GEMS

Galaxy Evolution from Morphology & SEDs

GOODS

Great Observatories Origins Deep Survey

Tidal Interactions and Mergers at Early Cosmic Times

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SUMMARY: We use panchromatic data from the two largest Hubble Space Telescope ACS surveys to date: Galaxy Evolution from Morphology and SEDS (GEMS) and the Great Observatories Origins Deep Survey (GOODS) to study the frequency and impact of tidal interactions and mergers out to z~1, when the Universe was half of its present age, in order to build a coherent picture of the decline in cosmic SFR density from z~1 to 0, the fueling of starburst/AGN activity, and the mass assembly of galaxies. We present here illustrations of our methodology and preliminary results.

GEMS and GOODS: **GEMS** (Rix et al. 2003) is a large-area (30'x30' or 150 Hubble Deep Field Areas), deep HST ACS 2-color (F606W, F850LP) survey centered on the Chandra Deep Field South (CDF-S). It focuses on galaxy evolution out to a redshift of 1.2 where the Universe was half of its present age. Redshifts and SEDS for 10,000 galaxies are available from the ground-based COMBO-17 survey (Wolf et al. 2003).
GOODS (Giavalisco et al. 2003) consists of deep HST ACS 4-color (F435W, F606W, F775W, F850LP) images, ground-based optical and NIR data, and planned SIRTF observations from 3.6-24 micron over two 16'x10' fields centered on the CDF-S and the HDF-N. Ground-based UV-to-NIR CDF-S data in 14 passbands are used to derive SEDs. Photometric redshifts and spectral types are estimated for individual galaxies by fitting the observed SEDs to template SEDs of E, Sbc, Scd, and Im (Coleman, Wu & Weedman 1980), and starburst (Kinney et al 1996).

METHODOLOGY: We quantify the frequency of tidal interactions and mergers using 2 independent methods: (1) The identification of nearest neighbors within a given selected radius (e.g., 40 kpc) and a narrow range in redshift provides an upper limit to the fraction of tidally interacting/merging systems. (2) Large asymmetries in the rest-frame B and R light are used to pick systems in the late stages of tidal interaction and mergers, providing a lower limit.

- We use the CAS asymmetry (A) index (Conselice et al. 2000) and concentration (C) index (Bershady et al. 2000) to quantify the structural properties of galaxies. The asymmetry index is obtained by rotating a galaxy image by 180 degrees, subtracting it from its pre-rotated image, summing the intensities of the absolute value residuals, and normalizing the sum to the original galaxy flux. The concentration index C is proportional to the logarithm of the ratio of the 80 % to 20 % curve of growth radii.
- C and A are measured in both rest-frame B (from z=0.2 to1.3) and R (from z=0.2 to 0.6) light using the GOODS and GEMS F606W, F775W, and F850LP filters. We present in Figures 1-4 illustrations of our methodology and preliminary results.

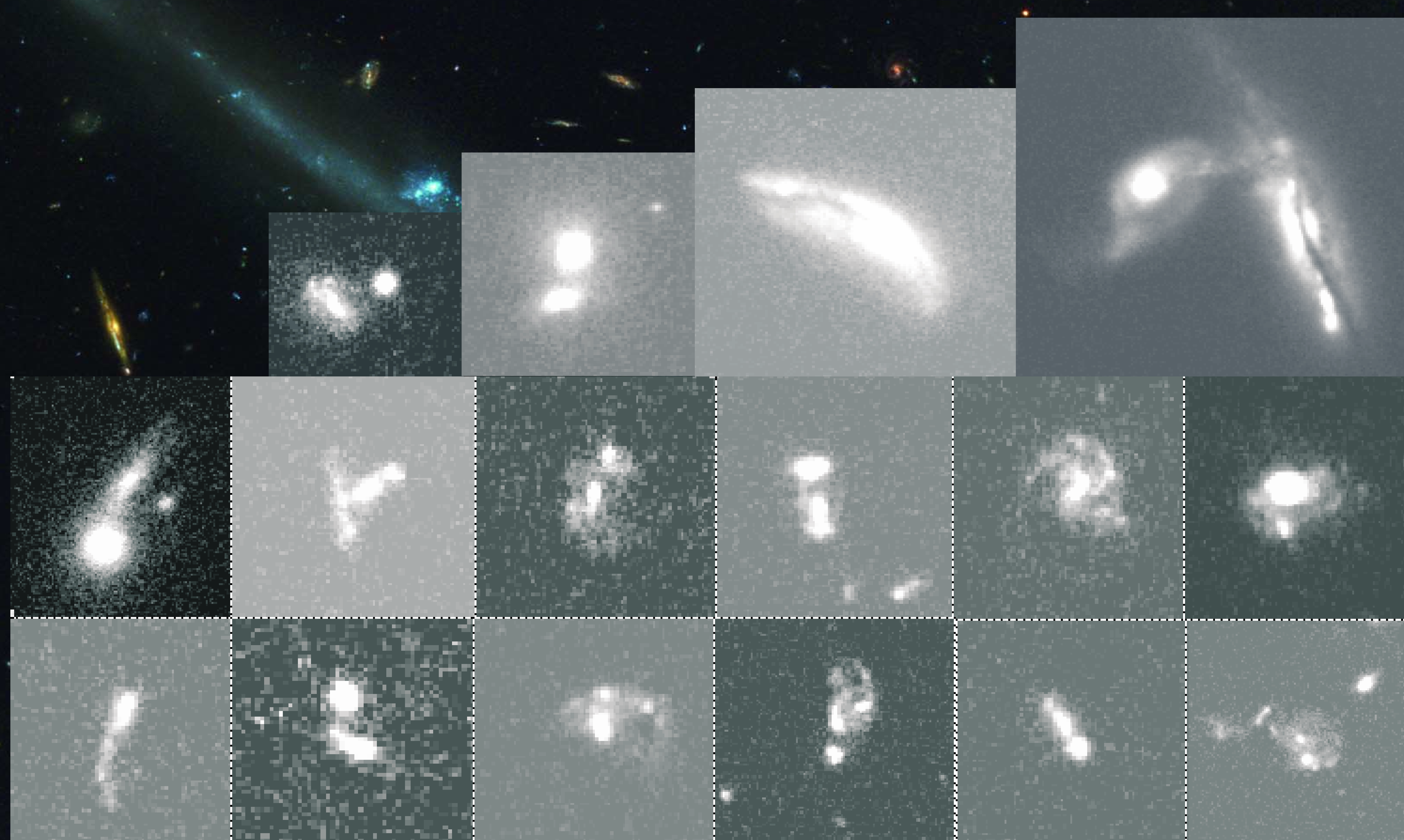
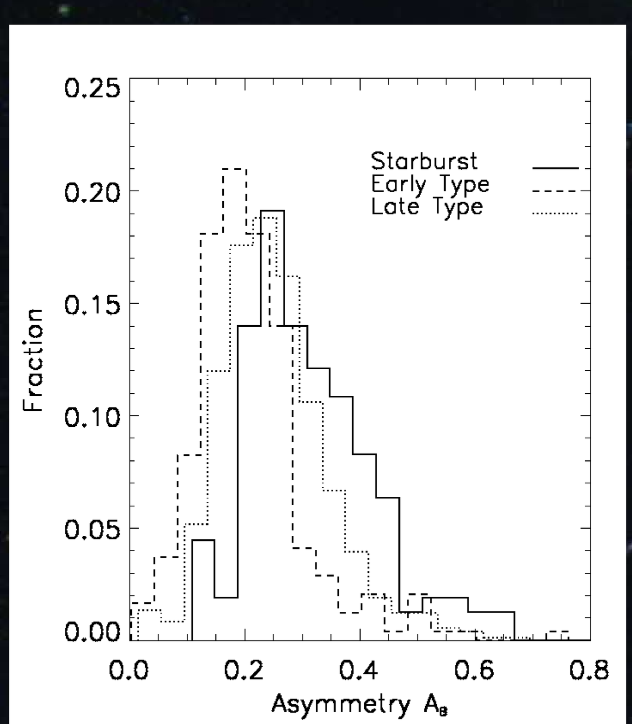


FIG. 1 - Galaxies with a large rest-frame B asymmetry index (A>0.35) typically show distorted morphologies, tails, double nuclei, and nearby companions. The mosaic shows the rest-frame B morphologies of galaxies with z=0.2-1.3 and large asymmetry indices (A>0.35) in GOODS and GEMS. Galaxies classified as early-types (E/S0) based on their SEDs rarely have high A, but a few rare examples are shown in the top row. Conversely, systems with starburst SEDs often have large A and are shown in the last two rows. The regions with emission shown typically span 20-30 kpc for a flat cosmology with Omega_Lambda =0.7 and a Hubble constant of 70 km/s per Mpc.



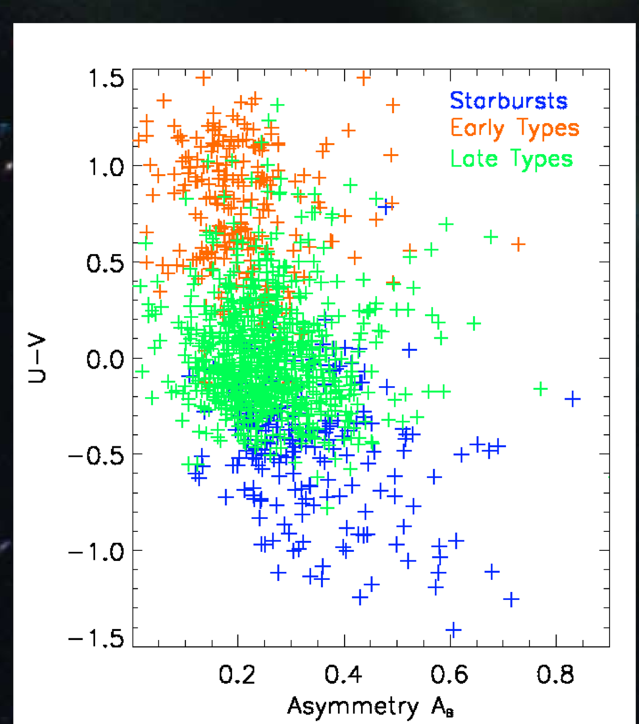


FIG. 2 - (Left): A comparative study is carried out of optically-selected starburst galaxies and a control sample of normal (early-type E/Sa and late-type) galaxies with R < 24 AB mag and z=0.2-1.3 (Mobasher, Jogee, Dahlen, de Mello et al. 2003). The spectral types are based purely on fitting observed SEDs to templates, without any morphological information. The distribution of asymmetry indices is shown. A larger fraction (50 %) of the starburst galaxies have a high A>0.3, compared to early-types (13 %) and late-types (27 %). This suggests that a significant fraction of the starburst activity is tidally triggered.

FIG. 3 - (Right): The rest-frame color versus asymmetry plot is shown. Notice the large fraction of starbursts with high A>0.3.

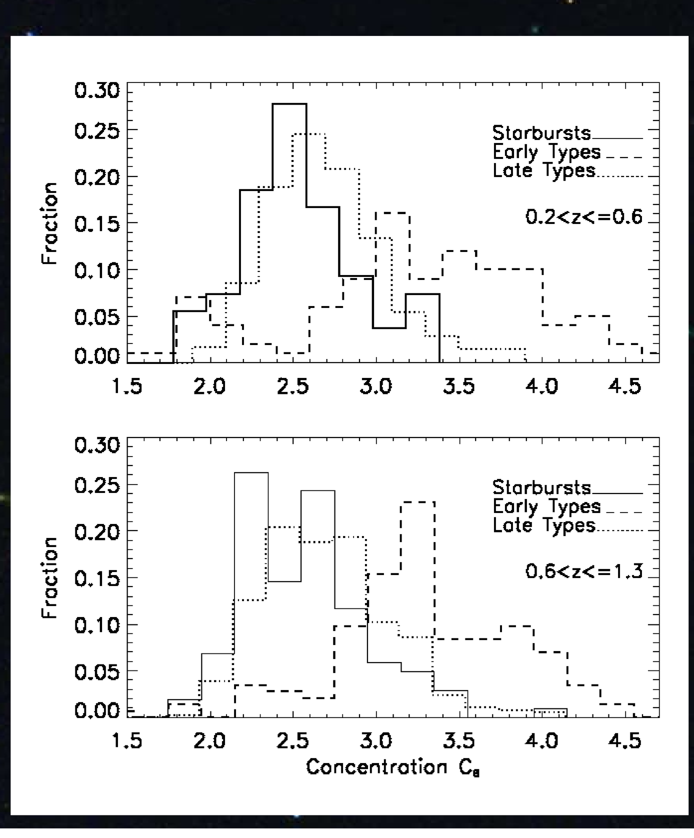


FIG. 4 - The distribution of rest-frame B concentration indices are shown. 73% of early types have large C (C> 3.4, typical of bulge profiles) compared to 12% starbursts and 18% late-types. By z~1, early-type systems seem to have already developed large C, likely associated with bulges.