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Star formation in Milky Way progenitors

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Abstract. We investigate the close relation between cosmic star formation and the properties of galaxies in terms of feedback processes acting through cosmic space and time. By adopting the recent semi-analytical model of galaxy formation GAMESH we explore how chemical and radiative feedback connect the current generation of galaxies with their candidate progenitors as suggested by a series of recent observations.

1. Introduction

Through the cosmic times of Milky Way (MW) evolution, stars shape the chemical composition of its interstellar medium (ISM). The transfer of their ionizing radiation also changes the temperature and ionization of the galactic and intergalactic gas.

Successive generations of MW progenitors evolve then regulated by chemical and radiative feedback acting between cosmic environments. Here we summarize the results of a MW formation simulation performed with the GAMESH pipeline (Graziani et al. 2015, 2017) computing the baryonic evolution of dark matter halos with self-consistent feedback and calibrated star formation efficiency; this ensures that the observed values of stellar, gas and metal mass ($M_\star$, M_{gas}, M_Z) are correctly reproduced.

With this approach the stellar population histories of the MW and its companion galaxies can be explored in a great level of detail.

2. Results

The simulated galaxies surrounding the MW halo satisfy a large number of observational constrains: the galaxy main sequence (see Fig. 1), the mass-metallicity and the fundamental plane of metallicity (FPZ, Hunt et al. 2016a) relations in $0 < z < 4$. They also show a correct stellar mass evolution of candidate MW progenitors in $0 < z < 2.5$: the most massive progenitors lie in fact within a factor of 2 of the main sequence, while the predicted SFRs of low stellar mass galaxies show an increasing scatter due to the rising importance of feedback effects. Since these scaling relations originate from the interplay between gas accretion, star formation and supernova-driven outflows, we conclude that GAMESH is capable to produce results consistent with observations.

The stellar populations of both mini- and Lyα cooling haloes have been investigated (see Fig. 2). At all but the highest redshifts, the SFR of the MW is dominated by a multiplicity of galaxies found in Lyα cooling haloes and hosting Pop II stars. They are progressively accreted in the major branch of the MW merger

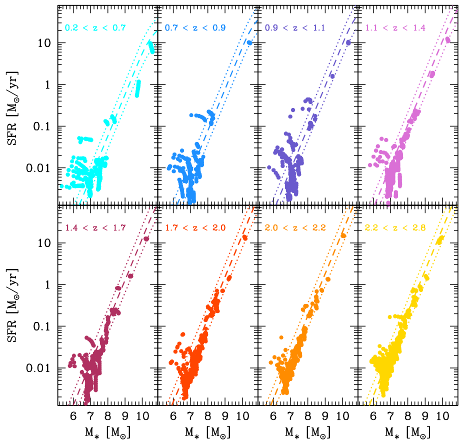

Fig. 1. SFR as a function of $M_\star$ of progenitors in different $z-$bins. In each panel, the points represent simulated systems while the dashed line shows the analytic fit to the main sequence taken from Schreiber et al. (2015). The dotted lines are a factor of 2 above/below the fit.

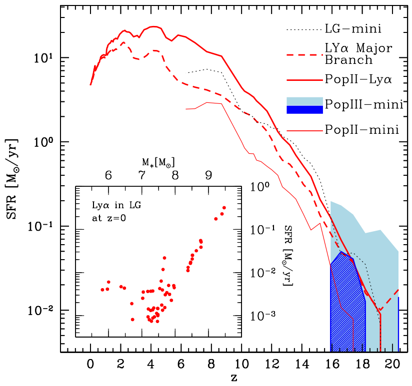

Fig. 2. Pop II stars SFR along the MW merger tree in mini-halos (solid thin red line) and in Lyα-cooling halos (solid thick red line). The dotted black line indicates the SFR history in the LG. Pop III SFRs are indicated by shaded areas (blue (in MW) and cyan in LG). SFR along the MW main branch is in red dashed line. The panel inset shows the SFR vs $M_\star$ of LG galaxies in Lyα-cooling halos at $z = 0$.

tree, which provides the dominant contribution to the SFR at $z < 1$.

The cumulative contribution of star-forming mini-haloes in the Local Group (LG) is comparable to the SFR along the MW merger tree at $z > 6$, indicating that these systems provide an important source of ionizing photons. Due to efficient metal enrichment, Pop III stars are confined to form in the smallest mini-haloes at $z > 16$, and their formation rate is larger in the LG than along the MW merger tree.

This suggests that traces of Pop III star formation are not confined to the MW and its satellites but may be found in external galaxies of the LG, although their detection may be challenging even for the next generation of telescopes. While a large number of high-z mini-haloes (having old stellar populations) are dragged into the MW, many systems forming at $z < 6$ can survive in the local Universe but, due to the effect of radiative feedback, they remain dark because they can never experienced star formation.

The interested reader can find more details and results in de Bennassuti et al. 2014; Graziani et al. 2017.

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