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From the Outskirts of Galaxies to Intra Cluster Light

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Abstract. We use the Magneticum Pathfinder (**www.magneticum.org**) hydro-dynamical cosmological simulation set to investigate the buildup of the stellar component within cosmological structures. These simulations result in the self-consistent formation of ICM, AGNs, and both spheroidal and disk galaxy populations, which properly reproduce the observed properties.

Keywords. hydrodynamics, numerical, galaxy: formation, clusters, dynamics

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1. The Magneticum Pathfinder Simultions

The simulations treat metal-dependent radiative cooling, heating from a uniform time-dependent ultraviolet background, star formation and the chemo-energetic evolution of the stellar population as traced by SNIa, SNII and AGB stars with the associated feedback processes, as well as formation and evolution of super-massive black holes and the associated quasar and radio-mode feedback processes. For a detailed description see Dolag et al. (in prep), Hirschmann et al. (2014) and Teklu et al. (2015).

2. Intra Cluster Light

In galaxy clusters, the velocities of the stars in the cD galaxy and the diffuse component (DSC) have dynamically well-distinct kinematic distributions, which can be well characterized by two Maxwellian distributions. While the velocity dispersion of the stars in the cD galaxy represents the central mass of the stars, the velocity dispersion of the DSC is much larger and typically reaches almost the values of the overall dark matter halo, see Dolag et al. (2010) for the predictions from hydrodynamical simulations and

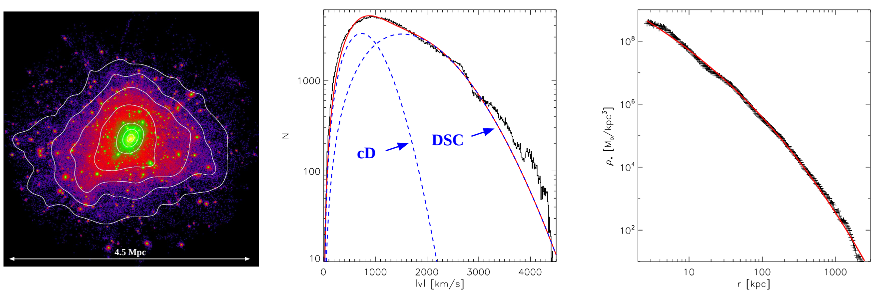

Figure 1. Stellar density map of the most massive cluster (color coded). The white contours show the diffuse stellar component plus the central galaxy (cD) after subtracting the stars from the other cluster member galaxies. *Middle:* Distribution of the stellar velocities for the DSC and the cD galaxy (black histogram) with a double Maxwellian fit (red line). *Right:* Radial stellar density profile of DSC and cD (black symbols) with a single Sérsic profile fit (red line).

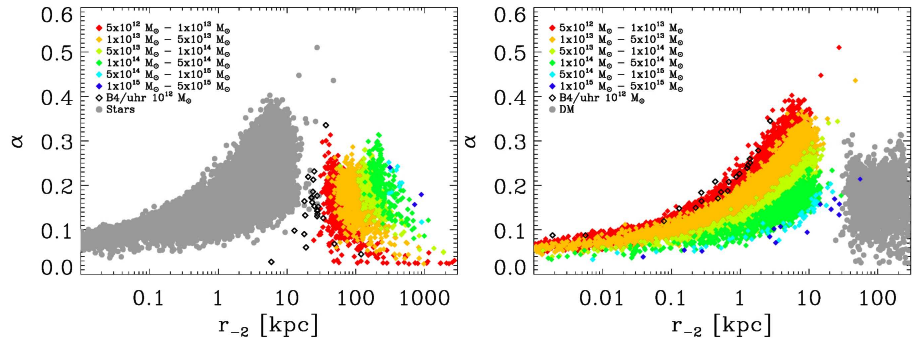

Figure 2. Best-fit parameters for Einasto profile fits to the outer halos of galaxies, ranging from halo masses of $10^{12} M_{\odot}$ up to massive clusters with several times $10^{15} M_{\odot}$ (color coded). *Left panel:* Fits to the dark matter components. *Right panel:* Fits to the stellar outer halos.

Bender et al. (2015) or Longobardi et al. (2015) for observational confirmation. The density distributions, however, can in most cases be described by a single, radial profile and only in rare cases need to be described by the sum of two components with different radial shapes.

3. Universality of Outer Stellar Halo Profiles

Our simulations show that not only the dark matter radial density profile but also the outer stellar radial density profiles can be well described by a universal profile. This profile, $\rho(r) = \rho_{-2}\ \exp\left\{-\frac{2}{\alpha}\ \left[\ \left(\frac{r}{r_{-2}}\right)^{\alpha} - 1\right]\ \right\}$ (where α controls the curvature and ρ_{-2} is the density and r_{-2} the radius at which $\rho(r) \propto r^{-2}$), is also known as Einasto profile Retana-Montenegro et al. 2012. We find that the fitting parameters of those Einasto profiles are not independent but closely correlated for fixed total mass, from galaxies to clusters, as can be seen as fig. 2. This universal profile exists over a large range of total masses and is found to be independent of galaxy type. This strongly indicates that the formation of the outer stellar halo is dominated by accretion, which occurs in all halos.

4. Conclusions

The amount of curvature of the outer stellar halo density profile is therefore a diagnostic for the merging history of galaxies. Since the Einasto profile is strongly curved at the outskirts, it can locally always be represented by a power law. For Milky Way mass halos, for example, we find slopes in the range of −3 to −6 at radii between 40–100kpc, as done in observations (e.g. Deason et al. (2014)). This can well explain the observed differences between the stellar outer halo density profiles observed for Milky Way and Andromeda.

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