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

Mid-Term 2

Sameer Patidar
SC19B161

Dual Degree (Astronomy & Astrophysics)
Indian Institute of Space Science and Technology

Supervisors : Dr. Vikram Khaire and Dr. Anand Narayanan

Thesis Phase I : Recap

Recap

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

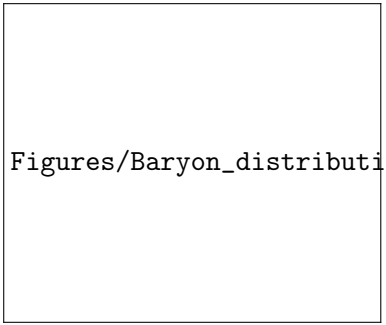

Figure 1: Baryon budget at $z \sim 0$.
Shull et al. (2012)

Recap

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

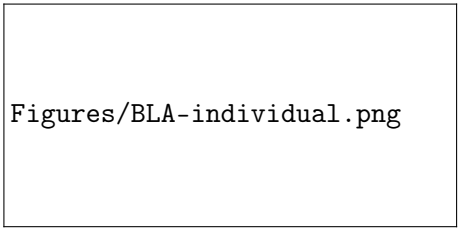

Figure 2: A BLA towards the LOS of quasar H 1821+643. Philipp Richter (2005)

Recap

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

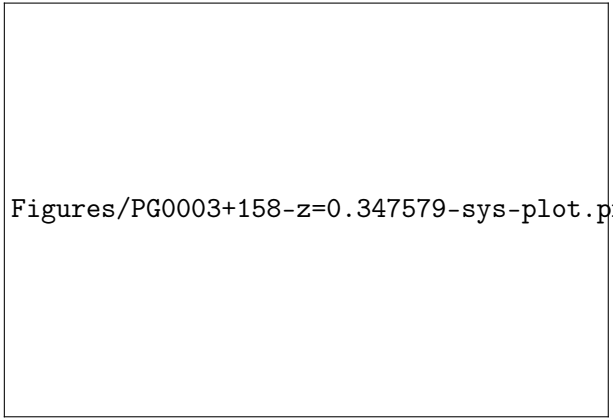

Figure 3: System plot of the absorber system towards PG 0003+158. Velocity is taken zero at z = 0.347579

Recap

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

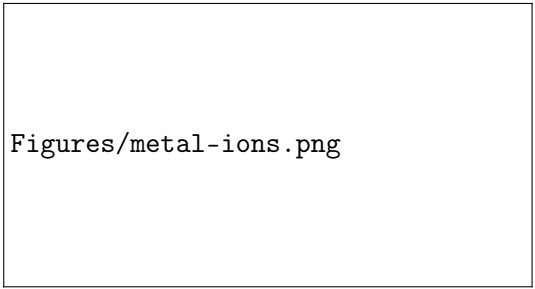

Figure 4: Distribution of metal ions in all 28 candidate BLAs

The BLA Survey

Survey so far...

Survey so far...

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

Survey so far...

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

Insights

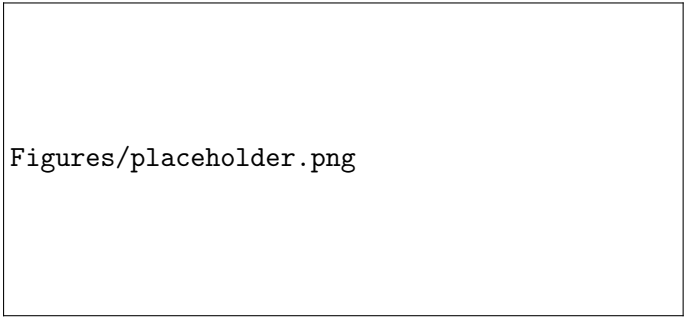

Figure 5: Distribution of H I column densities and Doppler parameters.

Insights

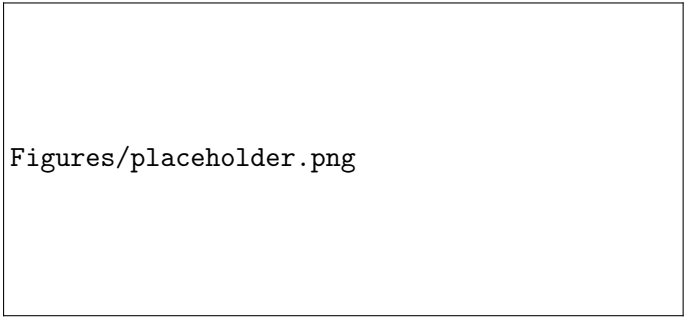

Figure 6: H I column density vs. Doppler parameter

Insights

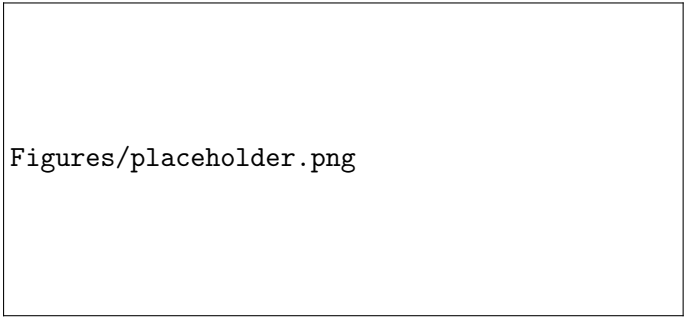

Figure 7: b(O VI) vs. b(H I)

Ionisation Modelling

Method

Method

- Grid of PI CLOUDY models : Density and Metallicity

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

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

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)

Scaling approximation

Scaling approximation

- 2d CLOUDY models : computationally expensive

Scaling approximation

- 2d CLOUDY models : computationally expensive
- Scale column density with metallcity

Scaling approximation

- 2d CLOUDY models : computationally expensive
- Scale column density with metallcity
- $\mathrm{N}(n_H, Z) = \mathrm{N}(n_H, Z_0) + \log(Z/Z_0)$

Scaling approximation

- 2d CLOUDY models : computationally expensive
- Scale column density with metallcity
- $\mathrm{N}(n_H, Z) = \mathrm{N}(n_H, Z_0) + \log(Z/Z_0)$
- $Z_0 = 0.1 Z\odot$

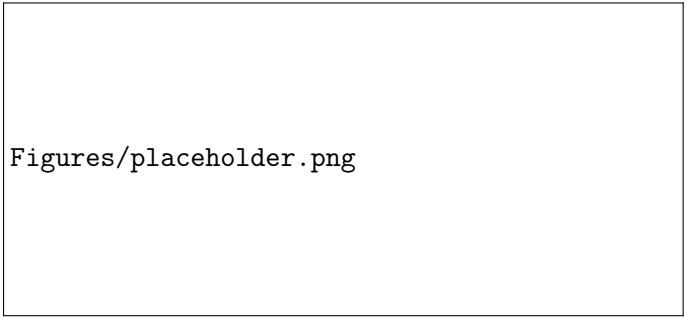

Figure 8: Column density of ion vs. Hydrogen densities at various metallcities

Results

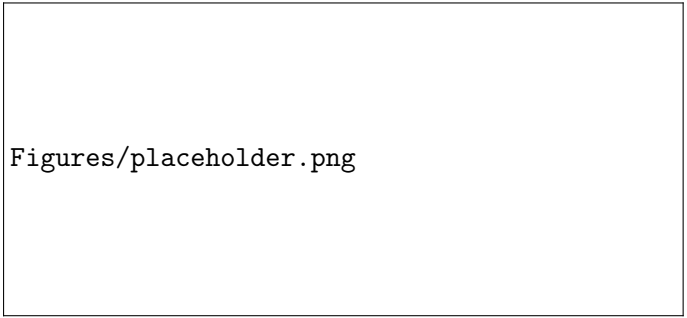

Figure 9: Distribution of no. of metal ions in the absorber systems

Results

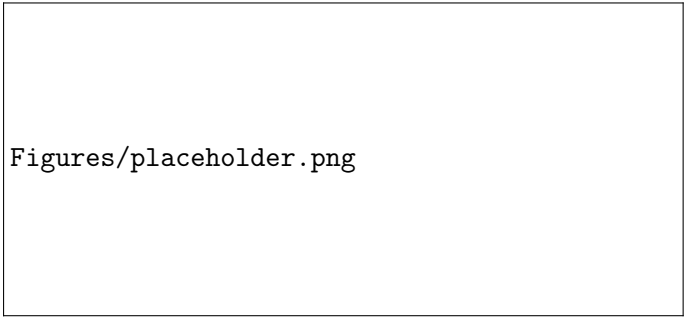

Figure 10: Distribution of no. of metal ions in the absorber systems

I

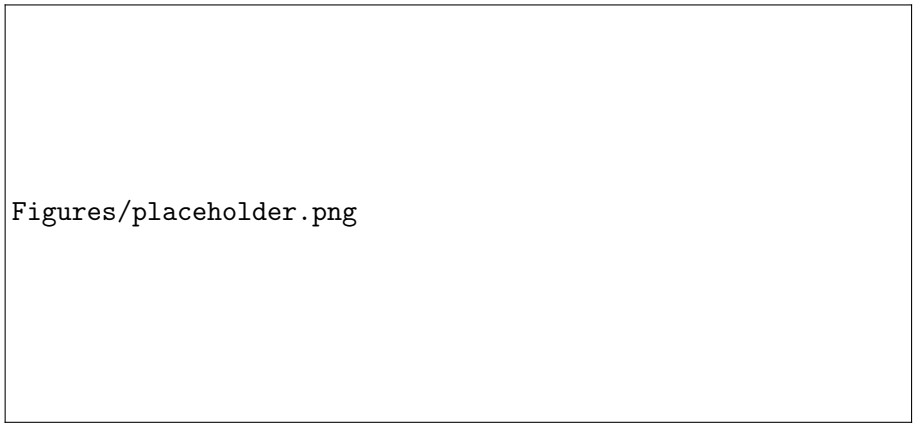

Figure 11: System plot of the absorber system towards LOS of

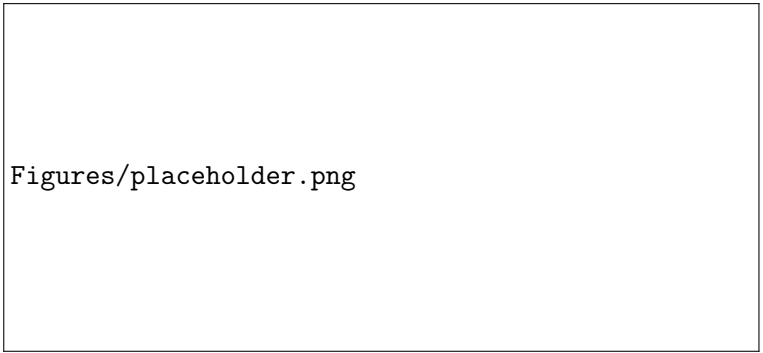

Figure 12: Observed and predicted column densities of the ions.

References

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

Cen R., Ostriker J. P., 1999, ApJ, 514, 1

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

Fukugita M., Hogan C. J., Peebles P. J. E., 1998, ApJ, 503, 518

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

Shull J. M., Smith B. D., Danforth C. W., 2012, ApJ, 759, 23

Tepper-García T., Richter P., Schaye J., 2013, MNRAS, 436, 2063