C IV Broad Absorption Line Variability in QSO Spectra

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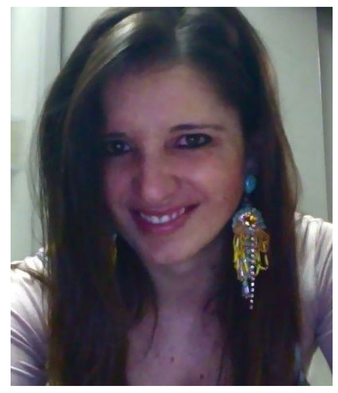


OVERVIEW

We present the results of our study of C IV broad absorption line (BAL) variability in the spectra of a large sample of QSOs from several SDSS I-III surveys up to BOSS.

Absorption lines in QSO spectra are due to outflowing winds which originate from the accretion disk, at a distance of about 10^{-2}-10^{-1} pc from the central super-massive black hole (SMBH). Winds trigger the accretion mechanism onto the SMBH removing angular momentum from the disk and, since they evacuate gas from the host galaxy, they are believed to play a fundamental role in galaxy evolution.

Absorption lines can be classified on the basis of their width and of the observed transitions, and their equivalent width can change on timescales from months to years, due to variations in the covering factor and/or in the ionization level.

Our sample is the largest ever used for such kind of studies.

AIM AND METHOD

We investigate C IV BAL disappearance in a sample of multiple spectra of 1263 sources, obtained at different epochs on a multi-year time-scale. For each source we have at least two spectra; we search for disappearing C IV BAL troughs by comparing each pair of spectra. A BAL trough has a width $\Delta v \geq 2000$ km/s and lies at least 10% below the continuum. We assume that a trough disappears if it has a width $\Delta v < 500$ km/s on the most recent spectrum.

Our goal is to characterize the sample of sources with disappearing BALs by investigating their properties (e.g., velocity, depth), in order to gain insight into the physics of QSO winds.

RESULTS

Sources with at least one disappearing BAL: 7.9% (100/1263, five times larger than the largest sample analyzed so far)

Disappearing BALs: 6.3% (112/1790)

We find that the fraction of disappearing BALs is three times larger than the one found in previous works. Strong evidence is found for a coordinated variability in spectra with multiple BAL troughs which may be interpreted in terms of disk-wind rotation, and/or variations in the physical status of the shielding gas. We also find that, in spectra with multiple BAL troughs, the disappearing ones are generally those with the highest central velocity.

Fig. 1

Disappearing BAL troughs generally have higher minimum velocity v_{min} and central velocity v_c than the whole BAL trough population. They are generally narrower than the BAL troughs in the main sample.

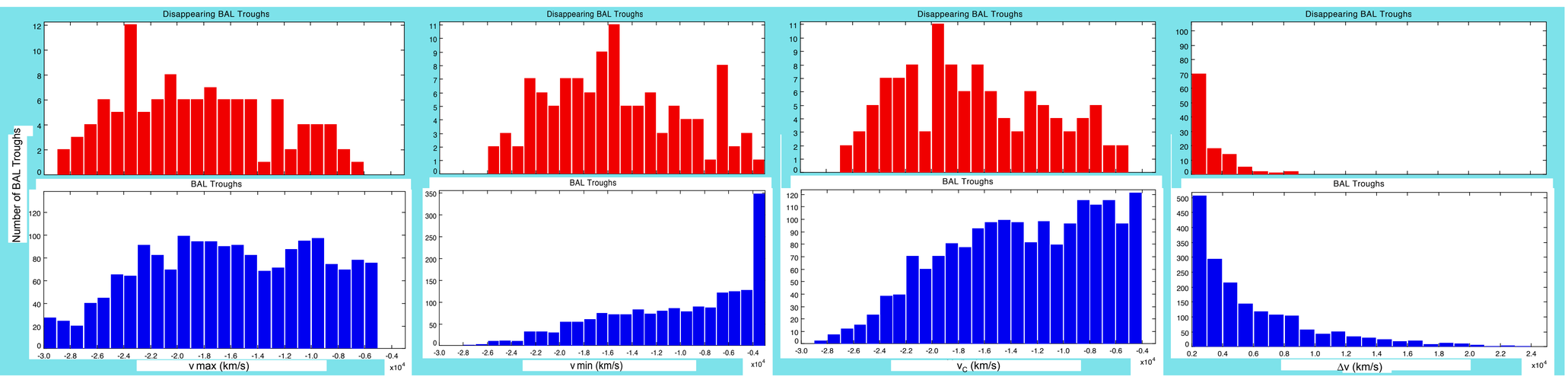


Fig. 2

Examples of spectrum pairs where C IV BAL trough disappearance can be seen. In some cases (*right panel*) there is more than one disappearing BAL, and there are additional BALs which do not disappear.

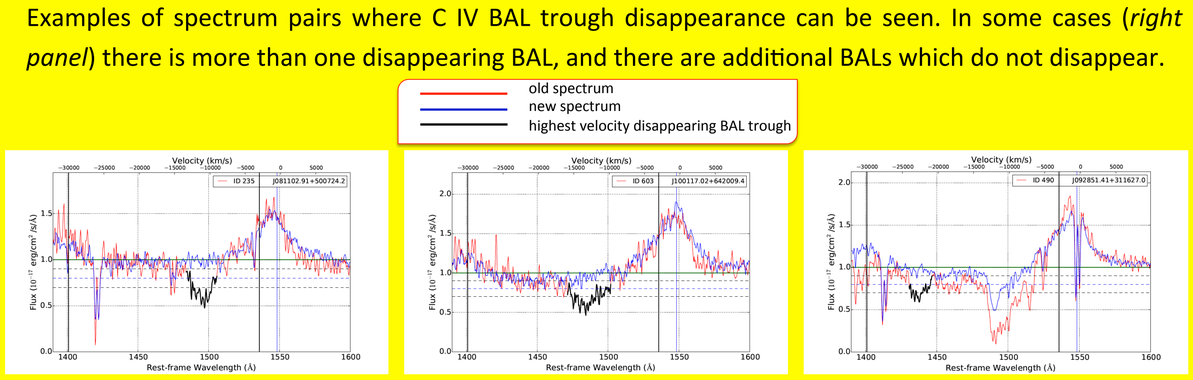


Fig. 3

In some cases the spectrum pair showing a disappearing BAL also shows one or more non-disappearing BALs.

We compare their EWs in the two epochs ($t_1 < t_2$) and find that 88% of them weaken in the most recent epoch. This suggests that the variability in QSOs showing multiple BAL troughs is somehow coordinated.

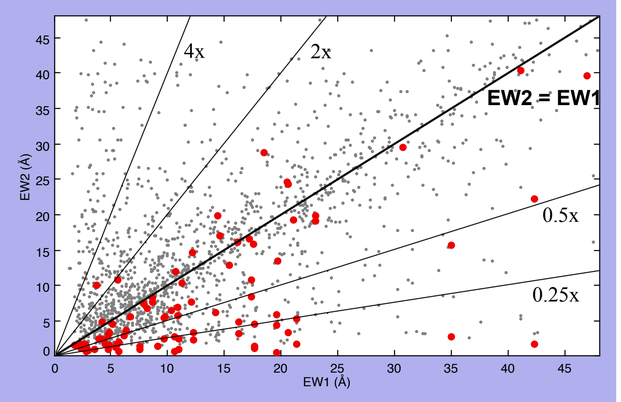


Fig. 4

The velocity offset between the non-disappearing and the disappearing trough is $v_{offset} < 0$ for 85% of the sample, indicating that the disappearing trough is generally the one with the highest velocity.

The fractional EW variation between the newer and older epoch in a spectrum pair is $\Delta EW/<EW> < 0$ for 88% of the sample, hence non-disappearing troughs generally weaken. This supports the idea of a coordinated variability (**Fig. 3**).

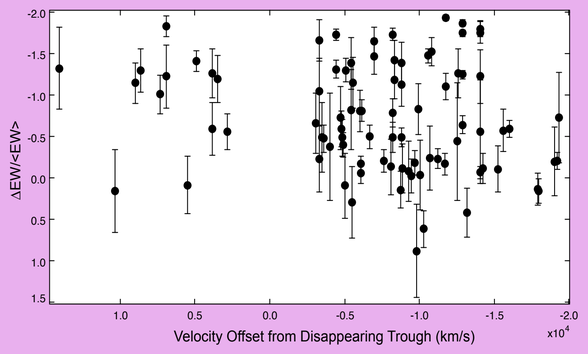


Fig. 5

Some spectra are characterized by two or more BAL troughs. Here we compare the EW variations of the lowest velocity and the highest velocity troughs for each spectrum pair. Correlation between the variability of the two troughs is apparent for all but the highest velocity range bin, altough the scatter is always large.

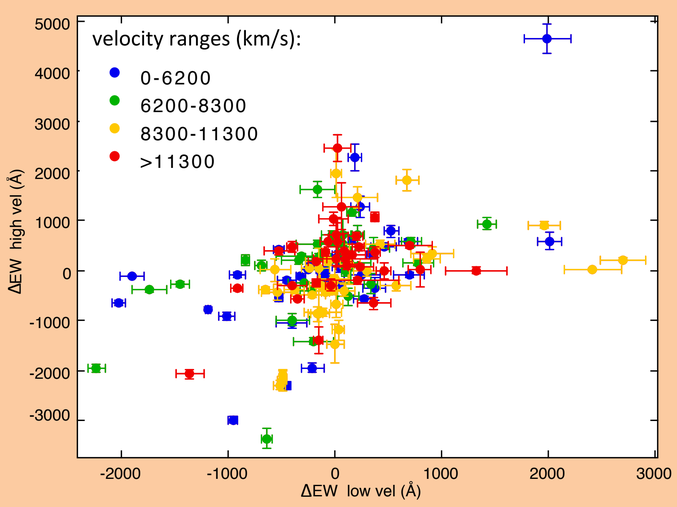
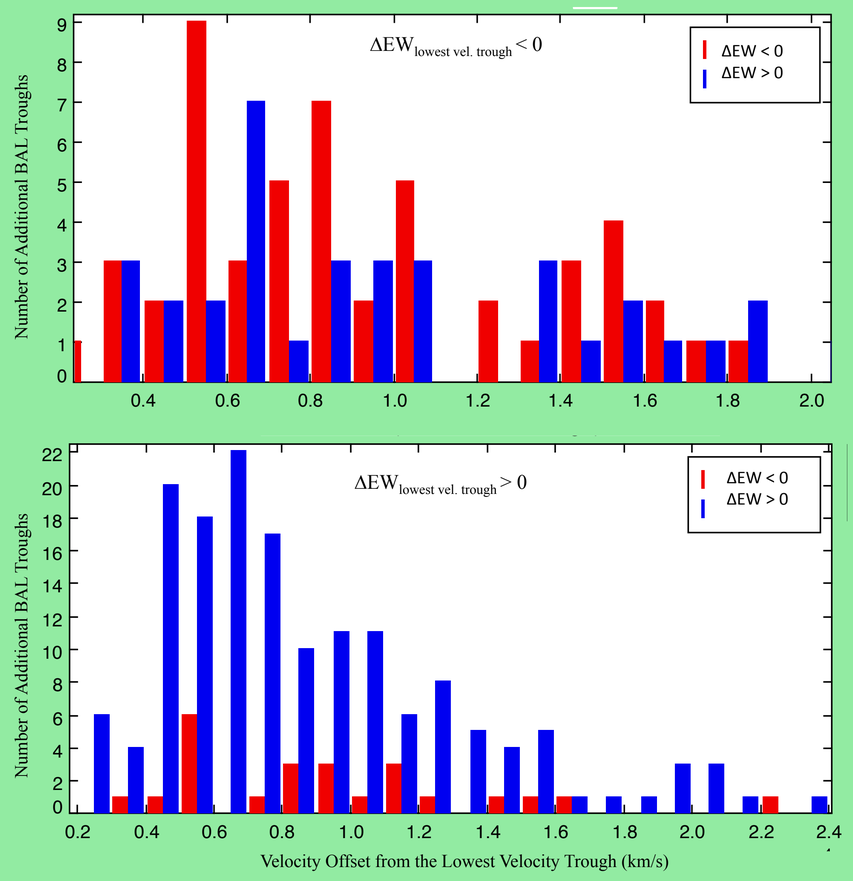


Fig. 6

We analyze the EW variations in spectra with multiple BAL troughs, to further test the hypotheses about coordinated variability. We show the trend of the EW variations of the highest velocity troughs in the two subsamples of spectra having $\Delta EW_{lowest\ vel.\ trough} < 0$ and $\Delta EW_{lowest\ vel.\ trough} > 0$. Both panels show that, in most cases, the changes in the EW of the highest velocity troughs follow the trend of the corresponding lowest velocity troughs.



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