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STUDYING THE EVOLUTION OF MULTI-WAVELENGTH EMISSIVITIES WITH THE VIMOS VLT DEEP SURVEY

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Abstract. The VIMOS VLT Deep Survey (VVDS) is a unique I-selected spectroscopic sample to study galaxies all the way from $z = 5$ to $z = 0$. We recapitulate the first results about the evolution of the galaxy populations as a function of type and luminosity.

1 Introduction

The construction of various distribution functions in different redshift bins leads to the description of these galaxy populations through cosmic time. In this process a key-point is to define and quantify the completeness of sources so we can compare galaxy samples both at different redshift bins within a single survey, and with other observed or simulated surveys (see discussions in Tresse, 1999). The luminosity function, $\phi(L)$, that is the distribution of the comoving number density of galaxies as a function of their intrinsic luminosity, is a fundamental measurement to quantify the evolution of the galaxy populations. Moreover, integrated quantities such as the luminosity density, $\int \phi(L)LdL$, are little dependent on the individual evolutionnary histories, and are solid links to the underlying processus of galaxy evolution and formation, such as the Star Formation Rate (SFR) history or the stellar mass assembly. Nevertheless, because galaxy evolution involves a complex interplay of galaxy morphology, color, SFR, mass accretion and environment, it is necessary to acquire large samples to trace the galaxy populations sorted out according to these parameters. These galaxy characteristics are supplied by the new generation of redshift surveys, like the VVDS, over the same regions of sky as broad-band or follow-up observations.

2 The VIMOS VLT Deep Survey

The VVDS redshift survey is based primarily on observations with the 8.2m ESO-VLT Melipal telescope in Paranal, Chili. It consists of spectra of over 10^5 faint sources covering ~ 10 deg^2 in five regions of sky. The survey is divided into three selection functions with sources selected to have $17.5 \leq I_{AB} \leq 24.5$ (VVDS-Deep), $17.5 \leq I_{AB} \leq 22.5$ (VVDS-Wide), and $I_{AB} \leq 25.75$ (VVDS-Ultra Deep). Sources have been targeted on the sole criterion of an I_{AB} flux limit. No pre-selection has been applied in term of colors, sizes, photometric redshifts, or peculiar sources. We present results from the first epoch observations (VVDS-Deep) obtained in two fields of view, VVDS-02 and VVDS-CDF (see details in Le Fèvre et al. 2004; Le Fèvre et al. 2005). The sample is composed of 11564 spectra over 2200 arcmin^2 of sky area observed in UBVRI broad-band photometry. The measured redshifts are at $0 < z < 5$ with an average redshift of 0.76 (and a median of 0.9) and with a 1σ accuracy of the z measurement of 0.00009. We adopt the set $(\Omega_M, \Omega_\lambda, h) = (0.3, 0.7, 0.7)$ for the cosmological parameters.

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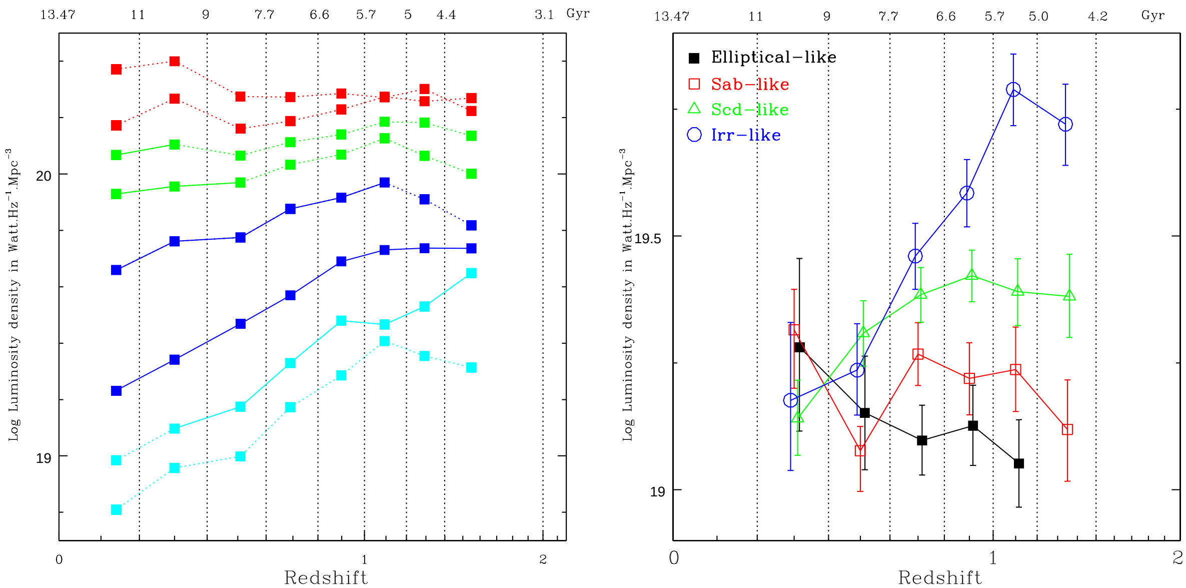

Fig. 1. From left to right. (a) Comoving luminosity densities in the rest-frame FUV, NUV, UBVRI and K bands from bottom to top, respectively. The solid line connects points where the rest-frame band is observed in the optical. They evolve with redshift over $0.05 \leq z \leq 1.2$ as proportional to $(1_{+}z)^{x}$ with $x = 2.05, 1.94, 1.92, 1.14, 0.73, 0.42, 0.30, -0.48$, respectively. (b) Comoving LDs in the rest-frame B-band from early to late types. (from Tresse et al. 2006)

3 The Evolution of Galaxy Population Emissivities

3.1 Since $z = 2$

We have built the luminosity functions (LF) using the VVDS multi-wavelength data in the rest-frame bands U-3600, B-4400, V-5500, R-6500, I-7900 (see Ilbert et al. 2005), in the GALEX rest-frame bands FUV-1500 (see Arnouts et al. 2005) and NUV-2800, and in the rest-frame K-22000. The corresponding Luminosity Densities (LD) are derived in summing them over all luminosities (see Fig. 1a). The global galaxy population exhibits a clear differential, wavelength-dependent evolution which undergoes an upturn at redder wavelengths than the I-band. This evolution is related more or less directly to the very different stellar populations which dominate a given rest-frame band. Although error bars are still large, most LDs display a transition at $z \simeq 1.1$ in the evolutionary tendency. Over the last 8.5 Gyrs, the SFR-related LD(FUV) drops by a factor 4 while the stellar mass-related LD(K) increases by a factor 1.3 in the last 4.5 Gyrs. It might be evidence for recent merger events, but which should produce little star formation.

3.2 Since $z = 5$

Within a single survey, it makes possible to compare the galaxy populations all the way from $z = 5$ to $z = 0$. We begin to see structures in the global emissivity evolution, such as the several up-and-down phases through cosmic time of the global rest-frame LD(FUV) (see Fig. 2). In particular, from $z = 5$ to $z = 3.4$ it increases by at most a factor ~ 3.5. From $z = 3.4$ to $z = 1.2$ it globally decreases by a factor 1.2, with a potential decline by a factor ~ 1.4 from $z = 3.4$ to $z = 2$, and an increase by a factor ~ 1.3 from $z = 2$ to $z = 1.2$. From $z = 1.2$ to $z = 0.05$ it declines steadily by a factor 4.

4 The Evolution per Galaxy Populations

Galaxies present various features which can be regrouped into classes related to fundamental observables, such as the morphology, the colors, the luminosity, the environment, etc. Classes are usually set using well-known local parameters. Through their individual history, galaxies might change of class through cosmic time, and thus

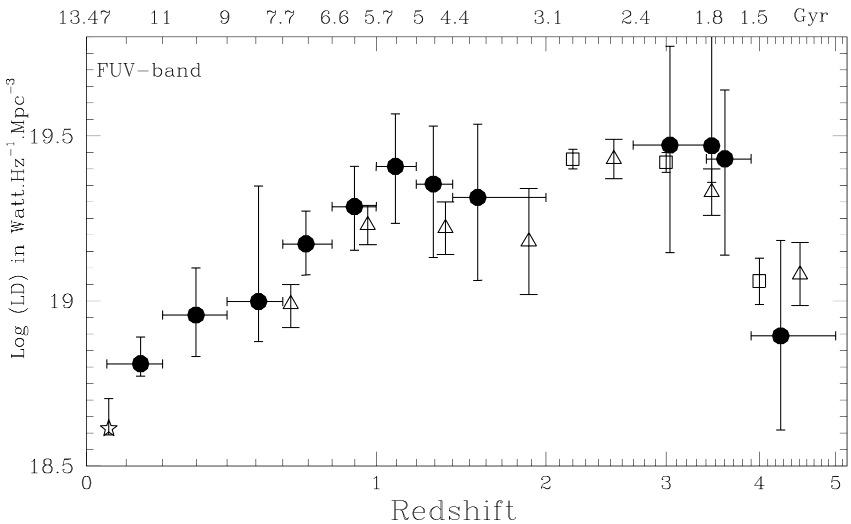

Fig. 2. Comoving luminosity densities in the rest-frame FUV from $z = 0$ to $z = 5$. The plain circles represent the VVDS data, the open star represents the GALEX-2dFGRS local point (Wyder et al. 2005), the open triangles represent data from the FORS Deep Field (Gabasch et al. 2004) and the open squares represent data from the Keck Deep Fields (Sawicki et al. 2006). (from Tresse et al. 2006)

the comparative study of the distribution functions built at different redshifts enables us to trace the evolution of galaxy populations, but not the evolution of individual galaxies.

4.1 Per spectral type

Using the whole photometric information, we have classified our galaxies in four VVDS spectral classes. From Zucca et al. (2006) and Tresse et al. (2006), we find the following for the early and late type classes up to look-back times corresponding to 30 percent of the current age of the Universe (see Fig. 1b). The LF of the early-type population is consistent with only passive evolution since $z \sim 1.1$, while the fraction of bright early-type galaxies ($M_{B(AB)} - 5log(h) < -20$ mag) increases from 0.05 to 55 percent from $z = 1.5$ to $z = 0.2$. The corresponding LD(B) increases continuously by a factor ~ 1.7. This population suggests that luminous red galaxies must appear at low redshifts to keep increasing the LD since this population is faintening by 0.3 mag only. The LF of the late-type population undergoes a strong evolution in density and luminosity. There is a steady decrease in volume density by a factor ~ 2 coming from both the bright and faint parts of the LF. The fraction of bright late-type galaxies decreases from ~ 35 to ~ 5 percent from $z = 1.5$ to $z = 0.2$. Thus the corresponding LD(B) decreases markely by a factor ~ 3.5. This population supports a downsizing scenario where most star formation is shifting to faint galaxies at $z < 1.2$.

4.2 Per intrinsic luminosity

The SFR-related LD(FUV) is strongly luminosity-dependent as shown in Fig. 3. The old, most luminous ($M_{AB}(1500A) < -21$) galaxy population has exhausted its cold gas reservoir during its early intense star formation which has occured in the early Universe at $z \gg 4$, and since $z \simeq 3.5$, i.e. 12 Gyrs, its undergoes passive evolution as star formation cease. It creates excellent dry candidates. Creation of new galaxies occurs as the threshold amplitude for forming bright galaxies decrease as described in Marinoni et al. (2005). That is the typical L^* of the population created at a given redshift will decrease with decreasing redshift. This imply that the younger, less luminous L^* galaxy population continues to efficently form stars with a large reservoir of cold gas up to $z = 0.2$. And at $z < 0.2$, this later population appears to have also exhausted its gas supply. The gas-exhaustion would favor the evolution of morphologies toward early-type galaxies.

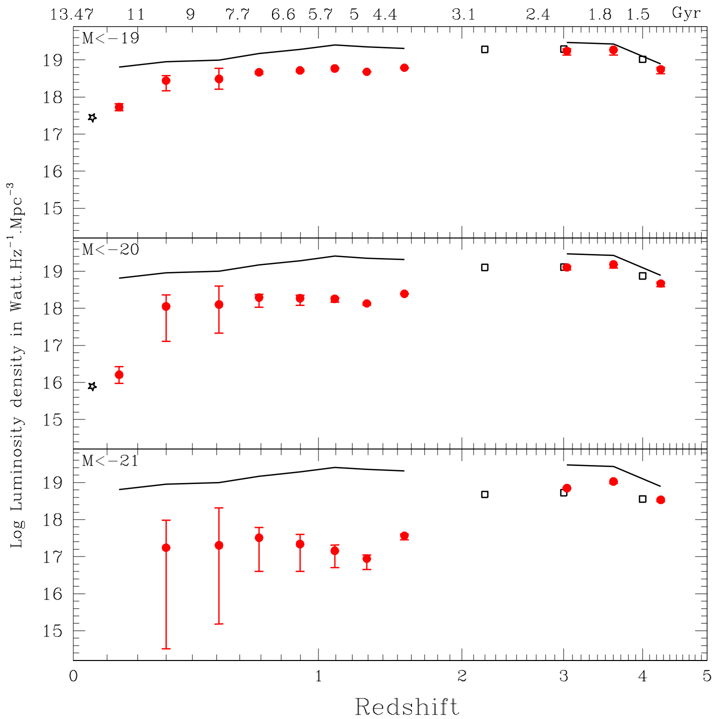

Fig. 3. Comoving rest-frame FUV luminosity densities from $z = 0$ to $z = 5$ for the bright galaxy populations defined as $M_{AB}(1500A) < -19, -20$ and -21 mag and represented by solid circles. In each panel, the solid line connects the VVDS points of the global LD(FUV) as displayed in Fig. 2.(from Tresse et al. 2006)

5 Summary

Within a single survey, as the VVDS, we have quantified the galaxy population distributions since $z \sim 5$. Our observed global evolution does not seem to be in agreement with a continuous smooth decrease from $z \sim 3.5$ to $\simeq 0$ as predicted by the simulations. It is related to both the characteristics of the dominant population at a given cosmic time and the evolution of the galaxy populations (per type, per environment, per luminosity). The picture is globally consistent with a downsizing scenario for the star formation rate in L^* galaxies, while the dwarf population undergoes density evolution.

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