Galaxy Evolution and Feedback across Different Environments
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ORAL CONTRIBUTIONS

The gas-loss evolution in dwarf spheroidal galaxies: Supernova feedback and environment effects in the case of the local group galaxy Ursa Minor

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Abstract. In this work, we performed two distinct non-cosmological, three-dimensional hydrodynamic simulations that evolved the gas component of a galaxy similar to the classical dwarf spheroidal galaxy Ursa Minor. Both simulations take into account types II and Ia supernovae feedback constrained by chemical evolution models, while ram-pressure stripping mechanism is added into one of them considering an intergalactic medium and a galactic velocity that resemble what is observed nowadays for the Ursa Minor galaxy. Our results show no difference in the amount of gas left inside the galaxy until 400 Myr of evolution. Moreover, the ram-pressure wind was stalled and inverted by thermal pressure of the interstellar medium and supernovae feedback during the same interval.

Keywords. galaxies: dwarf — galaxies: evolution — galaxies: individual(Ursa Minor) — galaxies: ISM — hydrodynamics — methods: numerical

1. Methodology and Results

Similarly to other classical dwarf spheroidal (dSph) galaxies, Ursa Minor is deficient in neutral gas (e.g., Grcevich & Putman 2009). The physical mechanism responsible for gas depletion in dwarf galaxies is still a matter of debate in the literature. Supernovae feedback and ram-pressure stripping are examples of mechanisms that are able of removing gas from those objects (e.g., Wada & Venkatesan 2003; Emerick *et al.* 2016).

In this work, we explored types II and Ia supernovae feedback and ram-pressure stripping as the main drivers of the gas loss in a dSph galaxy similar to Ursa Minor. We used the numerical code PLUTO (Mignone *et al.* 2007) to solve the three-dimensional hydrodynamic (HD) differential equations that rules the temporal evolution of the gas content. We simulated a cubic region of 3 kpc $\times$ 3 kpc $\times$ 3 kpc, using a non-uniform grid with 330 points in each Cartesian direction (spatial resolution of 8 pc per cell between -0.6 and 0.6 kpc and 10 pc per cell elsewhere). We also adopted a cored, static dark matter gravitational potential due to an isothermal, spherically symmetric mass density profile in our simulations.

Types II and Ia SNe rates used in our two simulations were derived by a chemical evolution model that reproduces several observational constraints (abundances of several chemical elements, the present day gas mass, stellar metallicity distribution) of the dSph galaxy Ursa Minor (Lanfranchi & Matteucci 2004, 2007). In addition, our code follows

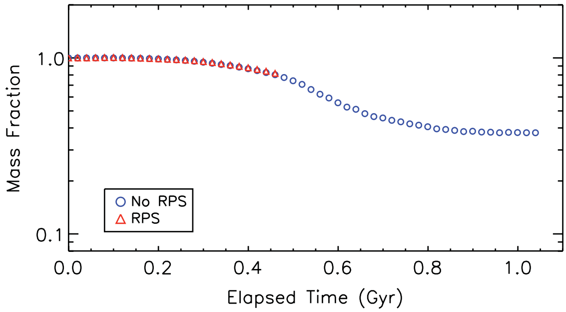

Figure 1. Comparison between the gas mass fraction inside the tidal radius of the galaxy for the HD simulations with SN feedback and with SN feedback plus RP stripping.

independently types II and Ia SNe rates, in contrast to Caproni *et al.* (2017). In the HD simulation including ram-pressure stripping (RPS), a wind is injected with constant number density of 10^{-4} cm^{-3} (in agreement with Grcevich & Putman 2009) and speed of 162 km s^{-1} (in agreement with Piatek *et al.* 2005) from one of the computational boundaries. This mimics roughly the motion of Ursa Minor through the hot halo of the Milky Way.

2. Final remarks

The two three-dimensional HD simulations discussed in this work were performed using one of the highest numerical resolution in the context of dSph galaxies up to now. SN feedback injects turbulence into ISM, producing complex patterns in the gas motions, as reported in previous works (e.g., Ruiz *et al.* 2013; Caproni *et al.* 2015; Caproni *et al.* 2017). No difference in the gas losses was detected during the first 400 Myr of evolution when RPS is included in the calculations, as it can be seen in Fig. 1. Moreover, RP wind is stalled and inverted by thermal pressure of the interstellar medium and SN feedback during the same first 400 Myr of evolution. Additional HD simulations have been conducted to verify whether this behavior is sustained for a longer period of time.

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