A Spectroscopic Study of UM673 A & B: on the Size of Lyman-α Clouds

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UM 673 is a gravitationally lensed quasar at a redshift of 2.727 (Surdej *et al.*, 1987, Nature 329, 695). The two images have V magnitudes of 17.0 and 19.1, and are separated by 2″.2 on the sky. The redshift of the lensing galaxy is 0.493. The images are bright enough for absorption line spectroscopy, and the quasar redshift is high enough for the Lyα forest to be accessible. This is therefore an ideal case for studying the size and structure of Lyα clouds by cross-correlating the absorption spectra in the two images.

Several spectroscopic observations of these images were made in 1987–1988, using the MMT, the CTIO 4-m, and the ESO 3.6-m telescopes, with spectral resolutions ranging from 0.3 to 2 Å (FWHM). Great care was taken to ensure that the fainter image was not contaminated by light from the brighter image. Additional confirmation of these results has been obtained recently by S. D'Odorico *et al.* (private communication) using the long-slit mode of EMMI on the NTT at La Silla. Sample spectra of the two images are shown in fig. 1.

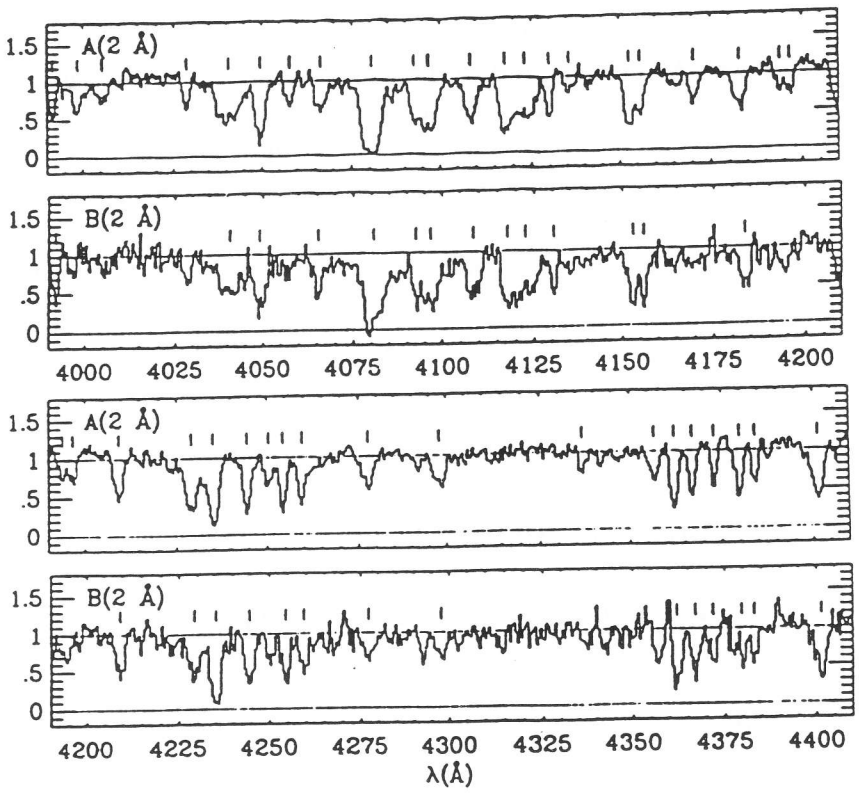

Figure 1. – Sample spectra of UM 673 A & B at 2 Å resolution obtained with the MMT.

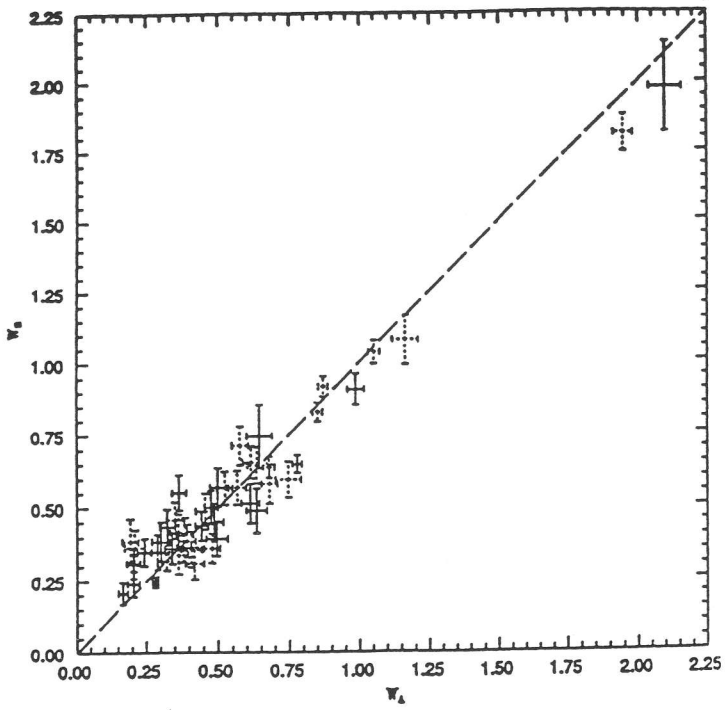

Figure 2. – Correlation between the rest equivalent widths of corresponding lines in the 2 Å resolution spectra of UM 673 A & B, for the 21 single and 26 blended Lyα lines (solid and dashed crosses respectively).

The results of our analysis of these data can be summarized as follows:

1. Almost all absorption lines are common to both spectra. All 68 lines present at 5σ in B are present in A; there are only two anti-coincidences (present in A, not in B at 3σ), and these could be a Mg II doublet.
2. The velocity differences between corresponding lines in the two spectra are consistent with zero ($\sigma = 17$ km s^{-1}).
3. The equivalent widths are strongly correlated in the two spectra (fig. 2), essentially proving that the two lines of sight intersect the same clouds.
4. The cloud diameters are in the range $12 < d < 160\ h_{50}^{-1}$ kpc (2σ limits),
   or, if the anti-coincidences are Mg II, $d > 23\ h_{50}^{-1}$ kpc,
   or, if the clouds are isothermal spheres, $d > 50\ h_{50}^{-1}$ kpc.
5. There is no correlation between velocity difference and equivalent width, hence no evidence for ordered mass motions.
6. The cloud "roughness" is less than 0.04 (σ/mean) on scales from 3 to 2000 h_{50}^{-1} pc. Any velocity gradients must also be very small.

Some heavy element absorption systems are also present, and again there is a strong correlation in the equivalent widths of corresponding lines from different ions in the same system. This indicates that there are no strong variations, either in density or ionization, over 1–2 h_{50}^{-1} kpc in these systems. If the two anti-coincidences in the Lyα forest are Mg II, then the distribution of Mg II varies over scales of 16 h_{50}^{-1} kpc.

A more complete account of this work has been submitted for publication in The Astrophysical Journal.