Probing feedback with Lyman-α absorption in the circumgalactic medium

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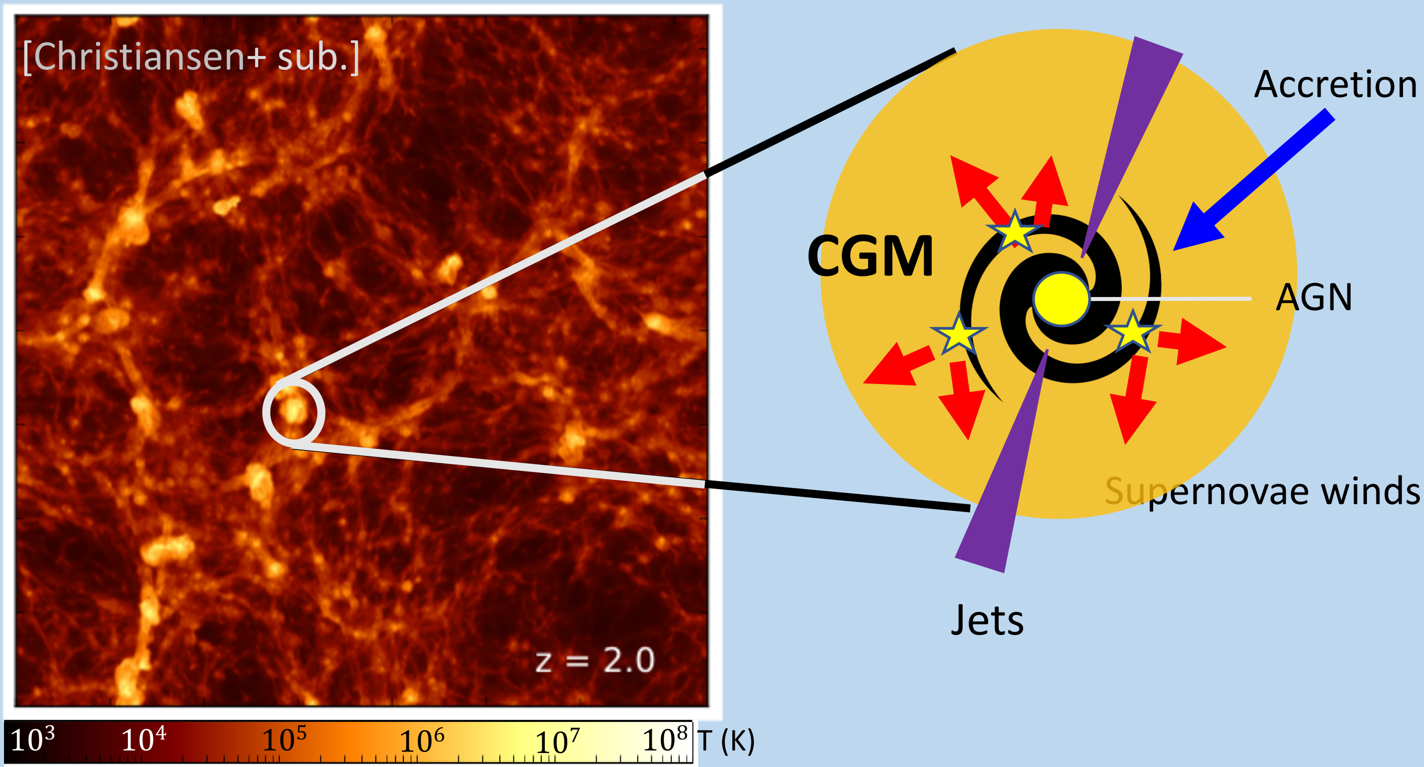


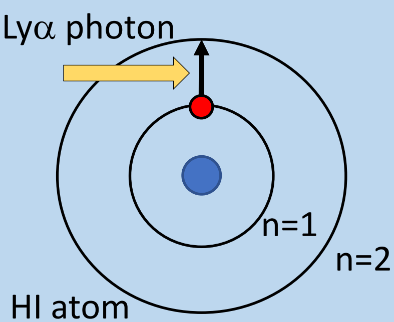
Galaxy formation depends critically on the properties of the gaseous environment that surrounds them (circumgalactic medium, CGM). Indeed, the CGM is affected by outflows from supernovae (*stellar feedback*) and/or jets powered by the black hole at the centre of the galaxy (*AGN feedback*).

Such physical processes are implemented in cosmological numerical simulations with physically motivated prescriptions that vary from code to code. It is imperative to constrain the parameters underlying feedback models with a wide range of observations to gain insight into the physics of the CGM and hence galaxy formation. Investigating the Lyman-α (Lyα) absorption properties of the CGM surrounding z~2-3 quasars offers a great opportunity in this respect.

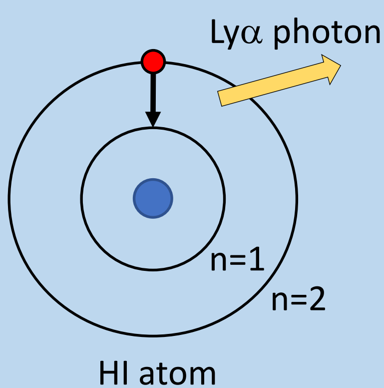
Lyman-α absorption as a probe of feedback

Atoms of neutral hydrogen (HI) in the intervening intergalactic medium can scatter Lyα photons emitted by a background quasar away from the line of sight.

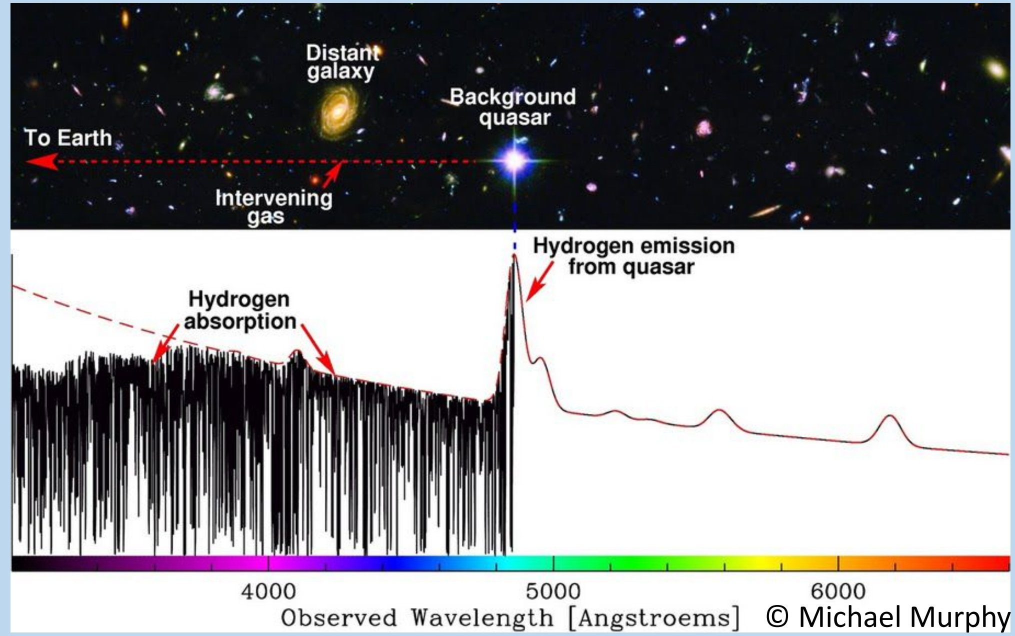
Higher HI density → more absorption



1 Incoming Lyα photon absorbed → excited state



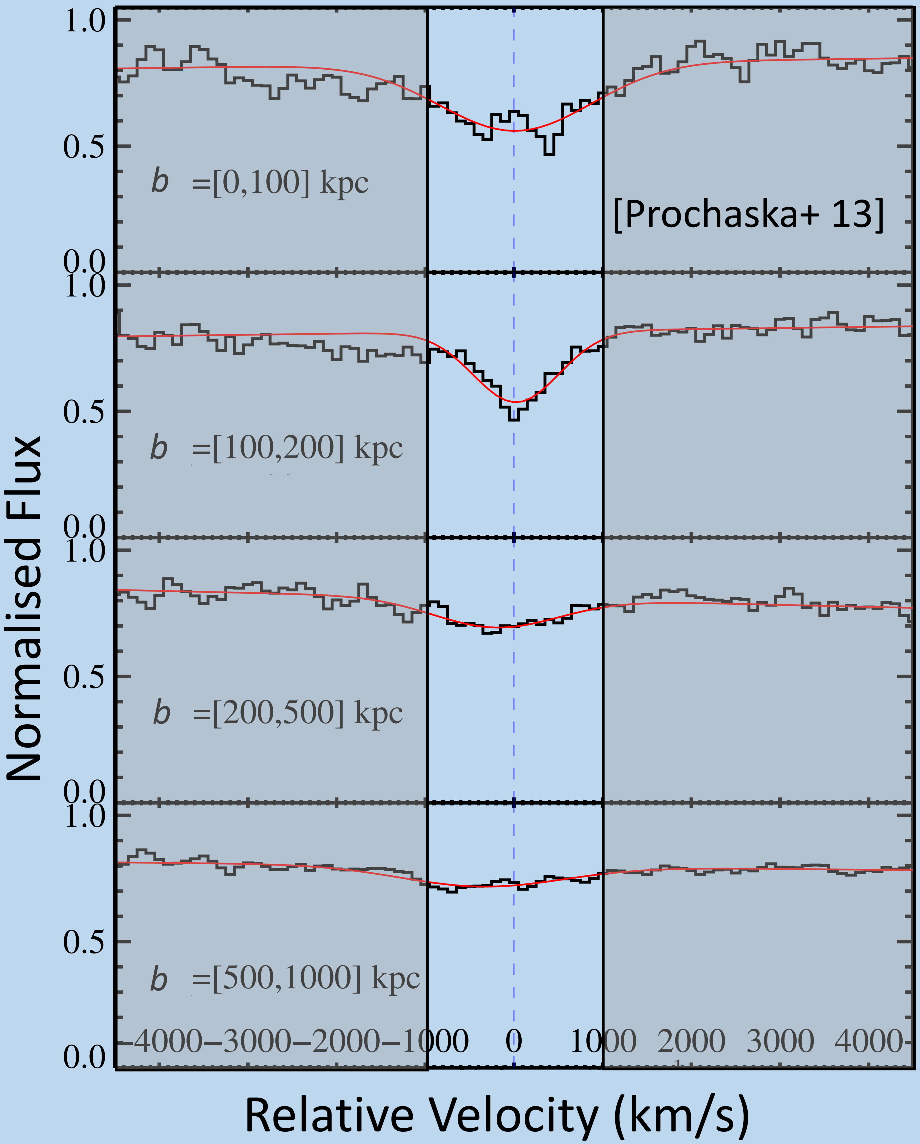
2 Back to ground state → Lyα photon emitted; in general, direction different from incoming photon

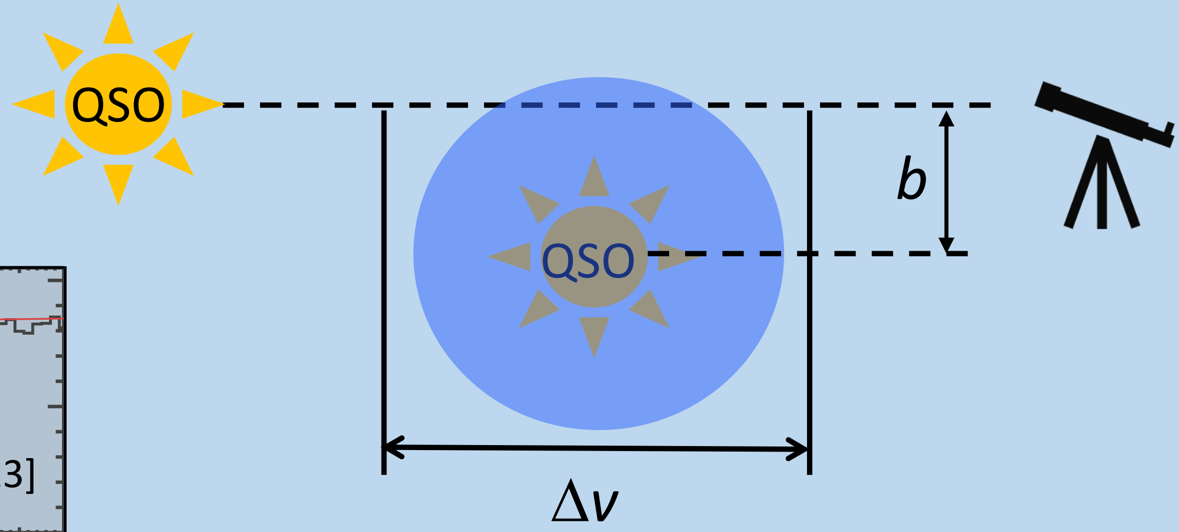


If the line of sight passes by a foreground galaxy or quasar, we can study the properties of its CGM via the associated Lyα absorption features in the spectrum of the background quasar. Indeed, the HI density within the CGM depends on the thermal state of the gas, which is sensitive to feedback processes. Therefore, we can exploit Lyα absorption data to constrain feedback models and understand the physics of the CGM.

Lyα Absorption Data → Constrain Feedback Prescriptions → Understand CGM Physics

What do observers measure?





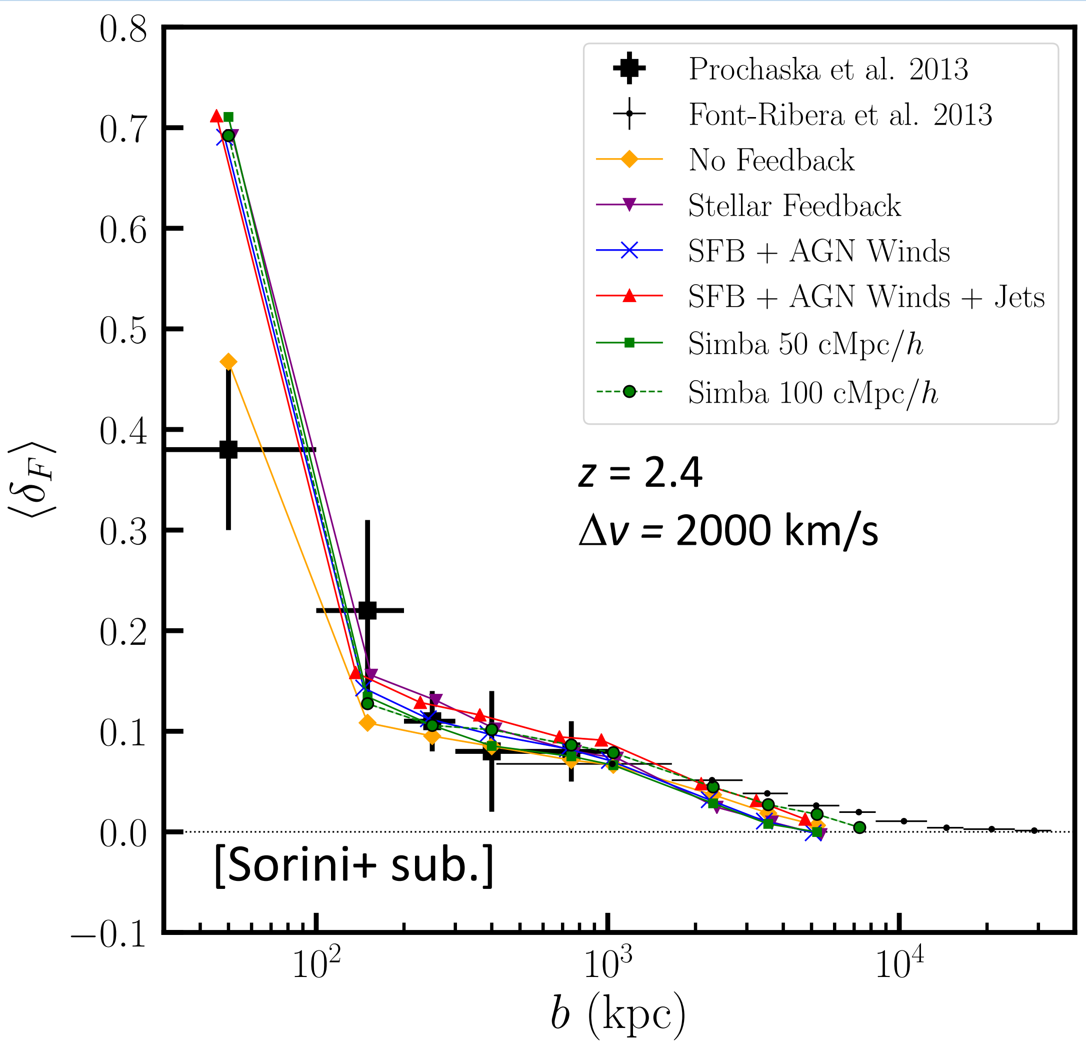
From a sample of quasar (QSO) pairs, observers can stack the spectra of the background quasars in bins of impact parameter *b,* and then measure the mean Lyα flux $\langle F\rangle_{\Delta v}$ within a certain velocity window Δv around the foreground quasar. If the mean Lyα flux in the intergalactic medium $\langle F\rangle_{IGM}$ (i.e., far from the foreground quasars) at the same redshift of the observations is known, it is possible to obtain the mean Lyα flux contrast as a function of *b.* This is defined as

$$\delta_F = 1 - \frac{\langle F\rangle_{\Delta v}}{\langle F\rangle_{IGM}}$$

FLUX CONTRAST

What can simulations tell us?

Mean flux contrast *vs* Impact parameter



*http://simba.roe.ac.uk   Davé et al. (2019)

We considered 5 runs of the **Simba*** cosmological hydrodynamic simulation: one with no feedback, one with stellar feedback only, and three others with stellar feedback and different AGN feedback prescriptions (winds, jets, and X-rays). We used them to reproduce the mean Lyα flux contrast profile around QSOs and compared it with the observations described earlier. We find that:

- All runs exhibit good overall match with data @ b > 100 kpc
- @ b <100 kpc the run without any feedback prescription yields much less absorption than the other runs, which give similar predictions

The average properties of the CGM of z~2-3 quasars are primarily determined by STELLAR FEEDBACK rather than AGN FEEDBACK

More details in arXiv:2005:08971

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