EVOLUTION OF THE GALAXY LUMINOSITY FUNCTION IN THE FORS DEEP FIELD (FDF)

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Abstract With the large homogeneous dataset and the accurate photometric redshifts ($\Delta z/(z+1) \approx 0.03$) of the FORS Deep Field (FDF) we are able to study the evolution of the luminosity function in various bands from low ($\langle z \rangle = 0.3$) to high redshift ($\langle z \rangle = 4.5$). We find a strong brightening of M^* and decrease of ϕ^* with redshift in the restframe UV. We also find an increase of the star formation rate (SFR) between $0.5 < z < 1.5$, whereas the SFR remains approximately constant between $1.5 < z < 4.0$.

Keywords: galaxies: photometric redshift, luminosity function, star formation rate

1. The FORS Deep Field in Brief

The FORS Deep Field (Heidt et al., 2003) is a 9-band pencil beam survey observed with FORS at the VLT and SOFI at the NTT (NIR - data). It is about 8 times larger in area and nearly as deep as the HDFN. The 50% completeness limits for point sources are 26.5, 27.6, 26.9, 26.9, 26.8, ~ 25.5, ~ 25.8, 24.5, 23.5 in U, B, g, R, I, 834 nm, z, J and Ks (AB-system), respectively. The seeing varies from $0.5''$ in the I and z band to $1.0''$ in the U band. Furthermore the spectroscopic follow-up comprises more than ~ 400 sources (Noll et al. 2003, in preparation). The following results are all based on an I band selected catalogue which contains about 5560 galaxies within the overlap area of all 9 filters. Throughout the following AB magnitudes and a flat cosmology ($\Omega_M = 0.3$, $\Omega_\Lambda = 0.7$) with $H_0 = 70\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ are used.

2. Photometric redshift

The 9 bands of the FDF and the large spectroscopic sample allow us to derive precise distances using the photometric redshift technique (Bender et al., 2001). This method seeks optimal agreement between redshifted spectral templates and the observed photometry. The semi-empirical templates were constructed by fitting stellar population models of Maraston (1998) of different dust extinction and age to the observed broad-band energy distribution of galaxies with spectroscopic redshift.

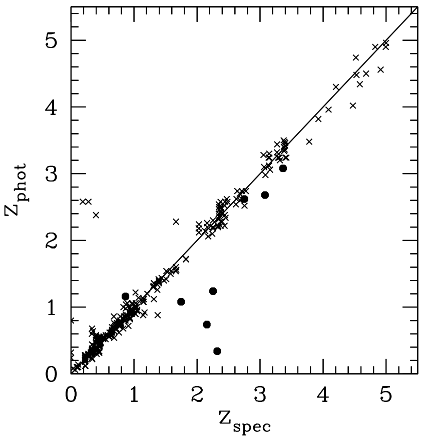

Figure 1. Comparison of spectroscopic and photometric redshifts of 362 objects. Crosses represent galaxies whereas filled circles represent QSOs.

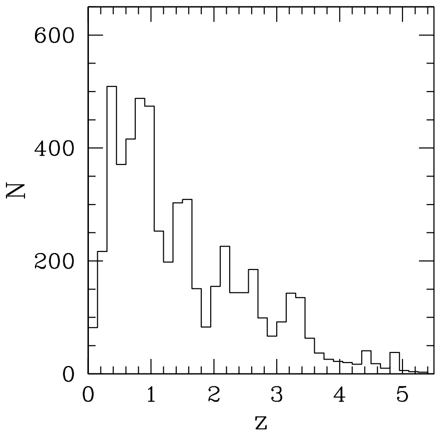

Figure 2. Redshift distribution of all 5558 objects.

A comparison of the photometric and spectroscopic redshifts of 362 galaxies in our sample is shown in Figure 1. The agreement is very good with a typical error of only $\Delta z/(z+1) \approx 0.03$. Furthermore we have only 7 outliers out of 362. 4 of these outliers are QSOs for which a determination of a photometric redshift is difficult because of their power-law SED. A detailed description of the photometric redshifts in the FDF can be found in Bender et al. (2003, in preparation).
In Figure 2 the redshift distribution of the galaxies in the FDF used to derive the luminosity function and SFR is shown. Even at high redshift ($z > 4.0$) we have more than 150 objects.

3. Luminosity function

We use the best fitting SED as determined by the photometric redshift code and the SED itself to derive the rest-frame luminosity of the galaxies. This procedure reduces systematic influences of measurements in a single observer frame waveband. The error budget of the luminosity functions include both the photometric redshift error as well as the statistical error. We perform Monte Carlo simulations including the redshift probability distribution P(z) of the best fitting SED of every single object to account for the photometric redshift error. A detailed description of the evolution of the luminosity functions in different wavebands with redshift as derived from the FDF can be found in Gabasch et al. (2003, in preparation).

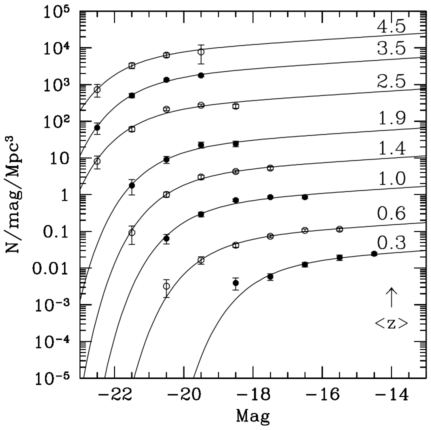

Figure 3. Luminosity functions at 280 nm from low ($\langle z\rangle = 0.3$) to high redshift ($\langle z\rangle = 4.5$). ϕ^* has been arbitrarily shifted by 1 dex per redshift bin for clarity.

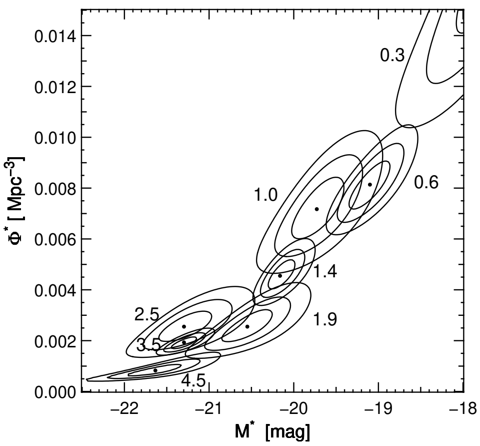

Figure 4. 1σ, 2σ and 3σ confidence levels in Schechter parameter space for a fit to the luminosity function at 280 nm from $\langle z\rangle = 0.3$ to $\langle z\rangle = 4.5$ with a fixed slope $\alpha = -1.15$.

As an example we show the evolution of the luminosity function at 280 nm from $\langle z\rangle = 0.3$ to $\langle z\rangle = 4.5$ for a fixed slope $\alpha = -1.15$ in Figure 3 and Figure 4. We find a strong brightening of M* and decrease of ϕ^* from low to high redshift. One can see from Figure 4 that we are able to derive M* and ϕ^* with small errors, because we have about 700 galaxies in all but the last redshift bin. Although the variation of M* and ϕ^* between adjacent redshift bins is in part influenced by large scale structure, the overall trend in the evolution of M* and ϕ^* seems robust.

4. Star formation rate

From the luminosity density at 280 nm we derive the star formation rate (SFR) following Madau et al. (1998). The error budget of the SFR includes again the photometric redshift error as well as the statistical error.

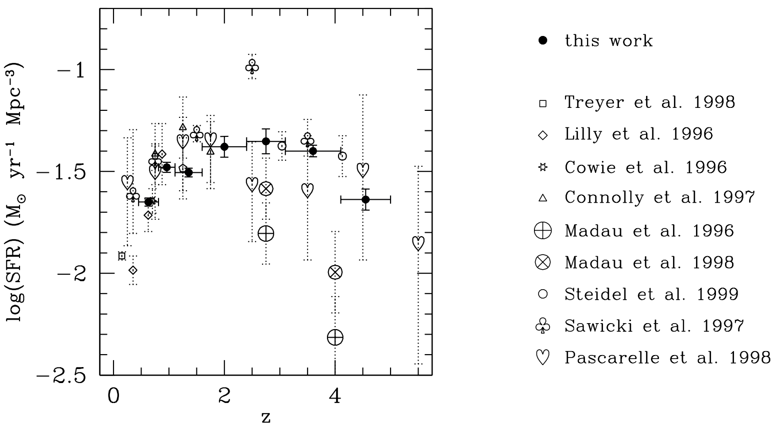

Figure 5. Evolution of the star formation rate derived from the luminosity density at 280 nm corrected for incompleteness, but not for dust.

In Figure 5 we show the evolution of the SFR assuming a Salpeter IMF. All points are corrected for incompleteness but, not for dust. The comparison with the literature (see Somerville et al. 2001 for the references) shows good agreement. Because of the large data sample of the FDF our errorbars are substantially smaller. A detailed description of the SFR in the FDF will be presented in Gabasch et al. (2003, in preparation).

Acknowledgments

This work was supported by the *Deutsche Forschungsgemeinschaft DFG*, SFB 375 *Astroteilchenphysik* and SFB 439 *Galaxien im jungen Universum*.

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