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

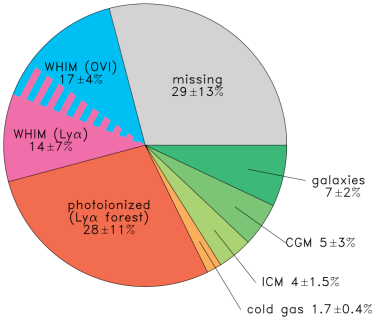

Figure 1: Baryon budget at $z \sim 0$.
Shull et al. (2012)

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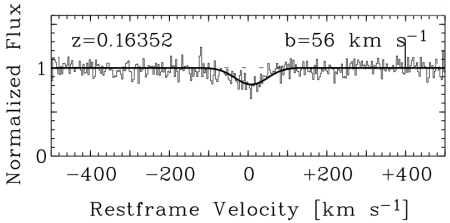

Figure 2: A BLA towards the LOS of quasar H 1821+643. Philipp Richter (2005)

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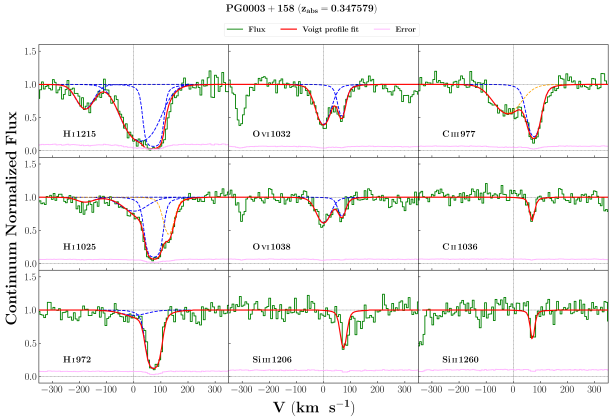

Figure 3: System plot of the absorber system towards PG 0003+158. Velocity is taken zero at z = 0.347579

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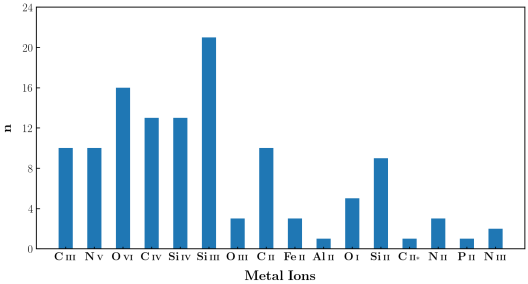

Figure 4: Distribution of metal ions in all 28 candidate BLAs

The BLA Survey

Survey so far...

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

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

Insights

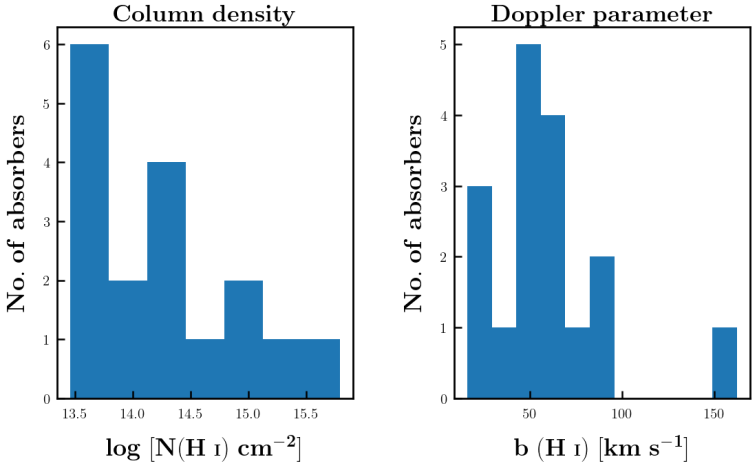

Figure 5: Distribution of H I column densities and Doppler parameters.

Insights

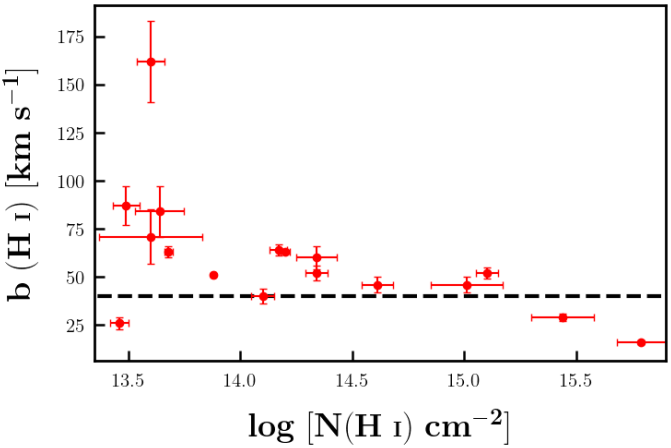

Figure 6: H I column density vs. Doppler parameter

Insights

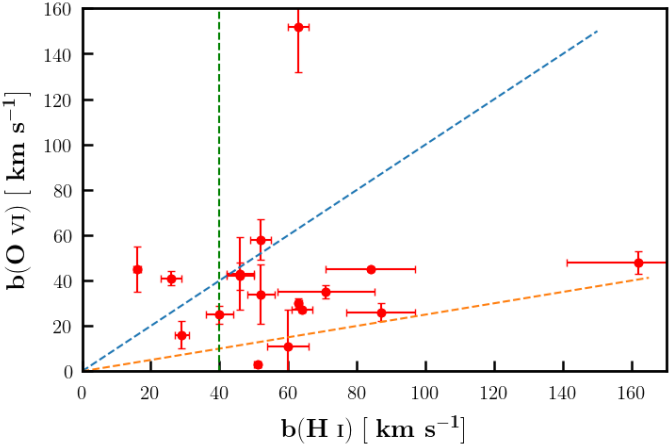

Figure 7: b(O VI) vs. b(H I)

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 0.02
- 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)

Scaling approximation

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- 2d CLOUDY models : computationally expensive

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- $Z_0 = 0.1 Z\odot$

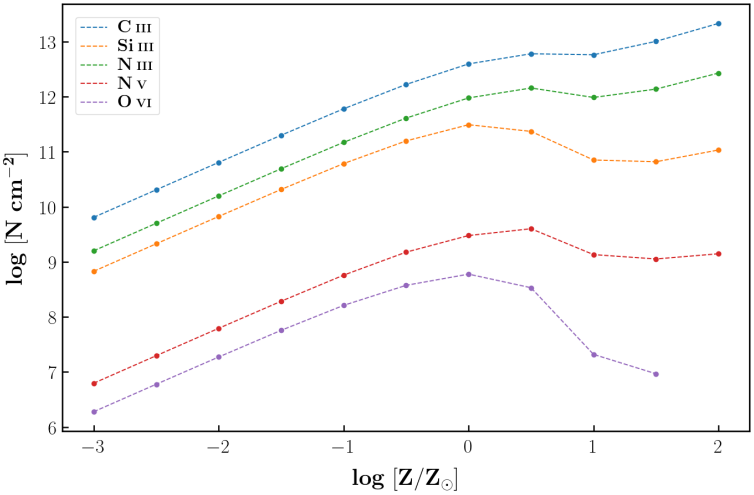

Figure 8: Column densities of various ions at different metallcity. N(H I)=10^{14} cm^{-2} and $n_H = 10^{-3}$ cm^{-3}

Results

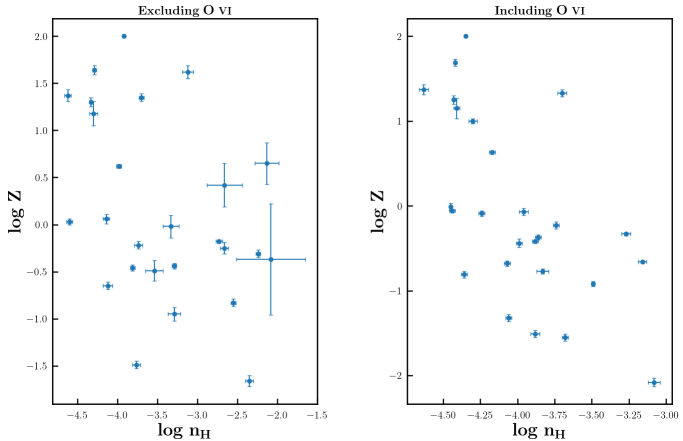

Figure 9: Ionisation modelling solutions for both excluding and including O VI cases.

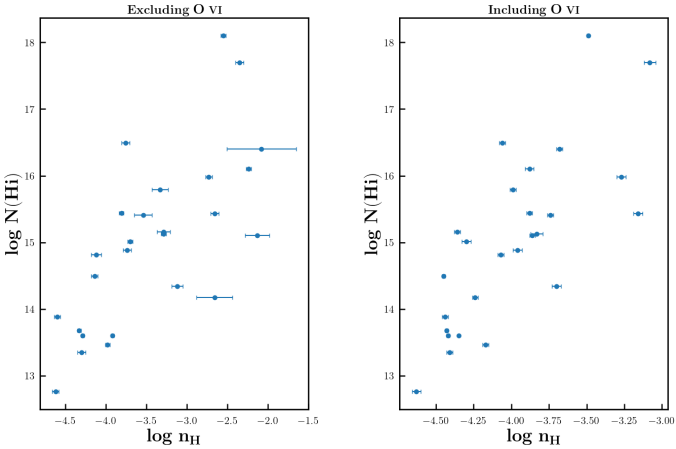

Figure 10: n_H vs. N(H I) for both excluding and including O VI cases.

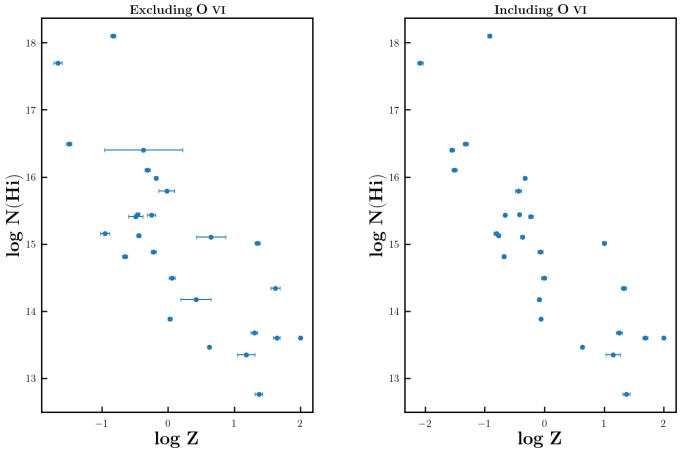

Figure 11: Z vs. N(H I) for both excluding and including O VI cases.

Towards *the end*

Ongoing and Future Work

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- Voigt profile fitting : 6

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

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