

Variability in Quasar Broad Absorption Line Outflows

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Keywords. galaxies: active, quasars: general, quasars: absorption lines

Broad absorption lines (BALs) in quasar spectra identify high-velocity outflows that likely exist in all quasars and could play a major role in feedback to galaxy evolution (e.g., Di Matteo *et al.* 2005). Studying the variability in these BALs can help us understand the structure, evolution, and basic physical properties of these outflows. We are investigating BAL variability in a sample of 25 luminous quasars at $1.2 < z < 2.9$ with multi-epoch observations that cover time scales from less than around a month to 7.7 years in the quasar rest-frame. We investigate changes in the C IV $\lambda 1549$ BALs, and we see a variety of phenomena, including some BALs that either appeared or disappeared completely and other BALs that did not change at all over the whole observation period. Our first results are for two subsamples of observations, one where the time baseline is 4 to 9 months (short-term) and the other where the time baseline is ~ 4 to 6 years (long-term). We find that 65% of the quasars varied in the long-term data, while 44% varied in the short-term data. Typically, only portions of the BAL troughs vary. We find that BALs at higher outflow velocities are more likely to vary than those at lower velocities and that weaker BALs are more likely to vary than stronger BALs. We also find that the fractional change in BAL strength correlates with the strength of the BAL feature, but not with the outflow velocity. These results are currently being prepared for publication (Capellupo *et al.*, in preparation).

We also have some preliminary results from our study of the entire dataset. We plot the fraction of quasars with C IV BAL variability versus the time interval between observations. This fraction decreases for shorter time scales, but we still find variability in an interval as short as 26 days. This implies that we have not yet found a time scale threshold below which there is no variability. We plan to expand on this work, in particular continuing the study of the time scales of variability and also investigating variability in the Si IV BALs in order to help define the actual time scales, the causes of the variability, and the sizes, locations, and volatility of the outflowing gas.

References

Capellupo, D. M., *et al.* 2010, in preparation

Di Matteo, T., Springel, V., & Hernquist, L. 2005, *Nature*, 433, 604