The dependence of star formation activity of z<1 galaxies on stellar mass surface density and Sersic index

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Motivation and zCOSMOS sample

- What physical processes inside galaxies drive changes in the SFRs in individual galaxies that, taken together, produce the large decline in the global SFR density since z~2 ?
- Many studies at intermediate redshifts of the SFR or specific SFR (SSFR) have been made as a function of stellar mass, but not using information on the internal structural properties of galaxies
- Studies using the local SDSS sample (Brinchmann et al. 2004, MNRAS, 351, 1151) argued that the surface mass density (Σ_M) may be more important than stellar mass in regulating star formation
- Using zCOSMOS and SDSS: study the changes that have occurred in the SSFR - Σ_M relation between redshift z~1 and the present epoch, selecting comparable mass-complete samples at 0.04<z<0.08 and 0.5<z<0.9
- zCOSMOS: large redshift survey covering 1.5 deg^2 of ACS COSMOS field (Lilly et al. 2007, ApJS, 172, 70)
- 10k zCOSMOS-bright: I_{AB}<22.5 sample of ~10000 galaxies at 0.1<z<1.2

SFRs, stellar masses, morphologies, and sizes

- Emission line fluxes and upper limits: derived using the Platefit_VIMOS automatic routine (Lamareille et al. 2008)
- SFRs for both zCOSMOS and SDSS from the [OII]λ3727 emission line at 0.5<z<0.9 using Moustakas et al. (2006, ApJ, 642, 775) conversion
- Stellar masses from restframe U-B and B-V colors using the Lin et al. (2007, ApJ, 660, 51) color-M/L conversion (which corrects for redshift evolution) for both zCOSMOS and SDSS to achieve internal consistency
- Sizes (half-light radii) and Sersic indices: for zCOSMOS from Sersic fits using GIM2D surface brightness fits (Sargent et al. 2007, ApJS, 172, 434)

zCOSMOS: stellar mass completeness

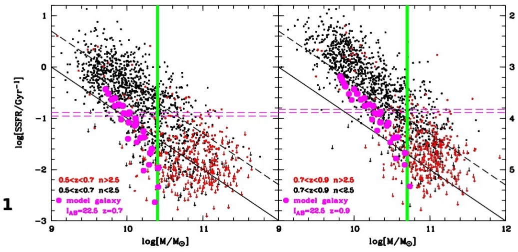

Fig. 1

- Specific SFR versus stellar mass as a function of Sersic indices for ~3000 zCOSMOS galaxies at 0.5<z<0.9
- The inverse of the SSFR, T_{SFR}, is the time required for the galaxy to form all its stellar mass at the current SFR
- The large magenta circles indicate the completeness limit of the sample --> logM>10.4 for 0.5<z<0.7, and logM>10.7 for 0.7<z<0.9
- Galaxies with different Sersic indices have different star formation histories: T_{SFR}>age of the universe (below magenta lines) for quiescent galaxies (higher SFR in the past)--> mostly early-type n>2.5 galaxies

Stellar mass – size relation at z<1

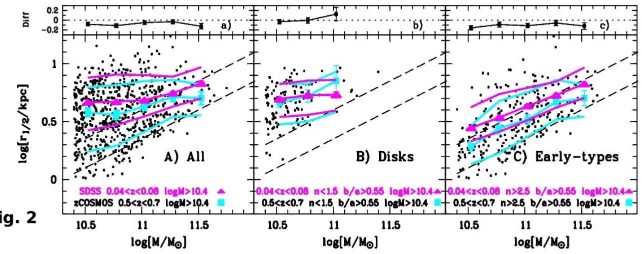

Fig. 2

- Semi-major half-light radius versus stellar mass for the mass-complete galaxy samples at 0.5<z<0.7 (zCOSMOS) and 0.04<z<0.08 (SDSS)
- For n<1.5 galaxies there is little change in the size – mass relation
- For n>2.5 there is modest evolution in the size-mass relation, with galaxies smaller by ~25% at z~0.7 compared to local SDSS galaxies
- The modest differential evolution in the size-mass relation of disk and spheroid galaxies can explain the shift in the Σ_{Mchar} step (see Fig. 4)

SDSS: SSFR – stellar mass density relation

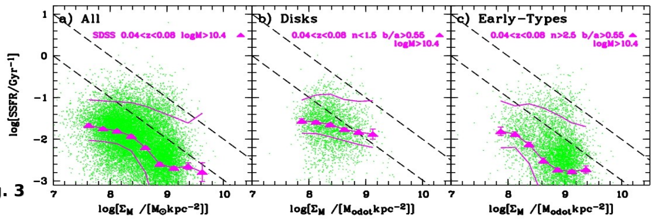

Fig. 3

- Specific SFR versus stellar mass surface density (Σ_M) as a function of Sersic indices for SDSS galaxies at 0.04<z<0.08 with logM>10.4
- The characteristic step-function dependence of the SSFR for the entire sample is due to the change-over from predominantly disk galaxies to predominantly spheroid galaxies at log Σ_{Mchar}~8 .5
- This change-over is clearly seen in Fig. 5: the fraction of n>2.5 SDSS objects shows a sharp increase at the point where the SSFR abruptly changes, i.e. at Σ_{Mtrans}~8 .45 (dashed magenta vertical line in Fig .5)

SSFR – stellar mass density relation at z<1

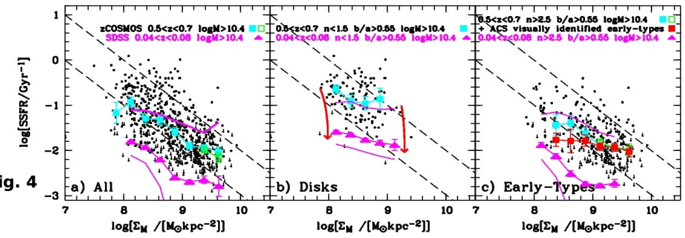

Fig. 4

- The shape of the specific SFR versus stellar mass surface density (Σ_M) relation for logM>10.4 zCOSMOS galaxies at 0.5<z<0.7 is very similar to that of SDSS galaxies, with a roughly uniform increase in the average SSFR by a factor of 5-6 that is broadly independent of Σ_M and which occurs in both n<1.5 and n>2.5 galaxies
- There is also a small increase of 0.1-0.2 dex of Σ_{Mchar} to z~0.7, but this can be explained by the modest evolution in the size-mass relation (Fig.2)
- Low Sersic index galaxies have a SSFR almost independent of Σ_M

Conclusions

- The characteristic step function dependence of the median SSFR on Σ_M in SDSS, seen by Brinchmann et al. (2004), is due to the change-over from predominantly disk galaxies to predominantly spheroidal galaxies at a surface mass density logΣ_{Mchar}~8.5 at which the SSFR is seen to drop (Fig. 3 and 5)
- zCOSMOS 0.5<z<0.9 galaxies show a similar shape for the median SSFR- Σ_M relation, but with median SSFR values that are about 5-6 times higher than for SDSS, across the whole range of Σ_M, and in galaxies with both high and low Sersic indices (Fig.4)
- Galaxies of all types are contributing, proportionally, to the global increase in star formation rate density in the Universe back to z~0.7 (Fig. 4)
- The Σ_{Mchar} step shifts to slightly higher values of Σ_M in zCOSMOS relative to SDSS, but this can be explained by a modest differential evolution in the size-mass relations of disk and spheroid galaxies (Fig. 2)
- Low Sersic index galaxies have a SSFR that is almost independent of Σ_M, and the same is probably true of high Sersic index galaxies once obvious disk systems are excluded (Fig. 4)

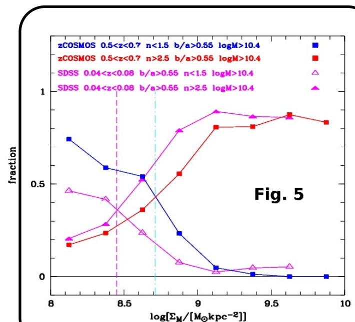

Fig. 5

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