How extinction correction influences the estimate of Lyα escape fraction?

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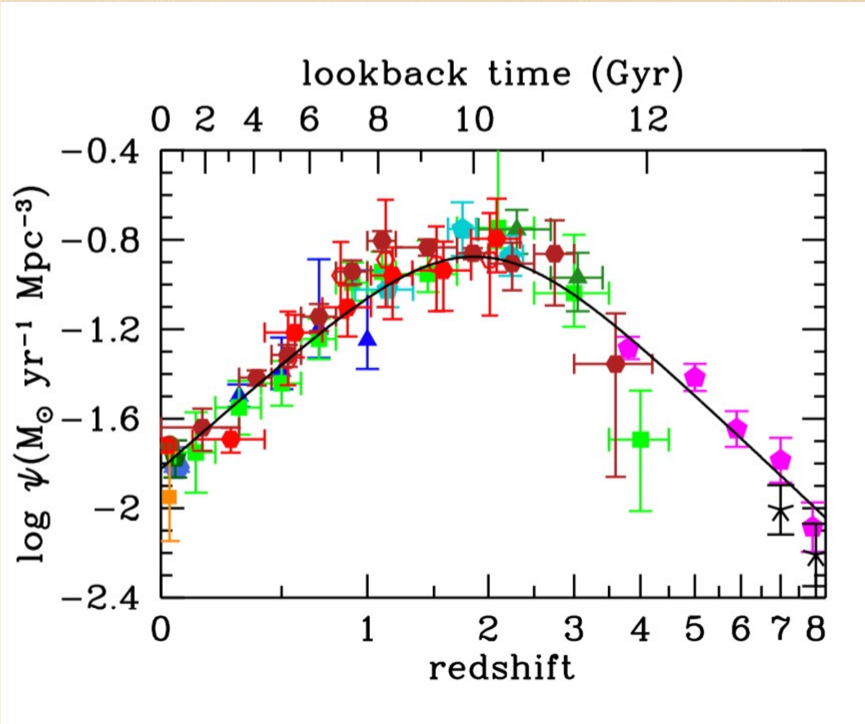
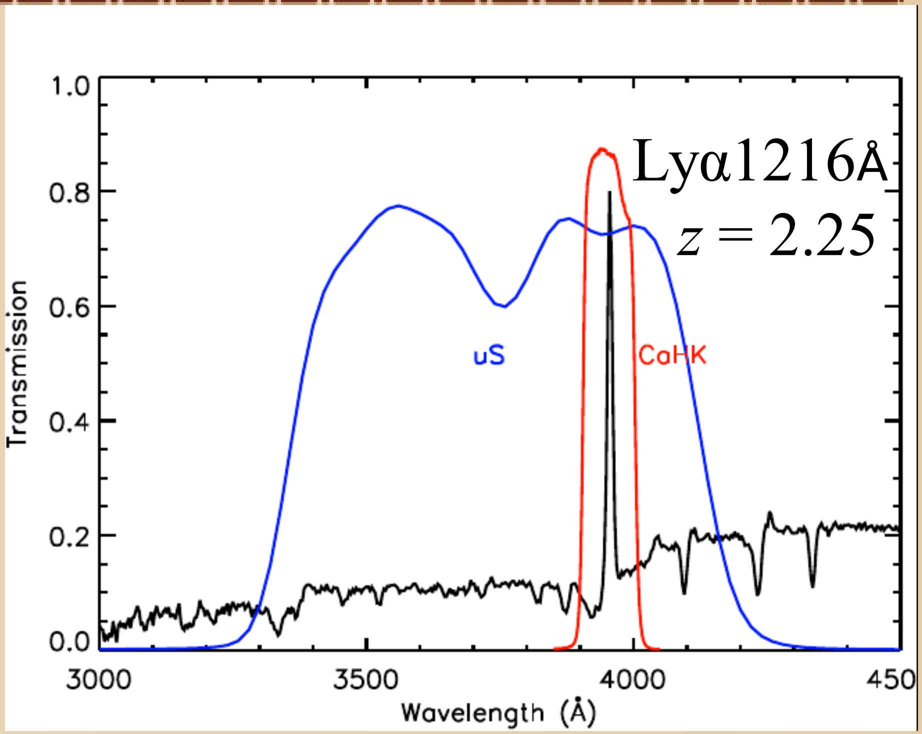
(arXiv: 1611.09860, accepted for publication in ApJ)

Outline:

- ✧ Background
- ✧ Dual Filter: Lyα vs Hα Emitters @ z=2.24
- ✧ The individual @ global Lyα escape fraction at z=2.24
- ✧ The influence of extinction correction

The Cosmic Star Formation History & Narrow-band Imaging Survey



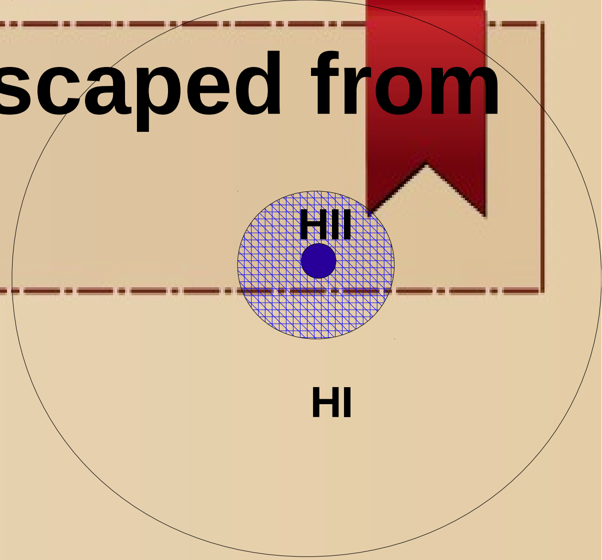


Madau & Dickinson (2014)

50% of local stars were formed before z~1.3,
25% before z~2, 25% after z~0.7,
<1% before z>6.

Narrow-band imaging survey
1) Emission-line Objects
2) Large sky coverage
3) $\delta z/(1+z) = 1 - 2\%$

How Lyα is Produced and Escaped from Galaxies



Produce:

Emitted by hot, young star—HI ⟶ HII;

Improtance:

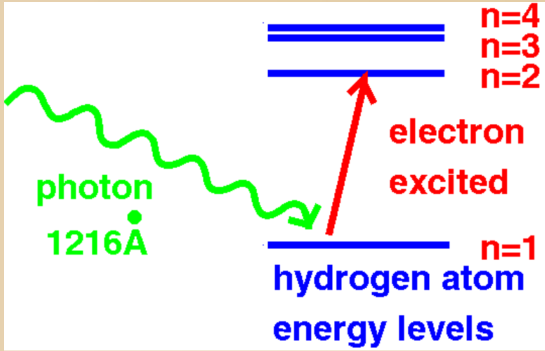
1. Galaxies properties: SFR, Dust attenuation, etc.

2. Extensive: Lyα: (1216 Å): Lyα has been successfully used to find galaxies across redshifts z ∼ 2−7,even probing the end of the epoch of reionization.

3. The amount of ionizing photons:

$$\xi_{ion}=Q_{ion}/L_{UV,int}\ Q_{ion}$$

$$Q_{ion}=L_{Ly\alpha}/c_{Ly\alpha}(1-f_{esc})$$

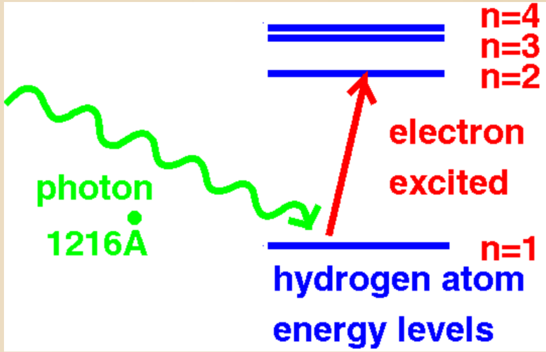


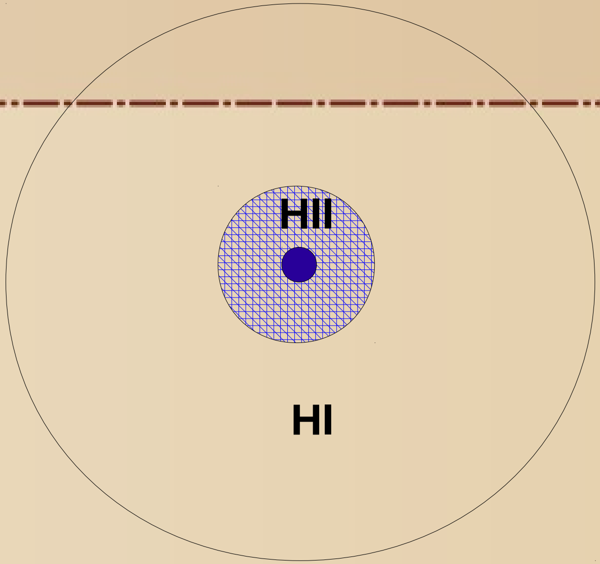
Escape:

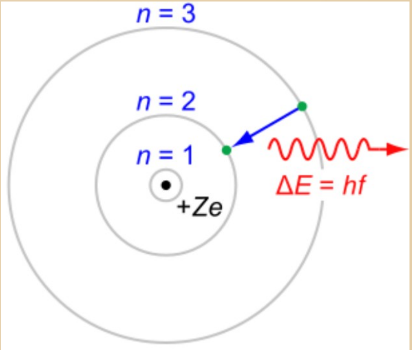
1. Lyα: (1216 Å) dust absorbing;

2. Lyα photons resonantly scatter on neutral HI gas.

Lyα escape fraction— Lyα/Hα







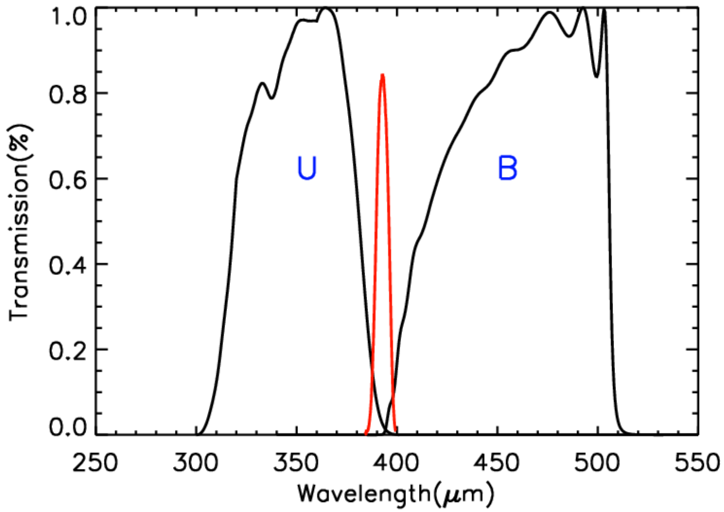
Lyα:

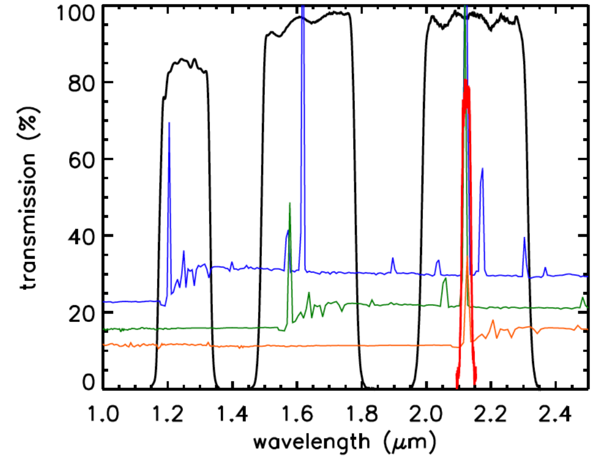
- Emitted by hot, young star—strong & physics of star formation;
- Resonant nature—distribution , Kinematics of a galaxy's ISM (HI);
- Dust absorption.

Hα:

- Same production mechanism as that of Lyα;
- Non-resonant recombination line (in Case B recombination: intrinsic Lyα/Hα=8.7);
- Less sensitive to dust.

Dual Filter: Lyα vs Hα Emitters @z=2.24

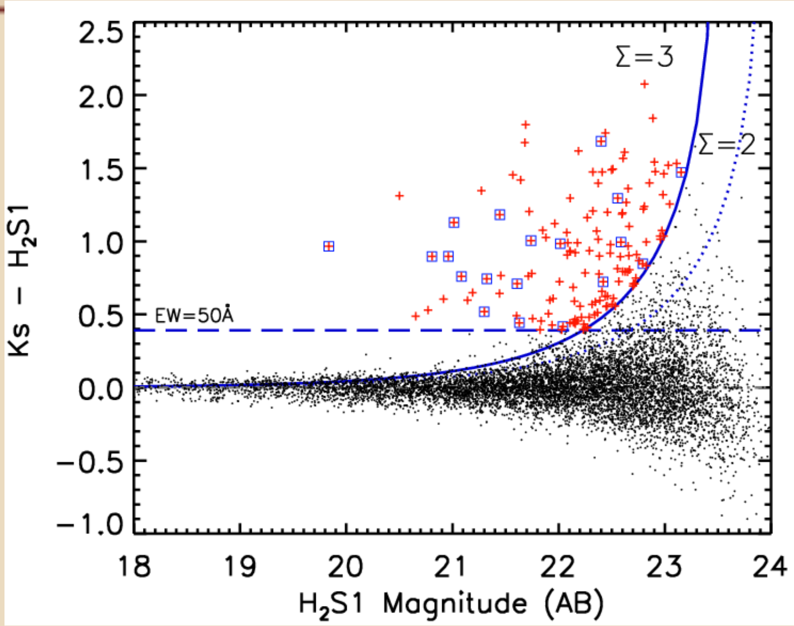


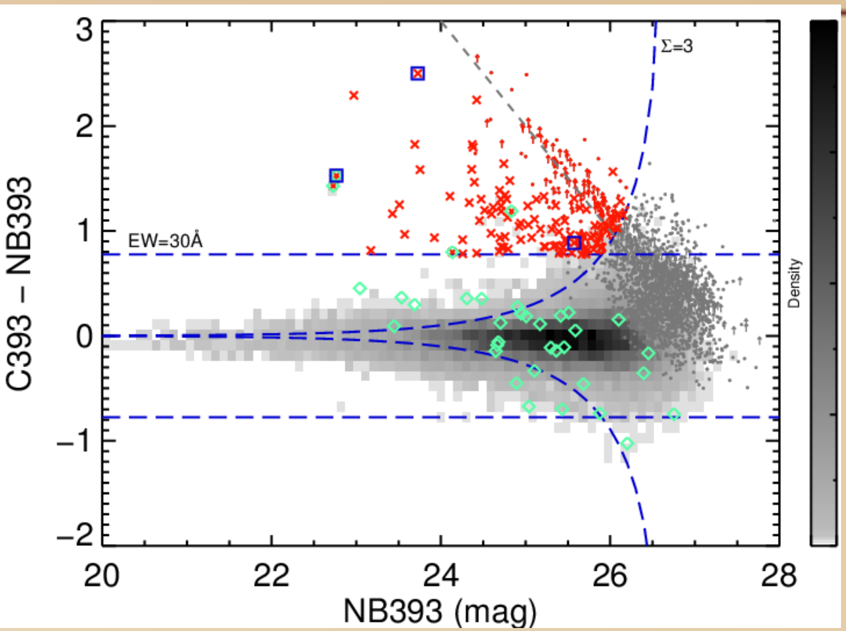


J.-S. Huang (PI)
Telescope: 6.5m Magellan/Megacam
Custom-made Filter: NB393(3928Å)
Coverage: 25’ x 25’
Fields: CDFS & COSMOS

X.Z. Zheng (PI)
Telescope: 3.6m CFHT/WIRCam
Filter: H_2S1 (2.13μm)
Coverage: 20’ x 20’
Fields: CDFS

Sample selection





CFHT/WIRCam AB=22.8 (5σ)

Magellan/Megacam AB=26.4 (5σ)

56 Hα emitters

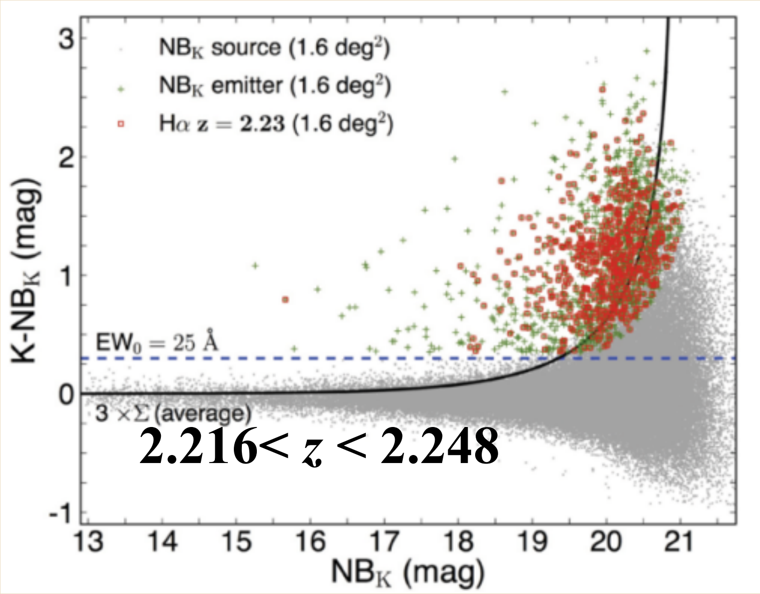
124/241 Lyα emitters

4
both lines
(LAHAEs)

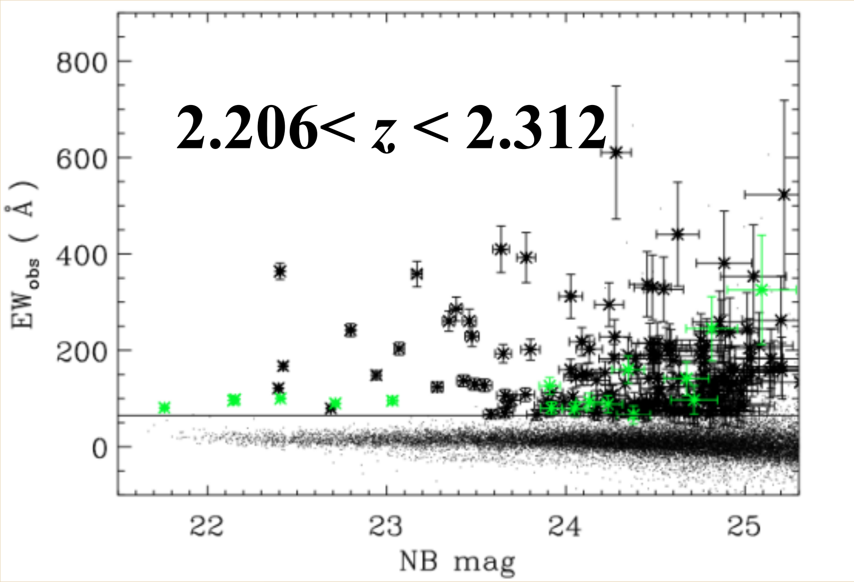
An, F. X., Zheng, X. Z., et al. 2014, ApJ, 784,152

An, F. X., et al. arXiv:1611.09860

LAHAEs in COSMOS



Sobral +13 Vega=22.0 (5σ)



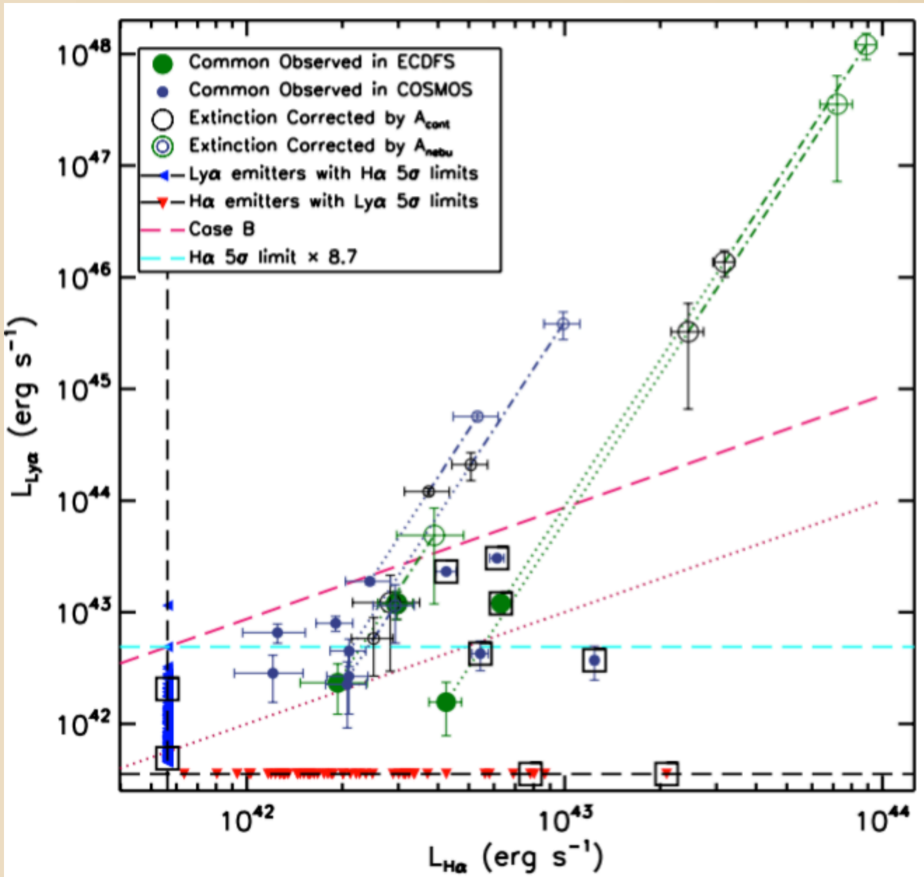
Nilsson +09 AB=25.3 (5σ)

158 Hα emitters

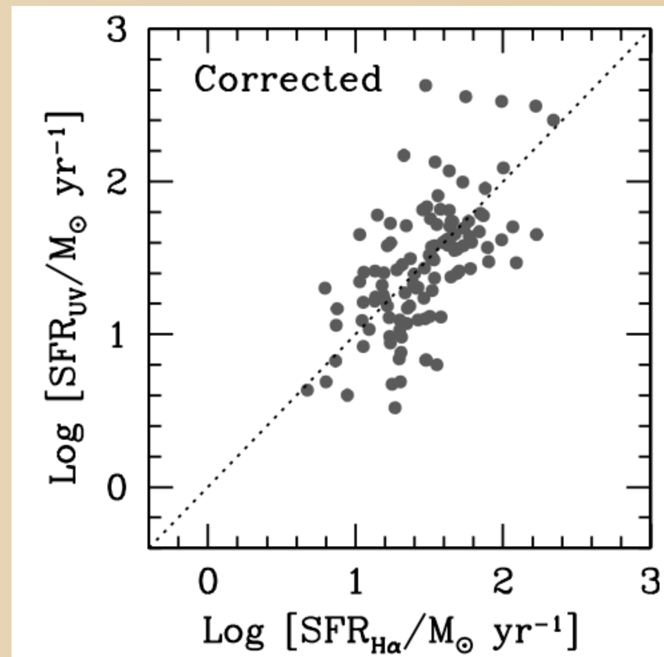
146 Lyα emitters

7
both lines

How extinction correction affect the estimate of Individual Lyα escape fraction ?

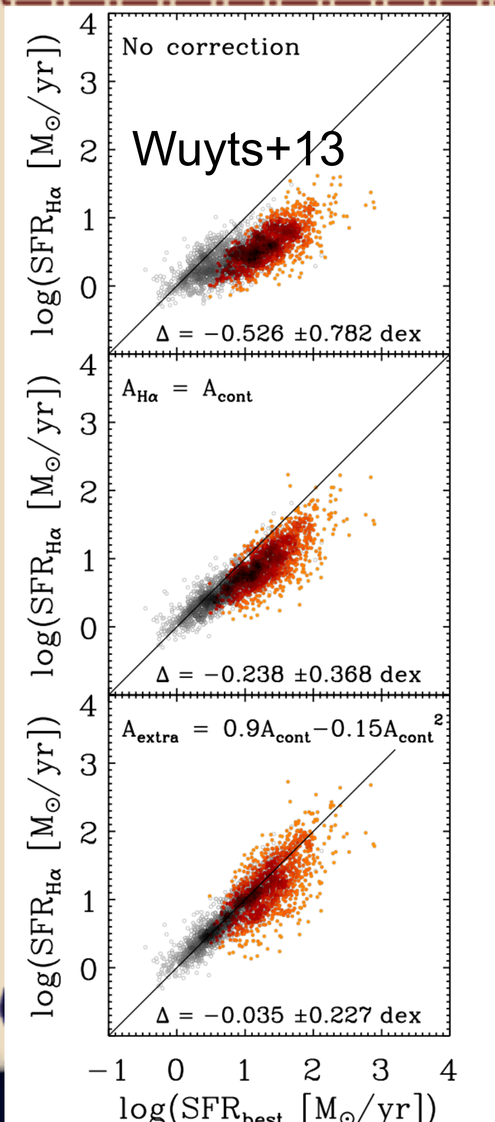


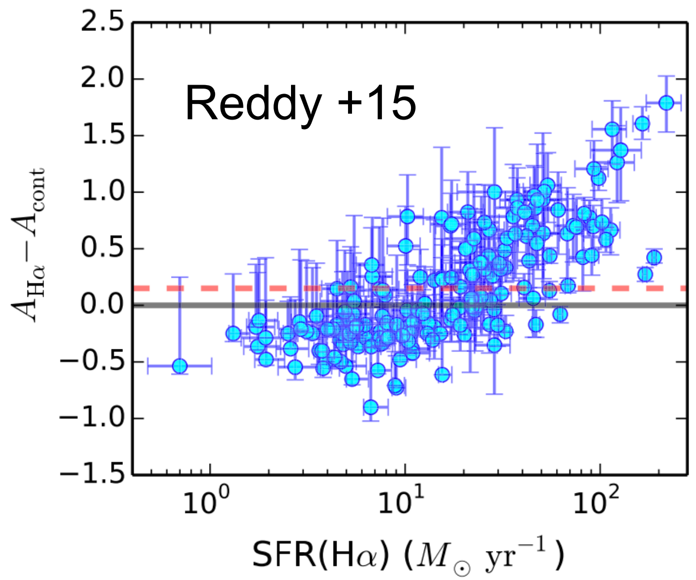
Extinction Correction in An+14:
Calzetti extinction law (Calzetti + 00) with the assumption of E(B-V)cont = 0.4E(B-V)nebu

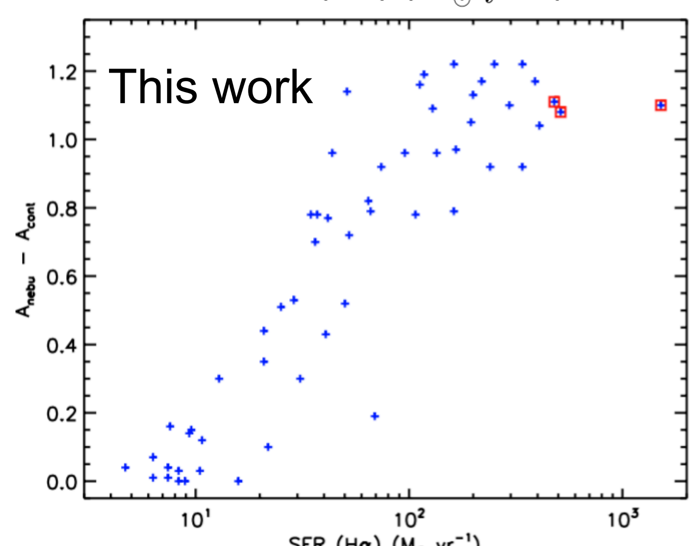


Erb+06
E(B-V)cont = E(B-V)nebu

How extinction correction affect the estimate of Individual Lyα escape fraction ?







Extinction Correction in this work:

Cardelli Galactic extinction law (Cardelli+89) with the assumption:

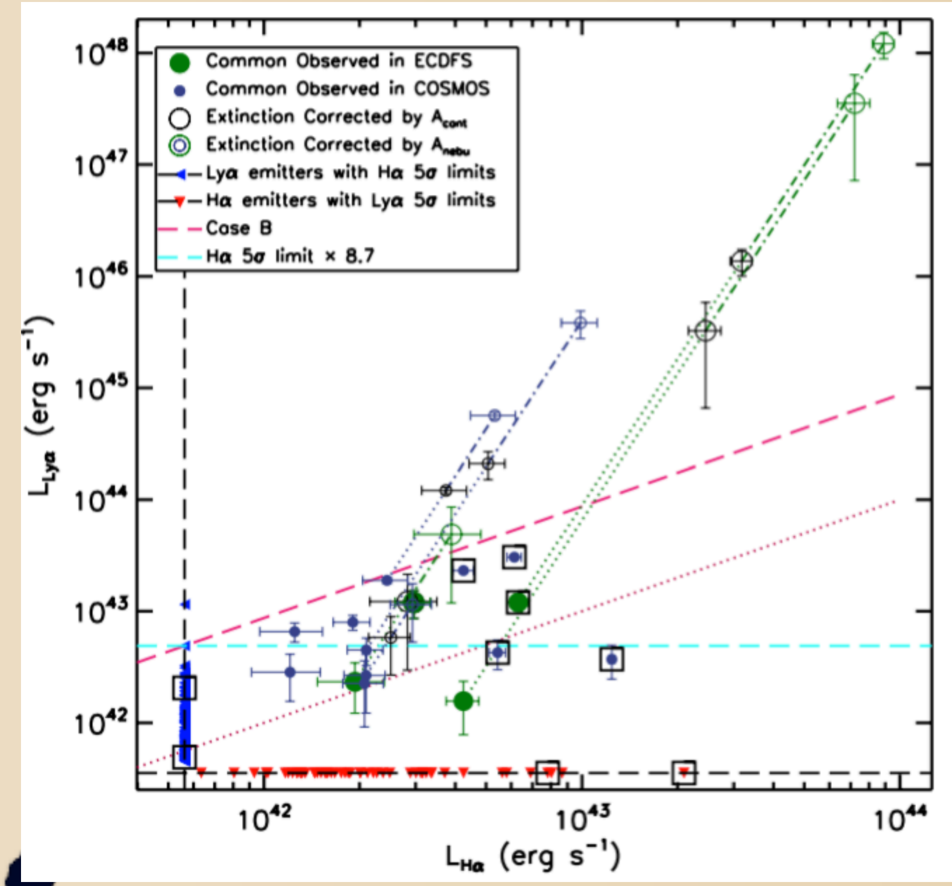
$A_{extra}=0.9A_{cont} - 0.15A^2_{cont}$

Lyα: E(B-V)nebu

$\kappa_{H\alpha}$(Cardelli)≈$\kappa_{H\alpha}$(Calzetti00) (< 0.01 mag)

$\kappa_{Ly\alpha}$(Cardelli) = 1.7×$\kappa_{Ly\alpha}$(Calzetti00)

How extinction correction affect the estimate of Individual Lyα escape fraction ?

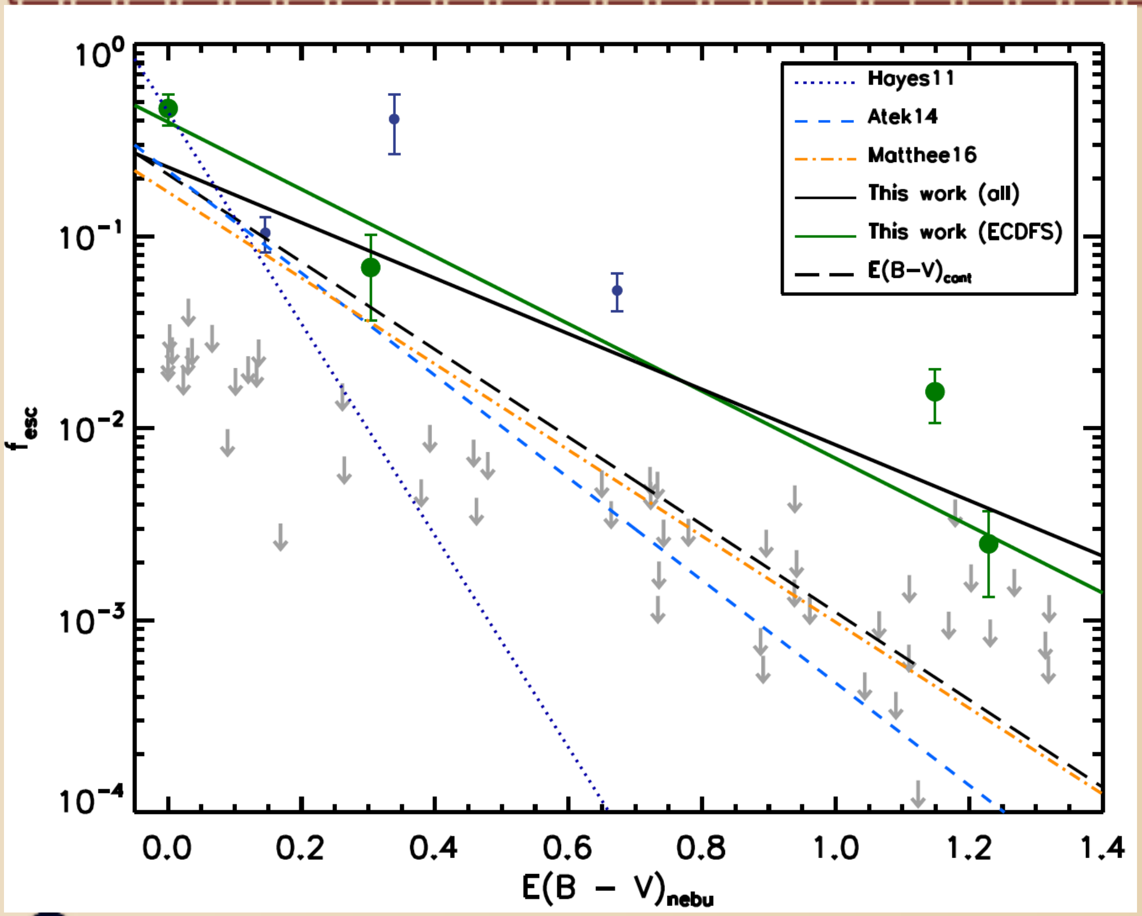


1. A **higher intrinsic Lyα/Hα** than case B:
   1):more complicated geometry and kinematics of the H I region; (e.g., Song14)
   2) collisional excitation by shock from AGN or supernova-derived winds

1/3 of LAHAEs are AGNs

2. **Uncertainties** caused by **extinction correction**:
   1) dust attenuation curve at high-z is correlated with stellar mass… (Zeimann15)
   2) the large scatter between E(B-V)nebu and E(B-V)cont

Correction between Lyα escape fraction and dust attenuation

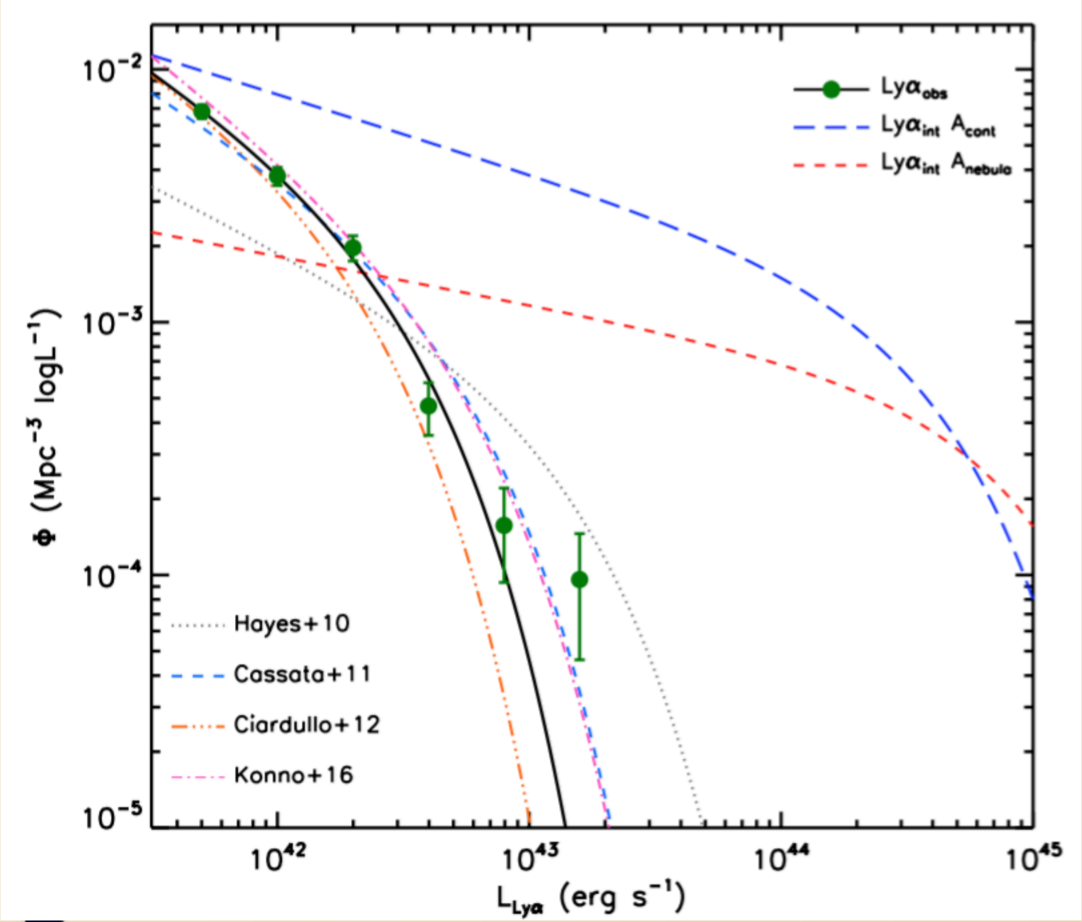


$f_{esp} = L_{obs}(Ly\alpha)/(8.7L_{int}(H\alpha))$

1. An **anti-correlation** between Lyα escape fraction and dust attenuation is found.
2. The **resonant scatter** on the neutral HI gas can **contribute** to **more than half** of the suppression of Lyα escape.
3. $E(B\text{-}V)_{nebu}$ vs $E(B\text{-}V)_{cont}$: **~3 percentage points** in individual Lyα escape fraction.

$$f_{esp} = C_{Ly\alpha} \times 10^{-0.4E(B-V)\ \kappa Ly\alpha}$$

How extinction correction affect the estimate of Volumetric Lyα escape fraction ?



$fv_{esp}=\rho_{obs}(L_{Ly\alpha})/(8.7\times\rho_{int}(L_{H\alpha}))$
$=(3.7\pm 1.4)\%$ (A_{nebu}-corrected)

1.Independence on cosmic variance, the evolutionary state of the galaxies, or calibration uncertainties;

2.This method is sensitive to the extinction correction.

A_{cont}-corrected: $(2.8\pm 1.2)\%$

The different assumption of $E(B-V)_{nebu}$ cause a deviation of 1 percentage point.

Summary

- **The different assumption of nebular color excess will cause a discrepancy of up to ~3 percentage points in individual Lyα escape fraction;**

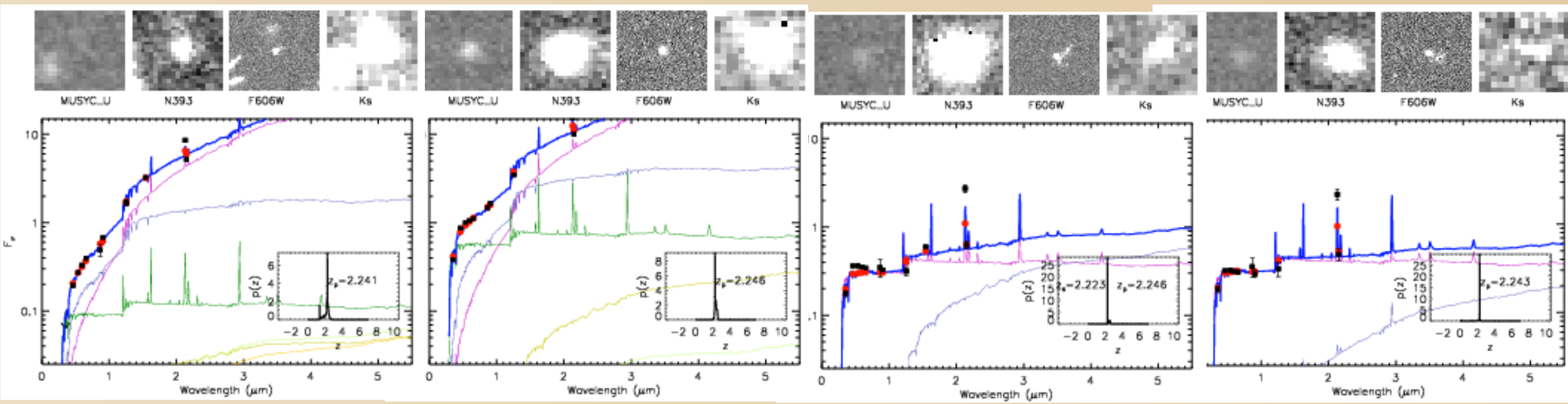
- **The Hα sample show an anti-correction of f_{esp} with dust content;**

- **The *global Lyα escape fraction* is ~4% at z=2.24 in ECDFS. The variation in the nebular color excess of extinction leads to a discrepancy of ~1 percentage point.**

Extinction correction significantly influence the estimate of both individual and global individual Lyα escape fraction!


Thanks for your attention!
Comments and Questions are Welcome!

Properties of LAHAEs



LHα=42.63 erg s^{-1}
LLyα=42.20 erg s^{-1}
Av=2.35 mag
Log $M/M_\odot$ = 10.75
Mergers/Close pairs

LHα=42.80 erg s^{-1}
LLyα=43.08 erg s^{-1}
Av=2.16 mag
Log $M/M_\odot$ = 11.14
Compact X-ray

LHα=42.47 erg s^{-1}
LLyα=43.08 erg s^{-1}
Av=0.003 mag
Log $M/M_\odot$ = 9.35
Mergers/Close pairs

LHα=42.29 erg s^{-1}
LLyα=42.36 erg s^{-1}
Av=0.51 mag
Log $M/M_\odot$ = 9.26
Mergers/Close pairs

Why only few galaxies in both lines ?

● So few Hα emitter are detected in Lyα:

1. κ1216(Lyα) = 20 while κ6563(Hα) = 3.3 (Cardelli Galactic extinction law);

2. Resonant scattering of Lyα.

● So few Lyα emitter are detected in Hα:

Lyα selection preferentially finds galaxies with high f_{esc} and small attenuation in Hα, resulting in line ratios nearernthe recomination value and comparatively faint Hα.