The General Assembly of Galaxy Halos: Structure, Origin and Evolution
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Formation and evolution of sub-galactic structures in a cosmological context

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Abstract. In this study, we aim to trace formation of the primordial globular cluster, ultra faint dwarf galaxy, and ultra compact dwarf in a cosmological context of a high-resolution hydrodynamic zoom-in simulation. We show that the baryon-dominated systems have experienced more interactions with the mini halos before infalling to the main halo.

Keywords. Galaxy: formation, methods: numerical, globular clusters: general

1. Simulation

Our goal is to trace formation of sub-galactic structures in ΛCDM cosmology. For this, we modify GADGET-3 (Springel 2005) code to include realistic baryonic physics. We calculate radiative heating/cooling rates using CLODY90 package (Ferland *et al.* 1998). Global reionization is considered in a whole simulation volume at redshift $z_{re} = 8.9$ (Haardt & Madau 1996). We assume that dense gas clouds of $n_H > 0.014\text{cm}^3$ are shielded from the universal UV radiation (Sawala *et al.* 2010). Stars form when gas particles satisfy star formation criteria of Saitoh *et al.* (2008).

Initial conditions are generated by a MUSIC software (Hahn & Abel 2011). Selected cosmological parameters are $\Omega_m = 0.3, \Omega_\Lambda = 0.7, \Omega_b = 0.048$, and $h = 0.68$. We perform a zoom-in simulation of a cubic box of side length of 1 Mpc/h with 170 million dark matter (DM) and gas particles from redshift $z = 49$ to $z = 1.765$. Particle mass for the DM and gas is $M_{DM} \approx 4 \times 10^3$ M$_\odot$, and $M_{gas} \approx 8 \times 10^2$ M$_\odot$, respectively.

In order to identify halos, we used an Amiga Halo Finder software (AHF; Knollmann & Knebe 2009). The main halo is a dwarf galaxy sized halo with a virial mass of $M_{vir} = 5.75 \times 10^9$ M$_\odot$/h at $z = 1.765$. We find 75 mini halos around the main halo, which can be formation sites for the globular clusters, ultra compact dwarfs, and the ultra faint dwarfs. They satisfy the following conditions: (1) the maximum baryon mass during the evolution is between 10^5 M$_\odot$ and 10^8M$_\odot$ (2) they are located in virial radius of main halo at $z = 1.765$.

2. Evolution of mini halos

We classify the mini halos with their closest distances to the main halo center as follows: R$_{peri}$/R$_{vir}$ >0.15 mini halos belong to Group 1, while that of R$_{peri}$/R$_{vir}$ <0.15 for Group 2, where R$_{peri}$ and R$_{vir}$ is a pericenter distance and a viral radius of the main halo, respectively.

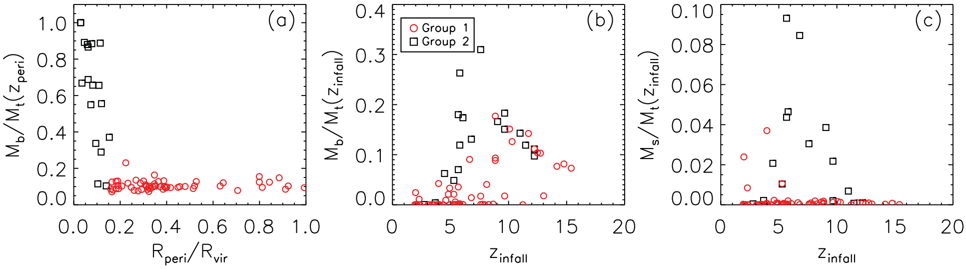

Figure 1. Diagram of baryon mass fraction and scaled distance to the main halo center (a). Baryon (or star) mass fractions of the mini halos when they infall to the main halo (b) and (c). The red diamonds and the black squares indicate the Group 1 and Group 2, respectively.

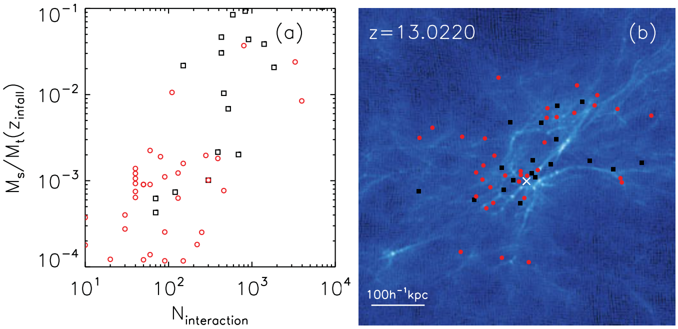

Figure 2. Diagram of star mass fractions of the mini halos when they infall to the main halo and number of interactions with the other mini halos (a). Distribution of mini halos on filamentary structures around the main halo (b).

We find that the Group 2 tends to lose more DM halos by stronger tidal force of the main halos (see Fig. 1a). They can evolve to the more baryon-dominated systems compared to the Group 1. The high baryon fraction of the Group 2 is also appeared even when the mini halos infall to the main halo (see Fig. 1b and 1c). Therefore, we infer that the different evolutionary tendency between the Groups is originated by the different environments that the mini halos have experienced before the infall.

To quantify the environmental effects on the mini halos before the infall, we count how many times the mini halos experience interactions with the other mini halos ($N_{interactions}$). Figure 2 shows that more interactions trigger the more stars formation, and that the Group 2 experiences the more interactions compared to the Group 1. Figure 2b shows that the mini halos of the Group 2 are preferentially located along the filamentary structures, where interactions between mini halos are more frequent.

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