Lyman-α blobs: polarisation arising from cold accretion

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Introduction

Lyman-α blobs (LABs) are extended nebulae seen in Lyα at $z \simeq 2-6$ around various types of objects (LBG, sub-mm galaxies, quasars, or nothing).

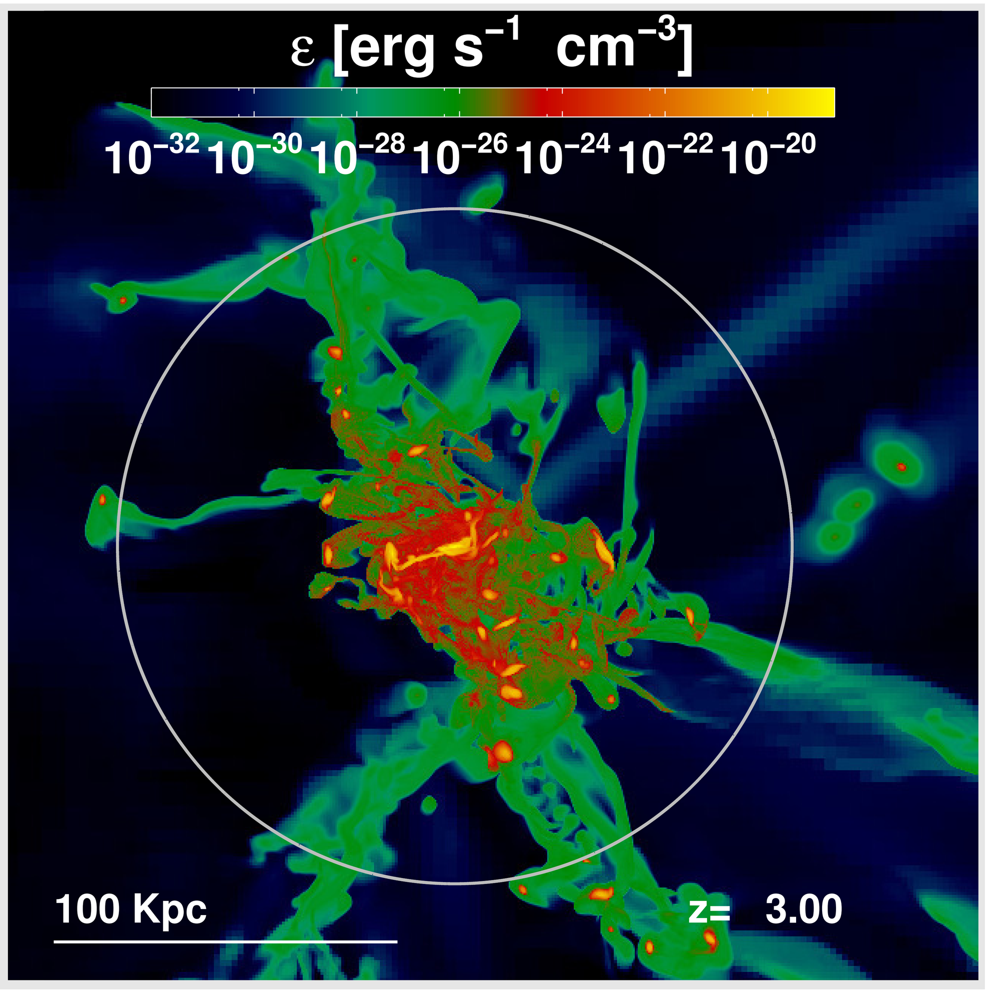
The origin of the Lyα emission is still debated, with several plausible scenarios:

- Lyα scattering in galactic outflows
- Fluorescence induced by UV background
- Gas cooling in outflows
- Cooling of accretion streams

We discuss the use of polarimetric observations as a tool to distinguish between these models, as suggested by Hayes et al. (2011, *Nature*, 476, 304).

Simulations

We use one of the blob simulations from Rosdahl & Blaizot (2012, *MNRAS*, 423, 344). They used the AMR code RamsesRT with a zoom technique allowing a spatial resolution of 434 pc. The simulation describes a large blob with $M_{\rm halo} \simeq 10^{12} M_\odot$ at $z = 3$.



The radiation-hydrodynamics (RHD) solver allows to resolve the competition between heating of the infalling gas and radiative Lyα cooling, and thus to compute accurately the gas temperature, ionisation state and Lyα emissivity.

Lyα radiative transfer

We followed the transfer of the photons through the blob with the MCLya Monte Carlo code. We keep track of the polarisation by assuming each MC photon is 100% linearly polarised.

We use two different Lyα sources:

- In situ gas emission
- Galactic emission

Results

With the output of MCLya, we can construct mock maps of the blob for surface brightness and polarisation degree. We produce such maps for multiple directions, and for each map, we compute the surface brightness and polarisation radial profiles. We then average the profiles to get a "typical" profile for a large LAB at $z = 3$.

Surface brightness

- We compare our SB profile to various observations of LABs and Lyman-α emitters. Our profile is consistent with most observations.
- Outside the inner region of the blob, the contribution of the gas is dominant.
- Scattering inside the blob has only very little impact on the SB profile.

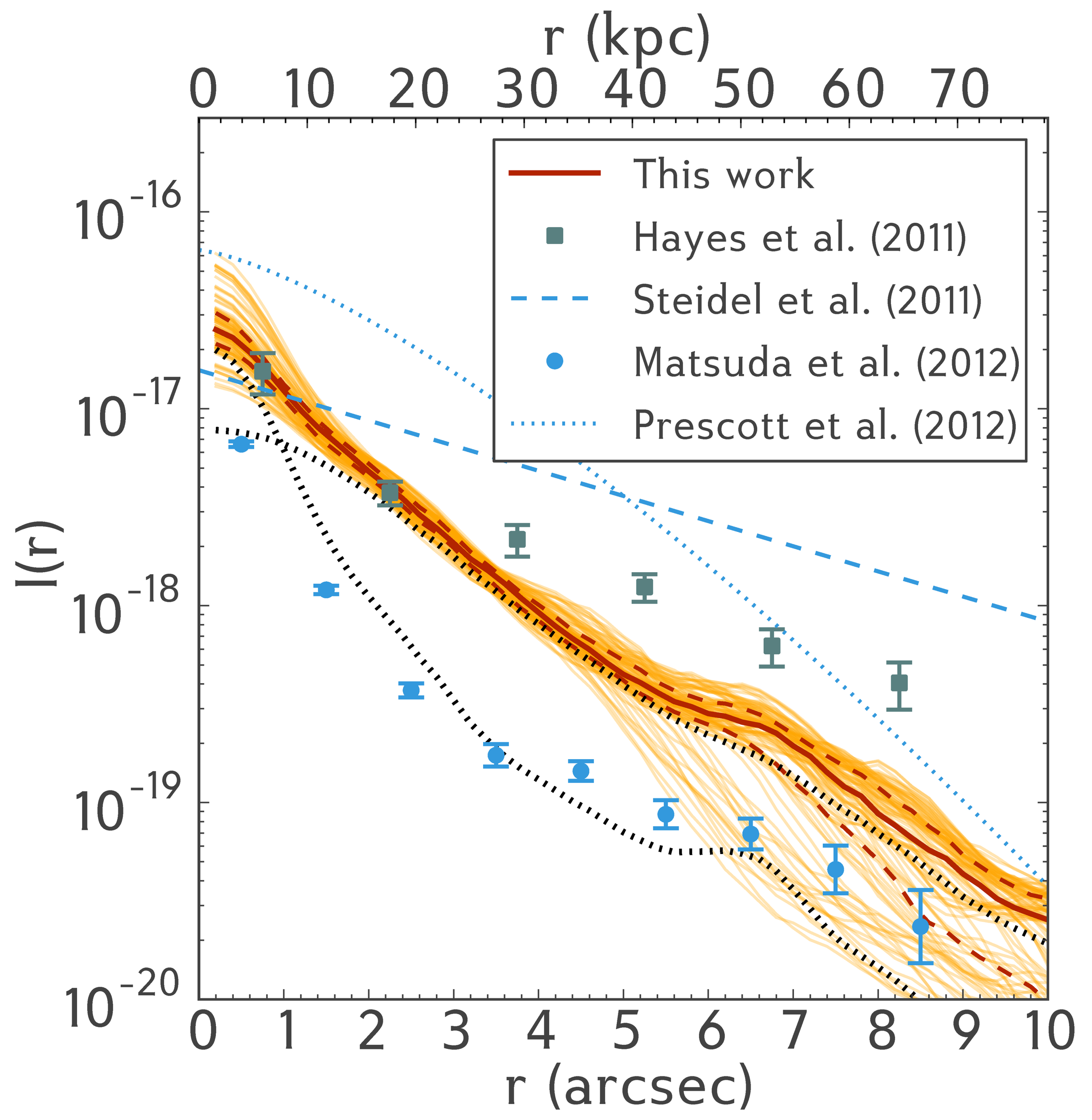


Figure 1: SB profile of a typical LAB. Upper black line: in situ gas emission. Lower black line: galactic emission.

Polarisation

We compare our results to the polarimetric observations of Hayes et al. (2012). Figure 2 shows side by side the polarisation profiles for a LAB with pure in-situ gas emission (left panel), only the galactic contribution to the Lyα emission (middle panel) and a combination of the two where only 5% of the galactic emission escape the interstellar medium (right panel). This corresponds to a situation where the Lyα emission from the infalling gas accounts for $\sim 2/3$ of the total Lyα luminosity.

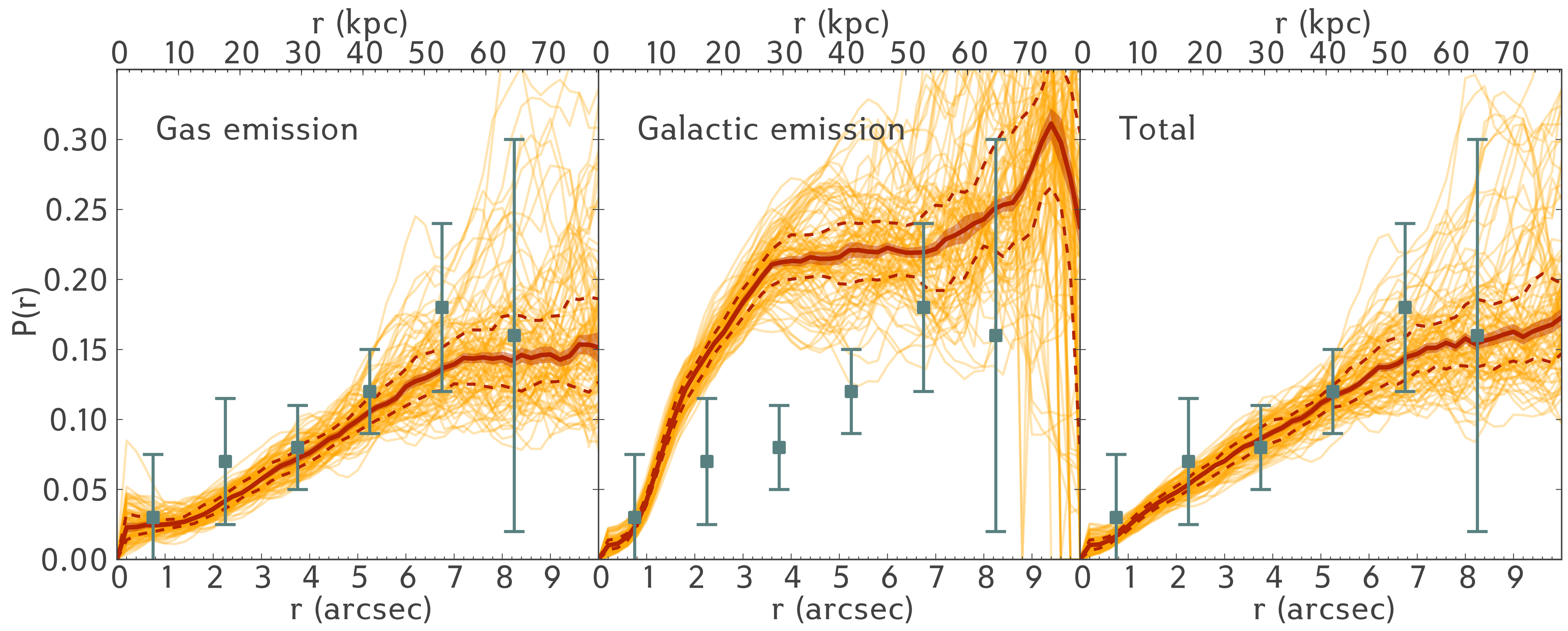


Figure 2: Polarisation profiles expected for the extragalactic, galactic, and total Lyα emission

Conclusions

- Lyα cooling radiation emitted inside the infalling gas and scattered through the blob gives a surface brightness profile consistent with observations.
- Since the emissivity profile of the blob is centrally concentrated, photons mostly travel from the inner region towards the external parts of the blob. This inhomogeneous Lyα emission is responsible for the observed polarisation.
- We can understand polarimetric observations with the combined contributions of accretion streams and galactic Lyα sources, assuming a typical Lyα escape fraction of 5%.

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