ($z < 0.2$) [2]. As a result of fitting, with residuals being minimized in L, they obtained the FP in the form: $L \propto R_e^{0.89\pm0.15}\sigma^{1.28\pm0.11}$.

To construct the scaling relations of our systems of galaxies (see the resume above), we used the one-dimensional dispersion of radial velocities of galaxies σ_{200} found within the radius R_{200}, near-infrared luminosity L_K, and effective radius R_e, enclosing half of galaxies, derived from the observed cumulative galaxy distribution considered as a function of the squared cluster-centric distance. The X-ray luminosity is based on the published data, e.g. [6, 7, 8]. We have found that the form of the FP of groups and clusters is consistent with the FP of the early-type galaxies (Fig. 1) defined in the same way. But they have different zero-points occurring, as we established, due to the difference in the mass-to-light ratio of galaxies and systems of galaxies. The fourth variable, the mass-to-light ratio, included by us in our FP reduces the scatter by about 16% [9], but the slope of the FP does not change.

[1] Special Astrophysical Observatory RAS, Nizhnij Arkhyz, Russia

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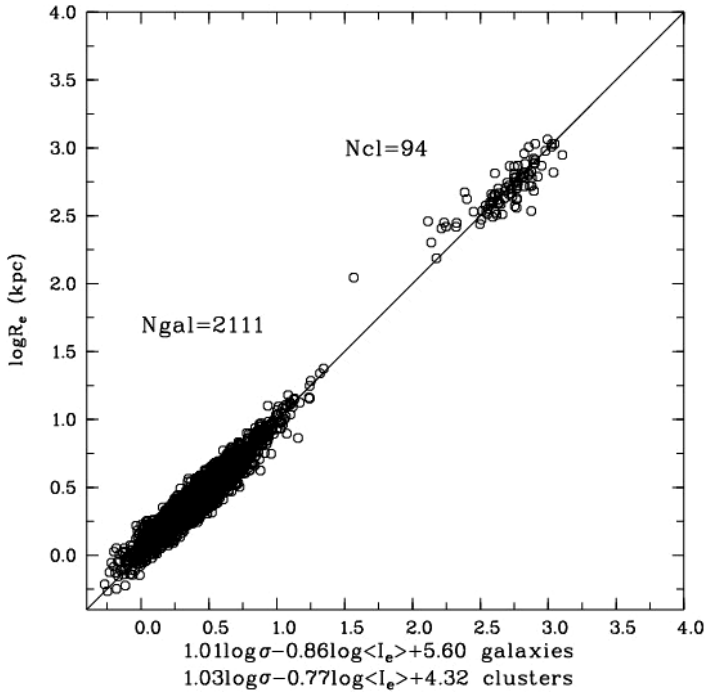

Figure 1: The Fundamental Plane of the galaxies, groups and clusters of galaxies. The effective radius R_e is the radius enclosing half of the galaxies.

References

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