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Constraints on Elliptical Galaxy Formation from Dry Mergers

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Recent observations suggest that dissipationless mergers of elliptical galaxies build up the population of massive early-type galaxies (Bell *et al.* 2004; Faber *et al.* 2006). This type of merger is observed in galaxy clusters (Tran *et al.* 2005) and predicted by semi-analytic models which find mass assembly times significantly later than star-formation times for the most massive elliptical galaxies (de Lucia & Blaizot 2006). Here, we use a semi-analytic model of minor mergers of dark matter halos to examine the role of dry minor mergers in elliptical galaxy formation.

We model two merging galaxies and define each galaxy with two components: a dark matter halo with a Navarro-Frenk-White density profile and a stellar bulge with a Hernquist density profile. To simulate a merger, we initially separate the satellite and host galaxy by the host's virial radius and allow the satellite to spiral in under the effects of gravity. Two major physical processes governing the dynamics of the galaxy merger are dynamical friction and tidal mass loss, both of which we model analytically. We end the merger when the two galaxies are separated by the sum of their stellar half-mass radii (typically a few kpc), where we define them to have formed a remnant. Our merger models are in good agreement with numerical simulations of minor mergers of galaxies, such as those of Boylan-Kolchin & Ma (2006) and Taffoni *et al.* (2003).

From a sample of 140,000 galaxies from the Sloan Digital Sky Survey, Shen *et al.* (2003) fit a power law $R \propto M^{\alpha}$ to describe the dependence of galaxy size on stellar mass. They find that early-type galaxies follow this relation for $\alpha = 0.56$, and in matching this result with our merger models, we constrain the baryon to dark matter ratio of progenitor galaxies in a 10:1 zero initial energy merger to roughly 5% to 9%.

Recent observations also suggest that the $R \propto M^{\alpha}$ relation is steeper for more massive galaxies up to BCGs than for normal elliptical galaxies, and we model mergers in group environments to determine if this difference in formation history might be the cause of the steepening. We find roughly no difference in the steepness of the $R \propto M^{\alpha}$ relation for group mergers, indicating that the observed steepening is not a trivial consequence of different mergers in different environments. Work is in progress to understand the conditions under which steepening does occur.

References

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