Multi-epoch observation of CIV absorption variability in APM08279+5255

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1. Introduction

Broad Absorption Lines (BALs), indicating the presence of high velocity gas outflow, appear in 10-15 % of QSOs. This fraction may be entirely explained by the geometrical structure of the outflow [5], or may be related to a transient phase of the QSO life [6]. In both cases, variability of the BAL spectrum can help understanding changes of the structure and physical properties of the outflow. Most existing studies of BAL variability [2,9,7] rely on observations taken at a few epochs, and ensemble properties have been derived. In the present contribution we present a "monitoring" of a single object, APM08279+5255, which has been observed for 19 times since 2003, in the framework of a spectrophotometric monitoring campaign including 3 other QSOs and devoted to the estimate of the mass of the central black hole of very luminous quasars (Trevese et al. 2007)[10].The BAL QSO APM 082979+5255 is one of the brightest quasars in the sky (V~15 mag). Its redshift z=3.911 implies that it is also one of the most luminous QSOs. Spectroscopic observations at very high resolution with the Keck telescope for the study of intervening matter, and medium-high resolution spectroscopic observation with HST of the triple gravitationally lensed image are also available. Including Keck and HST spectra, we extended the time interval from 1998 to 2011 with 21 epochs. An analysis of the variability of the BAL equivalent width W is presented and compared with the ensemble BAL properties described in the literature.

2. Observations and Data Reduction

Our reverberation mapping campaign, initiated in 2003, is being carried out in service mode at the 1.82 m telescope of the Asiago Observatory equipped with the Faint Object Spectrograph & Camera AFOSC. We adopted a 8"-wide slit and a grism with a dispersion of 4.99 Å pixel^{-1}, providing a typical resolution of 15 Å in the spectral range 3500-8450 Å. Spectrophotometric exposures are performed after orienting the slit to include both the QSO and the reference star as internal calibrator for the QSO spectrum, as described in Trevese et al.2007[10]. The wide slit is necessary to avoid different fractional losses of the star and QSO light which could cause spurious variation of the flux ratios. At each epoch, typical observations consist of two consecutive exposures of 1800 s, and the ratio of the QSO and reference star spectra is computed for each exposure to check the consistency. The average spectrum is then adopted for that epoch. Flux calibration of the reference star is performed at one reference epoch.

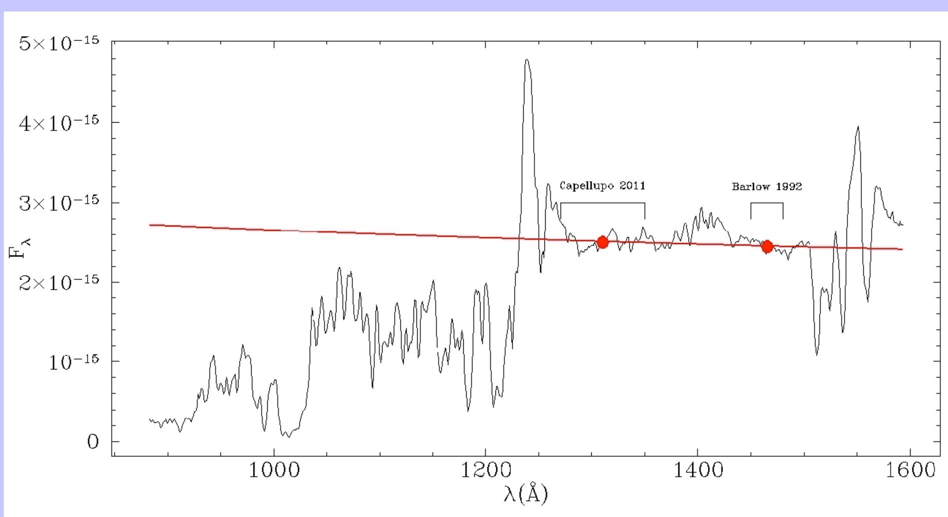

***Fig. 1**: a typical rest-frame spectrum of APM 08279+5255, in erg cm^{-2} s^{-1}. The red line represents a power-law fit through the two average values computed in the indicated intervals[1][2], at each epoch.*

3. Keck and HST Spectra and the Pseudo-continuum

- Two higher resolution spectra of APM 08279+5200 are available from the literature: one taken in 1998 at Keck with a resolution R=λ/Δλ~50,000 [3] and one taken in 2002 [8] with HST with R~4,500. These spectra allowed us to identify absorption free wavelength intervals even on the CIV emission line.
- On these spectra, after a smoothing which reduces the resolution to that of the Asiago spectra, we fit the emission line with a Gaussian profile, after removing a continuum determined as in Figure 1, and considering only absorption free regions (Fig. 2). This provides the emission wavelength λ_{em} and standard deviation σ.
- λ_{em} and σ are then assumed constant and the fit of the absorption-free points is repeated for each epoch with the emission line amplitude as the sole free parameter (FIG. 3). This provides, for each epoch i, the Pseudo-continuum :

$$P_i(\lambda) = K_i \lambda^{\alpha_i} + A_i e^{-\frac{(\lambda-\lambda_{em})^2}{2\sigma^2}}$$

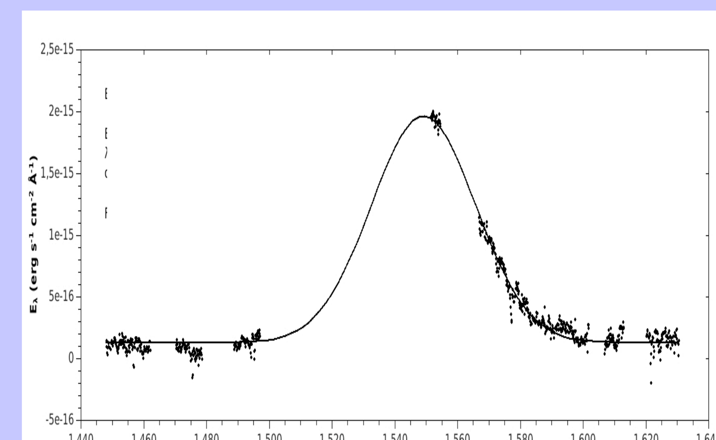

Fig. 2

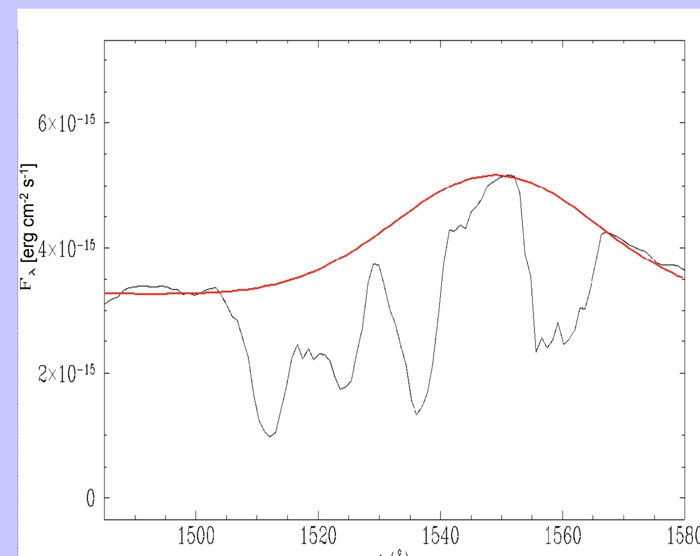

Fig.3

4. The equivalent width of the CIV BAL

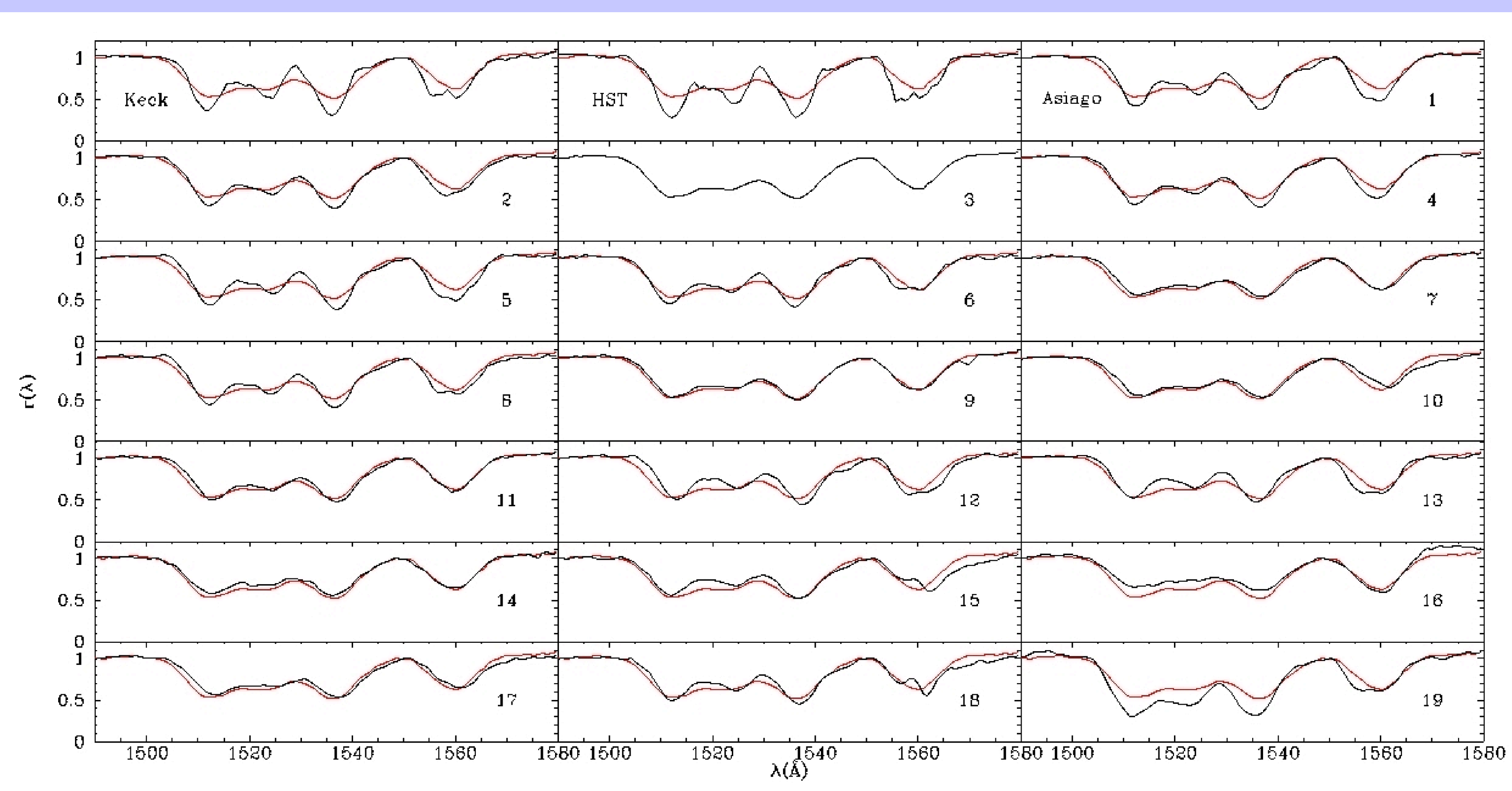

***Fig. 4.-** The rest-frame BAL spectrum of APM 08279+5255, normalized to the pseudo-continuum $P_i(\lambda)$ observed at 21 epochs: 1 Keck, 1 HST and 19 Asiago. The red line is the spectrum n. 3 of Asiago, reported for comparison*

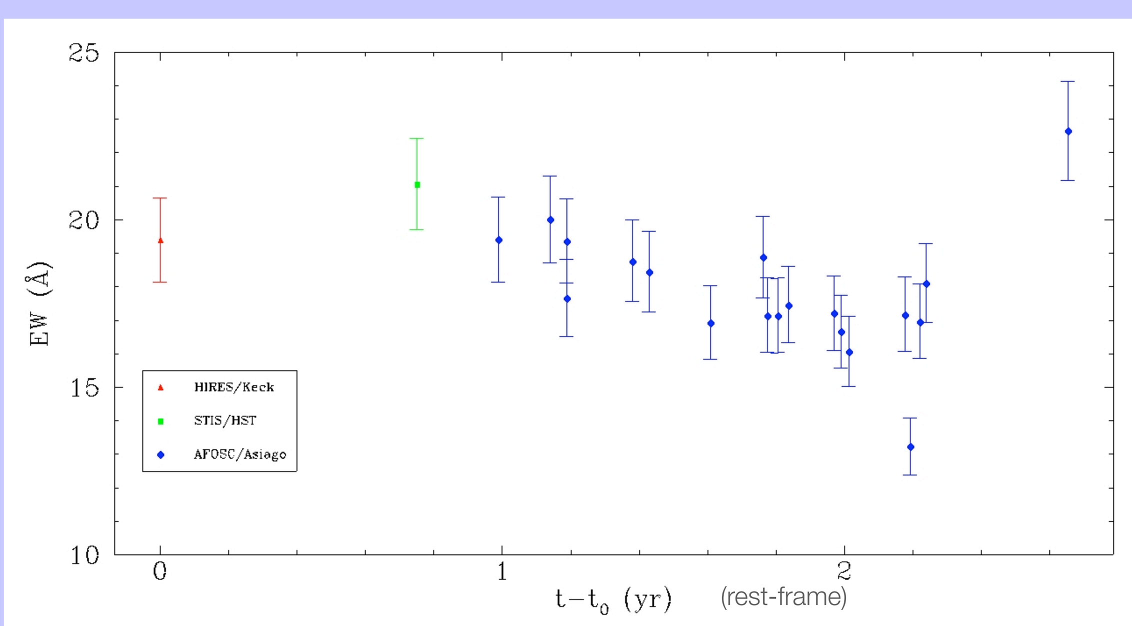

***Fig. 5.-** The equivalent width W as a function of the rest-frame time, computed from the normalized spectrum in the wavelength range 1495-1550 Å, excluding the non-BAL absorption at 1560 Å [4]*

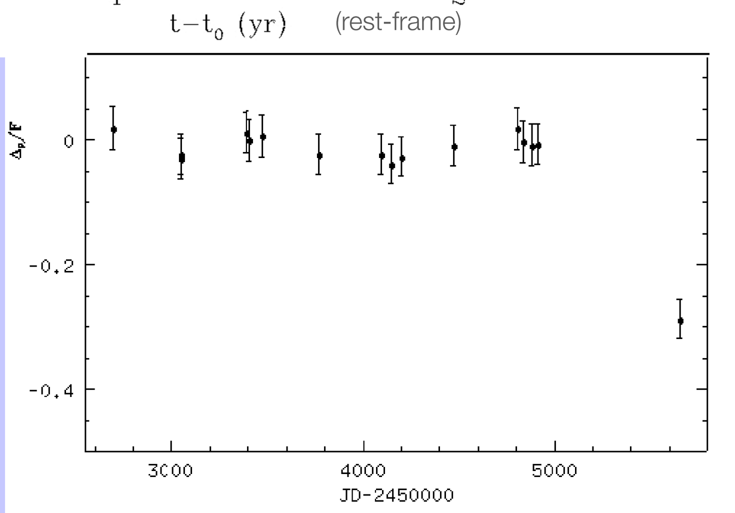

***Fig. 6.-** R band photometry relative to the reference star (not available for the epochs of Keck and HST observations). The QSO luminosity remains almost constant for 2800 < JD-2450000 < 5000, meanwhile W decreases with a typical rest-frame time scale T~5 yr. Between the last two epochs a decrease of ~30% of the R flux corresponds to an increase of ~22% of W.*

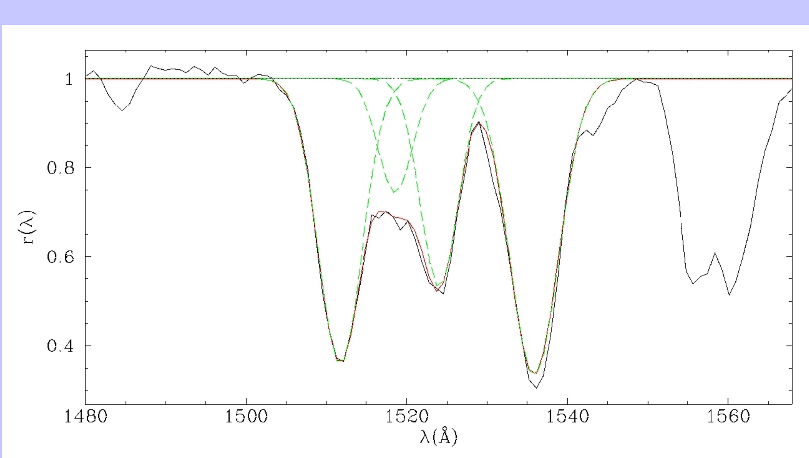

***Fig. 7.-** The BAL profile has been decomposed as a sum of 4 Gaussians (excluding the non-BAL absorption red-wards of the CIV emission[4])*

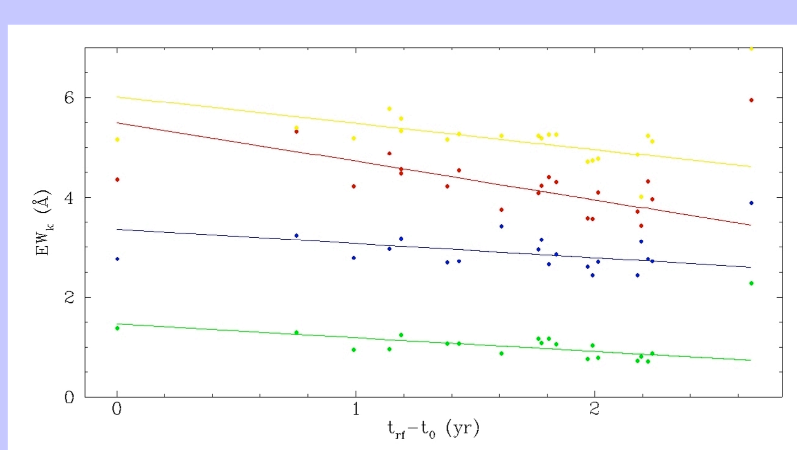

***Fig. 8.-** The central wavelength of each component stays almost constant while the equivalent widths show a behavior similar to the total W (Fig. 5)*

5. Discussion

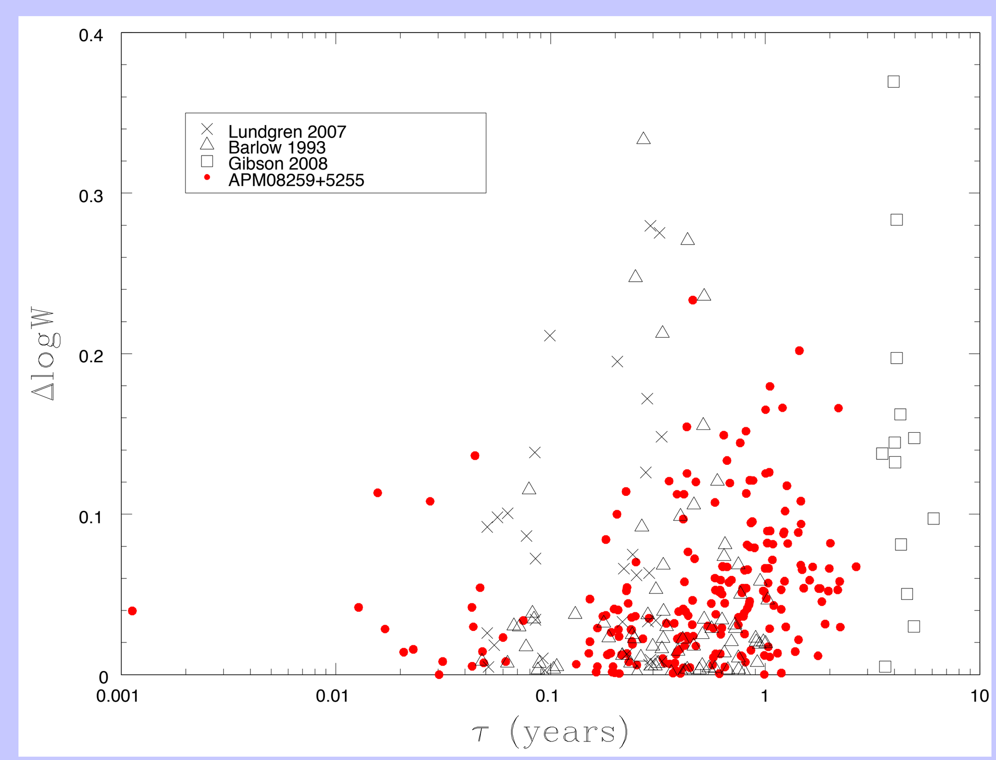

***Fig. 9.-** Variations of logW as a function of the rest-frame time interval τ between the observations. Black symbols: data from the literature; red dots: data from our analysis of APM 08279+5255*

- Our spectrophotometric monitoring of the BAL QSO APM 08279+5255 shows a variation of the equivalent width ΔlogW of the BAL absorption on time scales from days to ~2.5 yr rest-frame (thanks to the high redshift of the QSO studied, this result extends the analysis to shorter rest-frame time lags, respect to previous analyses)
- The general trend of variability ΔlogW versus time interval τ, resulting from our monitoring of a single object, is similar to the enseble of data collected from the literature referring to several QSOs, each observed a few times.
- The BAL profile mainteins its shape, as can be seen from Fig. 4, and as appears from the fact that a decomposition in 4 Gaussian profiles shows that the position of the minima do not change while the depth of the individual absorptions have a similar behaviour in time.
- This suggests that the distribution and velocity of the absorbing gas do not change. This would imply that changes in the ionization equilibrium could explain the observations.
- For most of the observing time the R band flux is almost constant, while W shows a decreasing trend. In the last time interval, an increase of W correspond to the sole large variation of the R band flux. If "large" R band variations mimic the variation of the ionizing flux, also this behavior could be consistent with a variation of the ionization equilibrium

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