Excerpt from COS / PG quasars paper on UV doublet analysis:

We characterize the doublet absorption features (N V $\lambda\lambda$1238, 1243; O VI $\lambda\lambda$1028, 1032; and P V $\lambda\lambda$1119, 1128) in the quasar spectra using model fits. Our goal is to measure the kinematics of the outflowing gas associated with these features (mass, momentum, and energy estimates are beyond the scope of the present paper, except for a few special cases discussed in Section X. If the lines within these doublets were unblended, fits to the intensity profiles of the individual lines would thus be sufficient. However, the doublet lines are often strongly blended because of (1) strong blueshifts due to high outflow velocities and (2) broad line profiles due to multiple clouds along the line of sight and/or large linewidths. We thus adopt the doublet fitting procedure of Rupke et al. (2005), which is optimized for blended doublets. In this method, the total absorption profiles of a feature are fit as the product of multiple doublet components. Each component is a Gaussian in optical depth τ vs. wavelength with a constant covering factor C_f. Within each doublet the two lines have a constant τ ratio. This allows us to simultaneously fit τ and C_f, which are otherwise degenerate in the fit of a single line. The free parameters in the fit to each doublet component are thus C_f, peak τ, velocity width, and central wavelength.

The general expression for the normalized intensity of a doublet component is

$$I(\lambda) = 1 - C_f + C_f e^{-\tau_{\rm low}(\lambda) - \tau_{\rm high}(\lambda)}, \tag{1}$$

where C_f is the line-of-sight covering factor (or the fraction of the background source producing the continuum that is covered by the absorbing gas; though scattering into the line of sight can also play a role) and $\tau_{\rm low}$ and $\tau_{\rm high}$ are the optical depths of the lower- and higher-wavelength lines in the doublet (Rupke et al. 2005). The covering factor is the same for both lines of the doublet. The peak (and total) optical depths of the resonant doublet lines in O VI, N V, and P V are related by a constant factor $\tau_{low}/\tau_{high} = 2.00$ because of the 4-fold degeneracy in the upper state of the higher energy transition compared to the 2-fold degeneracy in the lower state. (The higher degeneracy is due in turn to its higher total angular momentum quantum number j). For more than one doublet component, we use the product of the intensities of the individual components, which is the partially-overlapping case of Rupke et al. (2005).

Because the doublet profile shape–i.e., relative depths of the two lines and trough shape–does not change significantly above optical depths τ_{high} of a few, we set a limit of $\tau_{high} \leq 5$. Out of 59 O VI components, 19 have $\tau_{high} = 5$, or 32%. For N V, 13 of 62 components have $\tau_{high} = 5$, or 21%.

The results from these fits are also used to calculate the total velocity-integrated equivalent widths of the absorbers in the object's rest frame,

$$W_{\rm eq} = \int [1 - f(v)] dv, \tag{2}$$

the weighted average outflow velocity,

$$v_{\rm wtavg} = \frac{\int v[1 - f(v)] dv}{W_{\rm eq}}, \tag{3}$$

and the weighted outflow velocity dispersion,

$$\sigma_{\rm wtavg} = \left(\frac{\int (v - v_{\rm wtavg})^2 [1 - f(v)] dv}{W_{\rm eq}} \right)^{\frac{1}{2}}, \tag{4}$$

a measure of the second moment in velocity space of the absorbers in each quasar. These quantities are similar to those defined by Trump et al. (2006), but without the constraints on depth, width, or velocity. These constraints have little effect on the results for our sample, but we find it useful to include possibly inflowing absorbers.

The optical depths and covering factors derived from our fitting scheme are approximations. Though it is a physically-motivated way to decompose strongly-blended doublets, the method implicitly assumes that the velocity dependences of C_f and τ can be described as the sum of discrete independent Gaussians. In reality, they are probably more complex functions of velocity (e.g., Arav et al. 2005, 2008). In several cases–the N V absorbers in PG 1001+054, PG 1411+442, PG 1617+175, and PG2214+139, and the O VI absorbers in PG 1001+054, PG 1004+130)–the fits include very broad components that cannot be distinguished from complexes of narrower lines given the data quality. In two O VI absorbers (PG 0923+201 and PG 1309+355), there is no data on the blue line because it is contaminated by geocoronal Lyα, so any constraints on τ and C_f come solely from line shape. Finally, in four O VI fits (PG 1001+054, PG 1004+130, PG 1126−041, and PG 1617+175, the Lyβ and O VI absorption blend together and cannot be easily separated in the fit. In three of these cases (all but PG 1001+054), we simply fit the visible absorption as due solely to O VI at wavelengths in which there is at least some O VI absorption contributing to the spectrum. For the fourth case, we are able to roughly separate the lines by fitting only down to a specific wavelength.