THE FUNDAMENTAL PLANE OF GROUPS AND CLUSTERS OF GALAXIES

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Gravitationally bound systems such as globular clusters, early-type galaxies, and clusters of galaxies lie on the fundamental plane (FP), relating size (effective radius), luminosity (average surface brightness) and velocity dispersion. The FP for early-type galaxies was built by Djorgovski & Davis, 1987, ApJ, 313, 59 and others. To determine these properties for 94 groups and clusters of galaxies we constructed profiles of cumulative distribution of number of galaxies as a function of squared clustercentric distance. Such profiles (Kopylov, Kopylova, 2015, AstBu, 70, 243) allowed us to determine the virialized part of the systems, to evaluate the background corrected luminosity and effective radius which contains a half of the total galaxies. The work is done using archival data from SDSS, 2MASX, and NED catalogues. Obtained by the method of least squares the optical FP of groups and clusters of galaxies in K_s-band along the longest side of the plane, the effective radius, is: $L_K \propto R_e^{0.70\pm0.13}\sigma^{1.34\pm0.13}$.

The X-ray FP is:

$L_X \propto R_e^{1.15\pm0.39}\sigma^{2.56\pm0.40}$.

The scatter in the X-ray FP are 2.5 times more than those obtained for the optical FP. The opical FP of system of galaxies is consistent with FP of early-type galaxies. A comparison with the FP of clusters of galaxies (Schaeffer et.al., 1993, MNRAS, L21, 263, D'Onofrio et al., 2013, AN, 334, 373) showed that the form and coefficients are almost the same within the errors. The existence of the cluster FP relation implies a regularity in their formation processes: galaxies must have formed or fallen in all clusters in a similar way. Also any trend of cluster mass-to-light ratio must be taken into account for a proper interpretation of the observed scaling relations. Other cluster scaling relations obtained by us are:

$L_K \propto R_e^{0.74}\sigma^{1.69}(M_X/L_K)^{0.28}$;

$L_K \propto \sigma^{1.79\pm0.11}$, the Faber-Jackson relation;

$L_K \propto R_e^{1.62\pm0.15}$, the KR.

Fig.1

The FP (in SDSS r-band) derived by the regression relative to the $\log L_r$ for 2111 early-type galaxies (red circles) from rich clusters and for 94 groups and clusters of galaxies (blue circles) ($z < 0.1$). This edge-on view is along the longest side of the plane, the effective radius.

Fig.2

The optical FP for groups and clusters of galaxies shown along the $\log L_K$. The rms scatter of the FP is 0.15.

Fig.3

The combined X-ray and optical FP for groups and clusters of galaxies shown along the $\log L_K$. The rms scatter of the FP is 0.19.

Fig.1

Ncl=94

Ngal=2111

$\log R_e$ (kpc)

$1.01\log\sigma - 0.86\log\langle I_e\rangle + 5.14$ galaxies
$1.03\log\sigma - 0.77\log\langle I_e\rangle + 3.90$ clusters

Fig.2

$\log\ L/L_\odot(M_K < -21^m)$

$0.70\log R_e(N/2) + 1.34\log\sigma + 7.08$

Fig.3

$\log\ L/L_\odot(M_K < -21^m)$

$0.81\log R_e(N/2) + 0.30\log L_X - 2.77$