ARE CLUSTER ELLIPTICALS FORMED BY MERGERS?

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A major argument against forming ellipticals by mergers is that the large velocity dispersions of clusters preclude slow enough encouters that may lead to mergers (Ostriker 1980). We show below that the observed morphology-density relation in clusters (Postman & Geller 1984) is consistent with the formation of cluster ellipticals by mergers, using a simple "chemical evolution" calculation embedded in the standard spherical cosmological infall scenario.

We consider disk (spiral and lenticular) and non-disk (elliptical) galaxies, and assume the three reactions $D + D \rightarrow E$, $D + E \rightarrow E$, and $E + E \rightarrow E$, where D and E refer to disk and elliptical galaxies, respectively. We assume that all three reactions occur with the same rate $k = \int_0^\infty \pi p^2(v,t) v f(v,t) dv$, where the maximum impact-parameter for mergers, p, is a decreasing linear function of relative velocity v, as given in Roos & Norman (1979). One then finds that the merger rate $k \sim r_h^2 v_g K(x)$, where r_h and v_g are the galaxy half-mass radii and internal velocity dispersions, respectively, K is a dimensionless function, and $x \sim v_g/v_{\rm cl}$, where $v_{\rm cl}$ is the local cluster velocity dispersion.

For a cosmological density parameter $\Omega_0 \leq 1$, spherical cosmological infall is well described by the simple model of adjacent shells of matter piling up onto one another. Whatever the assumed cluster velocity anisotropy profile, the local cluster velocity dispersion varies as a self-similar function of radius, smoothly truncated at the radius where there is no more shell crossing. Neglecting these surface effects, the variation *in time* of the local cluster velocity dispersion is constant. Then assuming that the tidal field of the cluster is strong enough to set the sizes of the infalling galaxies to their tidal limit, then the rate k is time independent. In the "pile-up" infall model the mass-density is constant in time, and with the assumption of tidally fixed galaxy sizes (hence masses), we arrive at the conclusion that the total merger rate nk (n being the local number density of galaxies) is constant in time.

From Postman & Geller, we adopt a field elliptical abundance of 0.1 and a mean galaxy luminosity $M_B = -17.5 + 5\log h$, which yields $v_g = 188\,{\rm km\,s^{-1}}$ and $hr_h = 15[(m/l)_g/100h]\,{\rm kpc}$. We then obtain a present-day morphology-density relation that matches well the observed one, if $hr_h = 12\,{\rm kpc}$, corresponding to the reasonable $(m/l)_g = 80\,h$, regardless of Ω_0, the maximum redshift of galaxy formation and the cluster M/L.

Thus, 1) *the local merger rate in a cluster is constant*; 2) *the observed cluster morphology-density relation is well explained by a model where ellipticals are formed by mergers.*

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