The Galaxy-Halo Connection

Joel Primack (UCSC)

Abstract: Galaxies form within dark matter halos, so it is natural to expect that the properties of the forming galaxies will to some extent reflect those of their host halos. This talk will describe recent work clarifying this galaxy-halo connection. I will start by summarizing what we know about the evolving population of dark matter halos from large cosmological simulations, based on the standard ΛCDM cosmological framework [1]. I'll then explain how we connect halos with galaxies by matching their abundances, how halo mass accretion is related to galaxy star formation [2], and how adding a little extra information about galaxies allows us to use halo demographics to address galaxy size growth, the effects of major and minor mergers, and the relation between galaxy central surface density and the quenching of star formation [3]. If we assume that abundance matching of galaxy luminosity at various wavebands is independent of environmental density, we can predict the observed distribution of galaxy luminosity and mass with environmental density [4]. We have found that dark matter halo properties depend on environmental density in interesting ways -- for example, we found that the halo spin parameter λ decreases significantly in low-density regions [5], and this allows us to see whether λ controls galaxy size [6] and may help explain why galaxy radii scale with their dark matter halo radii as observed out to redshift $z \sim 3$ [7]. We find that halo properties (except for orientation) in the nearby universe are controlled by their local environmental density, regardless of whether a halo is in a void, wall, or filament of the cosmic web [8]. Although the mass of most dark matter halos increases with time, a significant fraction of halos lose mass. We find that the main causes of halo mass loss are tidal stripping and halo relaxation after mergers, and we determine how these phenomena affect halo properties such as spin and shape [9]. Finally, by comparing Hubble Space Telescope observations with high-resolution hydrodynamic galaxy simulations, we find that the observed prolate ("pickle") shapes of low-mass forming galaxies at redshifts $z \gtrsim 1$ reflect the prolate shapes of their dark matter halos [10,11].

References

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