The evolution of the star formation of zCOSMOS and SDSS galaxies at $z < 0.7$ as a function of mass and structural parameters

Christian Maier

Institute of Astronomy, ETH Zürich, CH-8093, Zürich, Switzerland

and the zCOSMOS Collaboration

Abstract. We present in these proceedings some preliminary results we have obtained studying the evolution of the specific star formation rate as a function of surface mass density and Sersic indices at $z < 0.7$. These results are based on the consistent comparison of the properties of $\sim 650$ massive zCOSMOS galaxies in a mass-complete sample at $0.5 < z < 0.7$ with a mass-complete sample of $\sim 21500$ SDSS local galaxies.

1. Introduction

One of the key unanswered questions is what physical parameter(s) drive changes in the star formation rate in individual galaxies. Given the strong correlation (except at the highest masses) between star formation rate (SFR) and stellar mass (see, e.g., Fig.17 in Brinchmann et al. 2004), one can more easily study the relationship between star formation activity and the physical parameters of galaxies by normalizing the SFR by stellar mass. The star formation rate per unit stellar mass, the specific star formation rate (SSFR), is an indicator of galaxy star formation histories, since $1/\text{SSFR}$ defines a characteristic time-scale of star formation.

In the local Universe, there are several studies of the role of stellar mass, $M_*$, and stellar mass density, $\Sigma_M$, in regulating the star formation activity. Using the SDSS sample Brinchmann et al. (2004) found that a low SSFR peak becomes more prominent at high $\Sigma_M$ than at high $M_*$, and concluded that the surface density of stars is more important than stellar mass in determining when star formation is turned off.

We present here some preliminary results on the role of the stellar mass surface density in regulating the star formation activity at $z < 0.7$ for galaxies of different morphologies. This study is based on a $0.5 < z < 0.7$ mass-complete sample of zCOSMOS galaxies. The redshift range $0.7 < z < 0.9$ and more discussion of our results will be addressed in Maier et al. (2009).
2. Selection of the $0.5 < z < 0.7$ mass-complete zCOSMOS sample and the consistent determination of physical properties for zCOSMOS and SDSS

The Cosmic Evolution Survey (COSMOS) is designed to probe the correlated evolution of galaxies, star formation, active galactic nuclei (AGNs), and dark matter with large-scale structure up to high redshifts. COSMOS is the largest HST survey ever undertaken, imaging an equatorial, $\sim 2\text{deg}^2$ field, with single-orbit I-band exposures. Ancillary COSMOS data from Spitzer, XMM-Newton, VLA, and a large number of other ground-based telescopes are available.

zCOSMOS \cite{Lilly2007} is a large redshift survey that is being undertaken in the COSMOS field using 600 hours of observation with the VIMOS spectrograph on the VLT. The zCOSMOS survey consists of two parts: a) zCOSMOS-bright, a magnitude-limited I-band $I_{AB} < 22.5$ sample of about 20000 galaxies with $0.1 < z < 1.2$ covering the whole $1.7\text{deg}^2$ COSMOS ACS field; and b) zCOSMOS-deep, a survey of approximately 10000 galaxies selected through colour-selection criteria to have $1.4 < z < 3.5$, within the central $1\text{deg}^2$ of the COSMOS field.

This study is based on the zCOSMOS-bright sample, and the $0.5 < z < 0.7$ galaxies are selected from 83 VIMOS masks. Line fluxes from the spectra were measured using the automatic software Platefit \cite{Lamareille2008}. For galaxies where Platefit detects all three emission lines $\text{[OIII]}\lambda 5007$, $\text{H} \beta$, and $\text{[OII]}\lambda 3727$, we used the $\text{[OIII]}\lambda 5007/\text{H} \beta$ vs. $\text{[OII]} \lambda 3727/\text{H} \beta$ diagram to disentangle star-formation dominated galaxies from objects obviously containing an active nucleus (narrow-line AGNs) using the empirical threshold derived using the 2dFGRS by Lamareille et al. \cite{Lamareille2004}. Additionally, the X-ray identified AGNs were excluded.

Physical sizes of the zCOSMOS galaxies are computed from the half-light radii derived from GIM2D Sersic fits \cite{Sargent2007} on the ACS images. Stellar masses were derived using the relation between rest-frame U-B and B-V colors and mass-to-light ratio (M/L), using the equation (1) from Lin et al. \cite{Lin2007}, which corrects M/L for redshift evolution, as well as accounting for evolution in color. The $\text{[OII]} \lambda 3727$ line luminosities corrected for aperture effects are transformed into SFRs using a correction factor based on the galaxy’s B-band absolute magnitude, as given by a linear interpolation of the values in Table 2 of Moustakas et al. \cite{Moustakas2006}, and shown in their Fig. 19.

We used Bruzual & Charlot \cite{Bruzual2003} models to assess the mass completeness of the zCOSMOS sample. It turned out that a selection of $\log M_*>10.4$ for $0.5 < z < 0.7$ zCOSMOS galaxies is required to obtain a mass-complete sample which does not miss low mass early-type galaxies. This way we remained with $\sim 650$ zCOSMOS galaxies at $0.5 < z < 0.7$.

We would like to point out that masses (from colors), sizes (from g-band images), Sersic indices (from g-band images), and SFRs (from the $\text{[OII]} \lambda 3727$ line flux) were computed in a consistent way for the zCOSMOS and SDSS mass-complete samples. More details on the consistent derivation of physical parameters for the zCOSMOS and SDSS sample can be found in Maier et al. \cite{Maier2009}.
Figure 1. Specific star formation rate vs. stellar mass surface density for the zCOSMOS mass complete sample at 0.5 < z < 0.7 (individual measurements shown as cyan dots, and median values shown as black squares) compared to the median SSFR values in different $\Sigma_M$ bins of 0.04 < z < 0.08 SDSS galaxies (magenta triangles). Moreover, the 25th and 95th percentiles of SSFR in the respective SDSS $\Sigma_M$ bin are shown as solid magenta lines. Diagonal dashed lines correspond to SFR surface densities $\Sigma_{\text{SFR}} = 0.01 M_\odot / \text{yr}/\text{kpc}^2$, and 0.1 $M_\odot / \text{yr}/\text{kpc}^2$, respectively. For $n < 1.5$ galaxies (panel a) the SSFR stays roughly constant (or decreases slightly) with $\Sigma_M$, with the median SSFR at a given $\Sigma_M$ being higher in zCOSMOS than in SDSS. For $n > 2.5$ galaxies (panel b) the SSFR declines with $\Sigma_M$ for both zCOSMOS and SDSS galaxies, but there is a shift to higher $\Sigma_M$ for zCOSMOS galaxies, additional to the fact that the SSFR of zCOSMOS galaxies is higher than for SDSS. The median values of all $b/a > 0.55$ galaxies in the mass-complete samples of SDSS and zCOSMOS galaxies are shown as open symbols in panel c.

3. Specific star formation rate (SSFR) versus stellar mass surface density ($\Sigma_M$) at $z < 0.7$

Fig. 1 shows the SSFR vs. stellar mass surface density for the mass-complete sample ($\log M_\ast > 10.4$) of zCOSMOS galaxies at 0.5 < z < 0.7, and for $\log M_\ast > 10.4$ SDSS galaxies at 0.04 < z < 0.08, as a function of Sersic index $n$. We show in Fig. 1 only galaxies with an axis ratio $b/a > 0.55$, because of the lower inclination of these objects, which minimizes the effects of dust extinction on galaxy colors, used to derive stellar masses, and on the $\text{[O II]} \lambda 3727$ line flux, used to derive star formation rates.

The individual measurements for zCOSMOS 0.5 < z < 0.7 galaxies with $n < 1.5$ (disk galaxies) and $n > 2.5$ (early-type galaxies) are shown as cyan dots in panel a) and b), while panel c) compares the median values of zCOSMOS and SDSS mass-complete samples of $b/a > 0.55$ galaxies (open symbols) with the median values shown in panel a) and b) for low and high Sersic indices (filled squares for zCOSMOS, filled triangles for SDSS). Diagonal dashed lines correspond to SFR surface densities $\Sigma_{\text{SFR}} = 0.01 M_\odot / \text{yr}/\text{kpc}^2$, and 0.1 $M_\odot / \text{yr}/\text{kpc}^2$, respectively.

The 25th and 95th percentiles of the SSFR in the respective SDSS $\Sigma_M$ bin are shown as solid magenta lines in panel a) and b). The decrease in the 25th percentile of SSFR we see for SDSS $n > 2.5$ galaxies suggests that there is an increasing supression of star formation as the bulge of the galaxy becomes more...
dominant. This is unlike the situation for \( n < 1.5 \) SDSS galaxies, where the 25th percentile of the SSFR distribution decreases only slightly, which is due to the fact that most \( n < 1.5 \) galaxies have elevated levels of star formation.

For both zCOSMOS and SDSS \( n < 1.5 \) galaxies (panel a) the SSFR stays roughly constant (or decreases slightly) with \( \Sigma M \), with the median SSFR at a given \( \Sigma M \) being higher in zCOSMOS than in SDSS. A declining SFR in zCOSMOS \( n < 1.5 \) (disk) galaxies would explain their evolution in order to reach the location of SDSS \( n < 1.5 \) galaxies today. For \( n > 2.5 \) (early-type) galaxies (panel b) the SSFR declines with \( \Sigma M \) for both zCOSMOS and SDSS galaxies, but there is a shift to higher \( \Sigma M \) for zCOSMOS galaxies, additional to the fact that the SSFR of zCOSMOS galaxies is higher than for SDSS. Panel c) shows how the different behaviour of median values for low and high Sersic index galaxies can explain the general trend seen in the population (open symbols). A more in-depth discussion of these interesting results and additional analysis of the \( 0.7 < z < 0.9 \) zCOSMOS mass-complete sample is presented in Maier et al. (2009).

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