Analogues of the Milky Way in Cosmological Simulations

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The Milky Way (MW) is the most important galaxy we have at our disposal: not only does it hold special significance as our home, but it is also the galaxy we can study in the greatest detail. We aim to study galaxies similar to our MW, "Milky Way Analogues" (MWAs), as they provide us with an outside perspective to help make predictions for properties that can't be directly measured and help situate the MW in an extra-Galactic context. Our research hopes to answer the question "How 'typical' is the MW relative to all other galaxies?"

Although there has been increasing interest in MWAs from observational studies, not much research has been done to study MWAs in simulations. Simulations provide an opportunity to test our theories of galaxy formation and evolution, so studying their Milky Way-like galaxies helps us analyze how well the simulations are reproducing observations and, if so, to make predictions for the real universe. Using the EAGLE suite of cosmological simulations, we identify MWAs by assigning a "Milky Way-ness" parameter to each galaxy based on their stellar mass and star formation rate (SFR) at the present day. We then study our MWAs' present-day properties alongside their assembly and star formation histories throughout the simulation. Our findings show that the EAGLE simulations were able to predict well the MW's estimated colour and magnitude as a potential *red* spiral galaxy (most spirals appear blue). We were also able to demonstrate that, compared to other galaxies with similar stellar mass, our MWAs appear to be slightly more massive, assembled their mass more slowly, and have star formation rates (SFRs) that are declining more slowly. This slow drop-off in SFR is likely due to an ongoing reservoir of gas that fuels the slow decline, but future research is needed to confirm this.

The EAGLE simulations offer a controlled and data-rich environment for studying galaxy formation and evolution, particularly in the context of MWAs. To continue this research, more MWA studies in other simulations should be conducted. More properties of these MWAs should also be studied and compared against larger samples and observational results, both at higher redshifts and at the present day. The simulations should also be examined in greater detail on a particle-by-particle basis to investigate internal galaxy structure. Studies should also be extended to analogues of other nearby, well-studied galaxies, such as Andromeda and other members of the Local Group.

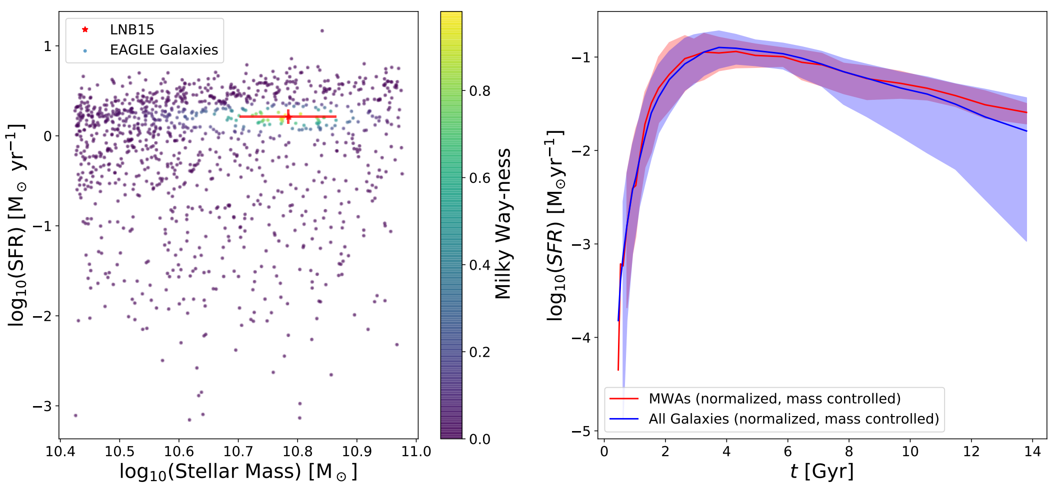

Figure 1: Left: Plot of star formation rate (SFR) vs stellar mass of our mass-controlled sample (galaxies within a reasonable range of our estimate for the Milky Way's (MW's) stellar mass). The colour scale indicates the "Milky Way-ness" of each galaxy with a maximum "likeness" of 1.0. The galaxies with the highest "Milky Way-ness" are closest to the observed value for the Milky Way (MW) in red (Licquia, Newman & Brinchman, 2015; LNB15).
Right: The star formation histories of EAGLE galaxies with roughly the same stellar mass as the MW (our mass-controlled sample; blue) and our Milky Way Analogues (MWAs) (red). The solid line represents the median star formation rate (SFR) throughout the sample, and the shaded region covers galaxies with SFR above 16% and below 84% of the entire sample. The data has been normalized, meaning that the plot shows the SFR at each time step as a fraction of the integrated SFR over all time in the simulation. The MWAs follow the trend of the mass-controlled sample, with a rapid increase and subsequent turnover in SFR, until ~ 4 Gyr ago, where MWAs maintain an overall higher SFR with a slower decline in SFR to the present day.