UV Properties of Primeval Galaxies

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Abstract
The problem of UV properties of primeval galaxies is briefly assessed from the theoretical point of view discussing its impact on the definition of the cosmological model.

1 Introduction

The recent major improvements in the observation of high-redshift galaxies, coming from HST (Williams *et al.* 1996; Madau *et al.* 1996) and other ground-based telescopes of the new generation (Koo *et al.* 1996; Lilly *et al.* 1996; Cowie and Hu 1998), have urgently called for a better understanding of galaxy UV spectrophotometric properties.

Optical and infrared observations of the most distant objects are in facts inspecting their restframe ultraviolet features, so that any chance of successful detection of primeval galaxies should eventually rely on their fair recognition in this photometric range.

A theoretical approach has to be preferred in this regard to match the data since ground-based observations prevent us to explore local galaxy templates in the extreme UV band with comparable detail.

In this note we would briefly complement Buzzoni's (1998a,b) full analysis assessing the general problem of the UV properties of primeval galaxies and its impact on the cosmological model.

2 UV Luminosity and Star Formation Rate

In Fig. 1 we show a synthetic c-m diagram in the U vs. $U-B$ plane for a 4 Gyr old simple stellar population (SSP) of solar metallicity generating from a burst star formation according to a Salpeter IMF (Buzzoni 1989). This diagram might probably match the real case of a young elliptical galaxy as seen about $z \sim 2$.

It is evident from the figure that the SSP UV luminosity is largely dominated by the stars around the main sequence turn off (TO) region (note, on the contrary, that red giant stars are definitely too cool to give any major contribution at short wavelength).

This tight dependence still holds even in a more complex evolutionary scenario dealing with a continuous star formation rate (SFR) so that a direct link exists between total UV luminosity of the composite stellar population and the relative number of young stars of higher mass (that is those with the hottest TO). One could therefore envisage a straightforward relationship between galaxy UV luminosity and *actual* SFR, as outlined in Fig. 2 according to Buzzoni's (1998b) calibration.

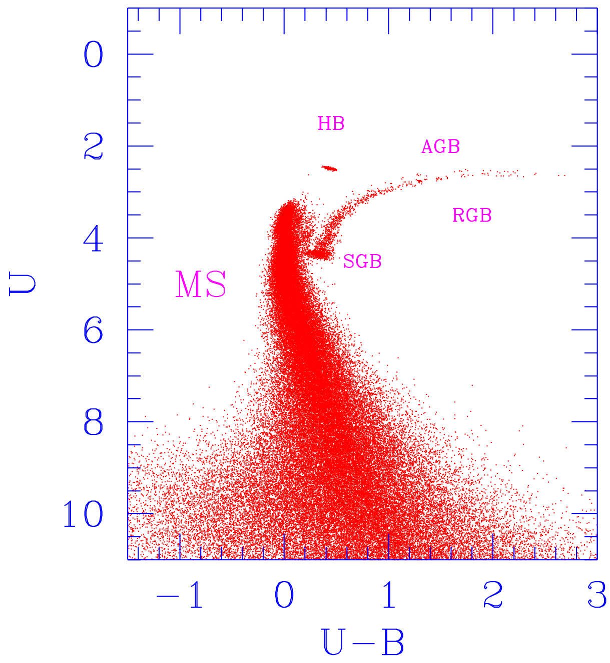

Figure 1: Synthetic c-m diagram for a 4 Gyr Salpeter SSP of solar metallicity (Buzzoni 1989). The random simulation consists of 10^5 stars. Data have been added a Poissonian photometric error such as $\sigma(U) = \pm 0.03$ mag at $U = +4$. The main stellar evolutionary phases are labelled in the figure. Note the major contribution to the total luminosity of the population from the stars around the MS Turn Off region.

3 The Cosmic SFR and UV Luminosity Density

As the prevailing characteristics of the UV radiation is to track galaxy SFR, this leads to a quite different interpretative approach to the galaxy luminosity function as observed in the restframe UV range. In this case in facts galaxy luminosity is not tracking the object size but rather its actual star formation activity.

A study of the luminosity function at low redshift clearly displays a change in the Schechter fitting parameters in the sense of a steepening in the faint-end tail of the function as far as we move from optical to ultraviolet wavelengths (cf. Fig. 3).

If this trend is maintained also at high redshift, then undetected "quiescent" galaxies might provide a major contribution to the cosmic UV background. Once trying to account for this large fraction of faint objects and correct accordingly the current estimates of the cosmic UV luminosity density, according for instance to Madau (1997b), the final result would lead to a measure of the cosmic SFR like in Fig. 4.

No evident signs of enhanced star formation at $z \sim 1.5$ appear from the figure, contrary to Madau's (1997b) original results. The inferred SFR is a flat or decreasing function of the cosmic age, depending on the assumed cosmological model. For an Einstein-De Sitter model, a power law such as SFR $\propto t^{-1}$ seems to consistently match the observations, while a low-density open Universe suggests a possibly constant SFR ~ 0.02 $[H_o/50]$ $M_\odot/yr$. This calls for a prevailing population of quiescent star-forming galaxies at high-redshift, although it does eventually not imply for those objects to be also *bona fide* "primeval" galaxies.

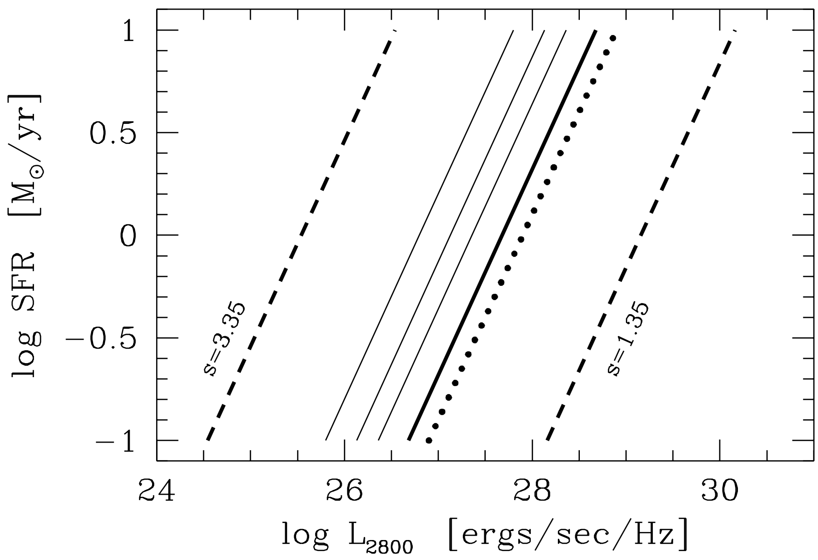

Figure 2: SFR vs. UV-luminosity relationship at 2800 Å according to Buzzoni (1998b). Solid lines (from the left to the right) display the galaxy calibration for a Salpeter IMF (s = 2.35) and upper star mass $M_{up} = 40, 60, 80$, and 120 $M_\odot$, with the last case marked in boldface. A change in the IMF slope (fixing M_{up} = 120 $M_\odot$ throughout) is explored by the two dashed lines for a power-law index s = 3.35 and 1.35, as labelled. Madau's (1997a) calibration for a Salpter IMF and M_{up} = 125 $M_\odot$ is also reported for comparison (dotted line).

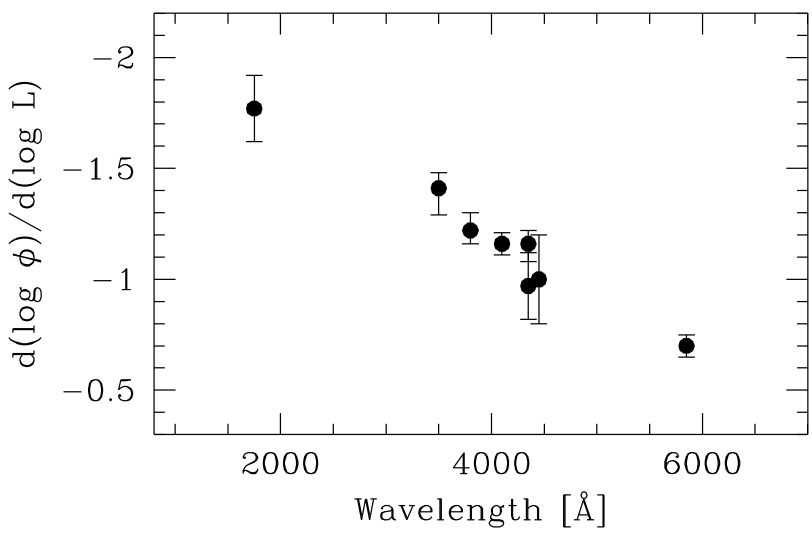

Figure 3: The observed faint-end slope of the Schechter galaxy luminosity function (ϕ) according to different low-redshift galaxy surveys as collected by Buzzoni (1998b). It is evident a steepening in the $\partial log\ \phi/\partial log\ L$ derivative approaching a value of –2 in the UV range.

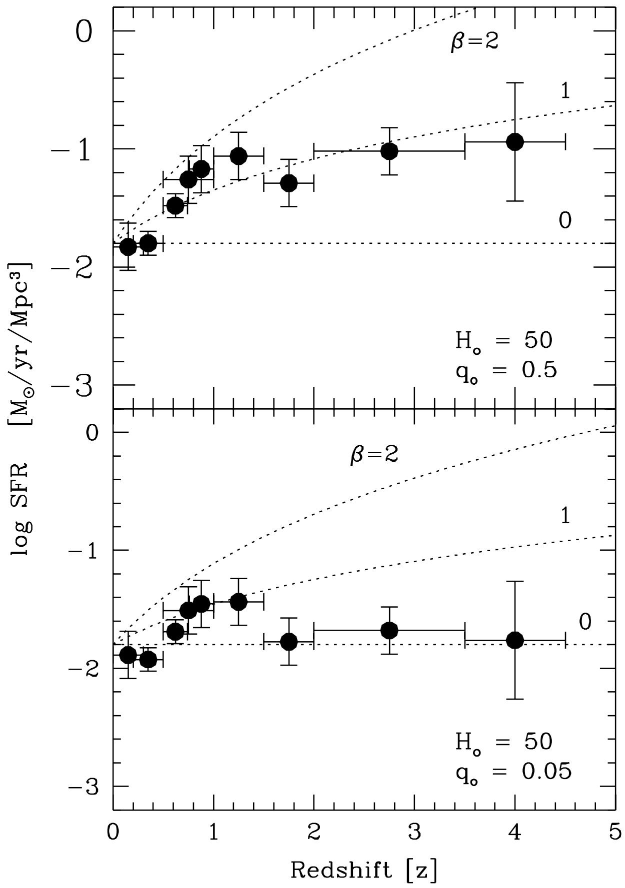

Figure 4: The cosmic SFR as derived from the UV luminosity density after correction for incompleteness in the faint-galaxy counts. Two cosmological models are considered with an Einstein-De Sitter metrics $(H_o, q_o) = (50, 0.5)$ *(upper panel)*, and a low-density open model with $(H_o, q_o) = (50, 0.05)$ *(lower panel)*. A power-law dependence with cosmic age such as SFR $\propto t^{-\beta}$ with $\beta = 0, 1$, and 2 is superposed on the plots (short-dashed lines).

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