3D Lyα RADIATION TRANSFER

Constraints on gas and stellar properties of $z \sim 3$ Lyman break galaxies(LBG) and implications for high-z LBGs and Lyα emitters

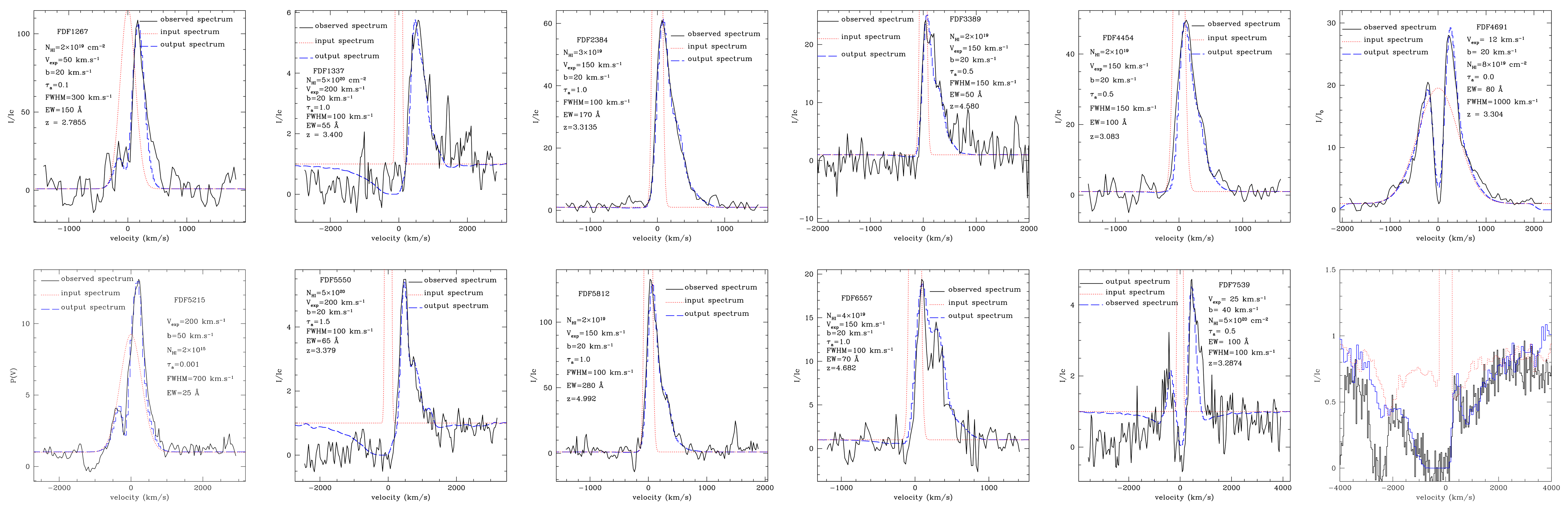
Abstract

The aim of our study is to understand the variety of observed Lyα line profiles and strengths in Lyman Break Galaxies (LBGs) and Lyα emitters (LAEs), the physical parameters governing them, and hence derive constraints on the gas and dust content and stellar populations of these objects.
Using our 3D Lyα radiation transfer code, MCLya (Verhamme et al. 2006), we fit the Lyα profiles of 12 LBGs at $z \sim 3$, with a simple geometry of a spherically expanding shell of H I.
The main results are presented hereafter (Verhamme et al. 2008, A&A accepted).

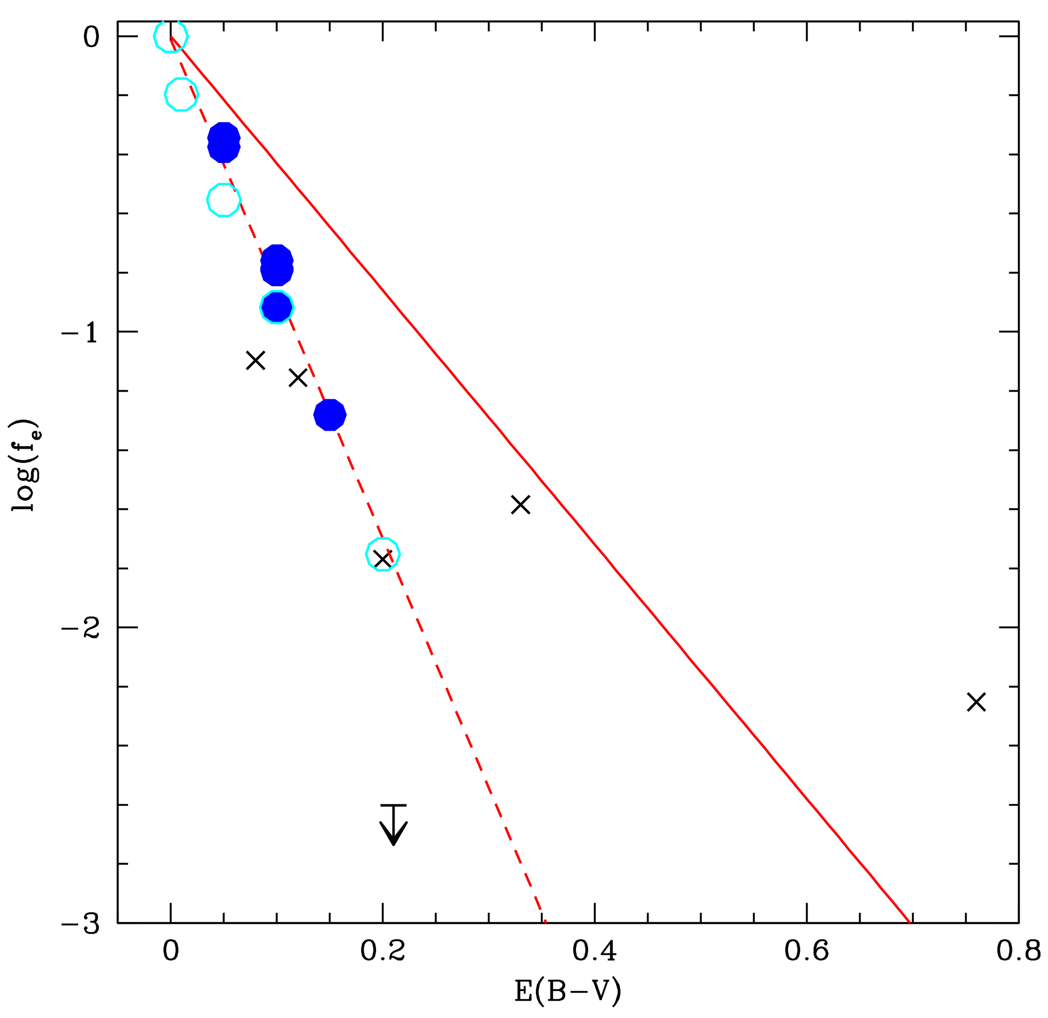
Motivation and Model

- what leads to the variety of Lyα profiles observed in LBGs, ranging from strong, asymmetric emission, to broad absorption, or rare double-peaked profiles, whereas they are all starburst galaxies, with a predicted strong Lyα emission ?
- observed correlations between EW(Lyα) and other observables (E(B-V), SFR UV...) are not well understood yet.
- A systematic detection of outflows is reported in the ISM of LBGs, with a velocity shift between the interstellar absorption lines and Lyα 3 times higher than the shift between the interstellar absorption lines and the stellar lines, as we predicted for a peculiar geometry of an expanding shell of neutral gas surrounding a Lyα source (Verhamme et al. 2006).

$\Rightarrow$ LBGs modelled by spherical H I shells surrounding a starburst



Correlation f_e vs E(B-V)



- The main parameter determining Lyα escape fraction in the dust extinction in the gas; even static media follow this trend !
- We propose a fit to predict the escape fraction of Lyα photons knowing the dust extinction (dashed curve):

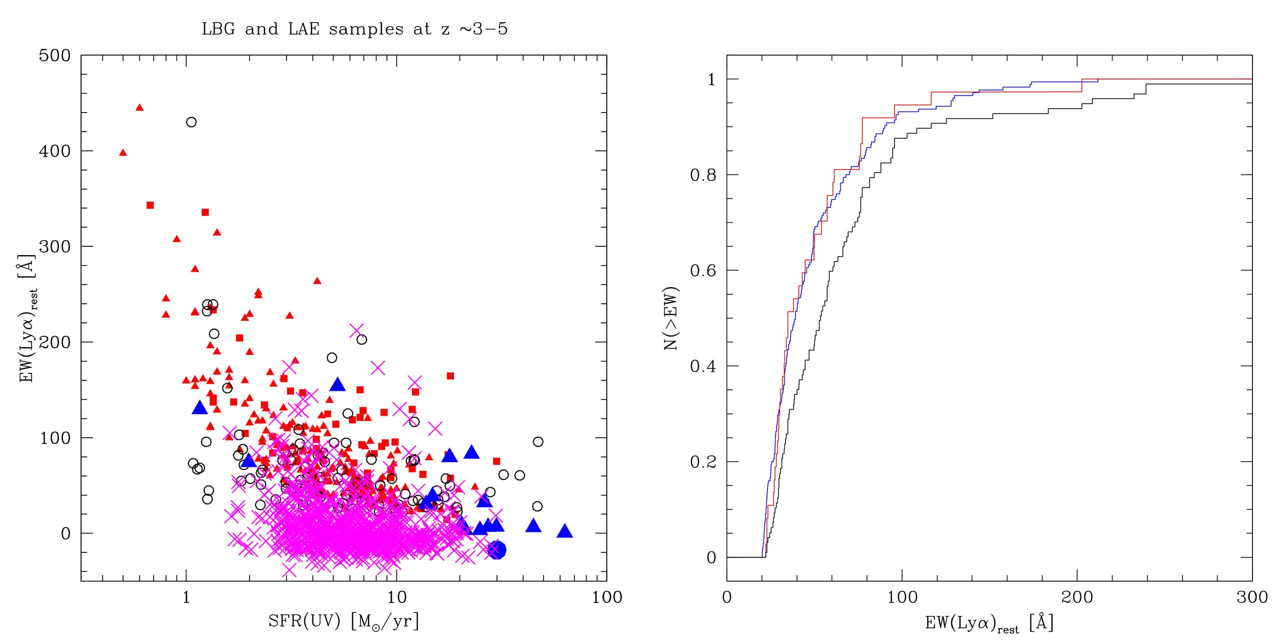
$$f_e = 10^{-7.71 \times E(B-V)^{gas}}. \quad (1)$$

- Adopting reasonable values for $\mathrm{EW_{int}}$ (Schaerer, 2003), this formula may be used to obtain a crude estimate of the extinction in LAEs based on a pure equivalent width measurement:

$$\log\left(\frac{\mathrm{EW^{rest}_{obs}}}{\mathrm{EW_{int}}}\right) = -E(B-V)^{\mathrm{gas}}(7.71 - 0.4k_\lambda r) \approx -5.6\ E(B-V)^{\mathrm{gas}} \quad (2)$$

where $k(\lambda = 1216\mathring{A}) \approx 12$ and $r = \mathrm{E(B\text{-}V)}^{\star}/\mathrm{E(B\text{-}V)}^{\mathrm{gas}} = 0.44$ according to Calzetti (2001). An extinction corrected SFR(Lyα) value can then be obtained from the Lyα luminosity using an appropriate SFR calibration, consistent with the assumed value of $\mathrm{EW_{int}}$.

LBGs and LAEs : two distinct populations ?



- When we apply the same selection criteria to a sample of LBGs and LAEs, the EW(Lyα) distributions are identical (cf left panel): LAEs above a certain magnitude are the same population as LBGs with Lyα emission.
- anti-correlation between SFR(UV) and EW(Lyα) in the right panel explained by radiation tranfer effects : assuming that the galaxy mass, and so the dust content increases with SFR(UV), we showed that the Lya escape fraction decreases with extinction.
- We conclude that LBGs and LAEs are two overlapping populations with a sequence mostly driven by mass

Main results (Verhamme et al. 2008)

- variety of profiles reproduced by a single model of an *expanding shell* surrounding a starburst
- no need to invoque IGM attenuation to reproduce the profiles, even at $z \sim 5$: alteration by ISM kinematics and geometry only
- ISM velocity well constrained : double-peaked profiles = static medium, asymmetric emission = outflow
- ALL intrinsic spectra in emission $\Rightarrow$ Radiation Transfer in a dense and dusty medium leads to the observed absorption in cb58, which reconciles UV/Lyα SFH diagnostics.
- unified senario for LBGs and LAEs