Emission from damped Lya galaxies

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We report the results from an ongoing integral field spectroscopic survey aimed to detect Lyman-a emission lines from galaxies associated with damped Lyman-a systems (DLAs) at z>2. DLAs have column densities suggesting that the line of sight towards the quasars intersect galaxy (proto) discs. The candidate DLA galaxies are found at distances at 10-25 kpc, implying that these high redshift galaxies are surrounded by neutral hydrogen at large distances. The emission line luminosities imply low star formation rates compared to luminosity selected high redshift galaxies. The Lya luminosities are compared with the metallicities and CII* column densities for the DLAs, but there are no clear signs that all strong metal absorbers have higher luminosities.

Context:

Statistics of quasar absorption lines have shown that the most neutral gas in the Universe resides in the highest column density absorbers - the DLAs that have log N(HI) > 20.3 cm^{-2}. DLAs at z>2 contain a significant fraction of neutral gas mass compared to the total mass in stars in present day galaxies, indicating that DLAs may be reservoirs for star formation.

Analyses of the associated metal absorption lines show evidence for increasing metallicity with increasing cosmic time, again indicating a connection with star forming galaxies.

Extensive observational efforts have been invested during the past 20 years to detect the galaxies responsible for the absorption. However, although more than 1000 high redshift DLAs are known, only 6 DLA galaxies have been found in emission.

Method:

Traditional methods to detect DLA galaxies involve a combination of deep images used to detect objects near to the QSO line of sight, followed by long slit spectroscopy to confirm the redshift of the galaxies.

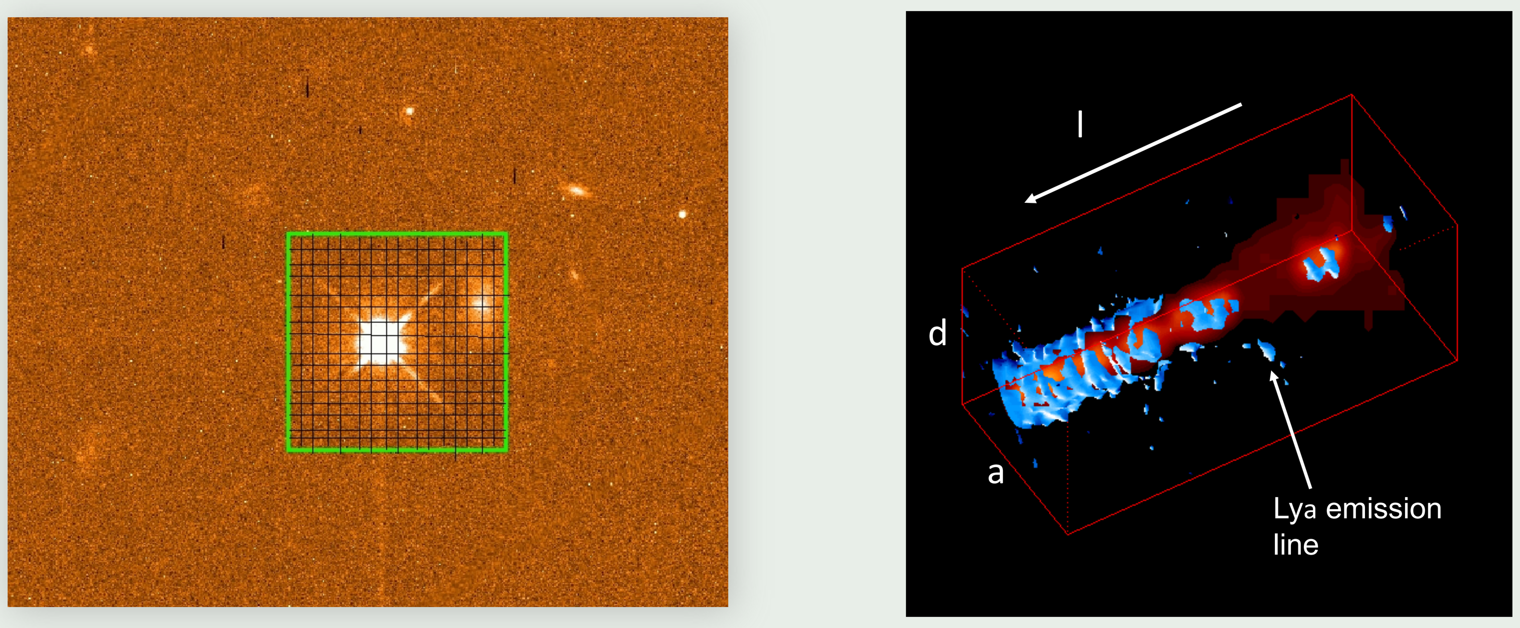


Fig1: Left: Illustration of a QSO known to have a DLA in its spectrum. The grid indicates the field of view of the PMAS IFU, where each little square gives a separate spectrum. The reduced data cube (right) can be searched for Lya emission from the DLA galaxy.

Integral field spectroscopy offers the advantage to do both simultaneously as illustrated in Fig. 1 and Fig. 2.

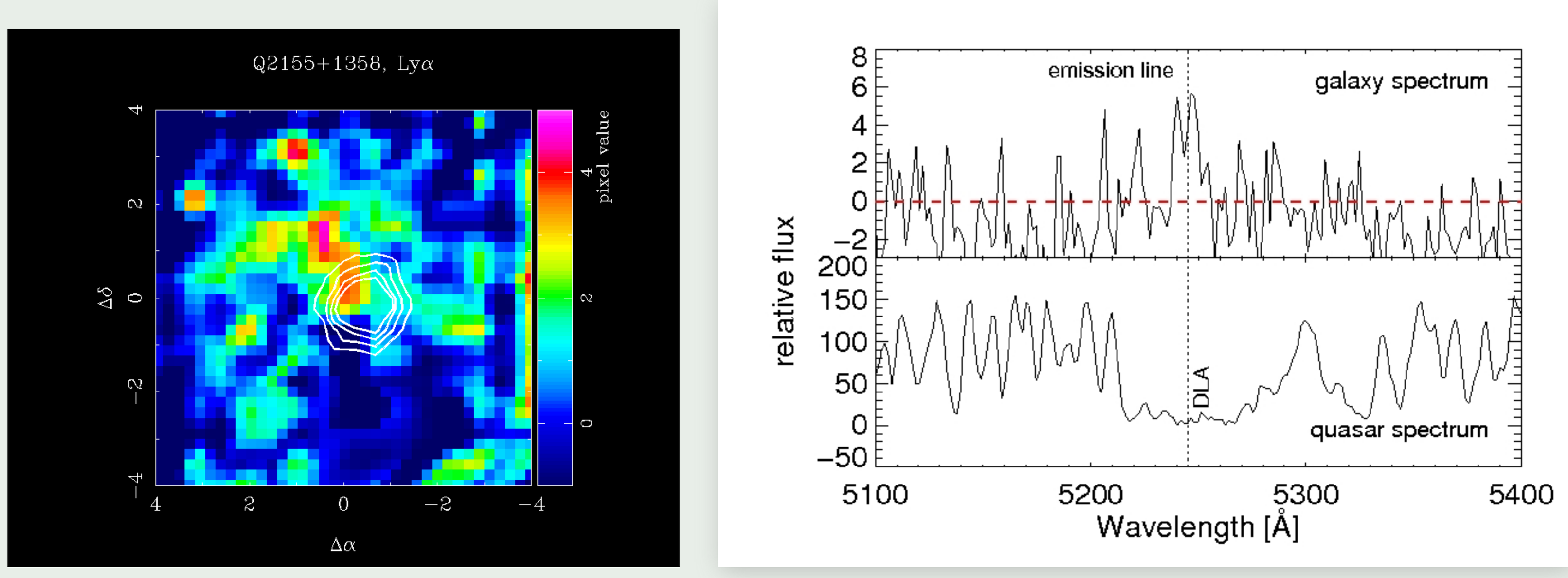


Fig. 2: Narrow band image of the QSO PSS J2155+1358. The image is created by selecting the wavelength slices in the DLA trough. The QSO PSF is outlined by the contours. A candidate DLA galaxy is found offset by 1 arcsec from the QSO.
From the data cube, spectra are extracted from these two regions. Lower panel: spectrum extracted from the QSO, which has a DLA at z=3.3. The spectrum of the candidate DLA galaxy has a Lya emission line coincident in wavelength with the DLA absorption line.

The survey:

- 42 DLAs at 2<z<4 (plus >15 sub-DLAs) from the following instruments: PMAS (Calar Alto), VIMOS (VLT), FLAMES (VLT), GMOS (Gemini-S).
- The flux limit for a 3s Lya emission line detection obtained with a typical 3 hour integration is 3-5×10^{-17} erg s^{-1} cm^{-2}
- To locate a candidate, a >3s detection in both spectra and narrow band is required
- 11 candidate DLA galaxies detected

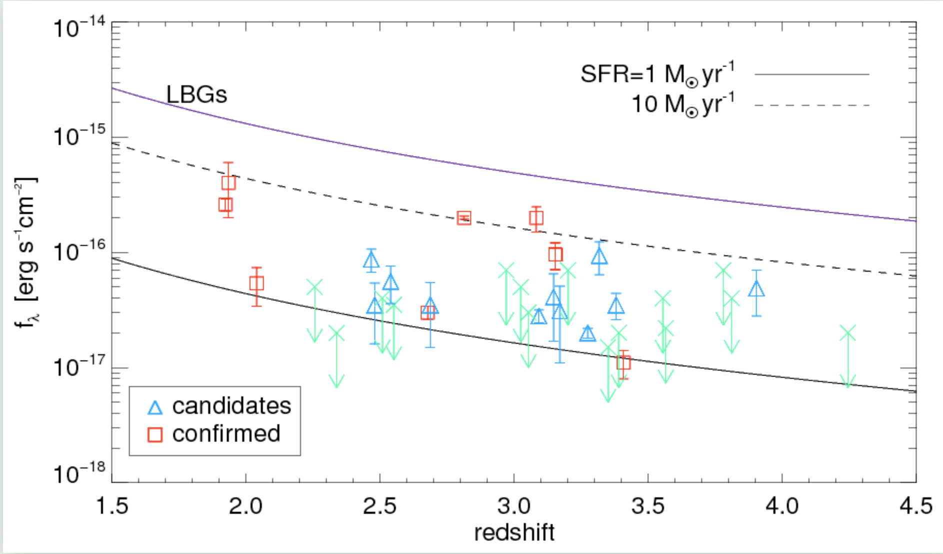
References:
Christensen et al. 2007, A&A, 468, 587
Christensen et al. 2004, AN, 325, 124
Moeller et al., 2002, ApJ, 457, 51
Ellison et al. 2007, MNRAS, 378, 801
Nagamine et al. 2007, ApJ, 660, 945
Wolfe et al. 2006, ApJ, 615, 625

Results:

Do DLAs belong to star forming galaxies?

- 11 good Lya candidates detected
- Line fluxes 2-8*10^{-17} erg s^{-1} cm^{-2}
- Corresponding SFRs: 1-10 M_O yr^{-1}
- Similar to known objects in the literature

Fig. 3 - Line flux of the emission line candidates as a function of their redshifts (blue triangles). The line fluxes and star formation rates appear similar to those from objects reported in the literature. Upper limits are indicated by the arrows.
The average SFR from Lyman break galaxies is also shown.



What is the typical size of a DLA galaxy?

- The spatial offset between the QSOs and the 9 candidates is 1-3”
- At the redshift of the DLAs: 7-25 kpc in projection
- Probe the size of the neutral gas disc around proto galaxies
- Numerical models predict sizes of 3-5 kpc - but larger gas discs can exist

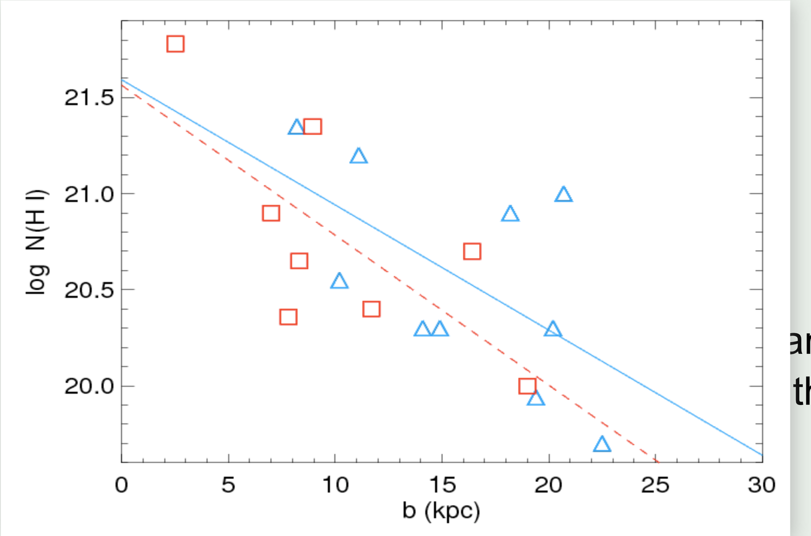


Fig. 4 - Distribution of DLA candidate galaxies (blue triangles) and objects know from the literature (red squares) . A fit of the DLA column density as a function of the projected impact parameter gives an exponential length of ~5 - 6 kpc.

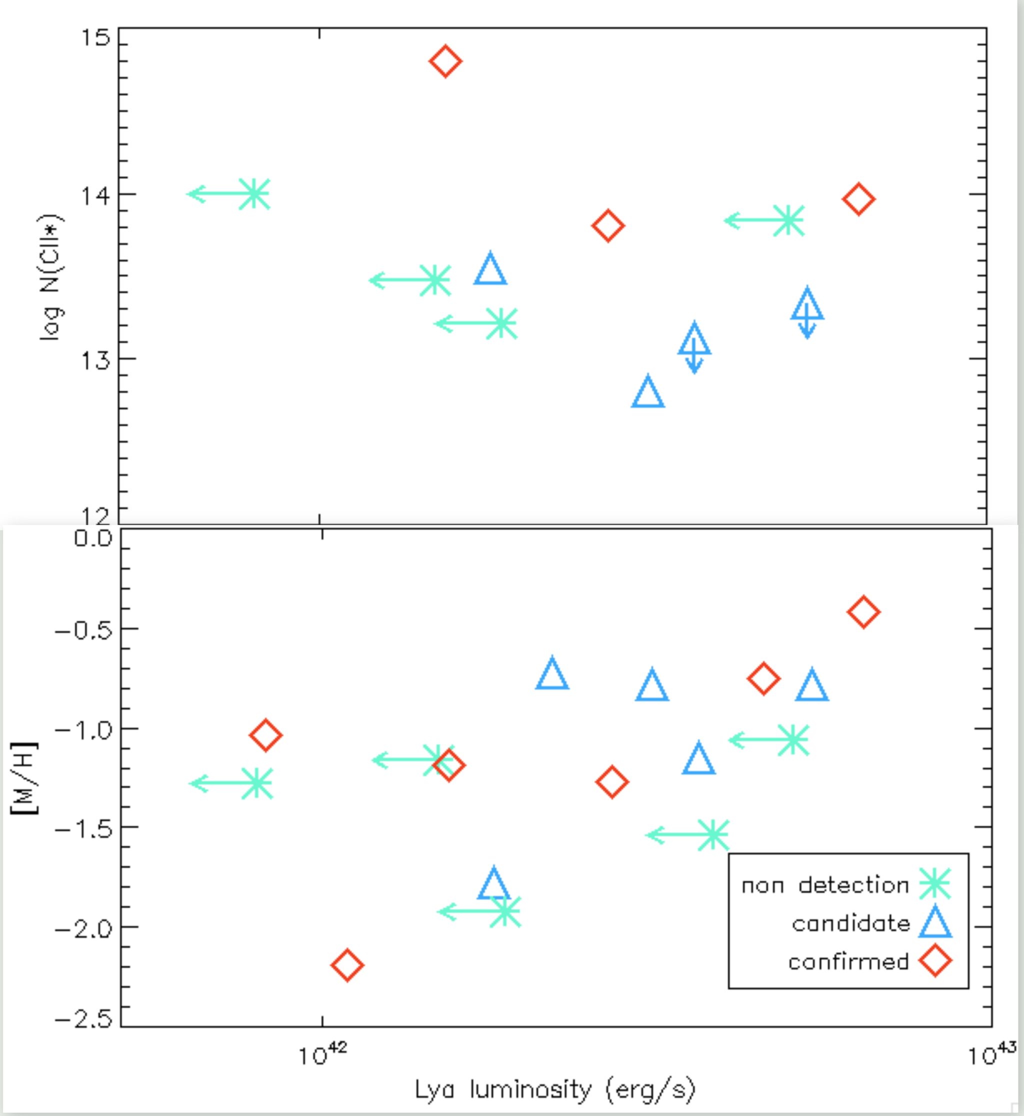
Which DLA galaxies are most likely to have Lya emission ?

Suggestions have been made that DLAs with high metallicities or large CII* l1335 column densities are most likely associated with bright star forming galaxies.

Fig. 5 – The upper panel shows the Lya luminosities vs N(CII*) for the candidates and confirmed object as well as those with limits. The lower panel shows the metallicities ([Si/H]) vs. the luminosities.

If the strongest CII absorbers or most metal rich systems only were Lya emitters, the objects with limits should be offset from the others. This is not the case.

Thus not all strong metal absorbers will be detectable in. Lya emission. A possible reason is extinction of the Lya photons by dust in the DLA cloud.



Conclusions

- We await more independent confirmation of the Lya candidates
- Candidate DLA galaxies have moderate to small SFRs (lower than Lyman break galaxies)
- Candidate DLA galaxies have similar luminosities as the known ones
- Large impact parameters -> neutral gas discs are extended or DLAs arise in galaxies associated with the Lya emitter
- High metallicity, or large CII* column density DLAs do not necessarily belong to galaxies that are detectable from Lya emission lines