The Complex Line of Sight Towards Q2059−360[1]

B. Leibundgut

European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching, Germany

J. Gordon Robertson

School of Physics, University of Sydney, NSW 2006, Australia

Abstract. Emission in a damped Lyman α system towards Q2059−360 has been confirmed. Three objects with similar redshift have to be considered along the line of sight: the absorption system, a spatially extended emission, and the quasar itself. The velocity separation between the DLA and the quasar is about 500 km s^{-1}, and is similar to the velocity offset between the DLA and the emission. The emission itself is traced to about $2''$ away from the quasar, which corresponds to 15 kpc (H_0 = 50 km s^{-1} Mpc^{-1}, $\Omega = 1$). The emission line profile changes with distance from the quasar sight line, although an interpretation as a rotation curve is unlikely. If placed in front of the damped system, the emission site moves with a considerable peculiar velocity, possibly indicating a group or cluster of galaxies. Another possibility is that the size of the absorber is very small and we are observing narrow-line emission regions near the quasar.

1. Introduction

Spatial information about objects responsible for the damped absorptions in quasar spectra is rare and has only recently been forthcoming. These observations should further elucidate the nature of these objects. Galactic disks are inferred from the high column densities and disk dynamics as derived from the profiles of unsaturated lines (Prochaska & Wolfe 1996) or spatially offset emission (Djorgovski et al. 1996, Lu, Sargent, & Barlow 1997). Alternatively, the damped lines could be caused by small, dense clumps falling together to form the large, present-day galaxies (Haehnelt et al. 1997). Emission from damped Lyman α absorbers (DLAs) has been detected in very few cases (Hunstead et al. 1990, Møller & Warren 1993, Pettini et al. 1995, Djorgovski et al. 1996, Møller, Warren, & Fynbo 1998, Leibundgut & Robertson 1998).

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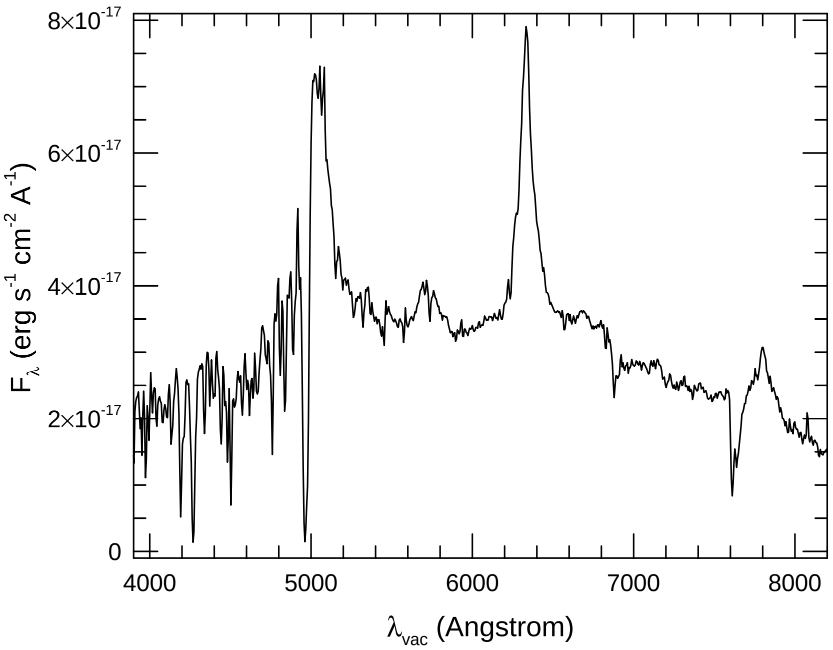

Figure 1. Low-resolution spectrum of Q2059−360 obtained by us with EMMI at the NTT in July 1997. The wavelengths are given for vacuum. The correction to heliocentric wavelengths is negligible.

2. Relationship of Quasar, Absorber, and Narrow Emission

The line of sight towards Q2059−360 contains a DLA at $z = 3.08303 \pm 0.00007$ as determined from metal lines (Fig. 1; Pettini et al. 1995, Leibundgut & Robertson 1998, Robertson & Leibundgut 1998). The quasar redshift measured from the CIV and the CIII] lines is $z_{QSO} = 3.092 \pm 0.002$, in excellent agreement with the redshift reported by Warren et al. (1991) and the reconstruction of the Lyα emission line (Leibundgut & Robertson 1998). Emission from SiIV+OIV is detected as well, but we cannot derive a redshift due to blending with a night sky line. The CIV and the Lyα/NV emission lines have similar equivalent widths which indicates that the DLA is absorbing a major fraction of the quasar Lyα emission line.

Lyβ absorption from the DLA is detected at 4192 Å. The low resolution is not enough to show any structure in this line. Lyγ, although in the spectral range, is not detected. We find another deep absorption at $\lambda = 4269$ Å, possibly another damped system at $z = 2.51$.

From our previous intermediate-dispersion spectroscopy we derive a column density of the absorber of $\log(N) = 20.85 \pm 0.03$ (Leibundgut & Robertson 1998). This value is slightly higher than found previously (Pettini et al. 1995), but we have accounted for the partial obliteration of the quasar emission line. There is an offset of 40 km s^{-1} between the Lyα absorption and the metal lines.

Our earlier observations show that the DLA is flanked on the red side by a narrow emission, which has been detected out to at least $2''$ away from the

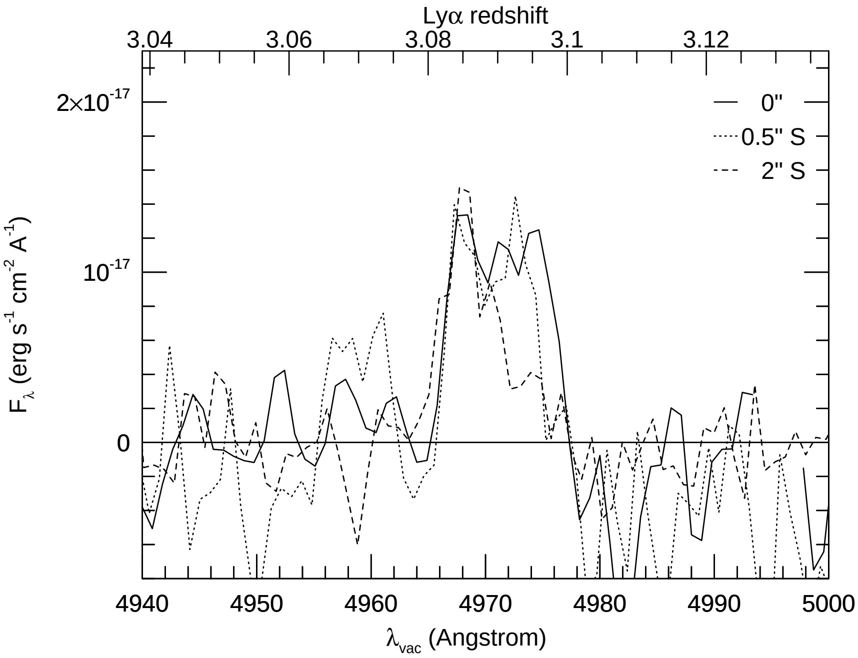

Figure 2. Emission line coincident with the DLA towards Q2059−360 for three different spatial positions. Scaled spectra of the quasar have been subtracted to isolate the emission.

quasar sight line (Fig. 2). It appears to be separated into two emission sites separated by about 300 km s^{-1}. The line profile changes with positional offset. One emission component maintains its strength at all offsets, while the other weakens away from the quasar sight line.

3. Discussion

The DLA cannot be located within the host galaxy of the quasar. The velocity offset is more than 500 km s^{-1}, which is a lower limit as high-ionization lines tend to be blueshifted in quasars (Tytler & Fan 1991, Møller et al. 1998). This is a substantial velocity for any galaxy size object. The DLA contains no high-ionization absorption lines, like Nv, and the metallicity is not enhanced. The most intriguing argument is that the DLA would have been completely ionized, if positioned within the host galaxy of the quasar. The DLA is hence not associated with the quasar and more like other intervening damped absorbers. This result is similar to two other DLAs observed near the quasar redshift (Møller et al. 1998).

The Lyα photons observed in the emitter could still come from clouds associated with the quasar and scatter near the rim of the DLA (Warren & Møller 1996, Charlot & Fall 1991). The extent of the emission of at least 15 kpc ($H_0 = 50$ km s^{-1}, $\Omega = 1$) makes this proposition rather unlikely. Another possibility is that the Lyα photons are coming from narrow-line regions associated with the quasar and the DLA acts as a coronograph eclipsing the quasar in Lyα. The photons would then be scattered into the absorption by the seeing disk.

This requires a small size for the DLA (cf. Fig. 6 in Leibundgut & Robertson 1998) and possibly an agglomeration of small, dense clouds. The line profiles of the emitter (Fig. 2) suggest such an interpretation with two emission components and strengths dependent on the offset. There is no detectable velocity shift in the lines but the redder component decreases in strength by a factor of about 3 from the quasar sight line to $2''$ to the South.

The large velocity offset between the DLA and the emitter suggests that absorber and emitter are not located in the same galaxy. Since the emission is shifted to the red, but the emission site has to be in front of the DLA, this implies a substantial peculiar velocity.

Infalling gas with velocities of the order of 100 to 300 km s^{-1} has been proposed for observed line shifts in nearby star-forming and high-redshift galaxies (Lequeux et al. 1995, Heckman & Leitherer 1997, Franx et al. 1997). The velocity difference we measure for the absorber-emitter system is larger.

4. Conclusions

We have found a galaxy-size object near a DLA absorbing system towards Q2059−360. The DLA is not associated with the quasar or its host galaxy, and is comparable to other intervening DLA systems. The velocity offsets between quasar, absorber, and emitter are substantial and exclude that they all are embedded within a single galaxy. They are similar to velocity dispersions observed in groups. The emitter redshift nearly coincides with the quasar redshift which may indicate a connection of these two emission sites. If so, this implies a small spatial extent for the absorber.

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