

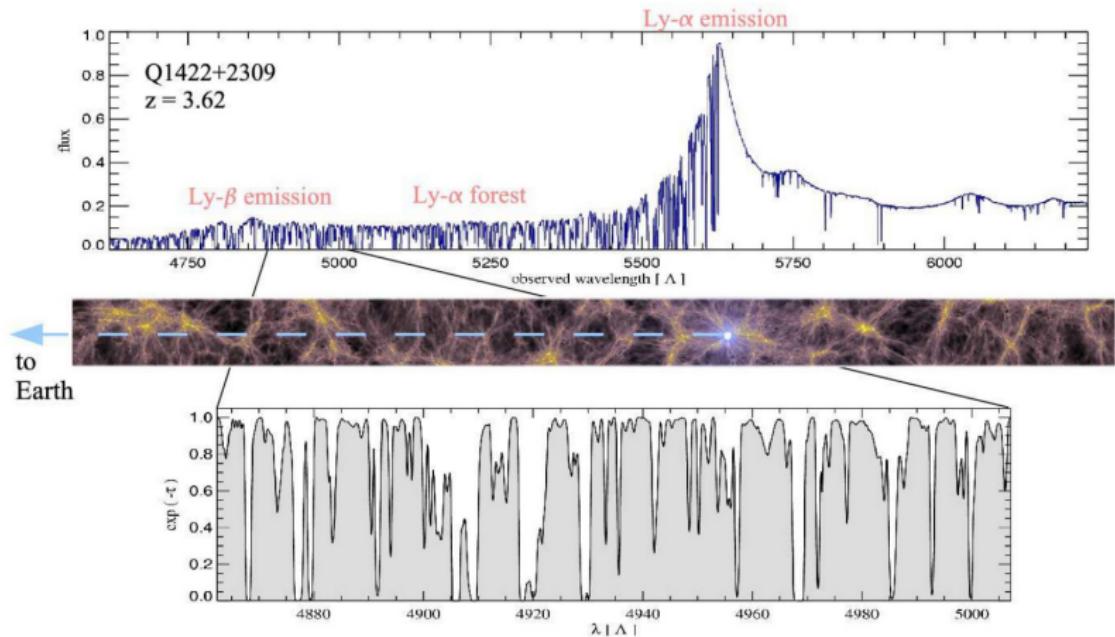
# Physical properties of the intergalactic medium

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# Introduction



Springel, V., Frenk, C. S., and White, S. D. M., "The large-scale structure of the Universe", Nature, vol. 440, no. 7088, pp. 1137–1144, 2006. doi:10.1038/nature04805.

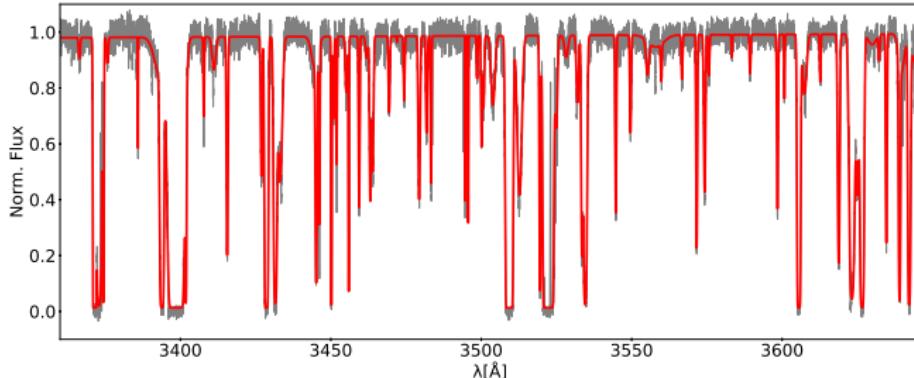
## Data and analysis

- ▶ effective equation of state of the IGM after reionization  
(Hui & Gnedin, 1997)

$$T = T_0 \left( \frac{\rho}{\bar{\rho}} \right)^{\gamma-1}$$

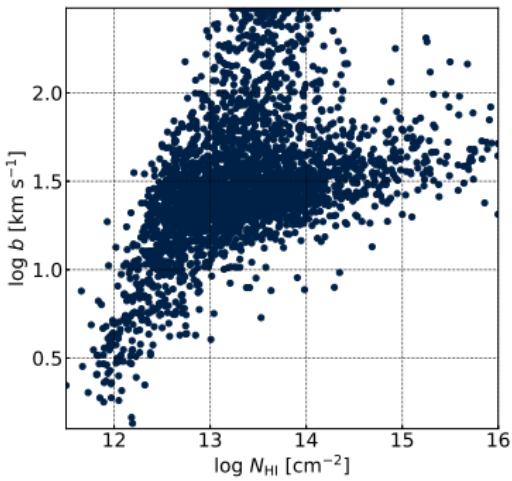
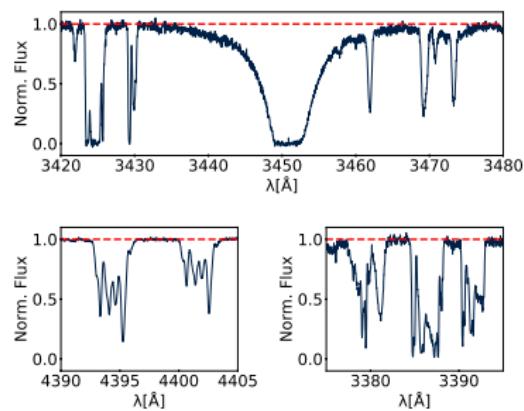
- ▶  $b(N)$  cut-off (Schaye et al., 1999)

$$b = b_0 \left( \frac{N_{HI}}{N_{HI,0}} \right)^{\Gamma-1}$$

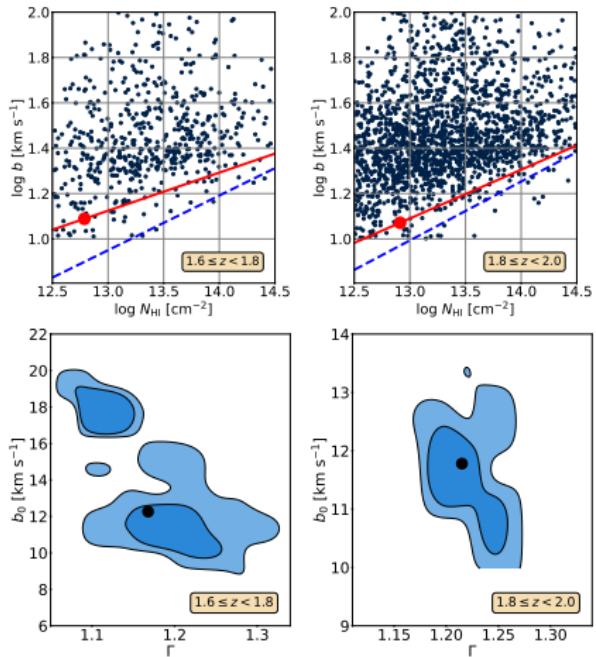


# Data and analysis

- ▶ 35 QSO spectra
- ▶ QSOs redshifts  $1.6 \leq z \leq 2.0$
- ▶ Metal line rejection



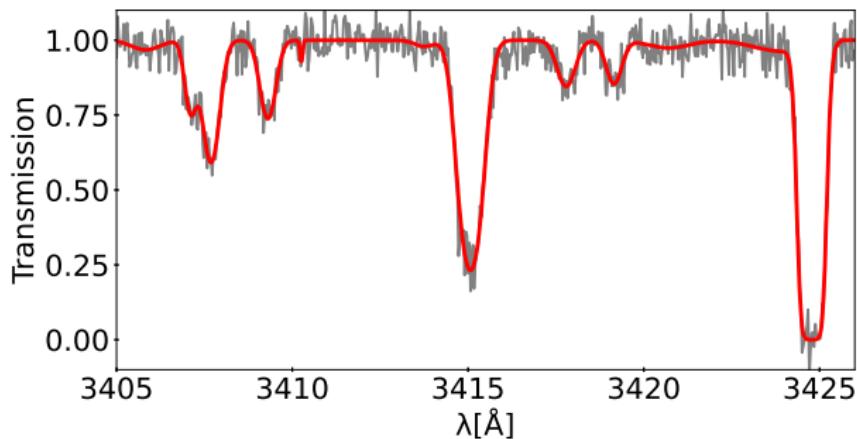
# Data and analysis



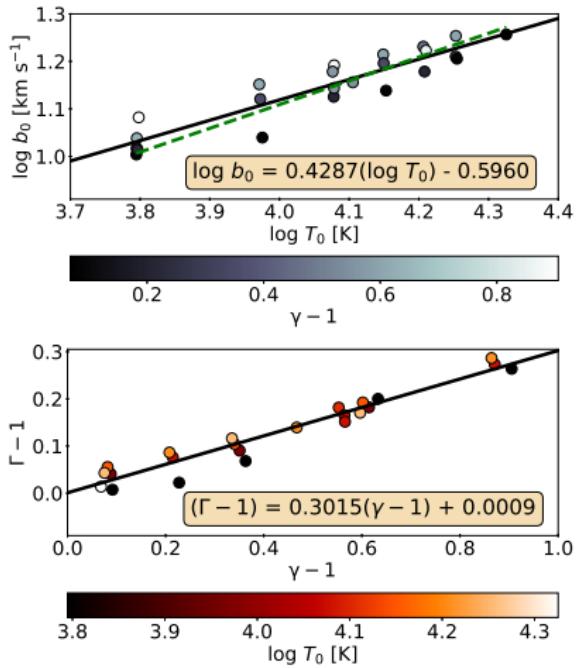
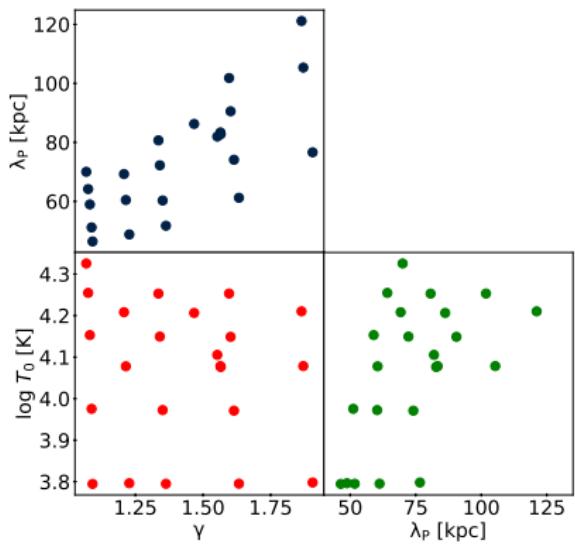
$$N_{\text{HI},0} \simeq 10^{13.23} \Delta^{3/2} \frac{T_4^{-0.22}}{\Gamma_{\text{ion,HI}}} \left( \frac{1+z}{3.4} \right)^{9/2} [\text{cm}^{-2}]$$

## Calibration using simulations

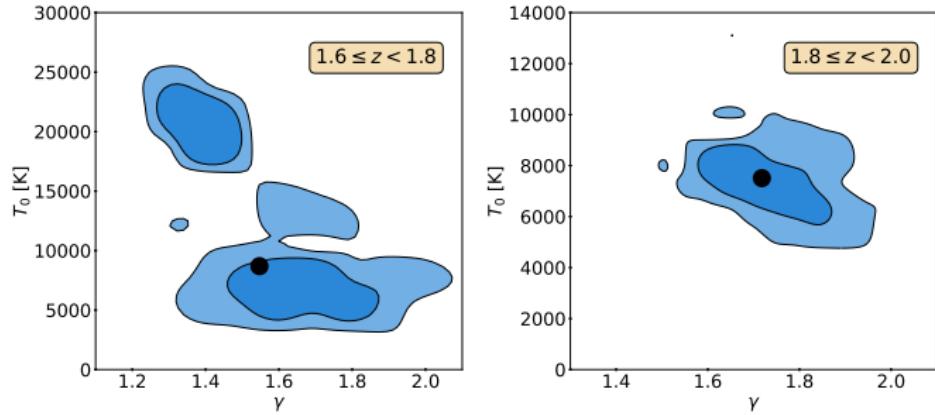
- ▶ THERMAL suite (Thermal History and Evolution in Reionization Models of Absorption Lines)
- ▶ box size  $L_{box} = 20 \text{ Mpc } h^{-1}$  and  $1024^3$  cells
- ▶ cosmological parameters were based on the results of the Planck mission



# Calibration using simulations



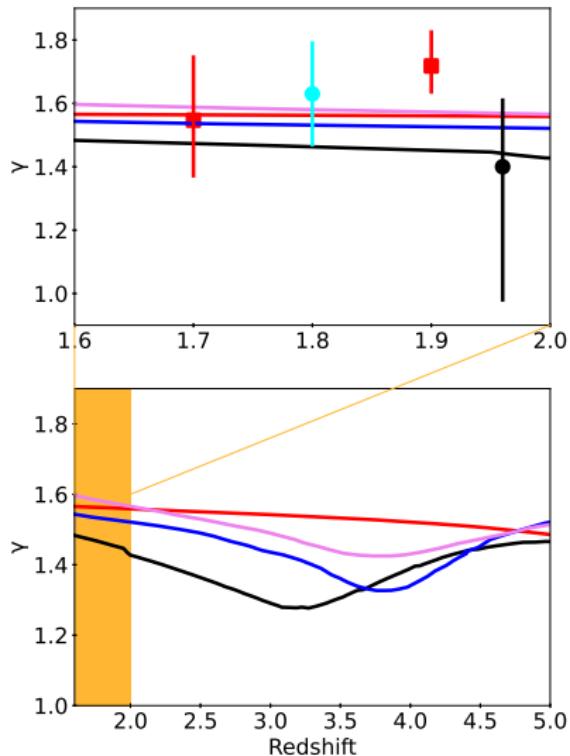
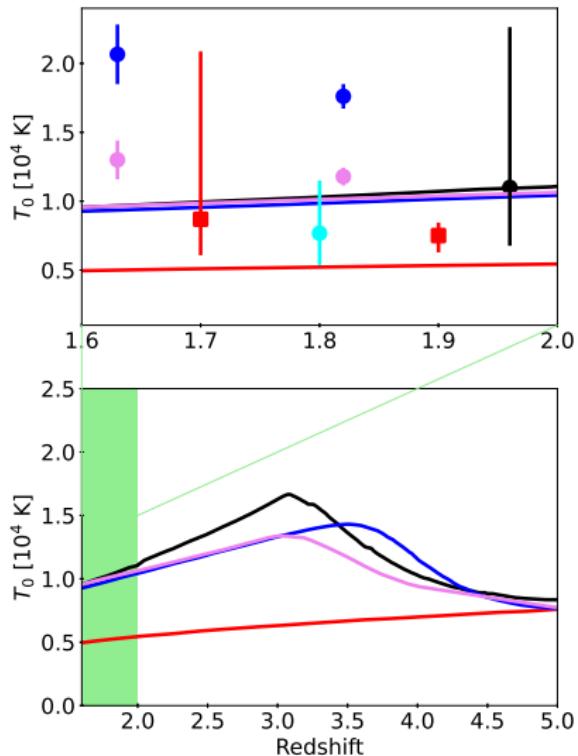
## Results



| Redshift<br>range          | $b_0$<br>[ $\text{km s}^{-1}$ ] | $T_0$<br>[ $10^3 \text{ K}$ ] | $\Gamma$               | $\gamma$               |
|----------------------------|---------------------------------|-------------------------------|------------------------|------------------------|
| $\langle 1.6, 1.8 \rangle$ | $12.26^{+5.67}_{-1.49}$         | $8.69^{+12.05}_{-2.48}$       | $1.17^{+0.05}_{-0.06}$ | $1.55^{+0.20}_{-0.18}$ |
| $\langle 1.8, 2.0 \rangle$ | $11.78^{+0.29}_{-0.83}$         | $7.51^{+0.81}_{-1.09}$        | $1.22^{+0.03}_{-0.02}$ | $1.72^{+0.11}_{-0.08}$ |

# Comparison with models of the IGM thermal evolution

- Schaye et al. (2000)
- Boera et al. (2014),  $\gamma \sim 1.5$
- This work
- Boera et al. (2014),  $\gamma \sim 1.3$
- Walther et al. (2019)



Thank you for your attention.