HIGH RESOLUTION SPECTROSCOPY OF ABSORPTION LINES IN THE Z = 1.7 BL LAC OBJECT 0215+015 *

J. Chris Blades
Space Telescope Science Institute

Richard W. Hunstead and Hugh S. Murdoch
School of Physics, University of Sydney

Max Pettini
Royal Greenwich Observatory

We describe the various absorption systems in 0215+015, and present results from our new, high-resolution studies at 10 km/sec (FWHM).

1. THE ABSORPTION SYSTEMS IN 0215+015

The radio source 0215+015 was shown by Gaskell (1982) to be a highly variable BL Lac object with absorption systems at $z = 1.345$, 1.549, and 1.649. Subsequent work has found 7 separate absorption systems in the optical spectrum of the object as well as a weak Lyman α forest (Blades *et al.* 1985).

The system at $z = 1.345$ exhibits a strong, mixed-ionization spectrum and is one of the richest found in any QSO—hence it is of considerable interest. We have detected 5 neutral species, H, C, N, O and Mg; 8 singly ionized species, C, Mg, Al, Si, Ca, Mn, Fe and Zn; as well as the higher ionization species, Al III, Si III, C IV and Si IV. This is the first time that Zn II has been found in any QSO absorption system. The ion column densities allows us to deduce depletions of factors between 10 and 4 relative to solar values for Mg, Al, Si and Fe, similar to the gas phase abundances of these elements in local, low-density, interstellar clouds. The Zn strength implies it has solar abundance (Pettini, 1985). In Blades *et al.* (1985) we attributed this absorption system to an intervening galaxy, with the sight line intercepting both halo and disc material. Indeed, judging by the strength and complexity of the lines, the intercept probably passes through the inner region of the intervening system.

The other six absorption systems in 0215+015 are of higher ionization, with species, C III, C IV, and S IV dominating (Blades *et al.* 1985; Bergeron & d'Odorico, 1985). When observed at high resolution, the $z = 1.549$ and 1.649 systems reveal highly complex C IV absorption, the latter showing at least nine distinct components over a velocity range of 910 km/sec. The origin of such complex absorption is not at all clear. In Pettini *et al.* (1983) we postulated two, rich clusters of galaxies at redshifts of 1.549 and 1.649, with the complex absorption occurring in overlapping halos and extended disks of individual galaxies in the sight line to 0215+015.

* Discussion on p.577

G. Swarup and V. K. Kapahi (eds.), Quasars, 571–572.

2. THE IMPORTANCE OF HIGH RESOLUTION OBSERVATIONS

In order to disentangle the complex absorption in 0215+015 we have found it necessary to use the highest possible spectroscopic resolution. Such observations yield detailed information on the overall velocity structure and give well-determined values for N and *b*. For this purpose we have been studying selected absorption lines in 0215+015 at 10 km/sec resolution, and we describe here our first results.

The adjacent figure compares the Fe II lines at 10 km/sec resolution (lower profiles) with an earlier observation of the λ2600 line at ~ 25 km/sec resolution. Even at the higher resolution we have not satisfactorily resolved the overall complex.

Nevertheless, our detailed model fit to the Fe II pair shows that there are at least 12 different velocity components over the 250 km/sec range, with individual values of the column density $N \sim 1 - 2 \times 10^{13}$ cm^{-2} and *b* values in the range 4 – 6 km/sec.

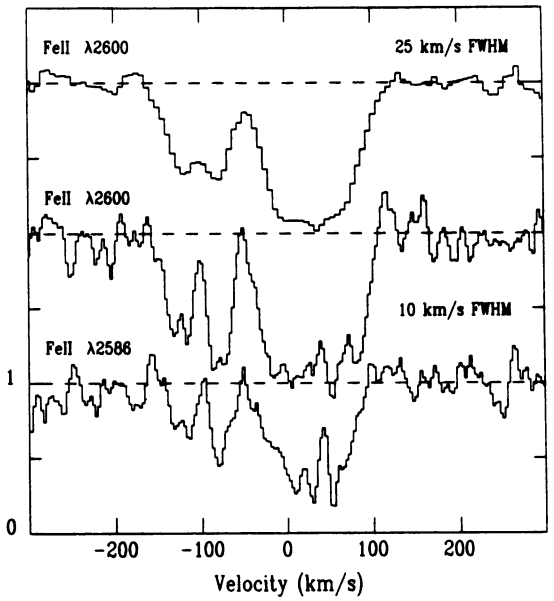

Figure 1. Fe II at $z = 1.345$.

For the case of the $z = 1.549$ C IV system, our new data show that some of the components that make up this redshift complex are exceedingly narrow, with *b*-values around ~ 5 km/sec, indicating that the lines must originate in gas with $T \sim 10^4$ K. This implies that photoionization is the principal mechanism for production of C IV, and is consistent with models of our own galactic halo that propose photoionization as the major means of producing highly-ionized species (see York 1982; Hartquist, Pettini & Tallant 1983).

REFERENCES

Bergeron, J. and d'Odorico, S., 1985, preprint.
Blades, J. C., Hunstead, R. W., Murdoch, H. S. and Pettini, M., 1985, *Ap. J.*, **288**, 580.
Gaskell, C. M., 1982, *Ap. J.*, **252**, 447.
Hartquist, T., Pettini, M. and Tallant, A., 1984, *Ap. J.*, **276**, 519.
Pettini, M., 1985, ESO Workshop on Production and Distribution of C, N, O Elements, Munich.
Pettini, M., Hunstead, R. W., Murdoch, H. S. and Blades, J. C., 1983, *Ap. J.*, **273**, 436.
York, D. G., 1982, *Ann. Rev. Ast. Astrophys.*, **20**, 221.