# Emission in the Damped Lyman $\alpha$ Trough of Q2059-360

Gordon Robertson[1,2], Bruno Leibundgut[2]

[1] *School of Physics, University of Sydney, NSW 2006, Australia*
[2] *European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85478 Garching, Germany*

**Abstract.** We confirm the detection of emission within the Damped Lyman Alpha (DLA) absorption line of Q2059-360. The emission line has a velocity offset of 490 km s$^{-1}$ with respect to the DLA absorption system, making it unlikely that both absorption and emission arise in a single galaxy. The emission feature itself is resolved in velocity, probably consisting of two components separated by $\sim$ 300 km s$^{-1}$. It is also spatially extended and we trace it to at least $2''$ (corresponding to 15 $h_{50}^{-1}$ kpc) from the QSO line of sight. It may arise from a galaxy grouped with the DLA absorber, or could be due to Narrow Line Region emission filaments of the QSO itself.

## 1 Introduction

The systems causing Damped Lyman Alpha (DLA) absorption troughs in quasar spectra are of interest because they may represent the precursors of today's disc galaxies [8], and they have been selected by passive absorption rather than by the presence of an active nucleus.

At low to medium redshifts, where Lyman $\alpha$ is in the UV, a variety of galaxy types have been shown to be responsible for the observed DLAs [5]. For higher redshifts, with Lyman $\alpha$ visible from the ground, many attempts have been made to detect Lyman $\alpha$ emission from DLA systems. Such observations are aided by the broad damped absorption which blanks out the (brighter) quasar over the relevant wavelength range. But only a small number of detections have been reported: Q0836+113 [4]; PKS 0528-250 [11]; Q2233+131 [2]; Q2059-360 [7] and Q0151+048A [3]. The low Lyman $\alpha$ fluxes may be the result of absorption by dust, in combination with resonant scattering of Lyman $\alpha$ line photons (*eg* [1]).

## 2 The emission feature in the DLA of Q2059-360

We have observed the quasar Q2059-360, using the 3.5 m ESO New Technology Telescope. Figure 1 shows the result of 5 hours exposure with the slit on or close to the quasar. The DLA trough redshift ($z_{\rm abs} = 3.0825$) is very close to that of the QSO's broad Lyman $\alpha$ emission line ($z_{\rm em} = 3.0954$). Hence the DLA removes much of the emission line flux, and the QSO line+continuum

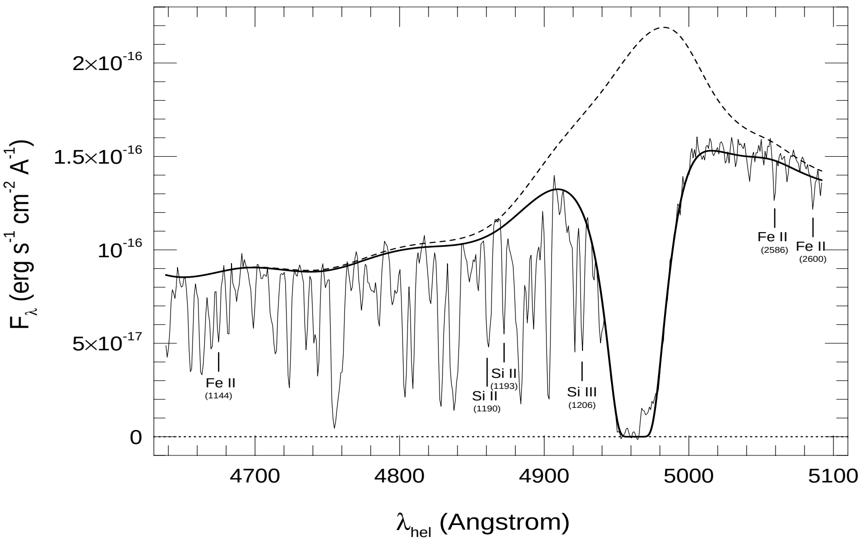


Figure 1: Spectrum of Q2059-360 recorded with the EMMI spectrograph on 29-31 August 1995. The spectral resolution is 1.5 Å, and the slit was oriented East-West for all exposures. The metal lines indicated are in the same redshift system as the DLA, except for the probable Fe II 2586,2600 lines in a low redshift intervening system.

spectrum that we show in Figure 1 (as the dashed line) is a reconstruction from a simultaneous fit to the DLA profile and a smooth incident spectrum [6]. Figure 1 also shows (as the heavy line) our fit of a Voigt profile to the DLA trough, with log N(H I) $= 20.85 \pm 0.03$. The observed spectrum shows clear excess emission at the red edge of the DLA trough, confirming the earlier detection [7].

Reasoning that the object causing the DLA system is likely to have an angular size of one to a few arcseconds if it is indeed of galactic dimensions, and that any putative emission need not peak at the exact position of the background quasar, we also observed with slit positions displaced from the quasar (a further $7 \times 1^{\rm hr}$ exposures). With the long-slit spectrograph, this provided a rudimentary two-dimensional spatial coverage with spectral resolution adequate to clearly resolve any faint emission feature from the quasar's spectrum. The results showed that the emission feature near 4970 Å is spatially extended, with detection continuing to our greatest slit displacement of $2.3''$ south (where none of the quasar's seeing disc remains on the slit). The observed extension establishes that the feature seen at the red edge of the DLA trough is indeed due to emission independent of the quasar nucleus, and cannot be caused by an unusual distribution of absorption. The line flux values that we find are $0.6 - 0.9 \times 10^{-16}$erg s$^{-1}$cm$^{-2}$, and the angular extent of at least $2''$ indicates a physical size of $> 15$ kpc ($H_0 = 50$ km s$^{-1}$ Mpc$^{-1}$, $\Omega = 1$).

With the good fit of a Voigt profile model DLA to the data as shown in

Figure 1, we have been able to subtract the quasar's light (suitably scaled) from all runs, including those on or near the quasar itself, to leave only the faint DLA emission feature. We find it to be resolved spectrally as well, with a suggestion of two components separated by $\sim 300$ km s$^{-1}$.

## 3 Relationships between the DLA absorber, emitter, and the QSO

Owing to the similarity of the redshifts of the DLA and the quasar itself, the interpretation of the physical system is more complex than for intervening absorbers well away from their background quasar. In Figure 2(a) we indicate schematically where the various emissions and absorptions occur on a radial velocity scale. The velocity origin has been taken as the QSO's Lyman $\alpha$ emission line (reconstructed as shown in Figure 1), with $\lambda_{\rm eff}^{\rm rest} = 1214.97$ Å [9]. There are several points to note:

(i) A probable velocity difference of 40 km s$^{-1}$ between the DLA hydrogen absorption and the metal lines in the same system;

(ii) The emission features cannot be located behind the DLA absorber, so peculiar velocities may be invoked to account for the relative velocities as shown (another alternative is discussed below);

(iii) The broad Lyman $\alpha$ and C IV emission lines of quasars are inaccurate indicators of the true systemic redshift of the quasar host galaxy, being subject to both a mean bias and large scatter [9]. If the QSO redshift is instead estimated from the broad C IV line (in the spectrum from [10], and using $\lambda_{\rm eff}^{\rm rest} = 1547.46$ Å [9]) the QSO's 'zero' velocity actually falls within emission component 2. Thus the observed redshifts allow interpretation of the emission feature(s) as emission line filaments of the quasar itself.

(iv) The mean velocity offset of the emission features with respect to the DLA absorption is $+490$ km s$^{-1}$.

In Figure 2(b) we show two possible spatial configurations of the absorber, emitter, and QSO. In both cases the minimum distance between the QSO and the DLA absorber is substantial. This limit arises from the requirement that the radiation flux from the QSO incident on the DLA cloud be low enough to avoid complete ionisation of the cloud in a time short compared with the age of the universe at $z = 3$ [6].

In the upper model of Figure 2(b), the emission features are shown as separate objects from the DLA absorber, owing to the large velocity offset (as suggested in [7]). The absorber and emitter may be members of the same group or cluster. The lower model accounts for the near equality of redshifts of the quasar and the emission feature. In this case, the emission is interpreted as coming from Narrow Line Region emission filaments surrounding the QSO itself or close companions to the QSO. This implies that the DLA cloud absorbs only over a small angular size, allowing part of the spatially extended or displaced emission region to be seen within the seeing disc of the quasar. The

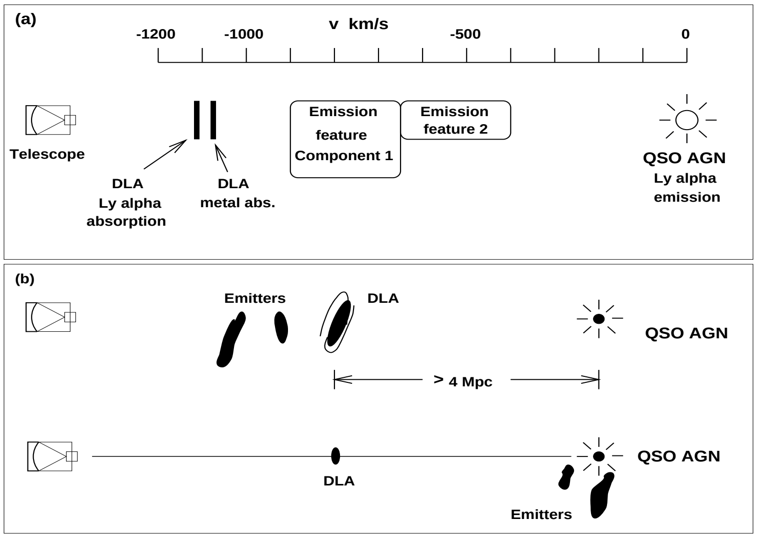


Figure 2: (a) Placement of the emission and absorption features on a radial velocity scale. (b) Two possible spatial configurations for the Q2059-360 system (not to scale).

DLA is thus acting as an occulting disc, allowing us to see any surrounding faint objects which emit in the appropriate band of wavelengths.

Further observations will include: (i) Low-dispersion spectra of the emission features, to search for other lines (especially C IV) and the continuum; (ii) an accurate systemic redshift of the quasar, *eg* from H$\alpha$ at $2.7\mu$; (iii) a more complete study of the metal lines in the DLA absorption system.

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