# FAR-UV SPECTRAL VARIABILITY IN UM425 & PG1115+080

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Determining the nature of spectral variability in gravitationally-lensed *BAL* (broad absorption line) quasars is important for time-delay and microlensing studies because the delay-times can be comparable with the time scales of intrinsic QSO ionization changes. Far-UV spectra of the candidate lens UM 425 = Q1120+019A and PG1115+080A (*Triple Quasar*) revealed the presence of strong O VI $\lambda$1033 emission. In both cases, absorption in the blue-wing of the O VI line profile indicated characteristic *BAL* outflow.

*IUE* spectra of UM 425 (Image-A, $m_v$ = 16.2) revealed complex line profile structure; in particular, the high-ionization emission lines of O VI $\lambda$1033 and N V $\lambda$1240 exhibit a broad ≈12,000 km/s *BAL* trough structure (Michalitsianos & Oliversen 1995). The Ly-$\alpha$ $\lambda$1216 emission centroid corresponds to a $z_{qso}$ = 1.471±0.003, which is slightly greater than the $z_{qso\ Mg\ II}$ = 1.467 redshift obtained by Meylan and Djorgovski (1989).

A comparison of our initial *IUE* spectra with data obtained ≈10 months later indicates significant changes occurred in both the *BEL* (broad emission line) and *BAL* regions, for example, the O VI emission component increased by a factor ≈2. Enhanced *BEL* ionization is also seen in S VI(1) $\lambda\lambda$937,945, C III(1) $\lambda$977, N III(1) $\lambda$990 and S IV(1) $\lambda\lambda$1063,1073. The Ly-$\alpha$ $\lambda$1216 flux increased by only a factor ≈1.3, where the small increase in Ly-$\alpha$ may be entirely due to a decrease in the N V *BAL* absorption at velocities $v_{BAL}$ >4000 km/s. Increased absorption at velocities $v_{BAL}$ <4000 km/s suggests new material may have been injected into the *BAL* flow, in a region where the acceleration is initiated. We find the greatest change in emission line intensity occurs in high-ionization lines, whereas Ly-$\alpha$ was unchanged. This suggests high-ionization emission lines and lower ionization species, including recombination lines, vary *independently*, similar to results obtained by Dolan et al. (1995) for Q0957+561. The time scale for O VI variations suggests an upper limit for the size of the *BEL* region of ≈0.1 pc (correcting for the 1+z time dilation), consistent with the size of



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the regions in QSOs in general. However, changes in O VI *BAL* trough absorption occurred on the same time scale, and the same dimensional upper limit thus applies to the *BAL* region. This argues the *BAL* region is comparable in size, perhaps slightly larger, say ≈1 pc, than the *BEL* region.

The detection of *BAL* spectral line structure in UM 425A is important because if similar distinct spectral features are found in UM 425B, the low statistical count of *BAL* QSOs and the low probability of finding another *BAL* QSO with the same redshift located ≈6″ from UM 425A would unambiguously show the system is lensed.

*IUE* spectra of PG1115+080A ($m_v$ = 15.8) revealed prominent O VI emission that is superimposed on strong continuum between $\lambda\lambda$900–1100Å ($z_{qso}$ = 1.722 rest frame). A comparison of these data with the only other *IUE* spectra of PG1115+080A taken in this wavelength range indicates O VI emission was not present in 1978; the spectrum showed only a featureless continuum (Green et al. 1980). The detection of O VI resonance line emission suggests a high state of ionization in the *BEL* region, which is emission is accompanied by absorption in the line core, and *BAL* absorption that truncates the blue-wing of the line profile.

After our initial detection, both the O VI emission and *BAL* absorption decreased in flux by ≈50% (relative to the local continuum) over ≈100 days. Absorption features within the O VI *BAL* trough also changed on time scales of months down to ≈1 day. Evidence for rapid time scale O VI absorption variability of ≈1 day implies an unreasonably small size of the *BAL* region, considering only the light-travel time for photo-ionization by the continuum source. However, there is growing evidence for rapid variations in the cores of related objects, such as *Active Galactic Nuclei (AGN)*. For example, *ASCA* X-ray spectra of the Seyfert 1 galaxy NGC 3227 by Ptak et al. (1994) indicate rapid changes in the O VI, O VII and O VIII metal absorption edges at 671, 739 and 879 eV, respectively, that occur on time scales of ≈10,000 seconds. It is possible that the ≈1 day O VI absorption variations in PG1115+080A are from the same type of process which leads to rapid changes in AGNs. This follows because both the O VI metal absorption-edge and O VI $\lambda$1033 resonance line are formed in the same gas. Further monitoring of PG1115+080 is required to confirm this result.

## References

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