Star formation through cosmic space and time as traced by Milky Way progenitors

Abstract

In this work the close relation between cosmic star formation and the proportion of galaxies is investigated in terms of feedback processes acting through cosmic space and time. Stars not only shape the chemical composition of the intergalactic ISM by enriching the surrounding gas with metals but the transfer of their ionizing radiation also changes the temperature and ionization status of the interstellar and intergalactic medium. Successive generations of galaxies evolve in redshift regulated by chemical and radiative feedback processes acting between cosmic environments.

By adopting the recent semi-analytical model of galaxy formation GAMESH [3,5] we explore how chemical and radiative feedback act through cosmic times and connect the current generation of galaxies with their candidate progenitors as suggested by a series of recent observations.

GAMESH: Star formation along galaxy evolution

The galaxy formation run has been performed with GAMESH [3,5] interfacing a dark matter simulation of an isolated Milky Way (MW)-like halo and its Local Group (LG), with a customized version of the data-constrained, semi-analytic model GAMEZE [2,3] and the latest version of the radiative transfer code CRASH [4].

The GAMESH pipeline is then capable to:

- compute the baryonic evolution of the dark matter haloes by accounting for different chemical and radiative feedback schemes.
- ensure that the MW galaxy has the observed values of stellar, gas, and metal mass: $M_*$, $M_{	ext{MW}}$, $M_2$ at $z=0$.

$\rightarrow$ The stellar populations of the Milky Way galaxy can be described with a great level of accuracy.

$\rightarrow$ The stellar population histories of the MW and its companion galaxies can be explored in detail.

Results: Local Group properties

Properties of simulated galaxies surrounding the MW have been verified to satisfy a large number of observational constraints: the observed galaxy main sequence, the mass-metallicity and the fundamental plane of metallicity relations $0 < c < 4$. GAMESH also accounts for the correct stellar mass evolution of candidate MW progenitors $0 < c < 2.5$.

Conclusions:

- The observed galaxies among the MW progenitors lie within a factor of 2 of the galaxy main sequence $c=0.5 \rightarrow 2$.
- The predicted SFRs show an increasing scatter towards low stellar mass due to the rising importance of feedback effects.
- Agreement found with the distribution of the simulated galaxies with the observed SFR $c_2=0.5 \rightarrow 2$.

Since these scaling relations are believed to originate from the interplay between gas accretion, star formation and supernova-driven outflows, we conclude that the description of these physical processes obtained by GAMESH leads to results consistent with observations.

Results: star formation rates

GAMESH can study the evolution of galaxy populations and their stellar content by following the standard classification of DM haloes in mini- and Lyman cooling haloes. Within each family it follows, in particular, their SFR, $M_*$, $M_2$ along the redshift.

At all but the highest redshifts, the SFR of the MW is dominated by a multiplicity of galaxies in Lyman cooling haloes, hosting Pop II stars. These systems are progressively accreted by the major branches of the MW merger tree, which provides the dominant contribution to the SFR at $z \lesssim 1$. The cumulative contribution of star-forming galaxies in the LG is comparable to the SFR along the MW merger tree at $z \lesssim 1$, indicating that these systems provide an important source of feedback phenomena.

Due to efficient metal enrichment, Pop II stars are formed to form in the earliest epoch at $z \sim 10$ and their formation rate is larger in the LG than along the MW merger tree. This suggests that most of the Pop III stars are not contained by the LG and its satellites but may be found in external galaxies of the LG, although their detection may be challenging even for the next generations of telescopes.

We find that a large number of multi-scale having old stellar populations are dropped into the MW or can survive in the Local Universe. However, due to the effect of radiation feedback, multi-scales collapsing at $z \sim 10$ remain instead dark because they never experienced star formation.

References

[8] Schneider C., et al., 2013, AIP, 175, 47A

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