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
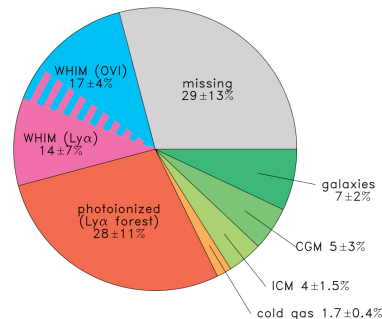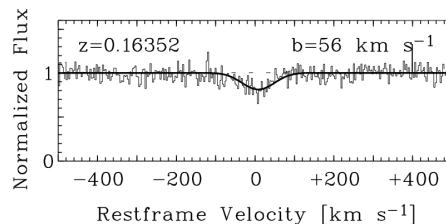- Absorber towards PG 0003+158
- BLA survey : 28 BLA candidates

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
- BLA survey : 28 BLA candidates

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

Recap

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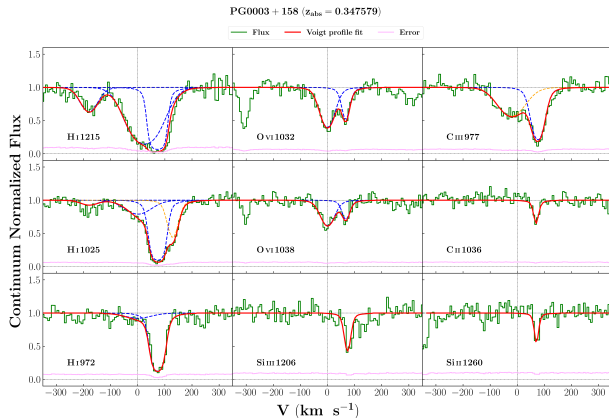

Figure 3: System plot of the absorber system towards
PG 0003+158. Velocity is taken zero at z = 0.347579

Recap

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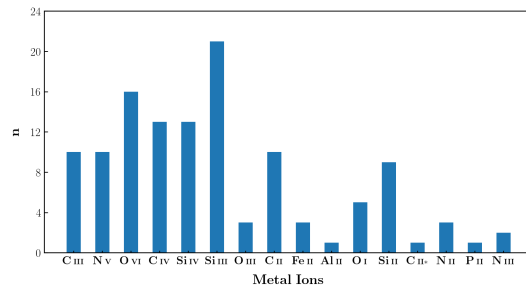- Absorber towards PG 0003+158
- **BLA survey : 28 BLA candidates**

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**
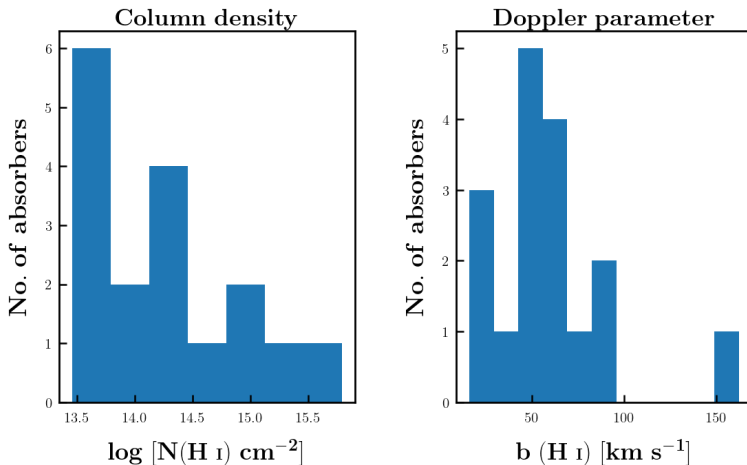- Ionisation Modelling : **16 (O VI)**

Insights

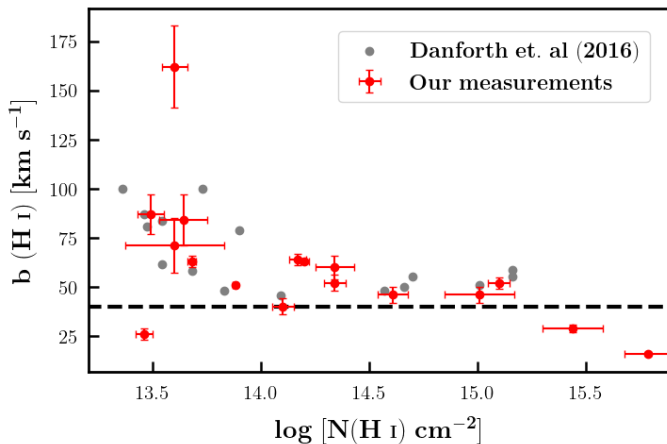Figure 5: Distribution of H I column densities and Doppler parameters.

Insights

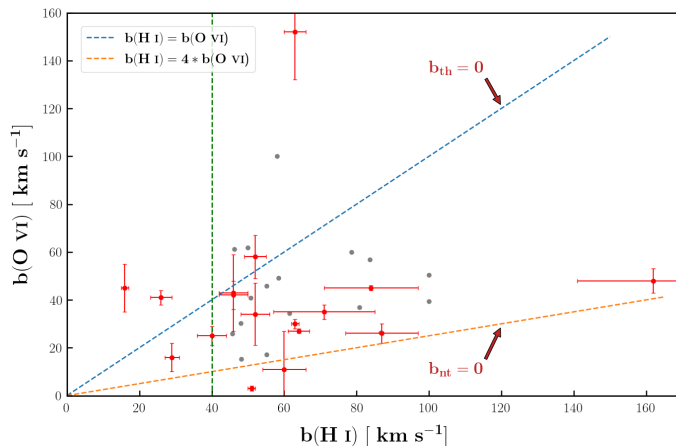Figure 6: H I column density vs. Doppler parameter

Insights

Figure 7: $b(\text{O\,VI})$ vs. $b(\text{H\,I})$. Grey filled circles are measurements from Danforth et. al 2016.
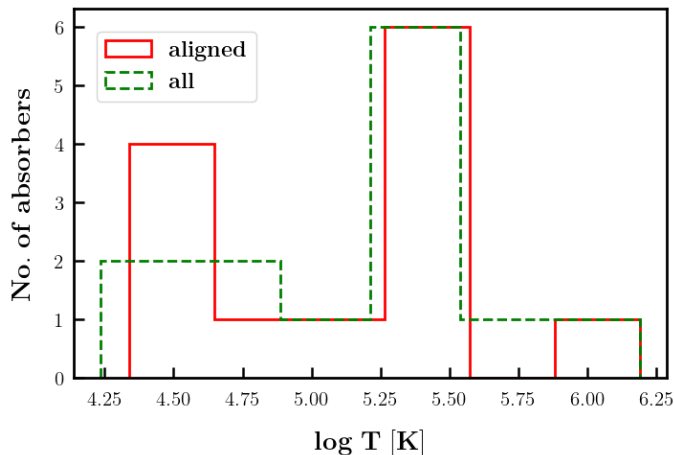
Insights

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)

Method

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- ‣ $\log (n_H/cm^{-3})$: -5 to 1 in steps of 0.02

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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

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

Ref. : 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

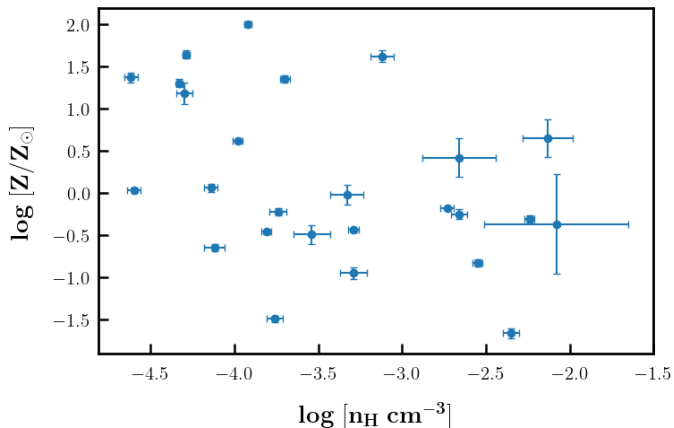Figure 9: Ionisation modelling solutions (n_H, Z) for all 26 components.

+ve correlation

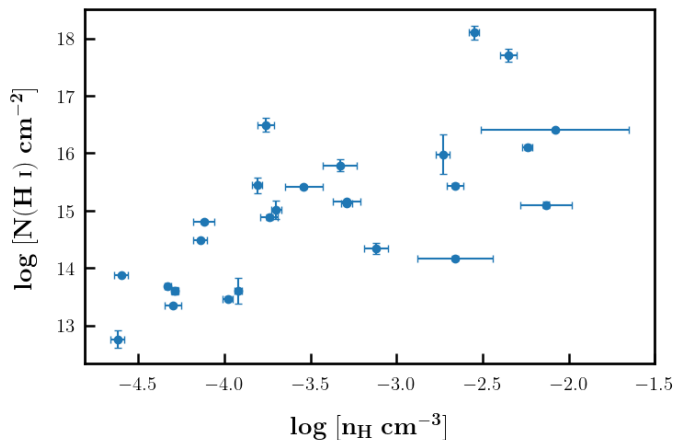Figure 10: Variation of N(H I) with n_H

O VI cases
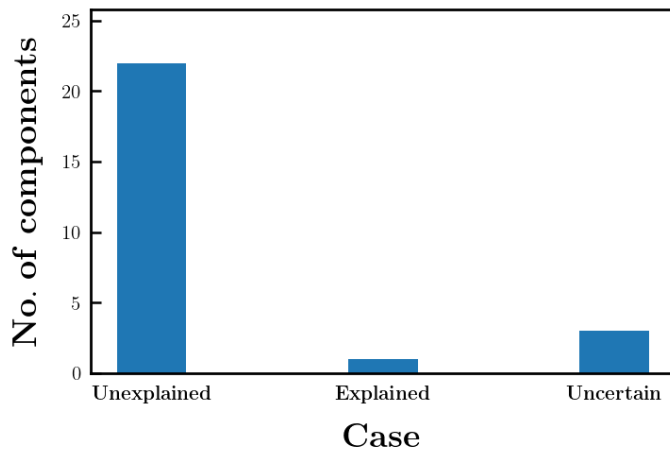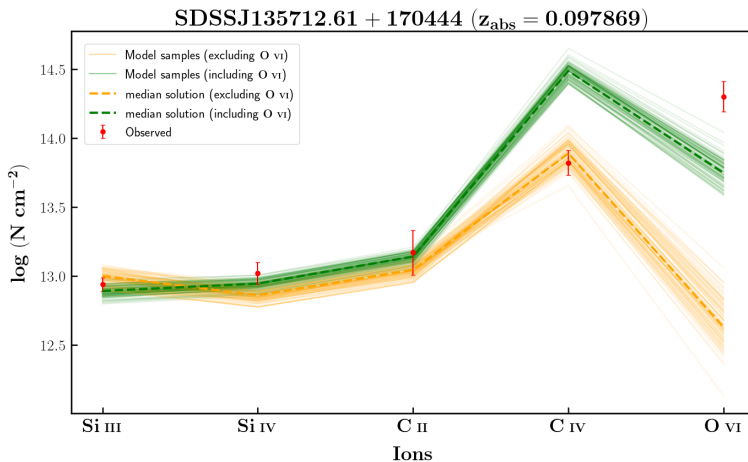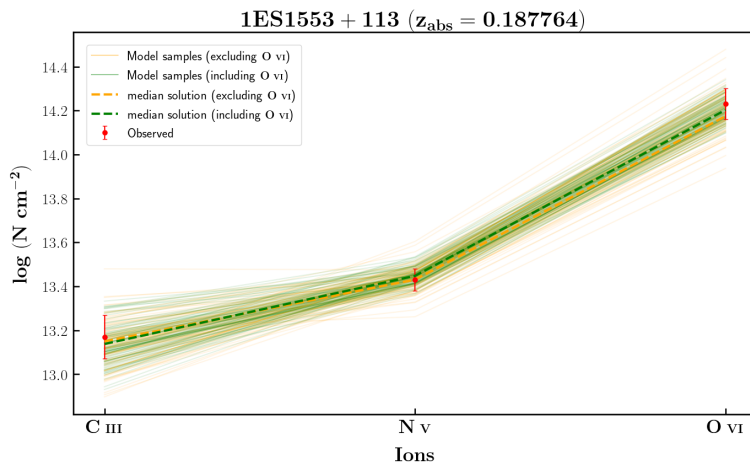

Figure 11: O VI column density predictions.

Ex-1

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

Ex-2

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

Ex-3

PKS0405 − 123 (z_{abs} = 0.167125)

Model samples (excluding O VI)
Model samples (including O VI)
median solution (excluding O VI)
median solution (including O VI)
Observed

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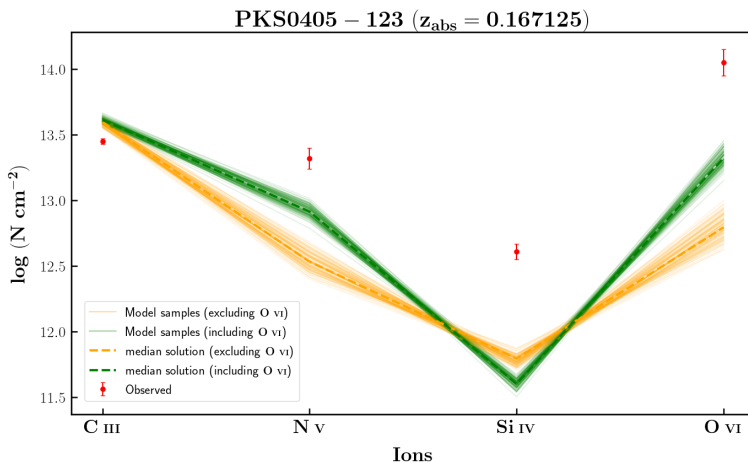
Figure 14: N(H I)=13.46 cm^{-2}

Towards *the end*

Ongoing and Future Work

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- Voigt profile fitting : 6

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- ▸ Ionisation modelling : 12

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Ongoing and Future Work

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

Summary

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

References

Acharya A., Khaire V., 2021, MNRAS, 509, 5559

Danforth C. W., et al., 2016, ApJ, 817, 111

Lehner N., Savage B. D., Richter P., Sembach K. R., Tripp T. M., Wakker B. P., 2007, ApJ, 658, 680

Richter P., Savage B. D., Sembach K. R., Tripp T. M., 2006, A&A, 445, 827

Savage B. D., Kim T. S., Wakker B. P., Keeney B., Shull J. M., Stocke J. T., Green J. C., 2014, ApJS, 212, 8

So much universe, and so little time...