Structure of Galaxy Groups and Clusters and Measurement of Their Masses

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We report the results of measurement and comparison of masses for a sample of 29 groups and clusters of galaxies ($z < 0.1$). We use the SDSS archive data to determine dynamical masses from the one-dimensional dispersion of radial velocities for virialized regions of radii R_{200} and $R_{\rm e}$. Our method for determination of effective radius of galaxy systems from the cumulative distribution of the number of galaxies depending on squared cluster-centric distance allowed us to estimate masses $M_{1/2}$ (within $R_{\rm e}$), which are related to the masses enclosed within R_{200}: $M_{200} \sim 1.65\, M_{1/2}$. A comparison of the inferred dynamic masses and the hydrostatic masses determined from the radiation of hot gas in galaxy groups and clusters (based on published data) led us to conclude that the inferred masses for the main sample of 21 groups and clusters agree to within 12%.

Galaxy clusters are the largest gravitationally bound structures in the Universe. About 80–90% of their mass is in the form of dark matter, and the remaining mass is represented by baryons, most of which (10–20%) are in the form of hot diffuse plasma with $T > 10^7$ K (it is the main component of the inner medium of galaxy clusters), which emits mostly in the X-ray domain. Galaxies contribute only several percent of the cluster mass. The mass function of galaxy clusters is sensitive to cosmological parameters, turning the measurement of their accurate masses a challenging task [1].

The aim of this study is to measure the dynamical masses of 29 groups and clusters of galaxies using various methods, intercompare the resulting mass estimates, and compare them with the masses inferred from the X-ray emission of gas. We have determined dynamical masses M_{200} of the clusters from the dispersion of radial velocities of galaxies assuming that the systems are in virial equilibrium. The empirical radius R_{200} and the group or cluster mass can be estimated by the equations: $R_{200} = \sqrt{3}\sigma/(10H(z))$ Mpc [2] and $M_{200} = 3G^{-1}R_{200}\sigma^2$, where $H(z)$ is the Hubble constant at redshift z, and G is the gravitational constant. The masses $M_{1/2}$ of spheroidal galaxies and clusters of galaxies with measured dispersions of radial velocities can be determined for the characteristic radius, which is approximately equal to the 3D radius of the galaxy containing half of its luminosity. Thus, the virial mass of the cluster is measured, which is independent of the anisotropy of galaxy velocities,

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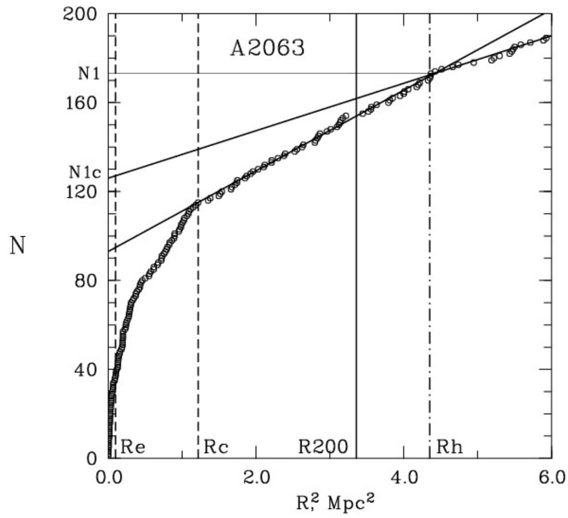

Figure 1: Cumulative distribution of the number of galaxies as a function of squared clustercentric distance for the A 2063. The solid vertical line indicates the R_{200}. The dashed-and-dotted line indicates the R_h radius bounding the cluster: core (c) and halo (h); the dashed lines indicate the R_c and R_e radii. The two solid lines show the distribution of galaxies located inside the halos of groups and clusters and the distribution of galaxies that do not belong to the cluster.

$M_{1/2} = 3G^{-1}\,\sigma^2_{1/2}\,r_{1/2}$ [3], where $r_{1/2} = 4/3R_e$ (R_e is the effective radius containing half of the luminosity emitted by the cluster or group).

We use a graphical method to determine the size and the number of galaxies of the system (R_h, N_h) and its effective radius containing half of the near-infrared luminosity (Fig. 1).

Our main results are as follows (see also [4]):

1. We developed an empirical method for identifying galaxy groups or clusters from the observed cumulative distribution of the number of galaxies depending on squared cluster-centric distance.
2. We show that the dynamic masses of galaxy groups and clusters for regions of radii R_{200} and R_e are related as $M_{200} \sim 1.65\,M_{1/2}$.
3. The inferred dynamic (M_{200} and $1.65\,M_{1/2}$) and hydrostatic ($M_{X,200}$) masses for 21 groups and clusters of galaxies agree with each other to within 12%.

References

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