A Massive Star Odyssey, from Main Sequence to Supernova
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Physical properties of low-luminosity galaxies at $z \approx 2$

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Abstract. We report the results obtained from VLT-ISAAC near-IR spectroscopy of two low-luminosity $z \simeq 1.9$ galaxies located in the core of the lensing cluster AC 114. The amplification factor allowed to obtain, for the first time, physical properties (SFR, abundance ratios, mass, *etc.*) of star-forming galaxies, 1 - 2 mag fainter than in previous studies of LBGs at $z \approx 3$.

Near-infrared spectroscopy provides a view of the physical properties of the high-redshift (up to $z \approx 6$) star-forming galaxies using various rest-frame optical line diagnostics (Balmer lines, [O II] $\lambda\lambda$3726,3728, [O III] $\lambda\lambda$4959,5007, [N II] λ6584, *etc.*) commonly applied for nearby galaxy studies. With the recent advent of near-IR spectrographs on 8-10m class telescopes, these studies have started in the $1.8 \leq z \leq 3.5$ domain (Pettini *et al.* 1998, 2001; Kobulnicky & Koo 2000). The main applications have been the determination of the star-formation rate (SFR) deduced from the Hα luminosity, the abundance of oxygen derived from the strong oxygen emission lines, and virial masses obtained from the emission line widths. The main goal of these studies is to derive the physical properties of distant galaxies, using the same parameter space as for galaxies in the local Universe.

We report results obtained on two lensed low-luminosity $z \simeq 1.9$ galaxies (S2 and A2) located in the core of the lensing cluster AC 114, including emission-line measurements on star-forming galaxies as faint as $M_B \approx -20$, thus 1 - 2 mag fainter than in previous studies of Lyman break galaxies (LBG) at $z \approx 3$ (*e.g.*, Pettini *et al.* 2001). VLT-ISAAC medium-resolution *JHK* spectra of the two galaxies S2 and A2 have been obtained in two hour exposures (per band and per object) on 26-27 September 2001. Bright rest-frame optical emission lines are measured (intensity and line width) with a high S/N ratio (see Figure 1) and have been used to perform a detailed analysis of the physical properties (SFR, chemical abundances, virial mass, *etc.*) of S2 and A2. The SFRs derived from Hα luminosity are 20 (S2) and 40 (A2) times larger than those derived from the UV (1500Å) luminosity, without dust extinction correction. The difference reduces to a factor of 3 (S2) and 6 (A2), assuming an extinction $E_{B-V} = 0.3$ mag, but still the SFR(Hα) > SFR(1500Å). These results suggest that quite large dust extinction corrections are needed for intrinsically faint optically-selected galaxies

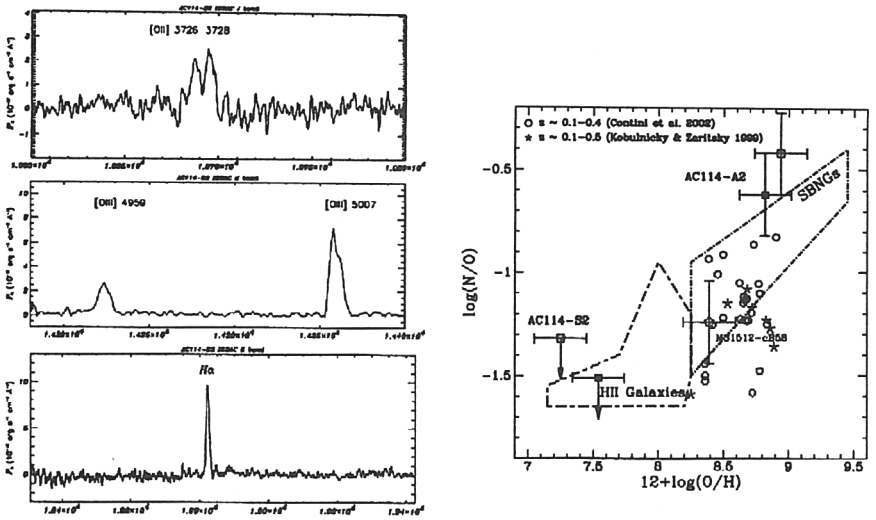

Figure 1. *Left:* VLT-ISAAC spectrum of the low-luminosity $z \simeq 1.9$ galaxy S2 in the core of the lensing cluster AC 114. *Right:* N/O *vs.* O/H relation for nearby (H II galaxies and SBNGs) and high-z star-forming galaxies. The location of the two low-luminosity galaxies S2 and A2 is shown without extinction correction (empty squares) and assuming $E_{B-V} = 0.3$ (filled squares).

compared to other samples of bright UV-selected distant galaxies (*e.g.*, Pettini *et al.* 2001). The large spectral coverage obtained, from [O II] $\lambda\lambda$3726,3728 to Hα,[N II] λ6584 allowed to set strong constraints on the abundances ratios of these two low-luminosity galaxies (see Figure 1). The behavior of S2 and A2 in terms of metallicity is very different, and they are also different from typical LBGs at $z \approx 3$. S2 is a low-metallicity object ($Z \simeq 0.03\,Z_{\odot}$) with a low N/O ratio, similar to those derived in the most metal-poor nearby H II galaxies. On the contrary, A2 is a metal-rich galaxy ($Z \simeq 1.5\,Z_{\odot}$), with a high N/O abundance ratio, similar to those derived in the most metal-rich massive SBNGs. The position of MS 1512-cB58, a lensed luminous LBG (Teplitz *et al.* 2000), is intermediate between these two extremes, showing abundance ratios typical of low-mass starburst nucleus galaxies and intermediate-redshift galaxies. These results suggest different star formation history for distant galaxies of different luminosities. Larger samples of faint high-z galaxies are urgently needed to conclude, in order to set strong constraints on the galaxy evolution scenario.

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