Evolution of Galaxies with Episodic Star Formation at 0.2<z<0.8 in COSMOS

M. Kajisawa, M. Ochiai, Y. Taniguchi, M. A. R. Kobayashi, Y. Shioya (Ehime Univ.), K. Matsubayashi (Kyoto Univ.)

Abstract

Using the COSMOS intermediate-band data set taken with Suprime-Cam, we investigated galaxies with episodic star formation at 0.2<z<0.8. We constructed the pseudo rest-frame UBV-bands two-color diagram for galaxies with Mv < -20 at 0.2<z<0.8, and measured color offsets from a sequence of the continuous star formation models to search for galaxies with episodic star formation, namely, old population + recent burst of star formation or post-starburst galaxies. We found that the dispersion of the color offsets increases with redshift, which suggests that the fraction of galaxies with episodic star formation decreases with time from z~0.8 to z~0.2. At z>0.6, fainter galaxies tend to have the higher fraction of these galaxies. We also examined the morphology of these galaxies with the HST/ACS images, and found that "old + burst" galaxies tend to show irregular/interacting morphology, while continuously star-forming galaxies tend to be normal spiral galaxies.

Introduction

Many studies have studied the cosmic star formation rate (SFR) density as a function of redshift, and found that the SFR density decreased by about an order of magnitude from z~1 to z~0. But the detailed star formation history at z < 1 of individual galaxy such as variation of SFR in a relatively short timescale of < 1Gyr is unclear.

The rest-frame UBV-bands 2-color diagram, which samples the Balmer/4000Å break, allows us to investigate recent (< 1 Gyr) star formation activities in detail, for example, to descriminate among continuous star formation, episodic starburst, post-starburst, and so on.

In this study, we construct the rest-frame UBV-bands 2-color diagram for galaxies at various redshifts over 0.2 < z < 0.8 in order to study star formation histories of galaxies in a short timescale.

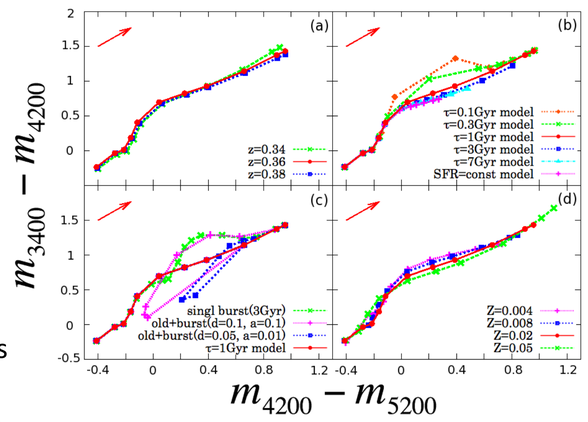


Figure 1: Model tracks with various star formation histories in the pseudo rest-frame UBV-bands 2-color diagram used in this study. The model by Bruzual & Charlot (2003) is used. **(b)** models of continuous star formation form a sequence in the diagram unless the decrease of SFR is so rapid (τ ≤ 0.5 Gyr). **(c)** if recent burst of star formation occurs in a galaxy with old population or star formation stops suddenly in star-forming one, galaxies go away from the sequence of the continuous star formation.

Data & Analysis

◆ COSMOS survey data

- ✓ Intermediate-bands photometry
  COSMOS photometric catalog (Capak+07)
- ✓ Redshifts & M_V
  photo-z with 31-bands data (Ilbert+09)
- ✓ Effective survey area is ~1.7 deg²

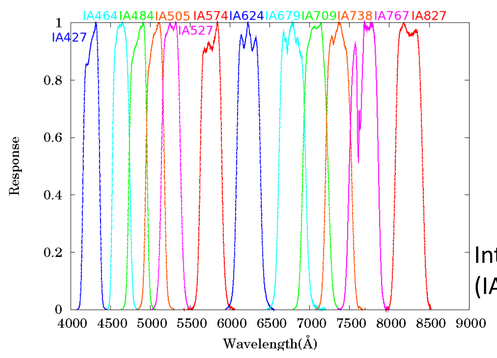
◆ Sample

galaxies with M_V < -20 at 0.2<z<0.8

➡ Small photometric errors even in high-redshift bins

Used filters & Sample size

redshift	rest 3400 Å	rest 4200 Å	rest 5200 Å	total number	color-selected number
0.24-0.28	IA427	IA527	IA679	410	236
0.34-0.38	IA464	IA574	IA709	1637	932
0.46-0.50	IA505	IA624	IA767	1191	749
0.58-0.62	IA527	IA679	IA827	1517	1110
0.72-0.76	IA574	IA738	z'	3039	2573
0.79-0.83	IA624	IA767	z'	3428	2582



Intermediate-band (IA-band) filter set

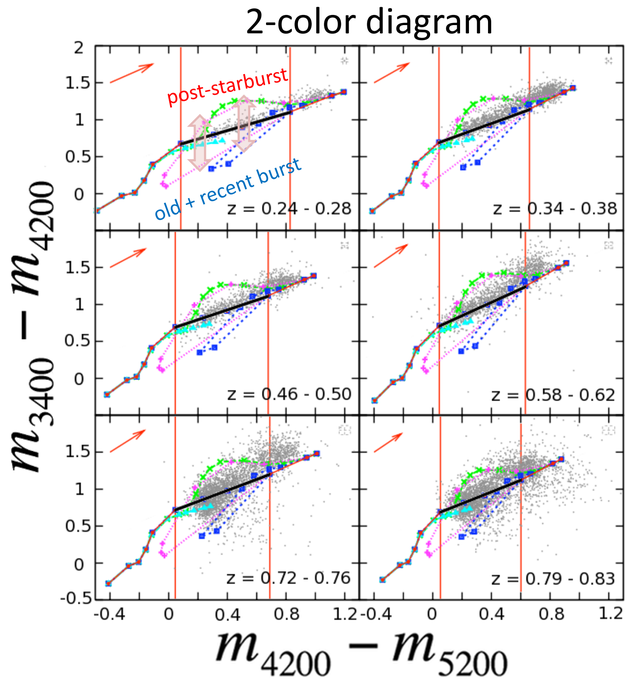
◆ 2-color diagram & redshift bins

- ✓ We directly used the observed IA-bands photometry to construct 2-color diagram (no K-correction).
- ✓ We chose the redshift ranges so that three of the IA bands sample the rest-frame 3400Å , 4200Å, and 5200Å.
  - The effects by the strong emission lines can be avoided.
  - The effect of the redshift offset/error on the rest-frame color is small (Figure 1a).

◆ color offset from the seqeuence of continuous star formation

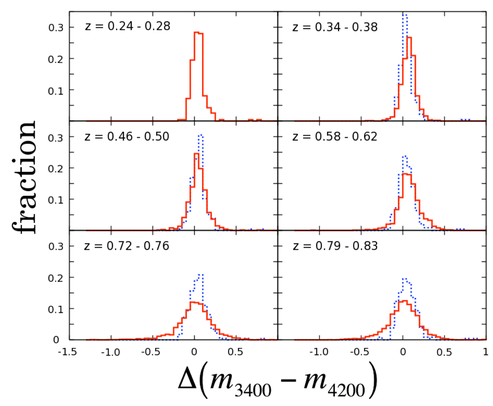
- ✓ As shown in Figure 1, the models of continuous star formation (CSF) form a sequence in the 2-color diagram.
- ✓ We used a color offset from the sequence of CSF in m_{3400}-m_{4200} color as a signature of episodic star formation.
- ✓ We excluded from the following analyses galaxies redder than the τ=1Gyr model at 5Gyr old and those bluer than the τ=1Gyr model at 1Gyr old in m_{4200}-m_{5200} color (vertical lines).
- ✓ We fitted the color track of the τ=1Gyr model between age=1Gyr and 5Gyr with a straight line, and use it as the sequence of CSF (the reference for the color offset).

2-color diagram



Evolution of the fraction of galaxies with episodic star formation

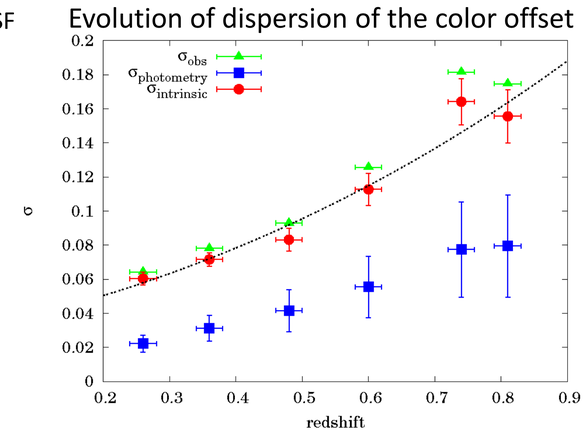
Color offsets from a sequence of continuous SF



Solid histogram shows the distribution of the color offset for each redshift bin, while blue histogram shows that of galaxies at z=0.24-0.28 convolved with the mean photometric error of galaxies in each bin.

<u>The distribution of the color offset is wider at z≥0.6 even if the photometric error is taken into account.</u>

Evolution of dispersion of the color offset



We calculated the dispersion of the color offset in each redshift bin, and correct it for the effect of the photometric error as

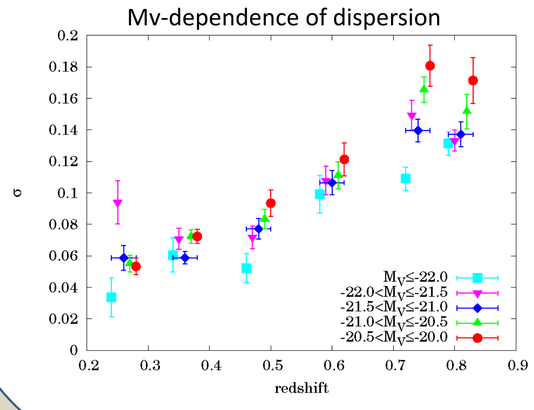
$$\sigma_{intrinsic} = \sqrt{\sigma_{obs}^2 - \sigma_{photometric}^2}$$

here $\sigma_{photometric}$ is the dispersion expected from the mean photometric error in the redshift bin.

The dispersion around the sequence of CSF increases with redshift as $\sigma_{intrinsic} \propto (1+z)^{2.9\pm0.2}$

➡ <u>The fraction of galaxies with episodic star formation decreases with time from z~0.8 to z~0.2.</u>

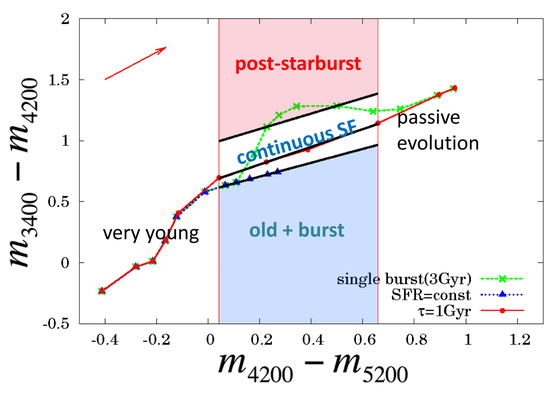
Mv-dependence of dispersion



We also calculated the dispersion for galaxies with different absolute V-band magnitudes.

- ✓ The dispersion increases with redshift for all the magnitude ranges.
  ➡ The photometric error does not significantly affect the results.
- ✓ At z ≥ 0.6, fainter galaxies show a larger dispersion.
  - Episodic star formation occurs more frequently in faint galaxies?
  - SEDs of fainter galaxies are more easily affected by such a burst of star formation?

Old + recent burst & Post-starburst populations



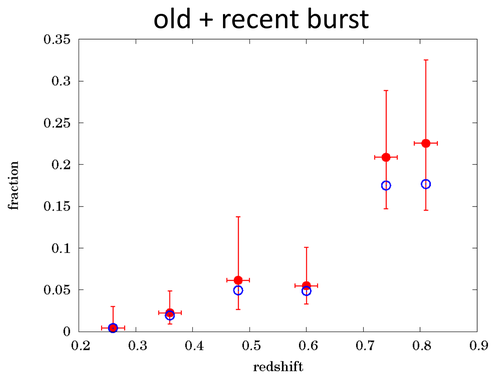
We divided galaxies with episodic SF into two populations, namely, old + recent burst population and post-starburst one in the 2-color diagram.

Bluer than the constant SFR model in m_{3400}-m_{4200} color
→ old + burst
0.05-0.5 Gyr after the star formation stopped
→ post-starburst

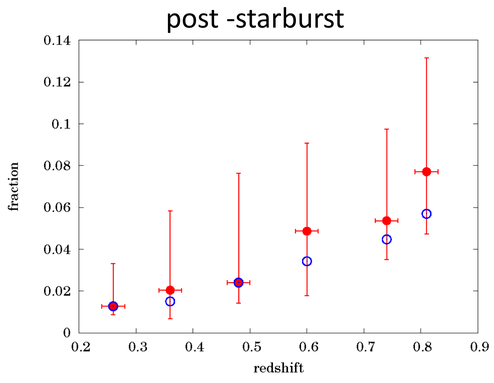
We investigated the fraction of the old+burst and post-starburst populations as a function of redshift separately.

➡ <u>The fraction increases with redshift for the both populations.</u>

old + recent burst



post -starburst

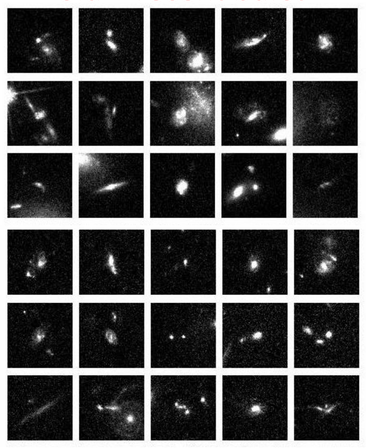


Fraction of old+burst/post-starburst galaxies as a function of redshift. The error bars include the effect of a possible photometric zeropoint offsets of 0.03 mag. Open symbols show the results when the color criterion is securely shifted by the mean 1σ photometric error.

◆morphology

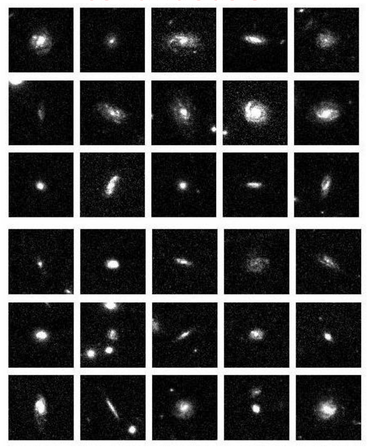
HST/ACS I_{F814W}-band images for galaxies at z≥0.6

old + recent burst



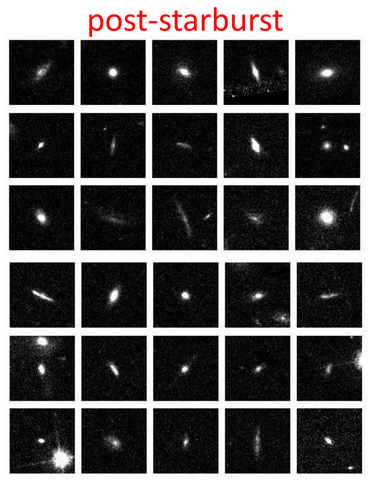
➢ Large fraction of irregular/peculiar or multiple morphology
➡ A burst of SF seems to be triggered by interaction/merger.

continuous SF



➢ Continuous SF galaxies tend to be normal spirals.

post-starburst



➢ Earlier morphology than continuous SF.
➡ Stopping SF & morphological transition are coeval?
➢ edge-on disks
dusty contaminants?