Surprising Inefficiency of Ram Pressure Stripping and Feedback in Quenching the Lowest Mass Milky Way Satellites

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Background:

The fraction of quenched satellites approaches unity for the lowest mass galaxies ($M < 10^7 M_\odot$). These galaxies are expected to rapidly and efficiently quench via ram pressure stripping (RPS) within ~ 2 Gyr of infall into their host halo. Supernova (SN) feedback is expected to play an important role in setting the quenching efficiency in these tiny galaxies.

We produce the first high resolution, 3D hydro simulations of RPS and feedback in these tiny galaxies, asking:

1. Can RPS + feedback alone be responsible for rapid quenching?
2. How important is feedback in stripping these low mass galaxies?

Methods:

We place two model dwarf galaxies in a wind-tunnel, simulating stripping with the AMR hydro code FLASH. These galaxies experience a constant $P_{\text{ram}}$ for 2 Gyr, using $n_{\text{h}} = 10^{-4} \text{ cm}^{-3}$ and a wind velocity of either 200 km $s^{-1}$ or 400 km $s^{-1}$. Our fiducial resolution is 9 pc; a resolution study shows this is sufficient to resolve both RPS and stripping from KH instabilities (see paper).

**Core collapse (CC) SNe explode stochastically with a rate that scales with the cold gas content. Type 1a SNe explode at a constant rate throughout the simulation. We compare stripping without feedback, and with an increased SN rate. Initial conditions are given in Table 1.**

Results and Conclusion:

Our results are given in Figure 1, summarized below. Example density slices of the simulated galaxies are shown in Figure 2.

1. Ram pressure can cause substantial mass loss for these low mass dwarfs, but cannot produce stripping within 2 Gyr in the more realistic 200 km $s^{-1}$ simulations. Additional physics must be at play.
2. SN feedback plays a minimal role in aiding quenching. SNe are too infrequent in these low star formation rate galaxies.

To account for the expected quenching timescales, some combination of additional physics, including tidal stripping of the satellite by the host, satellite-satellite tidal interactions during infall, cosmologically accurate orbits, or a denser / clumpier Milky Way halo may be necessary to account for the expected stripping times (see paper).

**Table 1:** Initial conditions for dwarf galaxy models for an initially isothermal gas distribution in HSE with a static NFW DM profile. \textsuperscript{*}Core collapse SN rates evolve with galaxy gas mass

<table>
<thead>
<tr>
<th>Property</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_{\text{DM}}$ ($r &lt; 300 \text{pc}$)</td>
<td>$7.3 \times 10^6 M_\odot$</td>
<td>$7.3 \times 10^6 M_\odot$</td>
</tr>
<tr>
<td>$r_{\text{scale}}$</td>
<td>$795 \text{ pc}$</td>
<td>$795 \text{ pc}$</td>
</tr>
<tr>
<td>$M_{\text{gas}}$</td>
<td>$2.4 \times 10^5 M_\odot$</td>
<td>$4.7 \times 10^5 M_\odot$</td>
</tr>
<tr>
<td>$n_{\text{o,gas}}$</td>
<td>$0.75 \text{ cm}^{-3}$</td>
<td>$1.50 \text{ cm}^{-3}$</td>
</tr>
<tr>
<td>$r_{\text{gas}}$</td>
<td>$300 \text{ pc}$</td>
<td>$300 \text{ pc}$</td>
</tr>
<tr>
<td>$T_{\text{o,gas}}$</td>
<td>$6000 \text{ K}$</td>
<td>$6000 \text{ K}$</td>
</tr>
<tr>
<td>CC SNR\textsuperscript{**}</td>
<td>$\frac{1}{52} \text{ Myr}^{-1}$</td>
<td>$\frac{1}{7.7} \text{ Myr}^{-1}$</td>
</tr>
<tr>
<td>Type Ia SNR</td>
<td>$\frac{1}{145} \text{ Myr}^{-1}$</td>
<td>$\frac{1}{43} \text{ Myr}^{-1}$</td>
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</table>

\textsuperscript{**}Core collapse SN rates evolve with galaxy gas mass

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