Evolution of Galaxy Morphology Since z~1

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Abstract

We study the morphologies of ~30000 star-forming galaxies (SFGs) & ~6000 quiescent galaxies (QGs) at $0.1<z<0.9$ in CLAUDS+HSC *ugrizy* bands. We find that the size-mass relation is weaker for SFGs than QGs. While the strong size evolution of QGs is consistent with other studies, we find a weak evolution of SFGs at $z<1$. Our results indicate the growth of bulges in SFGs as they evolve. However, the evolution of QGs could be driven by several physical processes.

Introduction

There are mainly two different galaxy populations in the universe: SFGs that actively form stars and QGs where star formation is either suppressed or minimal. Studying their morphology from the radial light distribution in the sky images can reveal their physical properties and processes that drive the evolution in physical properties of galaxies. This is a pilot study focusing on ~2 deg^2 of the central COSMOS before we expand it to cover the entire 18.6 deg^2 of CLAUDS+HSC survey.

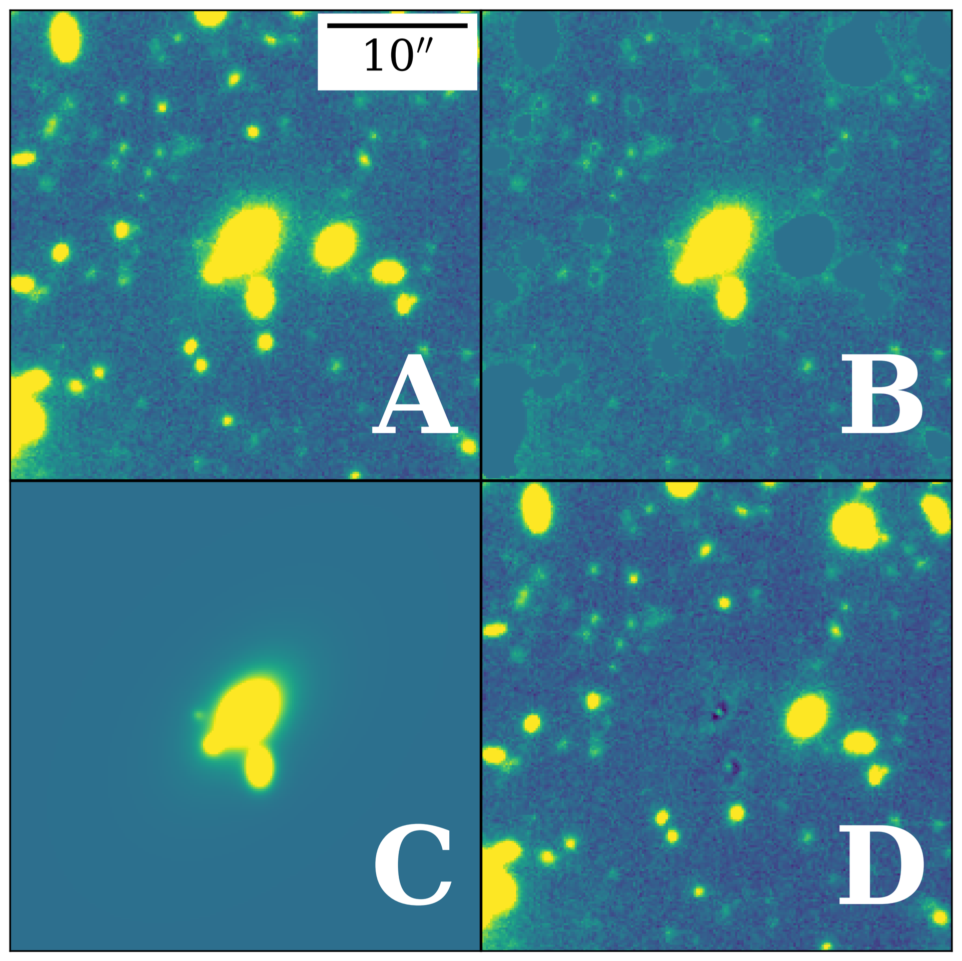

Figure 1: Image cutout in *i*-band (A), masked image (B), best-fit models (C) and residual image (D) of a sample galaxy.

Data & Methodology

We analyze the morphologies of SFGs ($M_*>10^{9.5}M_\odot$) and QGs ($M_*>10^{10}M_\odot$) at $0.1<z<0.9$ using CFHT CLAUDS[1] (u) and Subaru HSC[2] (g, r, i, z & y) data. We model galaxy light profiles with a single Sérsic profile

$$\log\left(\frac{\Sigma(R)}{\Sigma_e}\right) = -b_n\left[\left(\frac{R}{R_e}\right)^{\frac{1}{n}} - 1\right]$$

using GALFIT[3], a 2-D galaxy profile fitting software. Important Sérsic parameters are effective radius (R_e, size), Sérsic index (n, concentration). We simultaneously fit the target galaxy with neighboring galaxies and mask all other objects using watershed algorithm (Figure **1**). We measure the sizes of all galaxies at rest-frame 5000Å using the multi-wavelength data. We estimate the systematic uncertainties present in our measurements through simulations.

Size-Mass Relation

SFGs tend to be larger than QGs at a given stellar mass. We trace a positive correlation between galaxy size & mass (Figure **2**). The size-mass relation (SMR) is linear in log-log space:

$$\log R_e(m_*) = \log A + \log(m_*)\alpha\,; \quad m_* = \frac{M_*}{5\times10^{10}}$$

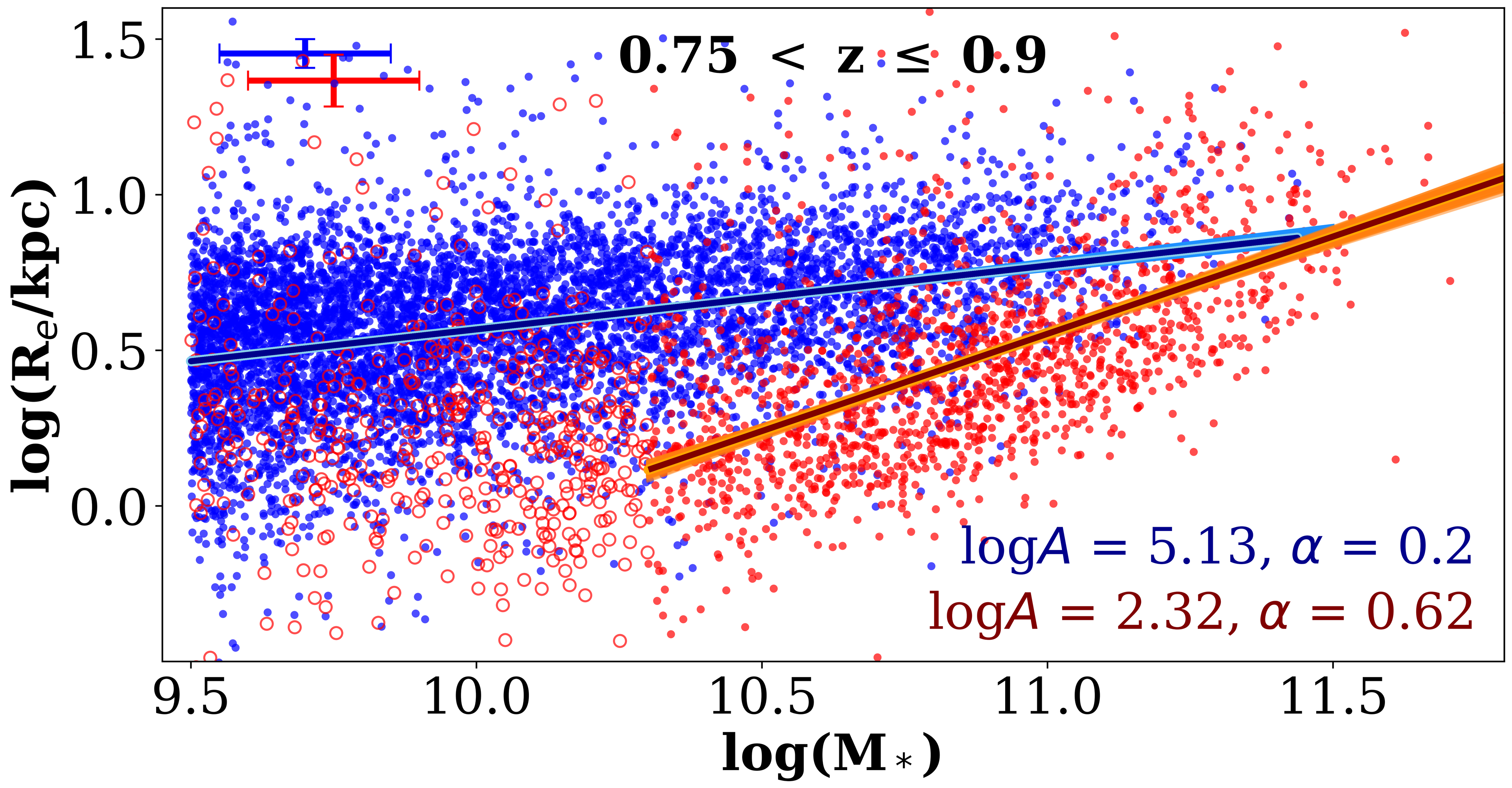

Figure 2: The SMR for SFGs (blue) & QGs (red) at $0.75<z<0.9$. Since QGs show a weaker relation at lower masses[4,5](empty circles), we fit only massive ones ($>2\times10^{10}M_\odot$, filled circles). The median error bars in mass and size measurements are shown in the top left corner.

Evolution of Characteristic Sizes

The characteristic sizes ($R_e(M_* = m_*)$) of SFGs & QGs increases with cosmic time (Figure **3**). We parametrize the evolution as

$$R_e(M_* = m_*) = A(1+z)^\beta$$

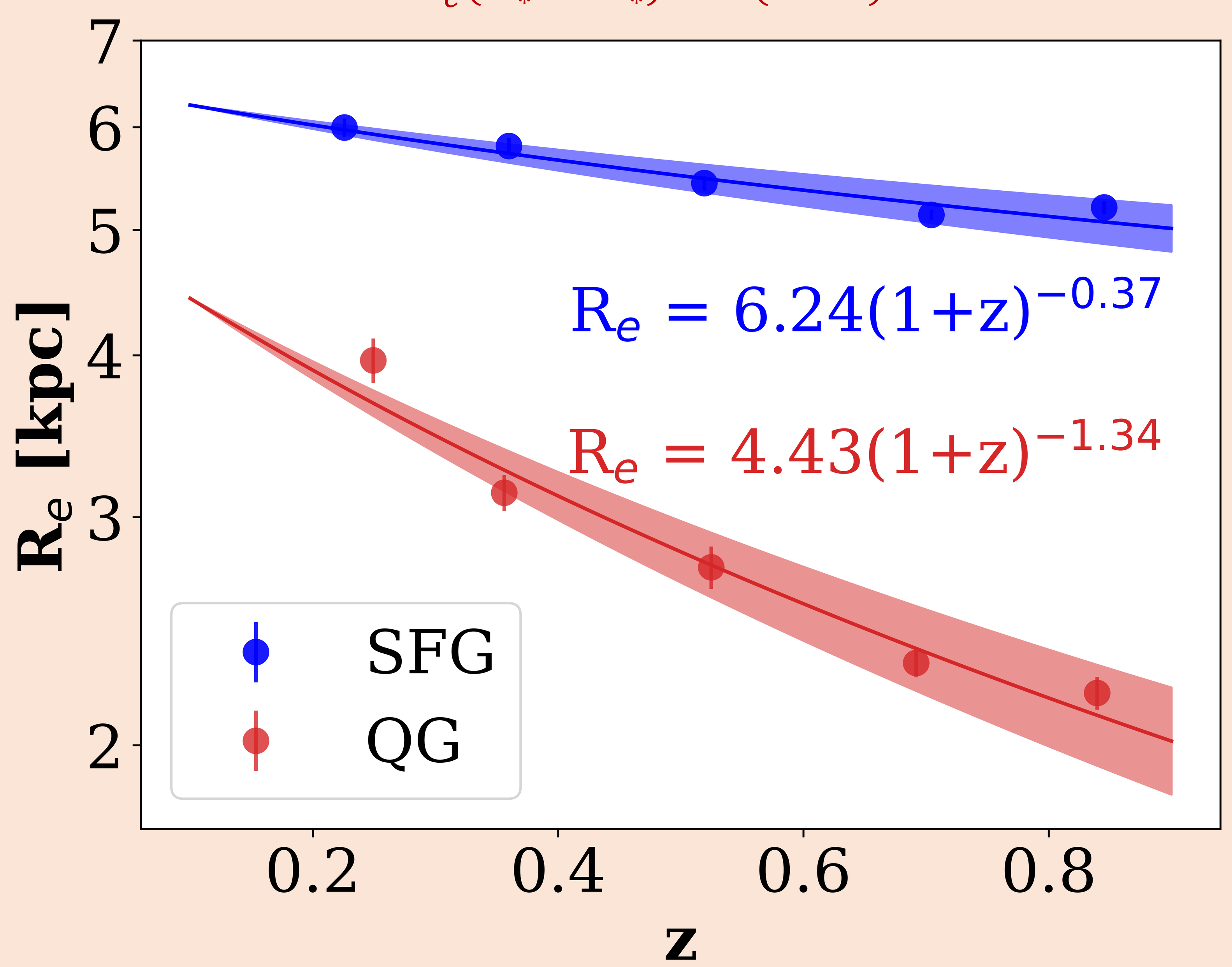

Figure 3: Power-law fits to the evolution of characteristic sizes of SFGs (blue) & QGs (red).

Star-forming Galaxies

Size evolution in SFGs at $z<1$ is slower than at higher redshifts ($z>1$)[4] indicating that the pace of size evolution slows down with time. At $z>1$, SFGs on an average grew by ~10% in 1Gyr compared to ~4% growth at $z<1$. We also find that the fraction of red galaxies (U-V>1) among SFGs increases with time (Figure **4**). The red SFGs tend to have higher n than blue SFGs: ~28% red SFGs have $n>1.5$ compared to ~17% blue ones. Our study suggests that the evolution in SFG morphologies could be driven by the **growth of bulges** in them.

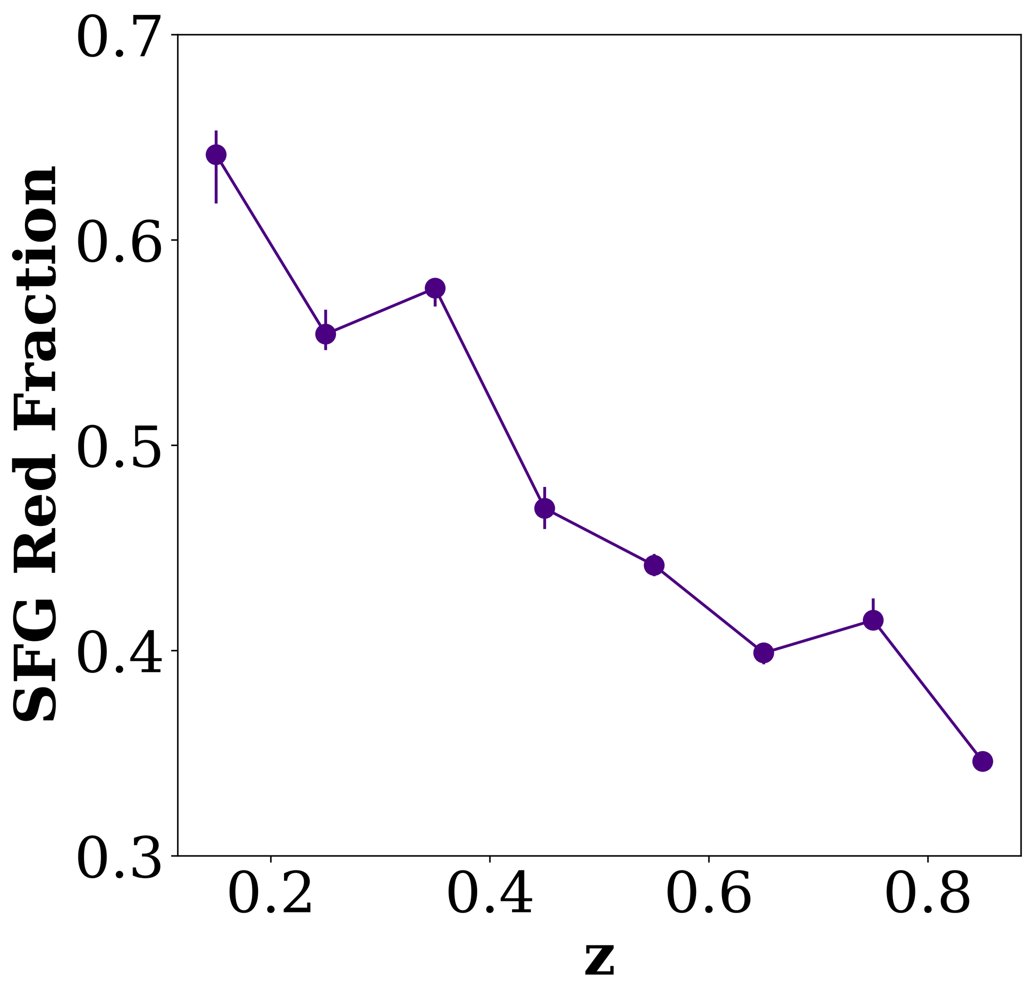

Figure 4: Fraction of red SFGs decreases with redshift.

Quiescent Galaxies

Size evolution in QGs is faster than SFGs, which is consistent with other studies. Several physical processes could be driving this fast size evolution in QGs including progenitor bias, fading of disks, minor mergers and accretion. We would be expanding the analysis to estimate the number of close companions to probe the effects of minor mergers and accretion. Further studies are required to investigate the impacts of other processes.

Conclusions

- SFGs are larger than QGs at a given stellar mass
- SMR is weaker for SFGs than QGs
- SFGs have a weaker size evolution than QGs
- Pace of size evolution slows down with time for SFGs
- Evolution of SFGs: bulge growth
- Evolution of QGs: several processes
- Future Works: Expanding the study to 18.6 deg^2 of CLAUDS+HSC survey

References

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[2]Aihara, et al., 2019, PASJ, 71, 114

[3]Peng, et al. 2010, AJ, 139, 2097

[4]van der Wel, et al., 2014, ApJ, 788, 99

[5]Mowla, et al., 2019, ApJ, 872, 6