AN UPPER LIMIT ON THE MASSES OF GALAXIES IN CLUSTERS

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Clusters of galaxies are believed to be dominated by dark matter. Some of this matter is presumably bound to galaxies in the form of massive halos, while the rest moves freely in the cluster potential well. The exact fraction of dark matter bound to galaxies is an important datum for models of cluster evolution, since time scales for orbital decay, merging, stripping, etc. are sensitive functions of galaxy mass. In this study we attempt to put a firm upper limit on the amount of dark matter associated with galaxies in clusters, by calculating the response of a galaxy with an initially massive halo to the *mean* tidal field produced by the overall cluster potential well. If the velocity dispersions of galactic halos are roughly equal to those of luminous galaxies, σ_g, it is easy to show that the truncated mass of a spherical galaxy orbiting near the center of a cluster is roughly $m_g \approx G^{-1}\sigma_g^3\sigma_c^{-1}R_c \approx 4 \times 10^{11}M_\odot$, where σ_c and R_c are the cluster velocity dispersion and core radius. The precise value of m_g must depend on the orbital geometry, as well as the number of pericenter passages since cluster formation, among other factors.

We used a novel scheme for following the evolution of a galaxy in a cluster potential well. At every time step, the force field in the neighborhood of the galaxy was assumed to be the sum of two components: a fixed component from the cluster, and a time-varying component from the galaxy. In order to be able to evolve a large number of galaxies over a Hubble time, we assumed that each galaxy remained *spherical*, and computed its potential on a radial grid fixed on its center. The accuracy of the spherical code was verified in a few cases by comparison with a more realistic, quadrupole-order code. The cluster dark-matter density was assumed to follow an analytic King model, i.e. $\rho_c(R) = \rho_c(0)\left(1 + R^2/R_c^2\right)^{-3/2}$. The initial galaxy mass for the runs shown below was $m_i = 2\,G^{-1}\sigma_g^3\sigma_c^{-1}R_c$, roughly twice the predicted, tidally truncated value; the initial galaxy velocity dispersion was 0.3 times that of the cluster. All galaxies were evolved until a time of $T = 50R_c\sigma_c^{-1} \approx 10^{10}$ years for a typical rich cluster.

The Table gives final galaxy masses in units of $G^{-1}\sigma_g^3\sigma_c^{-1}R_c$, as a function of pericenter and apocenter distances in units of R_c. Mass loss continues throughout a Hubble time, but most takes place during the first few billion years. Galaxies on elongated, high-energy orbits appear to be the most strongly truncated, although the dependence of final mass on orbital parameters does not appear to be great. Scaling our results to galaxies of various luminosities gives an upper limit of $\sim 15\%$ for the fraction of the dark matter bound to galaxies in a cluster like Coma. This value is consistent with upper limits based on mass segregation arguments.

R_{peri}	0	1	0	1	2	0	1	2	3
R_{apo}	1	1	2	2	2	3	3	3	3
m_g	1.17	1.33	0.81	1.10	1.25	0.88	1.08	1.29	1.47

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