Associated Narrow Absorption Lines in the spectra of the XQ-100 QSO Survey

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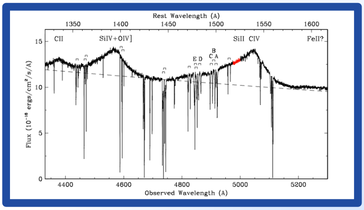

Figure 1: Keck/HIRES spectrum of the quasar J2123-0050 with variable CIV NALs (labeled A-E) that form in a quasar-driven outflow. Many unrelated NALs are also present (Hamann et al. 2011).

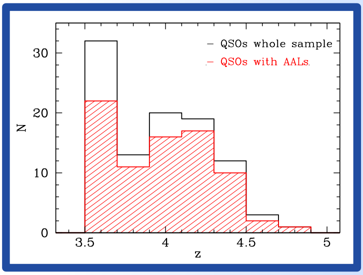

Figure 2: Redshift distribution of the 100 QSOs in the XQ-100 Survey (black line), and of the sub-sample with identified AALs (red line).

Introduction:

High velocity quasar (QSO) outflows appear to be a natural byproduct of accretion onto the SMBH, they have gained attention as a mechanism that can physically couple QSOs to the evolution of their host galaxies. Observation of outflows are mainly carried out in absorption against the central compact UV/X-ray continuum. These absorption lines are usually classified by the FWHM of their profiles.

In Fig.1 we can note that narrow absorption lines (NALs) have relatively sharp profiles with FWHM <~ 300 km s^{-1} so that important UV doublets, such as CIV 1548, 1550 Å, are not blended.

NALs are thought to form in a wide range of environments, from high speed outflows, to halo gas, to the unrelated gas or galaxies at large distances from the AGN. Those falling at less than 5000 km s^{-1} from the systemic redshift of the QSO, z_{em}, are usually called associated absorption lines (AALs), they are likely intrinsic and directly influenced by QSO radiation.

The outflow/intrinsic origin of individual AALs can be inferred from: i) time-variable line strengths, ii) resolved absorption profiles that are significantly broad and smooth compared to the thermal line widths, iii) excited-state absorption lines that require high gas densities, iv) line strength ratios in multiplets that reveal partial coverage of the background light source, and v) higher ionization states than intervening absorbers.

NALs represent an important diagnostic of quasar environment. We can use them to place new constraints on:
1) the nature and energetics of quasar outflows. This will improve our understanding on how quasars evolve and affect their environment on small and large scales. 2) The metallicities and physical conditions in the larger gaseous environments of quasar host galaxies.

Analysis of the sample:

We investigate the environment of 100 QSOs with $3.5 < z_{em} < 4.72$ through absorption lines. Our analysis is based on intermediate resolution and large spectral coverage X-Shooter observations collected in the **XQ-100 Legacy Survey**. These QSOs were originally selected without regard to AAL features, so these data allow us to construct a large and unbiased sample.

Basing our analysis on the associated CIV doublets, we found that: ~ 52% of the objects show at least one strong AAL with rest frame equivalent width EW(1548) > 0.2 Å; ~ 79% of the targets have at least one AALs (FIg. 2).

We use the complete AAL sample to investigate the number of AALs per equivalent width interval and per velocity interval. This is of interest because these relative numbers could be indicative of the ionization structure of the absorbers and also of their locations relative to the continuum source (Fig.4).

We searched for a correlation between the offset velocity and rest EW of CIV, but no evolution is apparent from Fig.5.

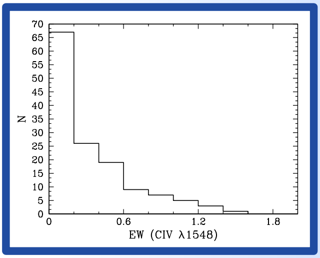

Figure 3: Distribution of rest-frame equivalent width, EW(1548), of all associated CIV systems.

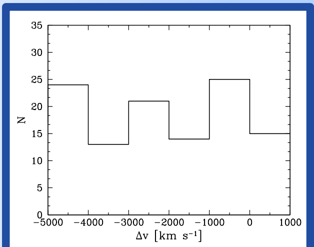

Figure 4: Velocity offset distribution of all associated CIV systems. The velocity offset is defined as negative for NALs that are blueshifted from the quasar.

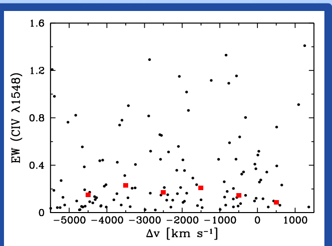

Figure 5: Relationship between the velocity offset of AALs and the rest-frame equivalent width. Red squares denote the median value of the EW in each bin of velocity. There seems to be no evolution in EW.

In **Figure 6** we compare our distribution with a cut at EW > 0.5 Å with the one done by Vestergaard (2003). She found that 27% of the QSOs in her sample had CIV absorptions for which the sum of the EW of the two members of the doublet was > 0.5 Å. In our sample we found 39% of QSOs with this characteristic.

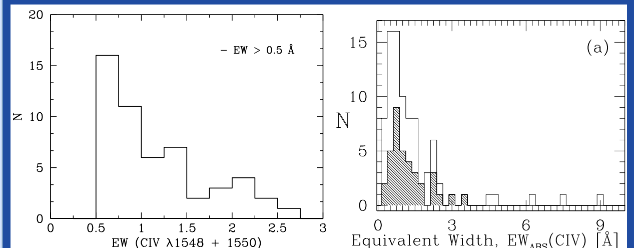

Figure 6: (Left panel) Distribution of rest-frame equivalent width of associated CIV doublets, with EW > 0.5 Å. (Right panel) Same type of distribution (open histogram) done by Vestergaard (2003), 114 QSOs with 1.5 < z < 3.6.

Work in progress:

We plan to carry out a statistical study of NAL properties with primary goals: 1) discriminate between AALs (velocity |v| < 5000 km s^{-1}) and NALs produced in cosmologically intervening structures; 2) compare them with the characteristics of the host galaxies, e.g. the fraction of radio-quiet and radio-loud QSOs showing AALs.

References:

Vestergaard, M., 2003, Apj, 599, 116
Misawa, T., et al. 2007, ApJS, 171, 1
Hamann, F., et al. 2011, MNRAS, 410, 1957