Field Dwarf Galaxies: their environments and contents in TNG50

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Abstract

Dwarf galaxies in the field are typically found in low-mass dark matter halos (Haas et al. 2012). Their large-scale environment determines their halo assembly while their baryonic contents can offer insights on the internal structure of the halos. Such dwarfs are predominantly star-forming (Geha et al. 2012) and in future Merian (Luo et al. 2023) and LSST are expected to survey large samples of them in the future.

Sample

- We select the sample of dwarf galaxies with stellar masses $7.5 < \log(\mathcal{M}_*/M_\odot) < 9.5$ situated in low-mass halos with virial masses $10 < \log(\mathcal{M}_{200}/M_\odot) < 11.5$ from the simulated volume of TNG50 (Nelson et al. 2019).

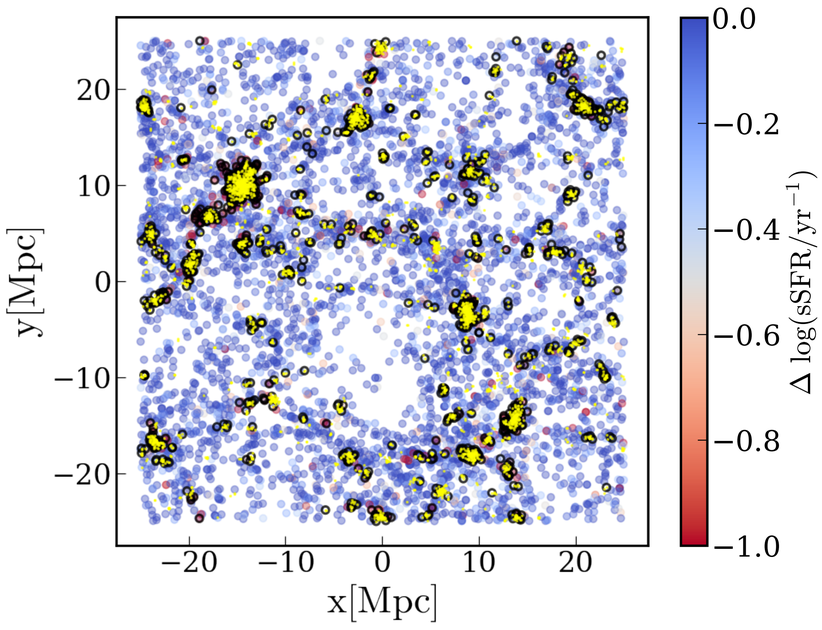

Figure 1: X-Y projection of the TNG50 box where the dwarf galaxies are the circles colored by their offset from the SFMS $\Delta(sSFR)$. The yellow circles are the massive galaxies while the backsplash galaxies around them are the cicles with black outlines.

Backsplash Dwarfs

- They comprise $\sim 3\%$ of all the dwarfs sample and have completed orbits inside a massive halo with $\log(\mathcal{M}_{200}/M_\odot) > 11.5$ but are situated outside the halo at distances of $1 < R/R_{200} < 6$ at $z = 0$.
- In contrast to the dwarf centrals with the same $\mathcal{M}_{200}$, they are quenched and tidally stripped. Due to this there are offset from the main-sequence of the SHMR and have depleted gas reservoirs.

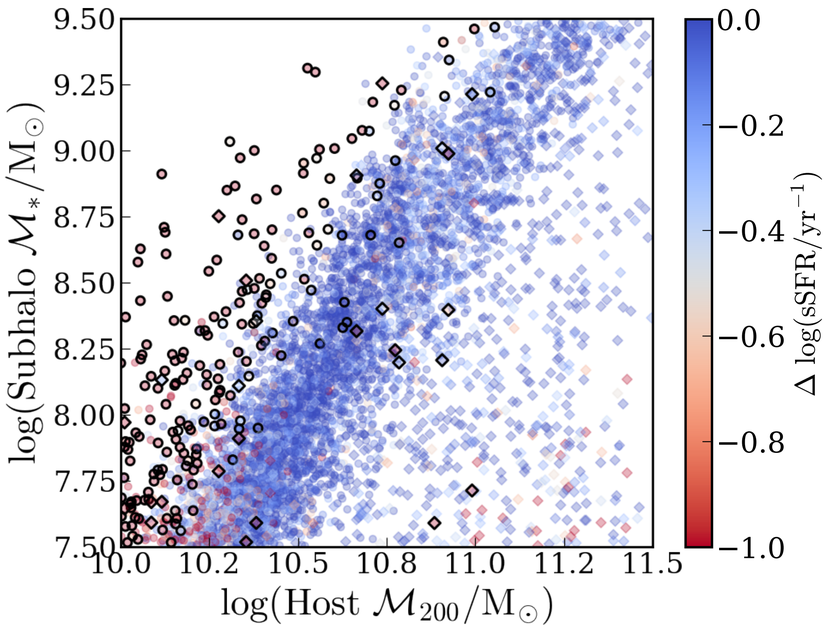

Figure 2: The stellar mass of the subhalos $\mathcal{M}_\star$ as a function of their host virial mass $\mathcal{M}_{200}$ in the dwarf sample. The circles colored by their offset from the SFMS $\Delta(sSFR)$ while the backsplash dwarfs are the circles with black outlines.

Quenched Fraction of the Dwarfs

- The distance to the nearest massive host galaxy $d_{\rm host}$ (Geha et al. 2012) is a commonly used tracer for a galaxy's large-scale environmental density.
- At fixed density, the dwarfs in the low-mass halos are more star-forming. 77% of these are located at $d_{\rm host} > 1.5{\rm Mpc}$ and of these only $< 2\%$ are quenched.

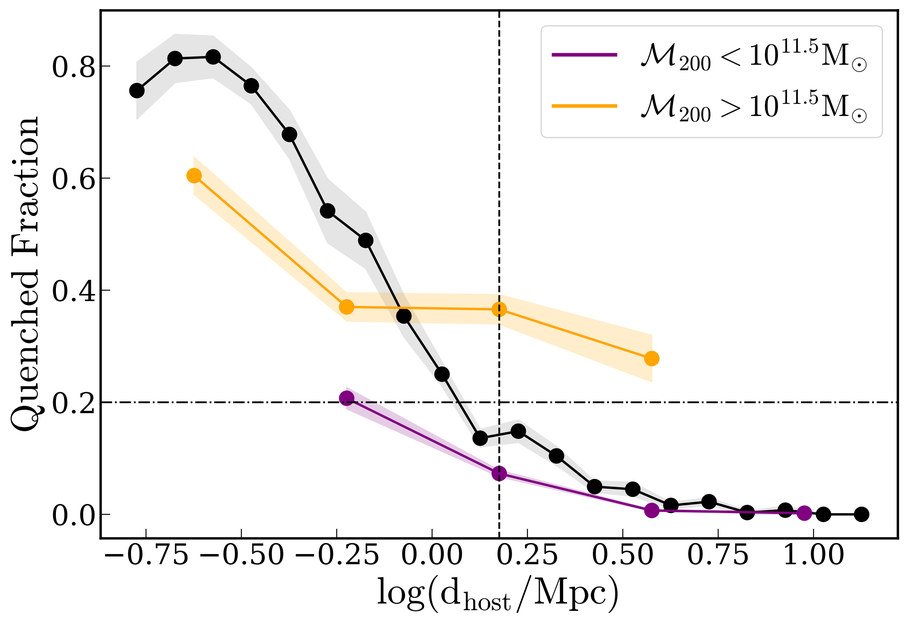

Figure 3: The quenched fractions of the dwarfs as a function of $d_{\rm host}$ for all the dwarfs is shown by the black profile while those for the dwarfs housed in massive and low-mass halos are shown in yellow and purple respectively. The dashed vertical line represents the $d_{\rm host} = 1.5{\rm Mpc}$ limit of Geha et al. 2012.

Dwarf Groups

- Dwarf groups or associations are composed of a < 5 members that have been assembled recently (Flores-Freitas et al. 2024) as a result of which most of the members are on infall orbits.
- Dwarf-dwarf interactions in these environments can lead to their quenching (Kado-Fong et al. (2023).

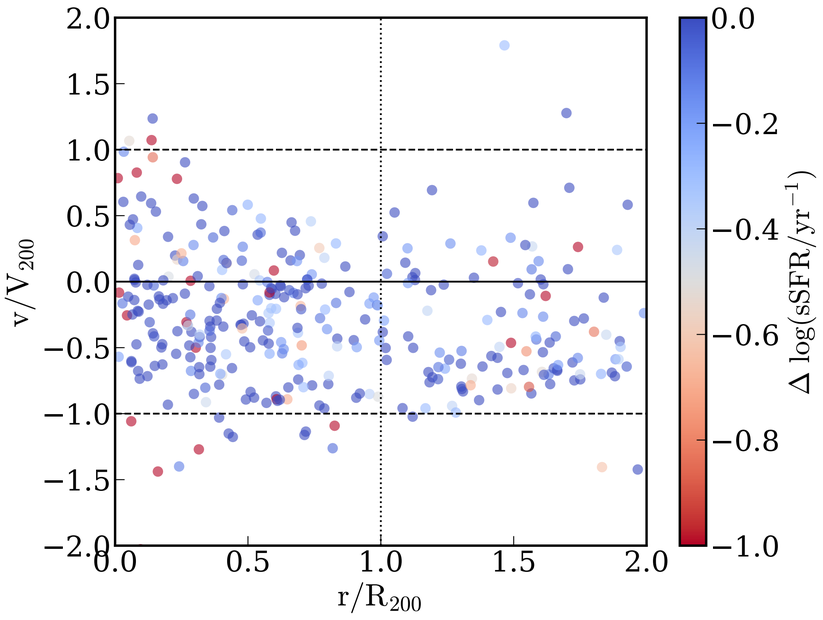

Figure 4: The phase-space diagram of all the dwarfs that belong to groups where the respective axes are normalized with respect to thehalocentric quantitites. The dwarf group members are the circles colored by their offset from the SFMS $\Delta(sSFR)$.

Outlook

These results point to the distinctive sub-classes of backsplash dwarfs and dwarf groups that are housed in the low-mass halos in the field. This warrants further exploration of their substructure, star-formation and orbital histories in the interest of constraining dark matter physics at the mass scale of these halos.