Searching for Signatures of Large-Scale Structure Interactions in Dwarf Galaxy Star Formation Histories with Rubin

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Introduction

It is broadly understood that environment influences galaxy evolution. Low mass galaxies serve as a particularly sensitive probe of environment. Since star formation within galaxies traces the physical properties that drive galaxy evolution, reconstructing star formation histories (SFHs) of low mass galaxies can provide insights into the history of the coevolution of galaxies and filaments.

Previous work has motivated the development of metrics for discovering and quantifying galaxy interactions with filaments that we test and refine using the New Horizon simulation before applying to Rubin data .

I. Dwarfs Synchronize Star Formation Across Cosmic Scales

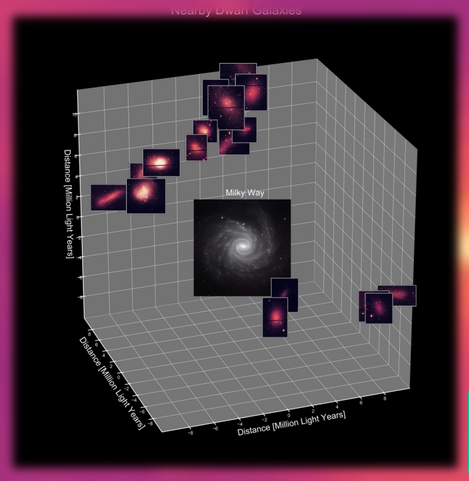

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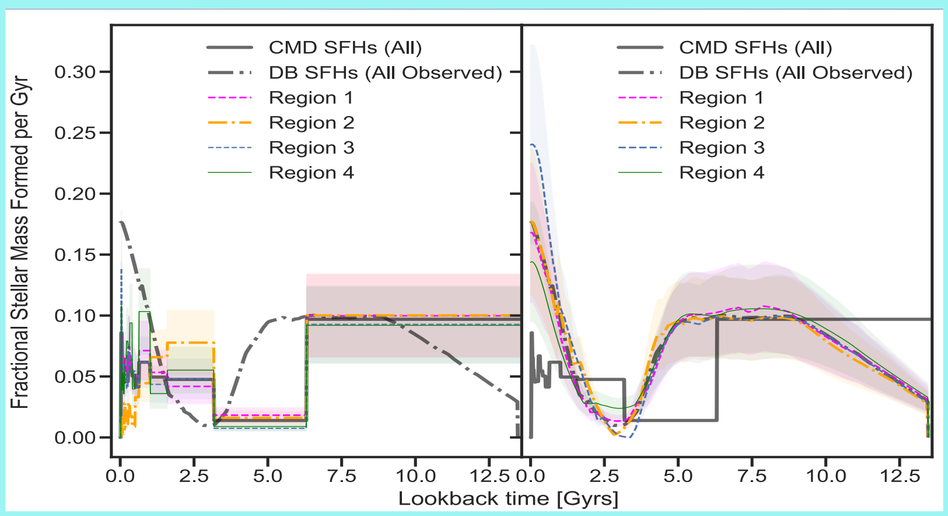
Illustration of galaxies used in Olsen+ 2021 from the **A**CS **N**earby **G**alaxy **S**urvey **T**reasury (ANGST), which is a volume-limited survey of nearby (D<4 Mpc) galaxies. ANGST has galaxies far enough away for careful integrated photometry, yet close enough to resolve individual stars

Olsen+2021 reconstructed the SFHs of 36 nearby dwarf galaxies (Fig 1) from color-magnitude diagrams (CMDs), and spectral energy distribution (SED) fitting . We find that regardless type of observation, method, or the area where the galaxies were located (Fig 2), the median of the normalized **SFHs all show a synchronous decrease and increase in star formation** at around 6 Gyrs and 3 Gyrs lookback time (Fig 3).



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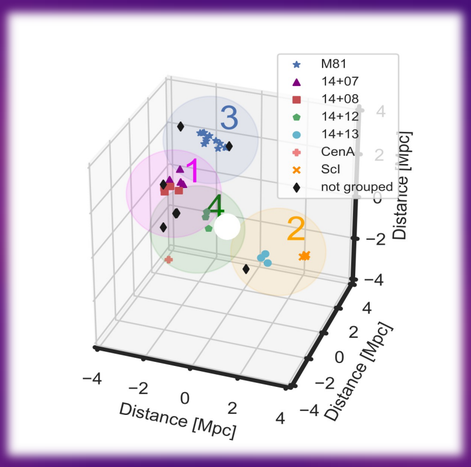
Median of the normalized SFHs for each region for CMD derived SFHs (left) and SED SFHs (right), the grey line in both panels is the median of the normalized SFHs of all galaxies in SED SFH and CMD SFH respectively as a reference



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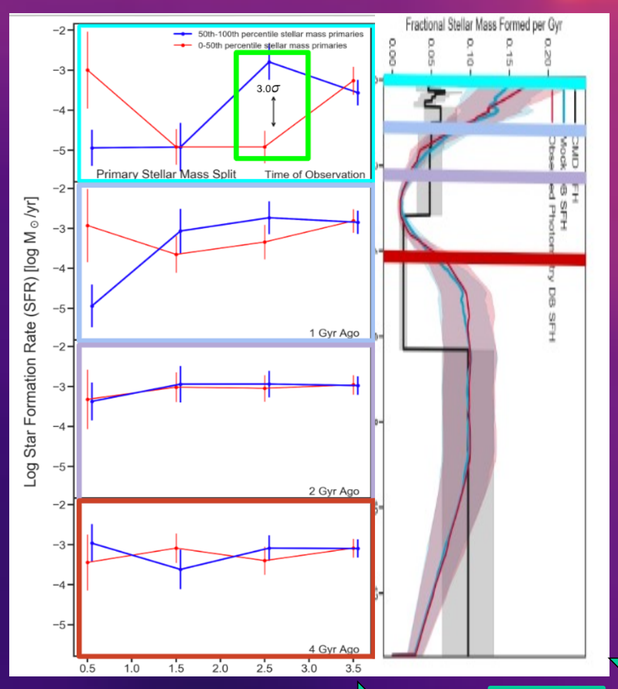
Galaxies in the sample grouped using a K-Means clustering algorithm to group them into similar but separated cosmic regions.

These results persist regardless of reconstruction method or type of observation -- more importantly they **extend over distances of > 6 Mpc**

II. SFHs Can Track Past Environmental Interactions



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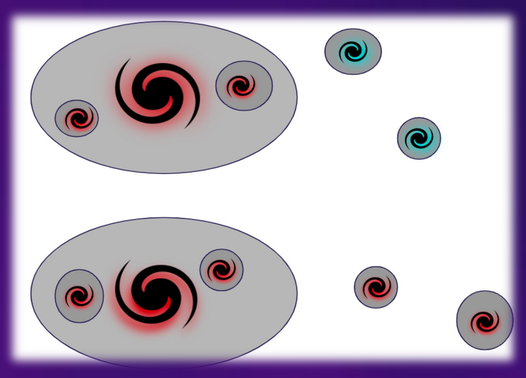
Tests of conformity for Local Volume galaxies in a <4 Mpc volume at time steps around the episode of synchronized star formation. Conformity tests are performed at the time of observation, and 1,2, and 4 Gyr lookback time. The SFH to the right illustrates the times at which tests were performed, and a signal of conformity is seen at the time of observation for galaxies 2-3 Mpc away from their primaries.

Olsen & Gawiser 2022 tested for **conformity** in the SFHs of Local dwarfs. Conformity quantifies correlations in properties between secondary galaxies at a particular physical separation from a primary galaxy (see Figure 4). The use of SFHs allows to test conformity of galaxy properties at different cosmic times (process illustrated in Fig. 5).

We find **no significant signal of conformity** in galaxies around the times of synchronized star formation (in **mauve** and **red**), but a surprising signal of conformity is seen in today's Universe (**cyan**).

- **The conformity observed in the sample is independent of the synchronized star formation previously seen.**
- **Synchronized star formation and conformity are potentially sensitive to different environmental effects.**



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A cartoon showing a possible example of conformity. Top shows a larger galaxy that shares the same colors as the galaxies within its halo, but not with those outside. Bottom shows a larger galaxy that shares the same colors with both galaxies within its halo and outside its halo. These are two naïve examples of one halo and two halo conformity.

Could synchronized star formation be caused by interaction with a cosmic filament?

III. Mapping Interactions Between Dwarfs and Filaments with LSST

The deep imaging of the southern night sky by the **Vera C. Rubin Observatory** offers a unique opportunity to study the effects of cosmic filaments on **large samples** of dwarf galaxies through reconstruction of both their SFHs and their large-scale structure network:
→ Currently testing our ability to extract filaments and track conformity over time from dwarf galaxy SFHs simulated DP0 Rubin data
→ Pipeline in preparation for Rubin DR1 data.

We synergize with the **New Horizon simulation** (shown in background), a 20 Mpc wide cosmological zoom ~34 pc spatial resolution with > 5000 dwarf galaxies at z=0.
→Distributions of dwarfs at z=0 are strongly impacted by the geometry and dynamics of the cosmic web (see work by J. Madhani)
→ Reconstruct properties of filaments and correlate these to simulated dwarf properties. (see work by M. Ramirez)
→ Makes predictions for LSST with simulated SFHs obtained from mock Rubin photometry.