QUIESCENT HALOS AROUND RADIO QUIET QUASARS

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We investigate whether extended Lyman-α haloes are ubiquitous around radio quiet quasars at redshifts 2.5<z<4.5. Such haloes are common for radio loud QSOs, where the extensions can be larger than 100 kpc. Recent results based on a small sample of objects have indicated that compared to lobe-dominated radio-loud QSOs, the Lyα haloes around radio quiet quasars are fainter by an order of magnitude, although the QSOs luminosities themselves are comparable. With integral field spectroscopy we can simultaneously study the morphology of the extended emission line regions around the QSOs and analyse the velocity structure.

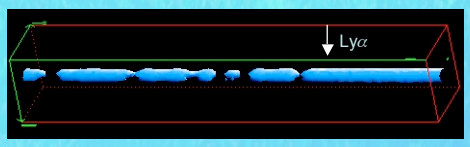
CONTEXT

The formation and evolution of galaxies is affected by gas outflows and inflows. Yet these quantities are poorly constrained by observations at high redshifts. Luminous QSOs reside in massive galaxies and the study of the gaseous haloes around QSOs may provide answers to the question of the origin of the gas. Much information has been gained from QSO absorption lines, yet the connection to galaxies remains unclear. Halo gas is easy to study in absorption, but restricting one to a one dimensional study. To get information about the halo structure and morphology the faint halos need to be studied in emission. The ionizing flux from a QSO enhances the flux detectable from the extended halos allowing us to probe processes of galaxy formation at high redshifts.

METHOD

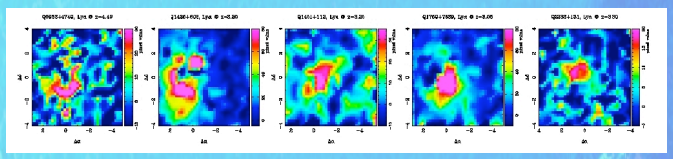
We use **integral field spectrographs** to obtain spectra in the QSO lines of sight. Since the spatial location of the extended emission is not known in advance IFU data have the advantage that no slit losses are present.

The QSO emission dominates in the data cube, and the extended halo emission is not directly visible in the cube view below:



THE DATA SET

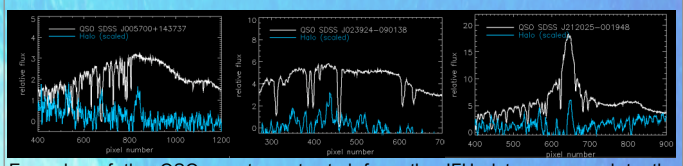
- At z>2 the Lyα emission line falls at optical wavelength
- 7 QSOs initially observed with the PMAS IFU on the 3.5 m telescope at Calar Alto: 5 QSOs were found to have extended emission (see post stamps below)
- 10 QSOs recently observed with the VIMOS IFU: **7 new detections** of extended emission
- PMAS observations of 6 additional QSOs to be analyzed



HALO EMISSION

In Christensen et al. (2006) we showed that the Lya emission from the halo is significantly narrower than the QSO broad emission lines. Following **properties** are found for the halos:

- Emission line velocity widths ~500 km/s
- Sizes of 20 - 40 kpc
- Halo Lya luminosities Log L ~ 43.5



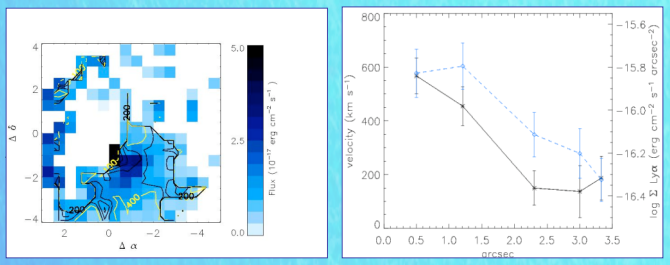
Examples of the QSO spectra extracted from the IFU data, compared to the extracted one-dimensional spectra of the halo spectrum after removing the QSO emission from the cube. The blue emission lines are much narrower than the QSO broad emission lines.

REFERENCES

Christensen et al. 2006, A&A, 459, 717
Courbin et al., 2008 (astro-ph/0803.2519)
Heckman et al. 1991, ApJ, 370, 78
Weidinger et al. 2005, A&A, 436, 825

MORPHOLOGIES AND KINEMATICS

IFU data allows us to simultaneously analyze the velocity structure of the nebulae

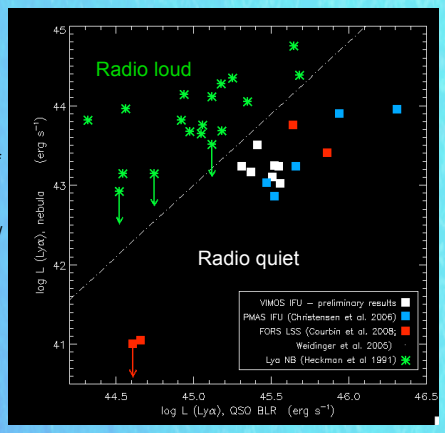


Left panel: Narrow band image extracted from the residual data cube. The Lyα emission halo has an extension of 30 kpc at the redshift of the QSO. **Right panel**: surface brightness and velocity profile for the halo.

LUMINOSITY CORRELATIONS?

We compare the halo luminosities to the luminosity in the quasar broad emission lines. For a given QSO broad line region (BLR) luminosity, radio loud quasars have more luminous haloes than does the radio quiet counterparts. This is confirmed by the new VIMOS data, and by data obtained with long slit spectra as found in the literature.

This tendency could be caused by **small number** of objects investigated, or the **different techniques** used (IFU/ long slit spectroscopy / narrow band Imaging) to derive the luminosities for the two samples.



CONCLUSIONS

- We find extended halos with Lya emission around most radio quiet quasars. The emission lines are narrow and the haloes are quiescent.
- Large extensions (~100 kpc) can be found depending on the depth of the observations. To the limit of the IFU observations (2×10^{-17} erg/cm^2/s/arcsec^2) the typical extension is 30 kpc.
- Line widths, halo extensions and luminosities are systematically smaller for radio quiet QSOs relative to the radio loud counterparts. A correlation between the QSO luminosities and the nebula luminosities is found.
- Future work to be done: check for redshift evolution, investigate halo mass correlations, search for associated metal lines.
- QSOs were pre-selected to have similar broad band luminosities and redshifts. To check the presence of a correlation, fainter QSOs and radio loud quasars need to be observed with IFUs.