# Charting the Lyman-$\alpha$ escape fraction in the range $2.9 < z < 6.7$ and consequences for the LAE reionisation contribution

I. Goovaerts[1], T. T. Thai[1,2,3], R. Pello[1], P. Tuan-Anh[2,3], N. Laporte[1], J. Matthee[4], T. Nanayakkara[5], and J. Pharo[6]

Context : **The escape of Lyman-$\alpha$ photons** at z>2 is an ongoing subject of study and an important quantity to further **understanding of Lyman-$\alpha$ emitters (LAEs)**, **the transmission of Lyman-$\alpha$ photons** through the interstellar medium and intergalactic medium, and **the impact these LAEs have on cosmic reionization**.

Aims : This study **aims to assess the Lyman-$\alpha$ escape fraction, $f_{esc,Ly\alpha}$**, over the redshift range $2.9 < z < 6.7$ using VLT/MUSE selected gravitationally lensed, intrinsically faint LAEs, which are of particular interest as the potential drivers of cosmic reionization.

Methods : $f_{esc,Ly\alpha}$ is assessed in two ways.

1. through **an individual study** of 96 LAEs behind the A2744 lensing cluster, with JWST/NIRCam and HST data
2. through a study of **the global evolution** of $f_{esc,Ly\alpha}$ using the state-of-the-art luminosity functions for LAEs and the UV-selected 'parent' population (dust-corrected).

How to assess $f_{esc,Ly\alpha}$

1. the ratio of the SFR inferred from the Lyman-$\alpha$ flux, to the dust-corrected SFR from the CIGALE SED fitting process.
   - conversion factor of 8.7 between Lyman-$\alpha$ and H$\alpha$ luminosities
   - using a Case B recombination scenario (Oster- brock 1989) ($T = 10^4$ K)
2. estimates of $f_{esc,Ly\alpha}$ in a global manner by comparing the Luminosity Function (LF) of LAEs and that of the 'total' galaxy population.
   - The ratio between **the LAE SFRD** and **the total, dust-corrected SFRD** in a given redshift interval
   - the SFRD obtained from UV LF is **treated as the total SFRD** of the entire galaxy population.

$$\rho_{Ly\alpha} = \int L_{Ly\alpha}\,\phi_{Ly\alpha}\,dL_{Ly\alpha}. \qquad \mathrm{SFRD_{Ly\alpha}[M_\odot yr^{-1}Mpc^{-3}]} = 7.9\times10^{-42}\times\rho_{Ly\alpha}/8.7.$$

Results (Method1) :

- We find **a negligible redshift evolution of $f_{esc,Ly\alpha}$ for our individual galaxies** (Fig.1)
- **a more significant evolution towards higher escape fractions with decreasing UV magnitude** and fit this relation. (Fig.2)

$$\log(f_{esc,Ly\alpha}) = (0.27\pm0.02)\,M_{UV} + (4.2\pm0.5).$$

Fig.1

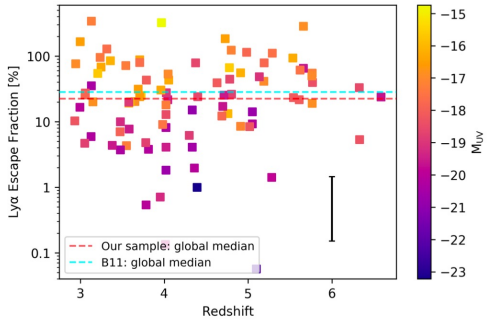
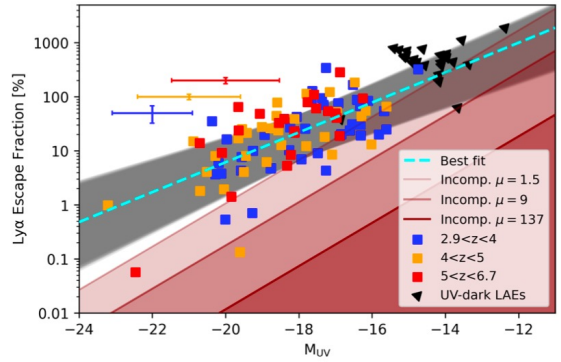



Fig.2




Results (Method2) :

Two limits of LF

- Fig.4 : $0.04L_{sun}$ for brighter galaxies ($\log L_{Ly\alpha}$ [erg s$^{-1}$] ~ 41 and $M_{UV} \sim -17$)
  - **agreement with previous literature** when integrating the luminosity functions to a bright limit.
- Fig.5 : $0.0006L_{sun}$ for faint regimes ($\log L_{Ly\alpha}$ [erg s$^{-1}$] ~ 39.5 and $M_{UV} \sim -13$)
  - we observed enhanced values of $f_{esc,Ly\alpha}$ , particularly around $z \sim 6$, **where $f_{esc,Ly\alpha}$ becomes consistent with 100% escape**.
  - This indicates for the faint regimes we sampled that **galaxies towards reionization tend to allow very large fractions of Lyman-$\alpha$ photons to escape**.
- For both cases, little evolution between $z = 3 - 5$ and a jump at $z \sim 6$
  - suggesting **a rapid evolution of the LAE population towards reionization**, although this effect is at $< 1\,\sigma$ for our dataset.

Fig.4

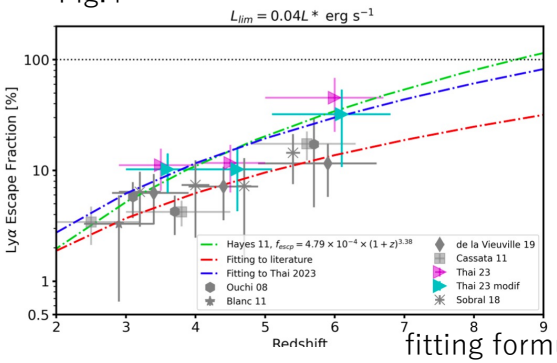
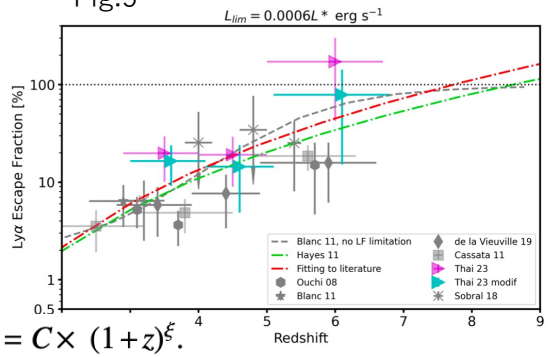



Fig.5




fitting formula $f_{esc}^{Ly\alpha} = C\times(1+z)^{\xi}$.

- **the contribution of the LAE population to reionization**

Taking the latest values $f_{esc,LyC}$ observed in LAEs at $z \sim 3$, we find that **LAEs can provide all the ionizing emissivity needed for reionization.**