Galaxy Formation: Mergers vs Gas Accretion

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Introduction

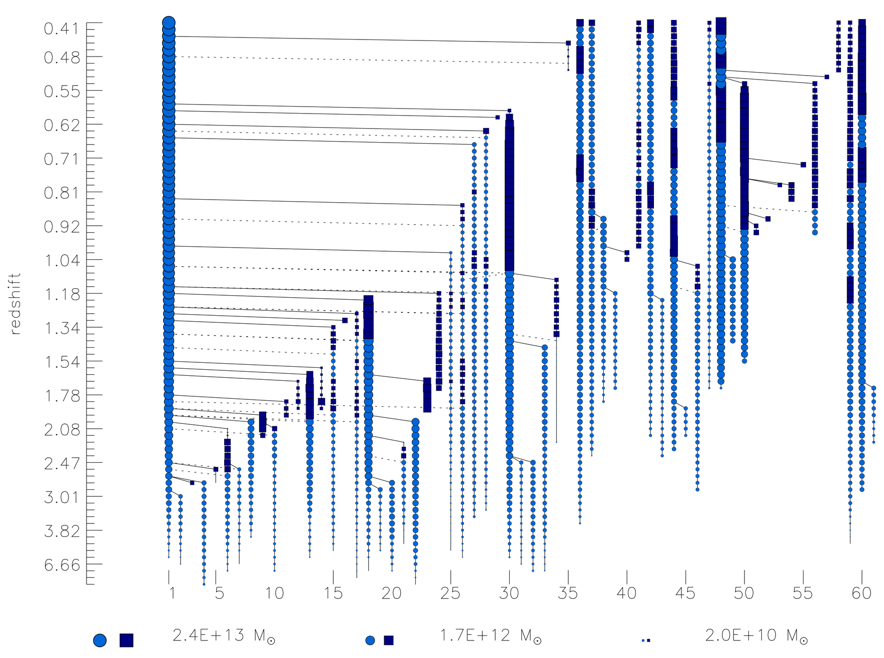
According to the hierarchical model, small galaxies form first and merge together to form bigger objects. In parallel, galaxies assemble their mass through accretion from cosmic filaments. Recently, the increased spatial resolution of the cosmological simulations have emphasized that a large fraction of cold gas can be accreted by galaxies. In order to compare the role of the two phenomena and the corresponding star formation history, one has to detect the structures in the numerical simulations and to follow them in time, by building a merger tree.

Method

We used AdaptaHOP (Aubert et al. 2004) to detect the DM haloes and subhaloes hierarchy. We also used AdaptaHOP to detect the baryonic galaxies (Fig. 1, Fig.2), with a better suited set of parameters.
We built the merger tree (Tweed et al. 2009) for dark matter and the baryonic merger tree of galaxies and their satellites: for a considered galaxy at final output, we trace back the main progenitor down to the output where it appears. Then at each timestep, we count the number of particles that enter the main galaxy through several modes:

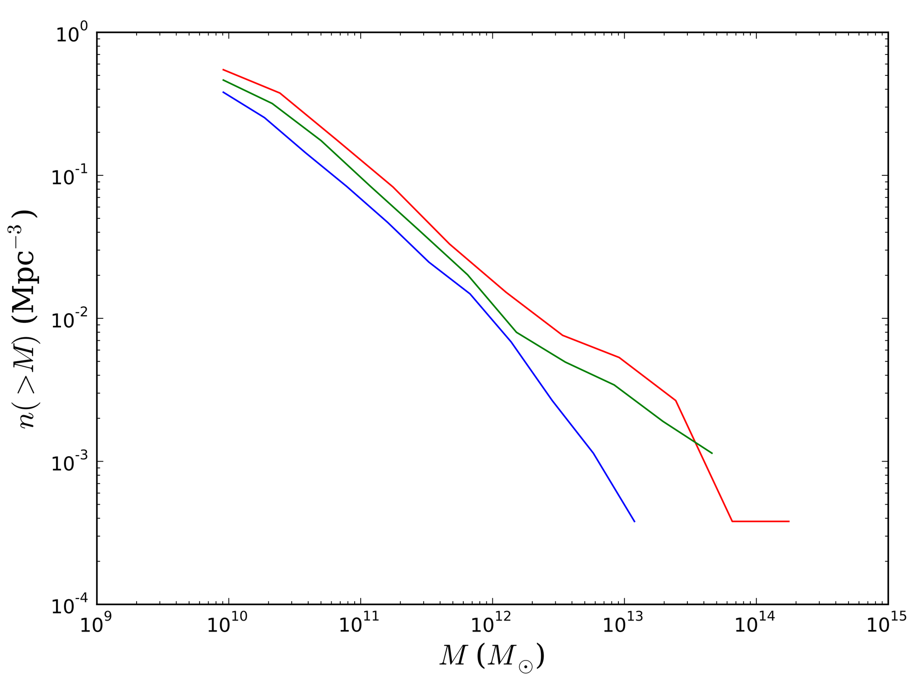
- smooth accretion: particles from the background that enter the main galaxy
- mergers: particles that come from another structure
- evaporation: particles leaving the main progenitor of the structure for the background
- fragmentation: particles leaving the main pogenitor for another structure

Merger Tree



Merger tree of the main galaxy of the simulation. Bright blue circles are galaxies and dark blue squares are satellites.

Mass function



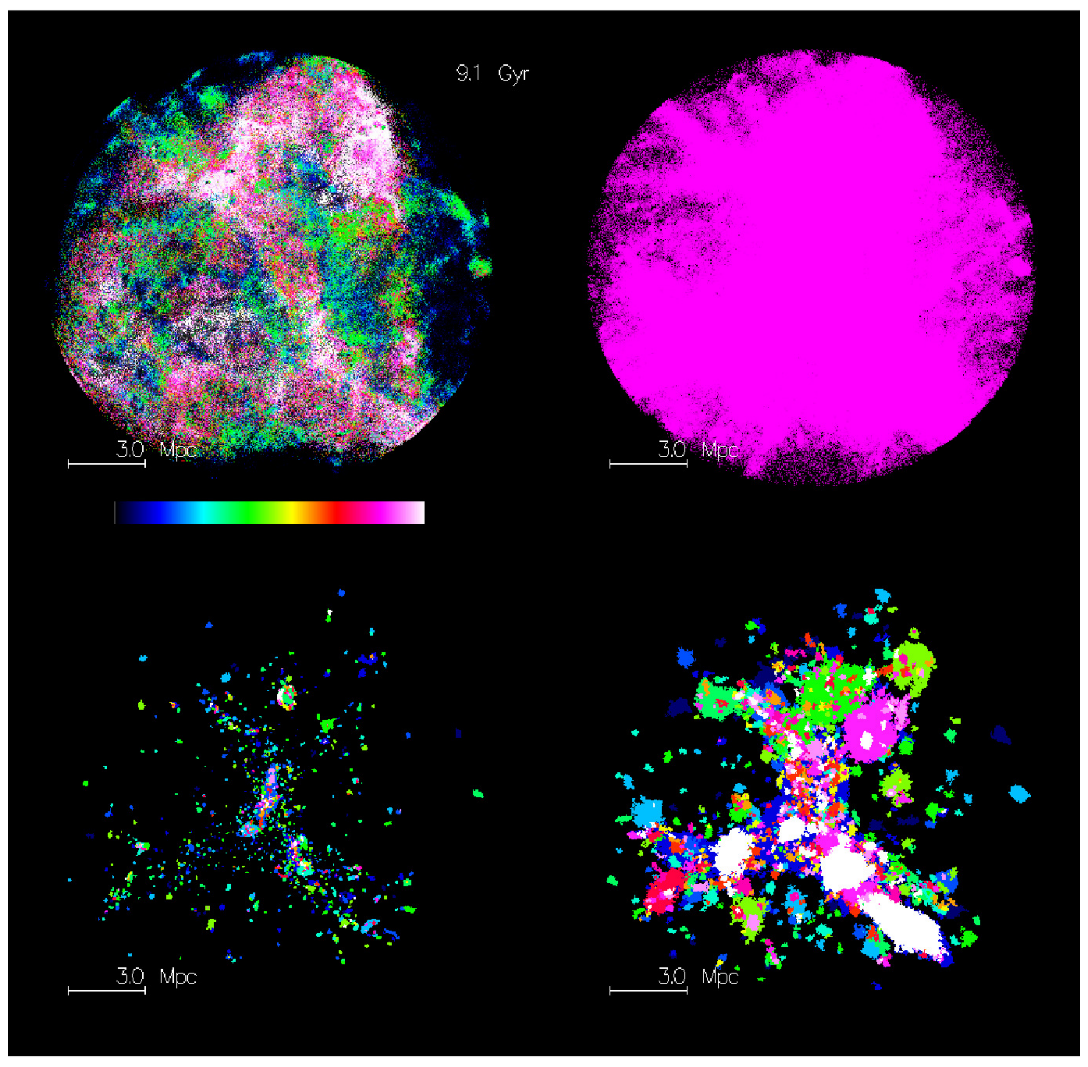
Mass function of DM haloes and subhaloes at $t = 3, 6,$ and 9 Gyr, respectively in blue, green and red. The hierarchical formation can be seen.

Simulations

We used a TreeSPH multizoom simulations (Semelin & Combes 2005), starting with a low resolution cosmological simulation, and resimulating a region centred on a cluster. At level 3, the density of the box at the last output ($t = 9.1$ Gyr) is $\sim 14 \times \bar{\rho}$. We used WMAP3 cosmological parameters $(\Omega_b, \Omega_m, \Omega_\Lambda, h, \sigma_8, n) = (0.0418, 0.24, 0.76, 0.73, 0.75, 0.95)$. Simulation parameters:

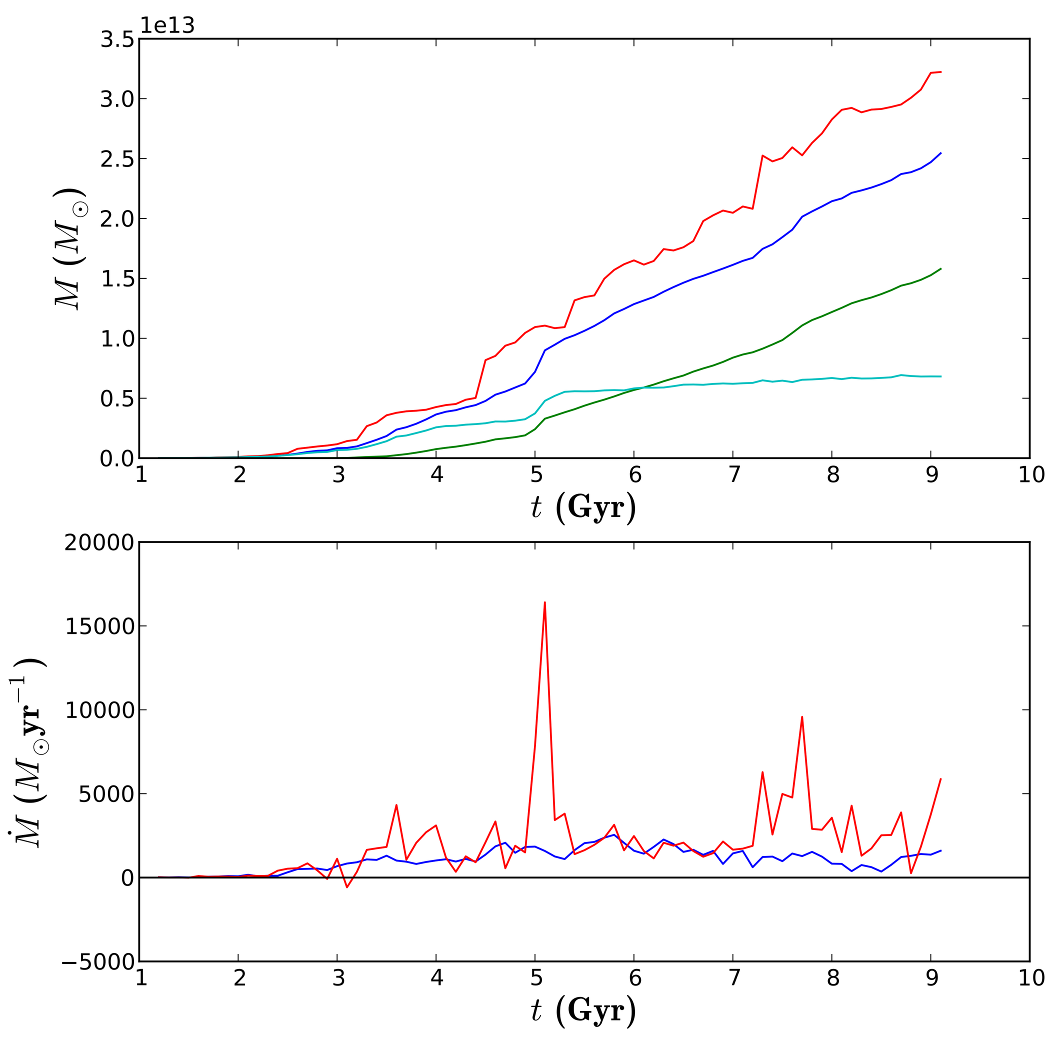
Zoom level	0	1	2	3
m_{DM} ($M_\odot$)	7.27×10^{10}	9.09×10^{9}	1.14×10^{9}	1.42×10^{8}
m_b ($M_\odot$)	1.54×10^{10}	1.93×10^{9}	2.41×10^{8}	3.01×10^{7}
L_{box} (Mpc)	137.0	68.49	34.25	17.12
Δt (Gyr)	0.2	0.2	0.2	0.1
z_{end}	0	0	0	0.46

Detected structures



Detected structures: Left: gas color coded by temperature, and stars; Right: Dark matter. Lower pannels: left: detected galaxies and satellites. Right: detected haloes and subhaloes.

Mass History

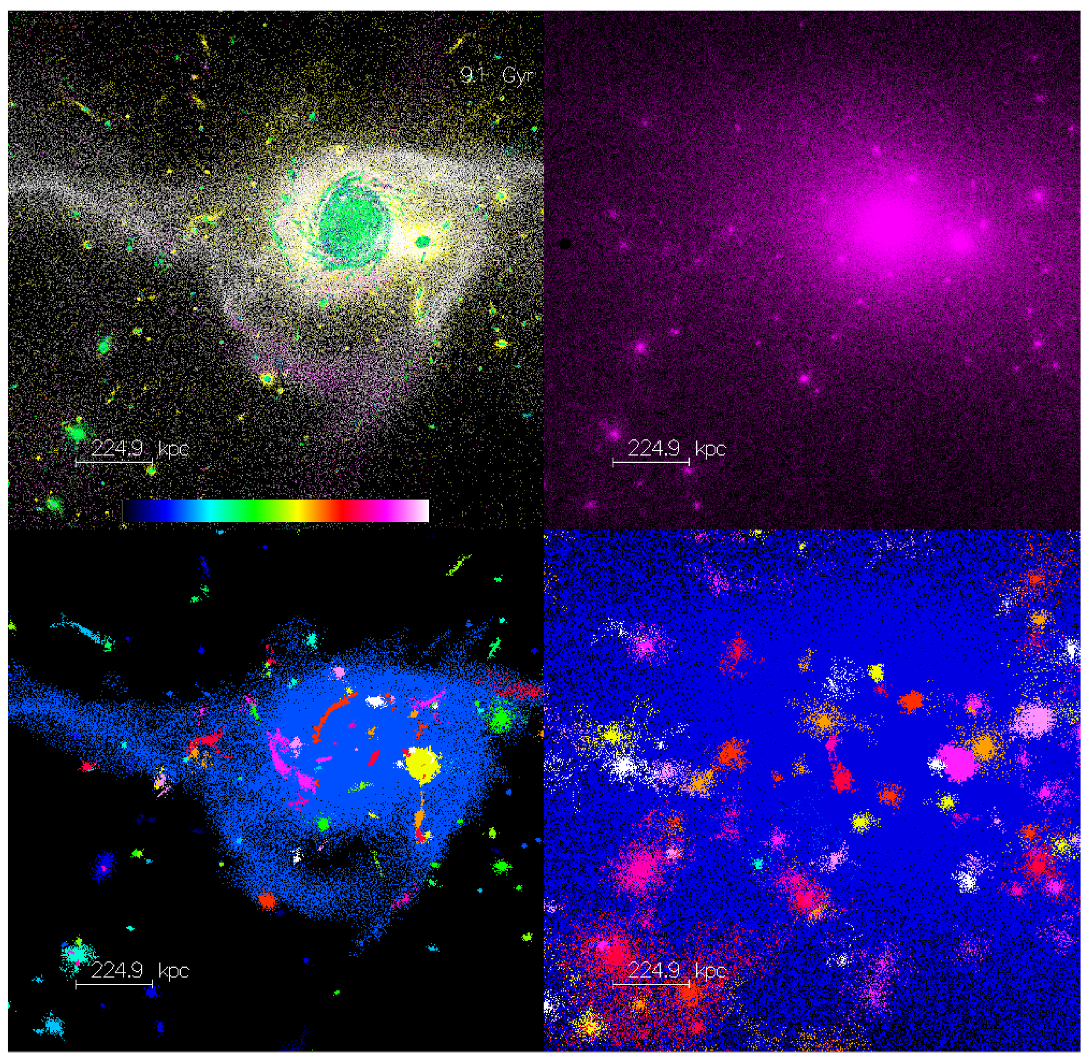


Mass history of the central galaxy of our most massive halo. Upper pannel: blue: Galaxy mass; red: galaxy + satellites mass; green: stellar mass; cyan: gas mass. Lower pannel: mass origin. Red: merger from another (sub)structure, blue: smooth accretion from background.

Outlooks

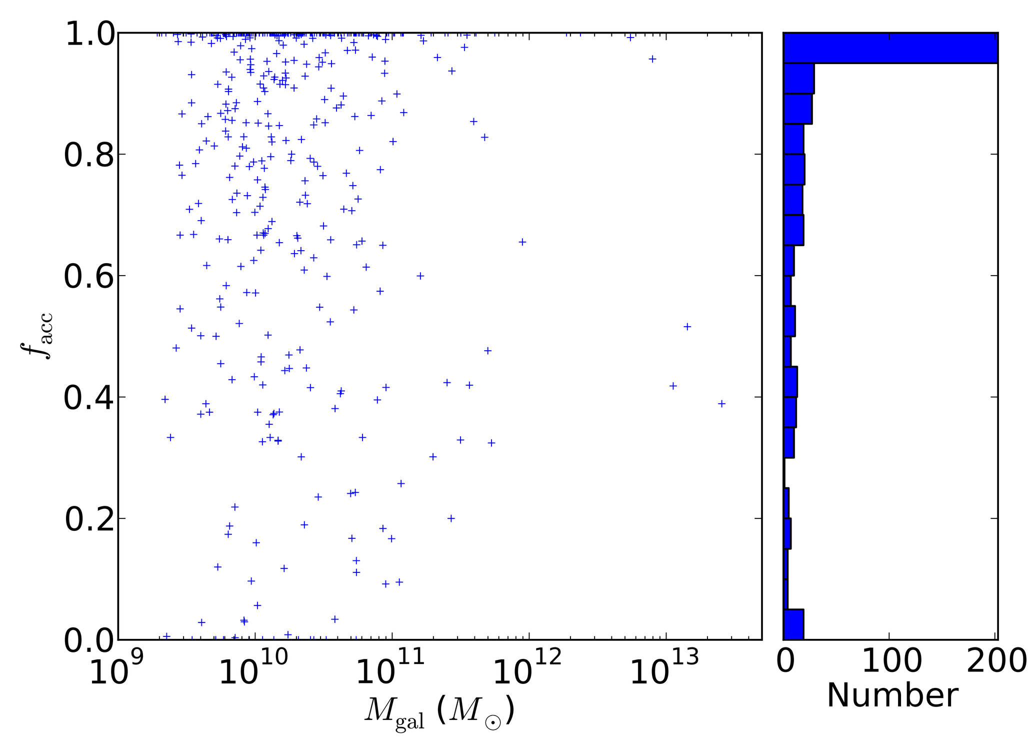
Mass assembly is dominated by smooth accretion. For further work, we aim at running new simulations including more physics, and study the effects of varying star formation and feedback.

Detected structures (zoom)



Zoom on a massive halo.

Accretion Fraction



Accretion fraction versus galaxy mass, and the corresponding histogram.
Mass assembly is clearly dominated by smooth gas accretion, with a mean accretion fraction of 77%. We computed the accretion fraction for galaxies that could be tracked back in time from before 7 Gyr.

References

References

Aubert, D., Pichon, C., & Colombi, S. 2004, MNRAS, 352, 376

Semelin, B. & Combes, F. 2005, A&A, 441, 55 (SC05)

Tweed, D., Devriendt, J., Blaizot, J., Colombi, S., & Slyz, A. 2009, A&A, 506, 647 (T09)