Tracing Baryons in the Warm Hot Intergalactic Medium using Broad Lyman-α Absorbers

Mid-Term 2

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Thesis Phase I : Recap

Recap

- **The missing baryon problem**
- BLAs : Way to probe WHIM
- Absorber towards PG 0003+158
- BLA survey : 28 BLA candidates

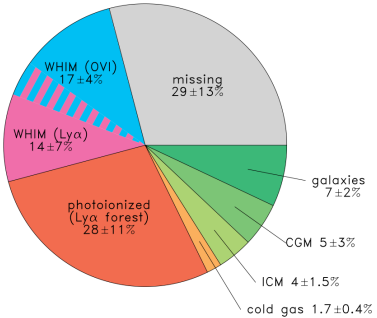

Figure 1: Baryon budget at $z \sim 0$.
Shull et al. (2012)

Recap

- The missing baryon problem
- **BLAs : Way to probe WHIM**
- Absorber towards PG 0003+158
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Ref. : Shull et al. (2012)

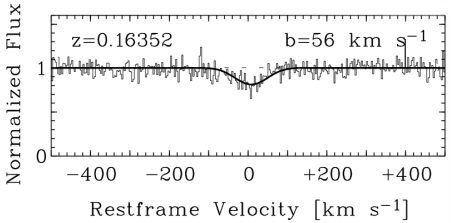

Figure 2: A BLA towards the LOS of quasar H 1821+643. Philipp Richter (2005)

Recap

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Ref. : Shull et al. (2012)

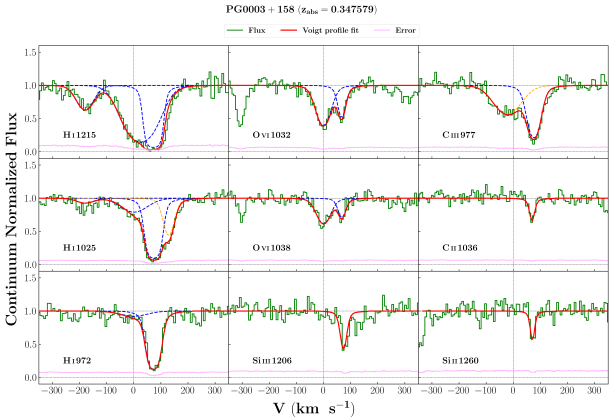

Figure 3: System plot of the absorber system towards PG 0003+158. Velocity is taken zero at z = 0.347579

Recap

- The missing baryon problem
- BLAs : Way to probe WHIM
- Absorber towards PG 0003+158
- **BLA survey : 28 BLA candidates**

Ref. : Shull et al. (2012)
Danforth et al. (2016)

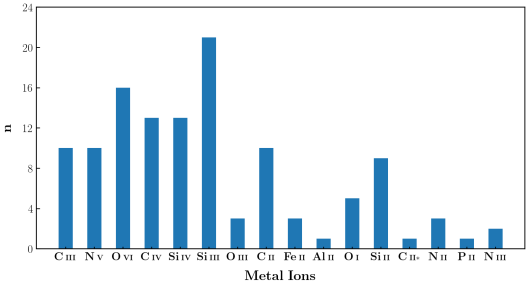

Figure 4: Distribution of metal ions in all 28 candidate BLAs

The BLA Survey

Survey so far...

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- Voigt profile fitting : 16 (O VI) + **6**

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- Voigt profile fitting : 16 (O VI) + **6**
- Ionisation Modelling : **16 (O VI)**

Insights

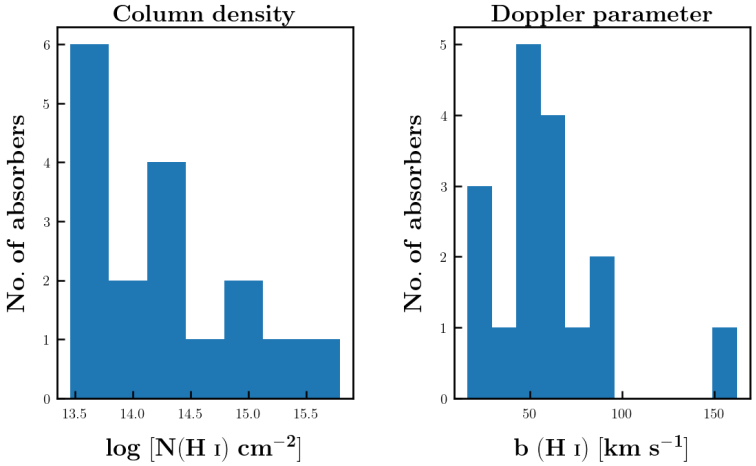

Figure 5: Distribution of H I column densities and Doppler parameters.

Insights

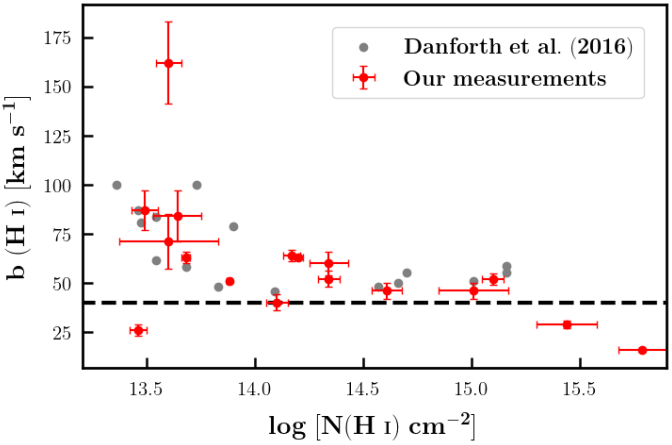

Figure 6: H I column density vs. Doppler parameter

Insights

$$b^2 = b_{th}^2 + b_{nt}^2$$

$$b_{th}^2 = \frac{2kT}{m}$$

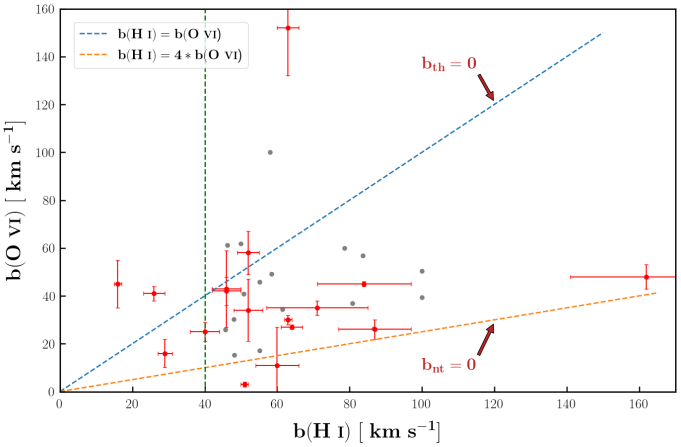

Figure 7: b(O VI) vs. b(H I). Grey filled circles are measurements from Danforth et al. (2016).

Insights

$$\mathrm{T} = \frac{8m}{15k}\left(b^2{}_{\mathrm{H\,I}} - b^2{}_{\mathrm{O\,VI}}\right)$$

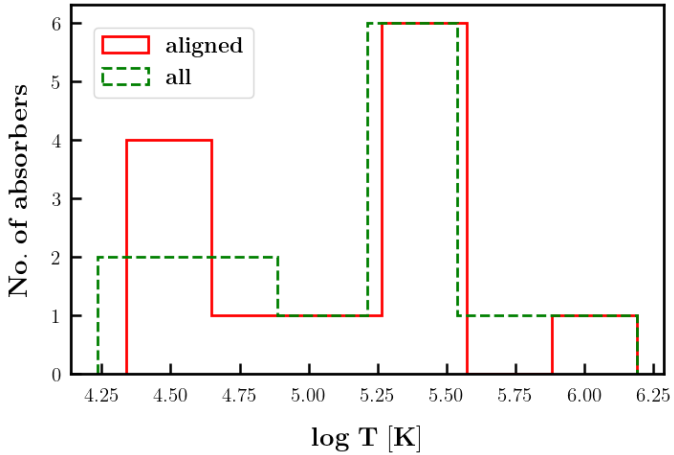

Figure 8: Distribution of temperature calculated from Doppler parameters of H I and O VI lines.

Ionisation Modelling

Method

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- Grid of PI CLOUDY models : Density and Metallicity

  Ref. : Acharya and Khaire (2021)

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- Grid of PI CLOUDY models : Density and Metallicity
- log(n_H/cm^{-3}) = -5 to 1 in steps of 0.2
- [X/H] = -3 to 0.5 in steps of 0.02

Ref : Acharya and Khaire (2021)

Method

- Grid of PI CLOUDY models : Density and Metallicity
- log (n_H / cm^{-3}) : -5 to 11 in steps of 0.02
- log (Z/Z$\odot$) : -3 to 2 in steps of 0.05

Ref : Acharya and Khaire (2021)

Method

- Grid of PI CLOUDY models : Density and Metallicity
- log (n_H / cm^{-3}) : -5 to 1 in steps of 0.02
- log (Z/Z$\odot$) : -3 to 2 in steps of 0.05
- Solution : Model that best predicts the observed column densities

Refer : Acharya and Khaire (2021)

Results

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- 16 O VI absorbers

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- 26 components

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- 16 O VI absorbers
- 26 components
- Origin of O VI

Solutions

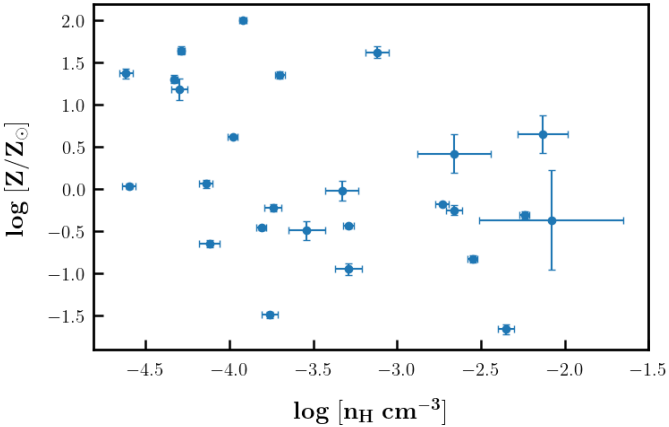

Figure 9: Ionisation modelling solutions (n_H, Z) for all 26 components.

+ve correlation

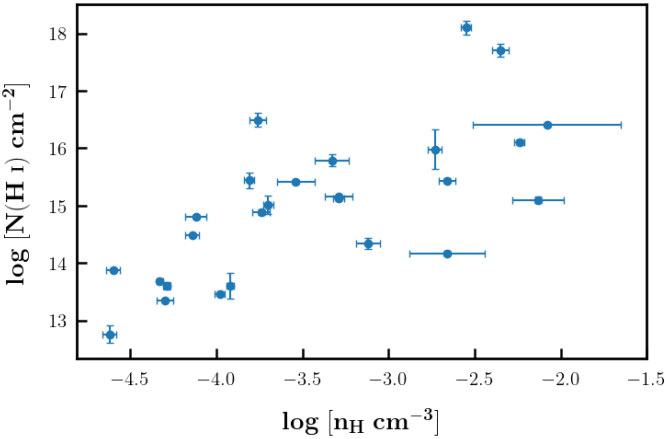

Figure 10: Variation of N(H I) with n_H

O VI cases

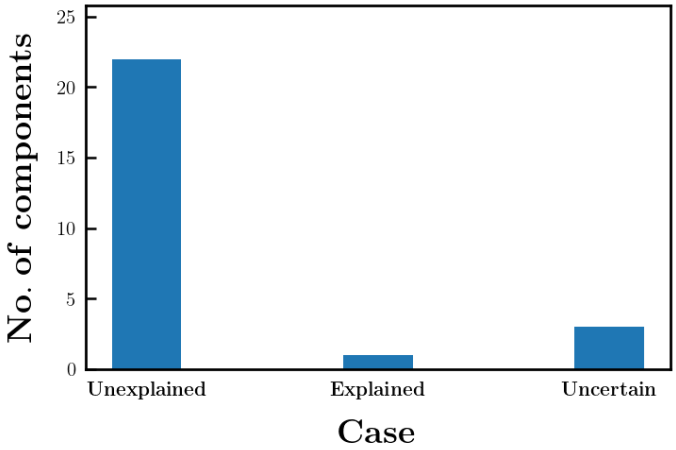

Figure 11: O VI column density predictions.

Ex : Unexplained

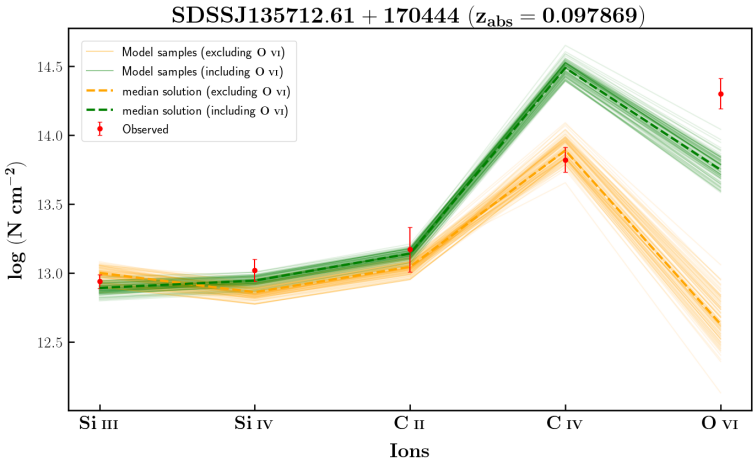

Figure 12: N(H I)=16.49 cm^{-2}

Ex : Explained

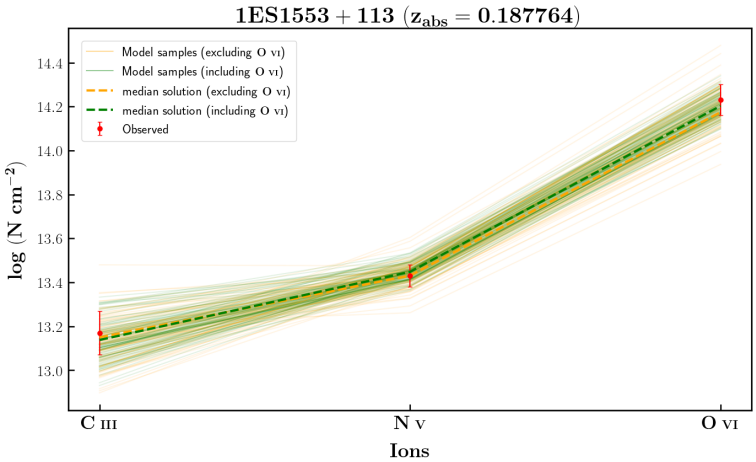

Figure 13: N(H I)=12.76 cm^{-2}

Ex : Uncertain

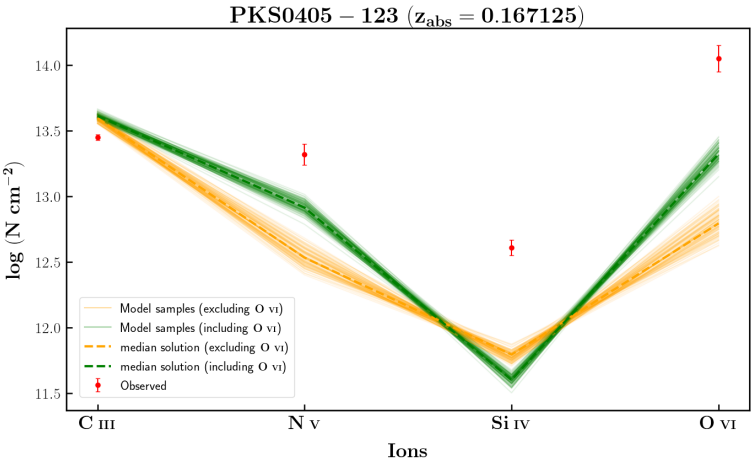

Figure 14: N(H I)=13.46 cm^{-2}

Towards *the end*

Ongoing and Future Work

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- Voigt profile fitting : 6

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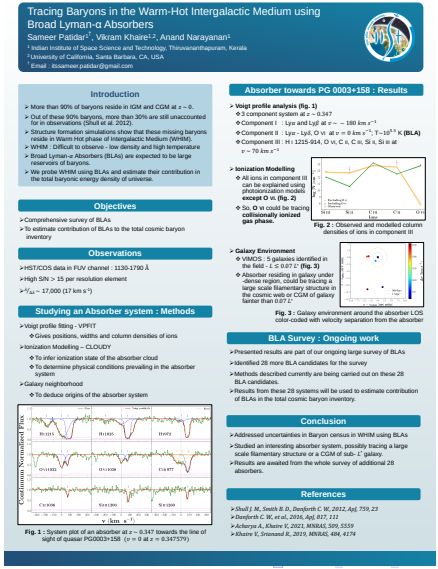
- Exploring the survey results

Ongoing and Future Work

- Voigt profile fitting : 6
- Ionisation modelling : 12
- Exploring the survey results
- *Finally*, calculating $\Omega_b(BLA)$

Outcomes

- Poster presentation at ASI-2024 meet titled "Tracing Baryons in WHIM using BLAs"



Summary

- Voigt profile fitting : 22 absorbers - 231 Voigt profiles
- Ionisation modelling : 16 absorbers - 26 components
- O VI couldn't be explained with photoionization models
- BLA survey towards completion

References

So much universe, and so little time...

Appendix

- Outlier b(O VI)

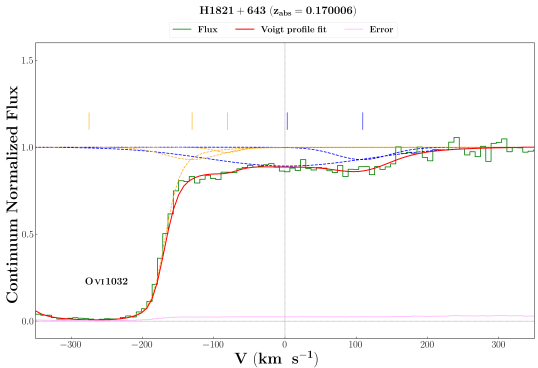


Figure 15: Voigt profile fit of O VI 1032 line in absorber system towards H1821+643 at $z_{abs} = 0.170006$