Constraining the Interaction History of Galaxies Over 8 Gyr

Kyle Penner[1], Shardha Jogee[1], Sarah Miller[1], GEMS collaboration

[1]University of Texas at Austin

Summary

The prevailing hierarchical λ-CDM model of galaxy evolution predicts that present-day galaxies grew via successive mergers of smaller systems. However, we lack strong empirical constraints on the variation of the merger rate out to z = 1. We describe an ongoing study whose goal is to constrain the merger and interaction history of galaxies over the last 8 Gyr, by taking advantage of ~8,500 high resolution Hubble Space Telescope (HST) images from the Galaxy Evolution from Morphology and SEDS (GEMS) survey (Section 1). We use visual and quantitative classification schemes (Section 2), illustrate the critical importance of avoiding bandpass shifting (from rest-frame optical to rest-frame UV — Section 3), and ensure sample completeness.

We present preliminary results (Section 4) indicating that the fraction of galaxies with strong morphological distortions does not significantly (by an order of magnitude or more) decline from z = 1 to z = 0.25 — the critical period where the cosmic star formation rate density declines by more than an order of magnitude (Figure 4).

If this result holds after a more extensive analysis that includes corrections for surface brightness dimming, it would imply that the decline in the cosmic SFR density over the last 8 Gyr is not primarily due to a decline in the frequency of strong mergers and interactions.

1 – Data

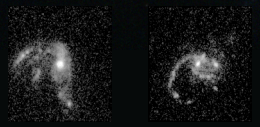


Figure 1: These images, taken with the Hubble Space Telescope (HST) as part of the GEMS survey, show distant, young galaxies at a lookback time of 6.4 Gyr, when the Universe was 53% of its present age. The images reveal signs of recent interactions or mergers, such as tidal tails, arcs, and other asymmetries. Each image is ~45 kpc wide.

2 – Method

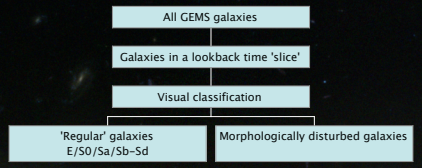
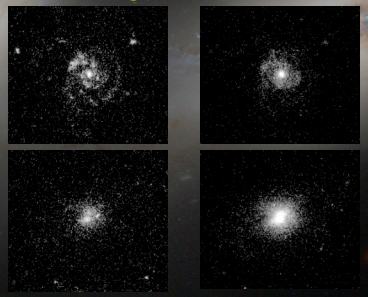


Figure 2: Obtaining a fraction of galaxies that are morphologically disturbed (upper limit) by visual classification.

The visual classifications are cross-checked with quantitative measures of asymmetry.

3 – Avoiding Bandpass Shifting



Filter	F606W	F850LP
Obs. λ	5915 Å	9103 Å
z	0.9	0.9
Rest λ	3113 Å	4791 Å

Figure 3: These images illustrate the effect of bandpass shifting. The two galaxies appear drastically different because the rest-frame wavelength shifts from the optical to the UV. In the rest-frame UV, even regular, non-interacting galaxies may appear morphologically disturbed; thus, it is desirable to work in the rest-frame optical over the whole redshift interval. For instance, at z = 0.9, twice as many galaxies would be classified as morphologically disturbed in the rest-frame UV than in the rest-frame optical.

4 – Results

- We use observations in the F850LP filter in order to work in the rest-frame optical and avoid bandpass shifting into the UV.
- We ensure completeness by applying a cutoff of $M_V = -18.7$ out to z ~ 0.6 and $M_V = -20.3$ out to z ~ 0.9, taking into account K-corrections.
- The table below shows how the percentage of galaxies with strong morphological distortions P_{dist} varies as a function of redshift, in 1 Gyr intervals.

Mean z	0.29	0.41	0.55	0.71	0.91
Lookback time (Gyr)	3.5	4.5	5.5	6.5	7.5
Rest λ (Å)	7030	6456	5892	5324	4766
$M_V < -18.7$					
# total	195	415	648	-	-
P_{dist}	5.1%	2.7%	2.5%*	-	-
$M_V < -20.3$					
# total	-	138	219	926	555
P_{dist}	-	3.6%	7.3%*	6.6%	7.4%

* Results at <z> = 0.55 are not final; classification is in progress for galaxies in the redshift slice z = 0.55 – 0.65.

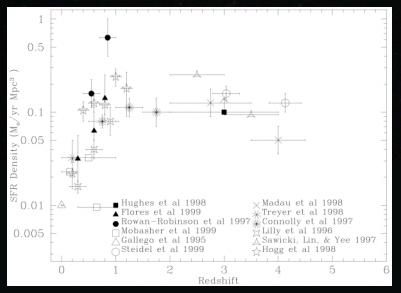


Figure 4: The cosmic SFR density falls by more than an order of magnitude from z = 1 to z = 0 (Haarsma et al. 2000). Our preliminary results suggest that this decline is not primarily due to a decline in the frequency of strong mergers and interactions.