Lighting up structure formation with Lyman-α emission

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WHAT?

Lyman-α emission is a prime tool for studying galaxy formation at high redshift and the diffuse gas in and around haloes. Many extended sources have been detected around z=3. It is still unknown what powers most of these Lyman-α blobs. Do they originate from cooling radiation or from photo-ionization by massive stars? The fraction of Lyman-α photons able to escape the star forming regions is uncertain. Can we put constraints on this quanitity?

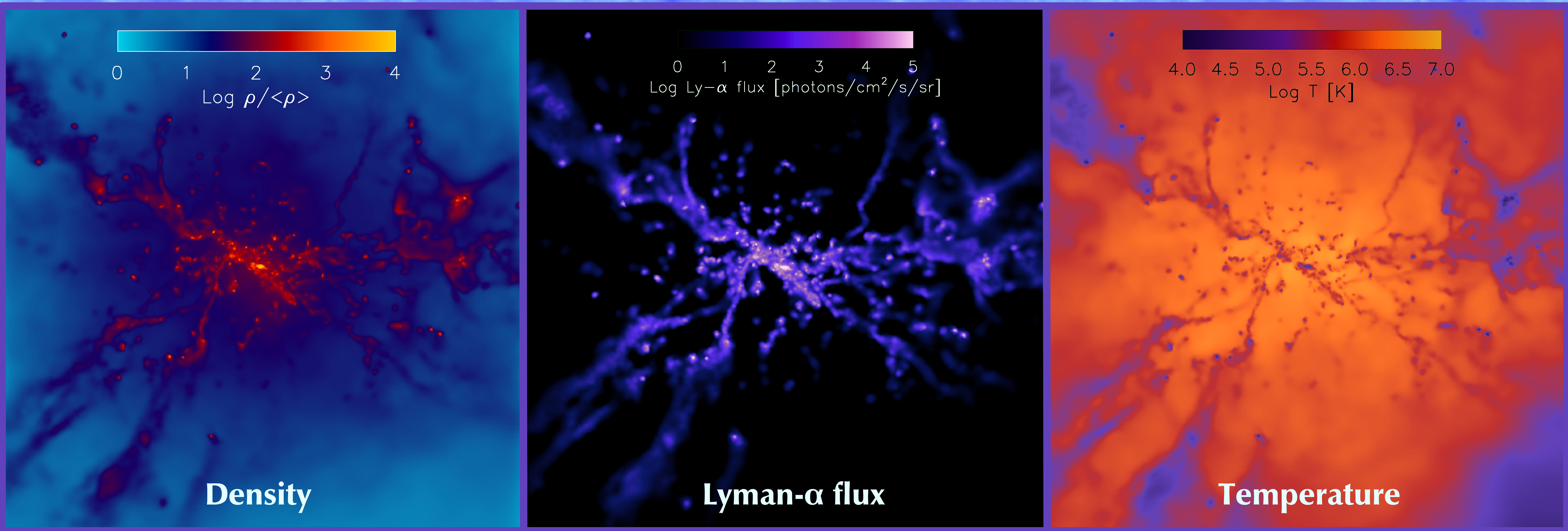
HOW?

We use state-of-the-art cosmological, hydrodynamical simulations to reproduce and understand existing observations. Knowing the temperature, density and chemical composition of the gas, we compute the Lyman-α emissivity from haloes in the simulations. The star formation rate of the gas is converted into a Lyman-α luminosity as well. We do not yet incorporate radiative transfer, which could change the results significantly.

WHY?

Observing and studying the diffuse haloes around galaxies enables us to study the interaction between galaxies and the intergalactic medium (IGM). The IGM is the gas reservoir from which the galaxy gets its fuel for star formation. On the other hand, galactic superwinds are thought to expel gas and enrich the IGM. With Lyman-α observations we can probe this region. Simulations are essential for interpreting these results.

Gas in and around a 10^{12} M_{sun} halo at z=3

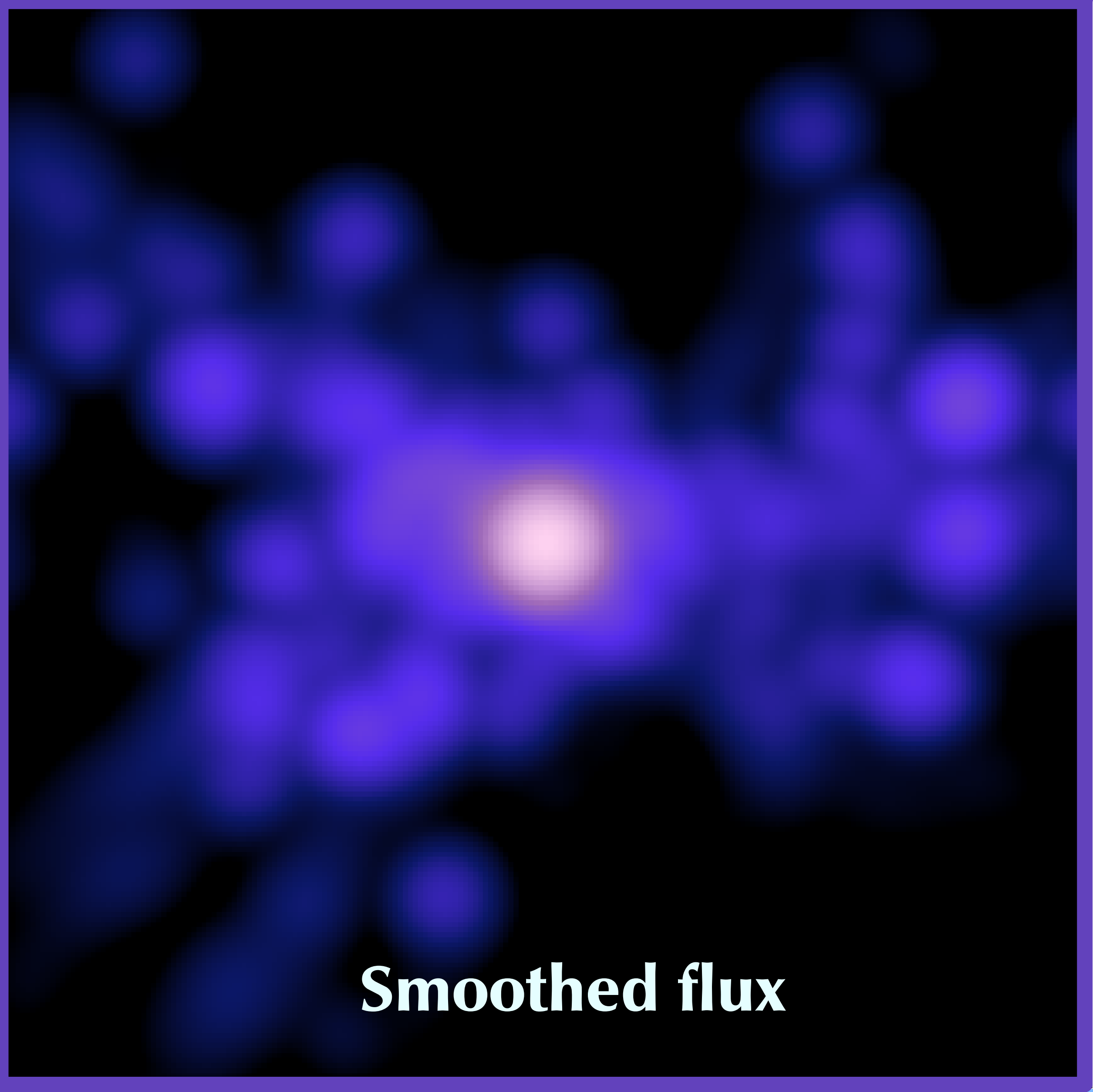


Density **Lyman-α flux** **Temperature**

CONCLUSIONS

Cooling radiation alone is not enough to explain the large sizes and high luminosities of the Lyman-α blobs. Most of the Lyman-α emission comes from young stars, at least in the optically thin limit without including destruction by dust.

The large sizes and luminosities of Lyman-α blobs are reproduced after including Lyman-α emission from star formation. It is essential to only include approximately 10% of the emission that is available from star formation and to smooth with a Gaussian with standard deviation of 1″, as was done for the observations.



Smoothed flux

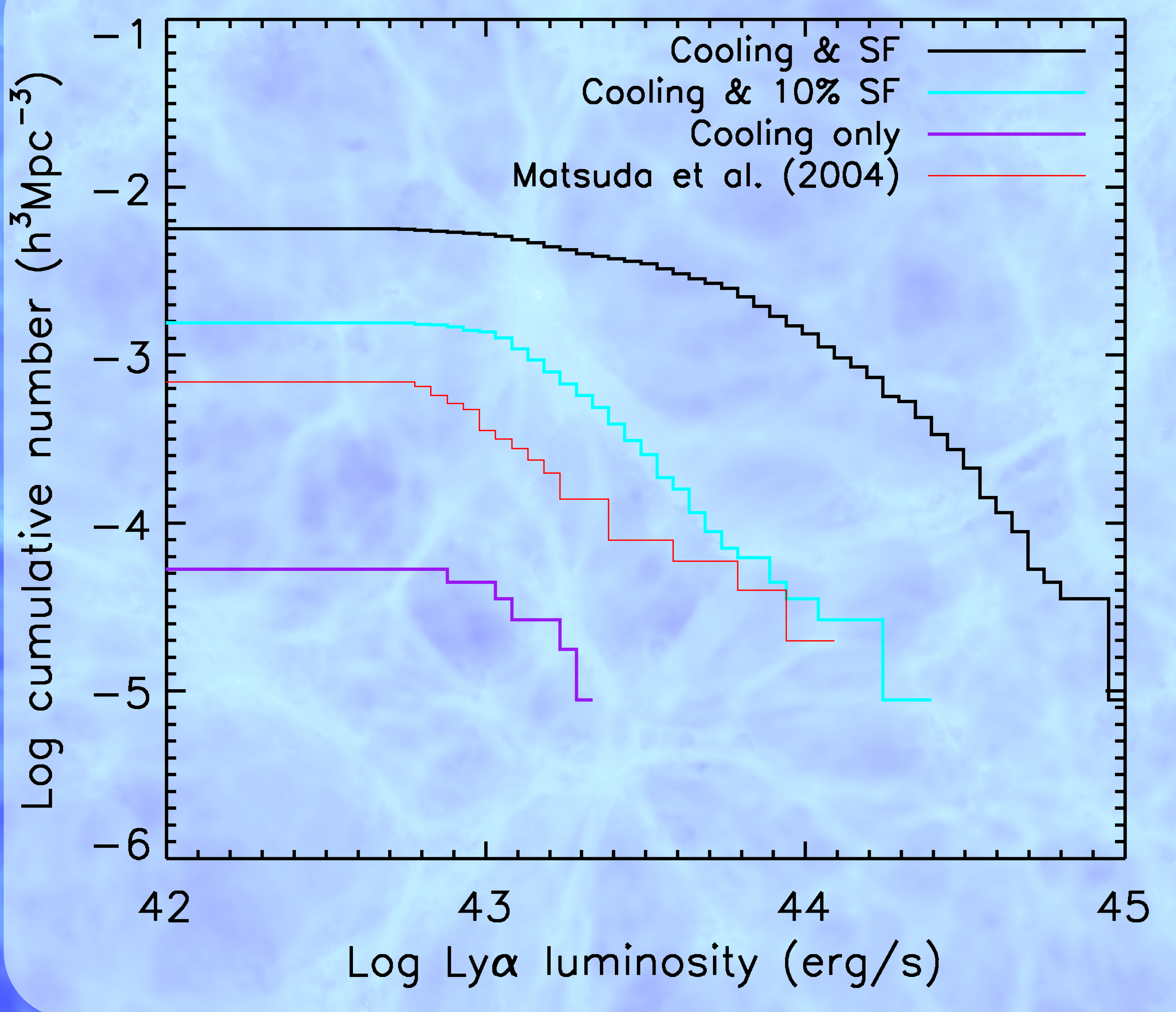


Fig. 1 The cumulative luminosity distribution function for a simulated protocluster (hydrodynamical resimulation of a +2σ region in the Millennium simulation, thick curves) at z=3 and for the observed protocluster SSA22 (Matsuda et al. 2004, thin, red curve). We only include high surface brightness objects with area > 16″² to match the observations. When only including Lyman-α emission from cooling, we find too few objects with too low luminosities (purple curve). When all Lyman-α photons from star formation are included, as well as from cooling, we find too many bright blobs (black curve). 10% of the Lyman-α photons available from star formation (cyan curve) does a reasonable job in reproducing the observations.

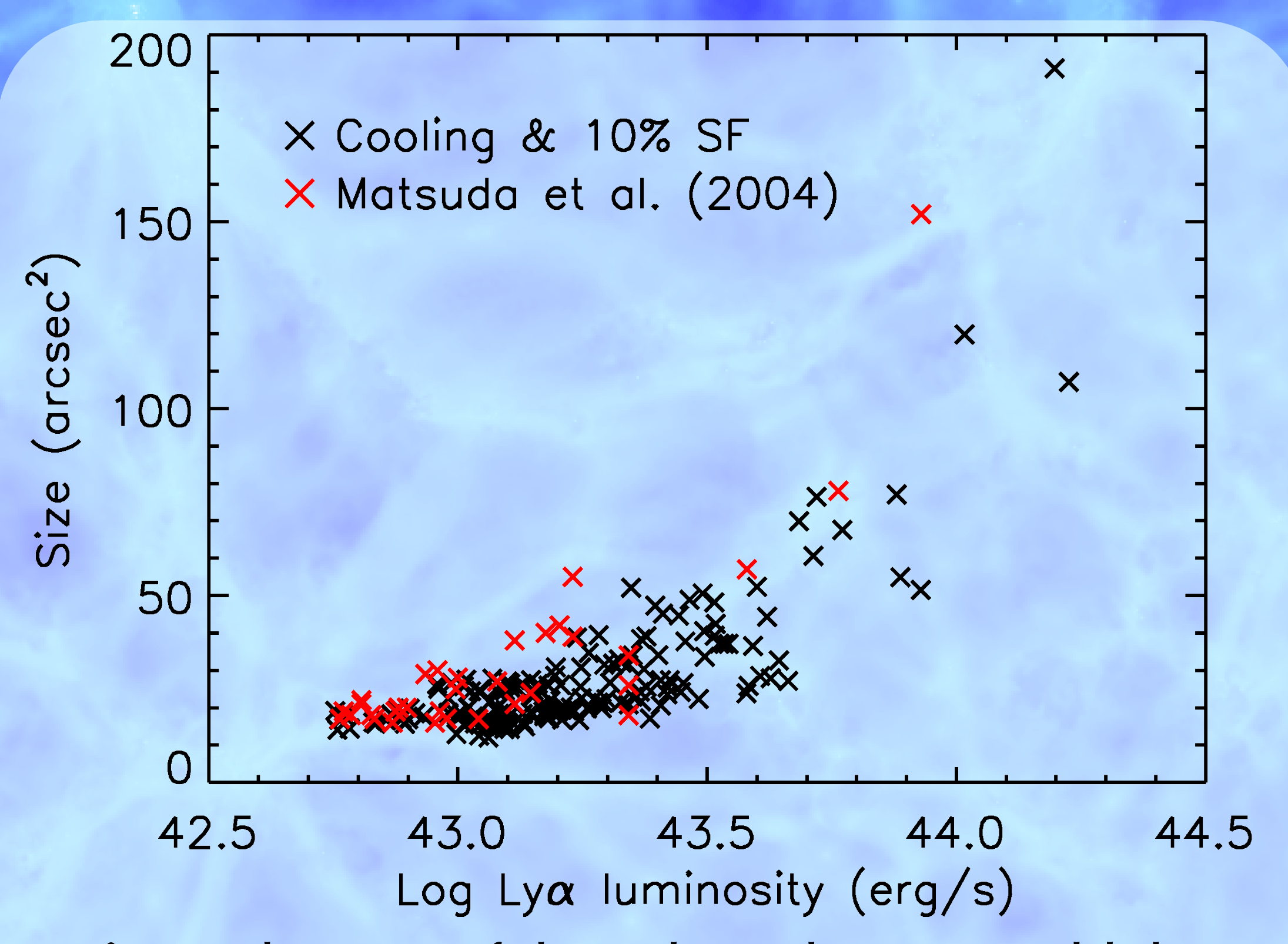


Fig. 2 The size of the selected Lyman-α blobs against their luminosity for the simulation (black crosses) and observation (red crosses)

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