Probing the time variability of high velocity outflows in QSOs

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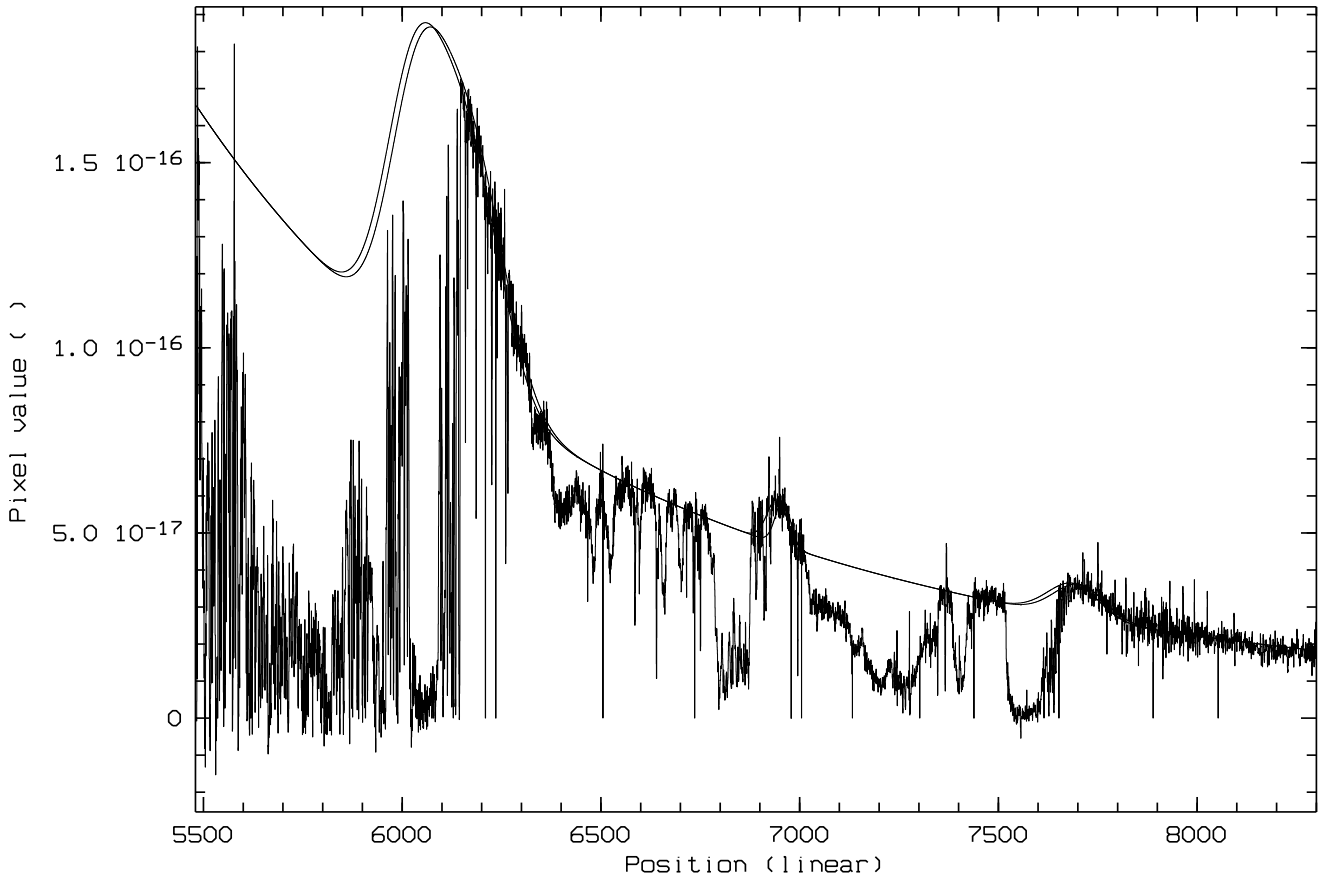
Why study outflows in QSOs?

- **Kinematics, dynamics, nature and origin of the flow:**
  - **Hydro dynamics, Radiation hydro-dynamics, MHD ?**
  - **Location, geometry, covering factor, stability and confinement.**
- **Chemical enrichment**
  - **Nature of star-formation activities in the Galactic centre**
  - **Starburst - Blackhole connection.**
- **Feedback to the structure formation**
  - **Birth of an AGN from the dusty central region.**
  - **Heating and enrichment of the IGM.**
  - **Heating of the intra-cluster medium.**
  - **Blackhole buldge relation.**

Broad absorption lines: Outflows



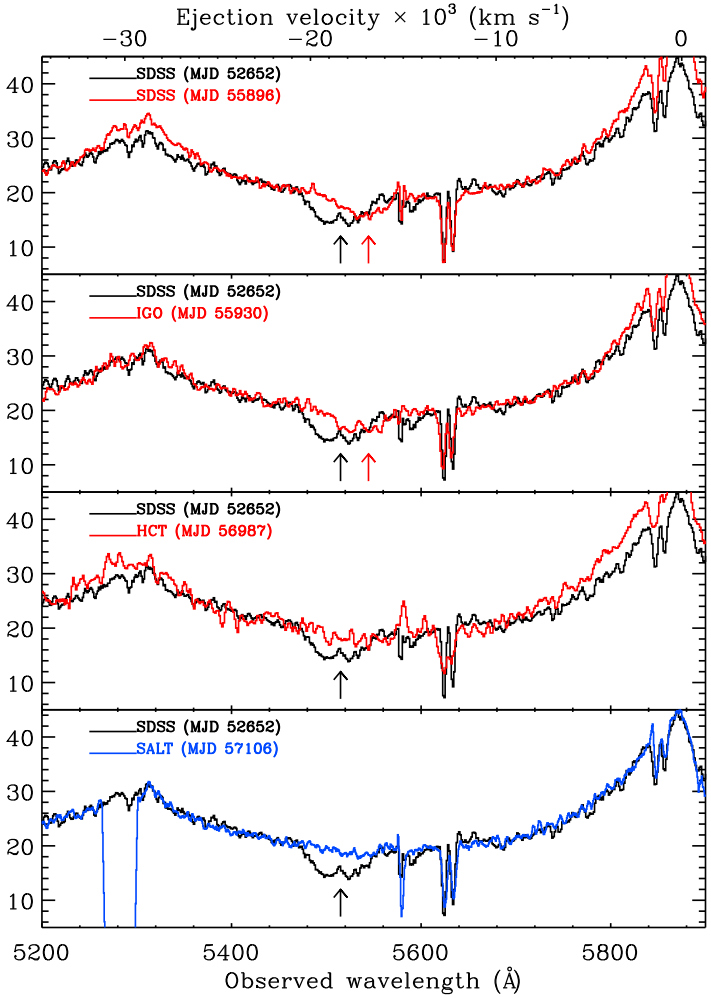
BAL variability programme with SALT

- Spectroscopic monitoring of BAL QSOs to look for,
  - optical depth variations
  - signatures of acceleration
  - emergence or recurrence of outflows
- We are following a sample of low ionization broad absorption line QSOs (Vivek + Neeraj Gupta + Britt Lundgren of university of wisconsin).
- Broad absorption line QSOs with emergence or disappearence.
- Broad absorption lines with $z_{abs} > z_{em}$
- Objects are typically brighter than r$\sim$19 mag.

Emerging/Disappearing BAL Sample:

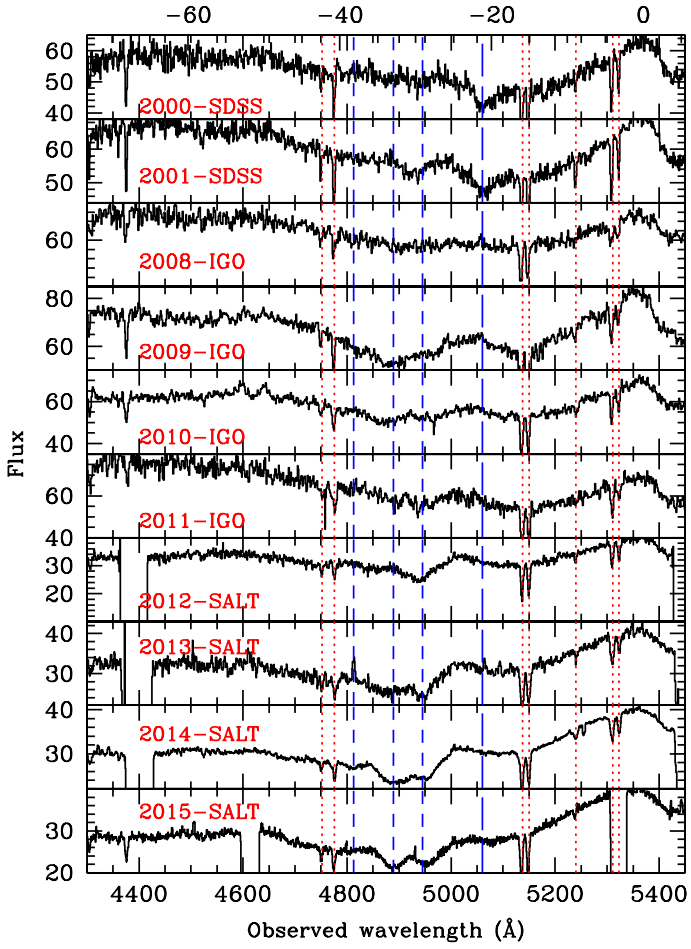
- We are monitoring about 15 bright BALQSOs accessible to SALT showing large optical depth variability between two epoch SDSS spectra (or from our IGO monitoring programme).
- Typically each object is observed for about 40 min (2x20 min) with SALT covering most interesting spectral range covered by absortion lines.
- Aim is to quantify the physics causing the strong variations and obtain characteristic time-scales involved in the problem.
- To obtain the densty, location and mass outflow rate so that one an estimate the mechanical luminosity and hence the efficiency of AGN feedback.
- First set of observations are completed for 8 sources (2014-2-SCI-0023; 2015-1-SCI-005).
- Here we present the initial (exciting!) results till now.

Disappeared BAL in X-ray loud QSO J0911+055



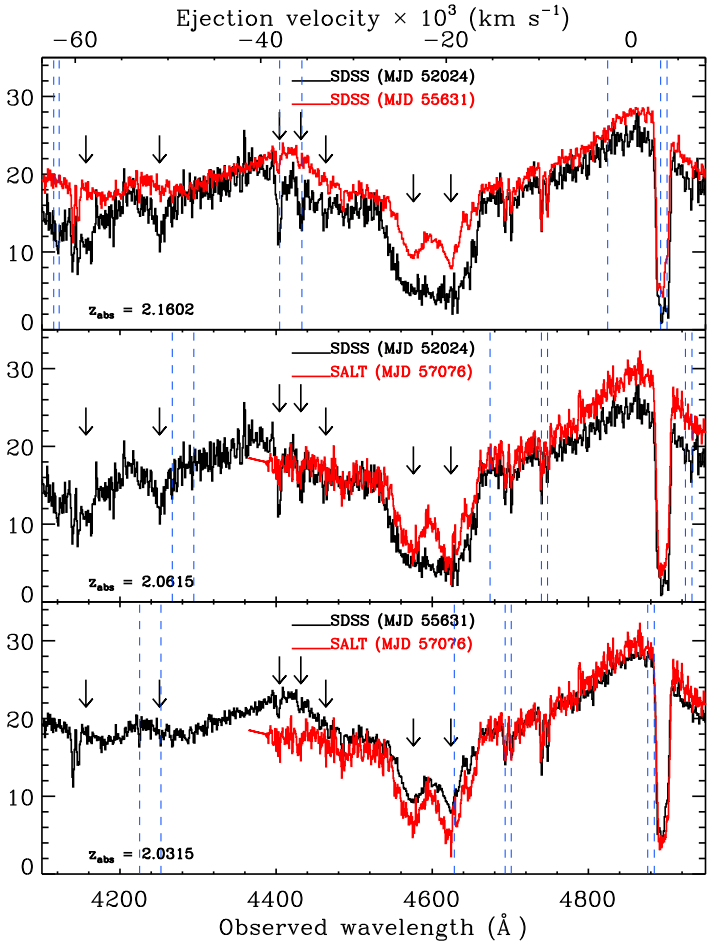
- X-ray loud BAL QSO with z_{em} = 2.793.
- Joshi et al. (2014) reported a possible decleration of -2.0 ± 0.1 cm s^{-2} over the QSO rest frame time-scale of 2.34 yrs.
- Deceleration is explained by making outflow in a curved path. If so the absorption will disappear when the transverse displacement is larger than the size of the accretion disk + absorbing cloud.
- The absorption is now disappeard in the latest SALT spectrum. We are modelling the flow to extact accretion disk and absorbing gas parameters and say some thing about magnetic fields.
- Future proposal: Has x-ray flux increased with the disappearance of the absorption.

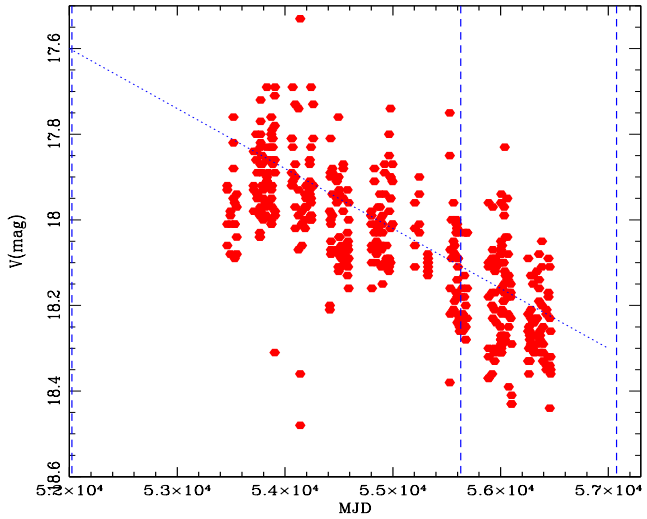
Recurring Mg II BAL absorption in J1333-0012



- Vivek et al. (2012) reported diappearing red and dynamically evolving blue component. Originally classified as Mg II BAL had become normal QSO again with out any absorption.
- This is the only known Mg II absorber that has shown such a large variability over time-scales of months to years.
- In the SALT spectrum the absorption reappears at the same wavelength as before. It has grown to a full strength and beginning to weaken. A future disappearence will confirm the recurring BAL.
- Future proposal: HST proposal submitted to get the UV absorption associated to the Mg II absorption. The main question is what is the velocity field of the outflow probed by high ionization species.

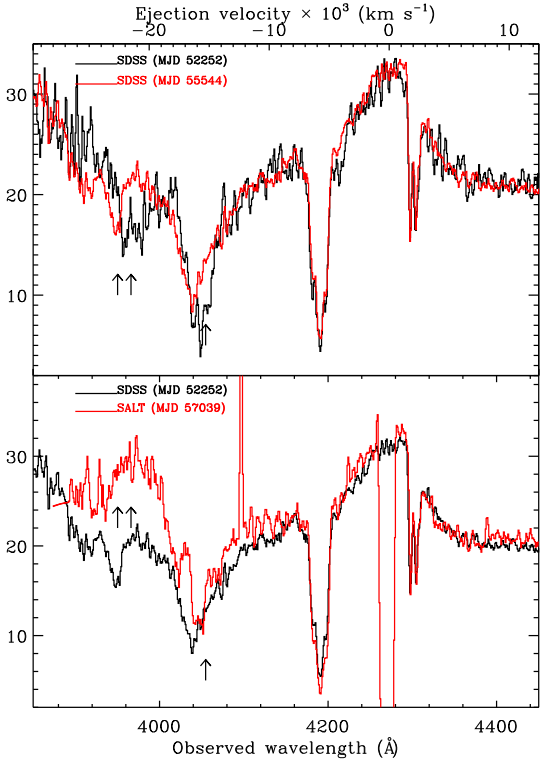
J1205+0134: Photoionization induced variability



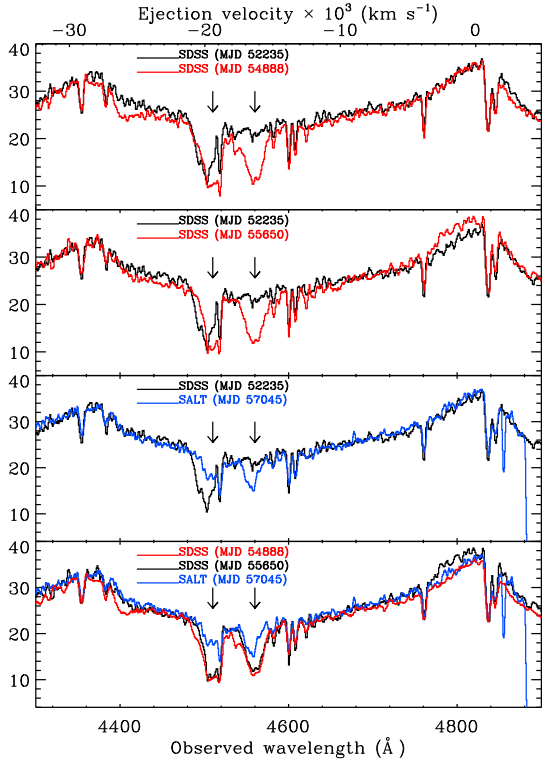


- An infalling gas with narrow absorption + broad outflowing gas + excess intervening C IV absorption seen.
- All the associated absorption + Emission lines show variability. Light curve also confirms continuum dimming.
- Variability time-scale = recombination time ==> density constraint; distance from ionization modelling and the gas carries enough mechanical luminosity to provide sufficient feedback.

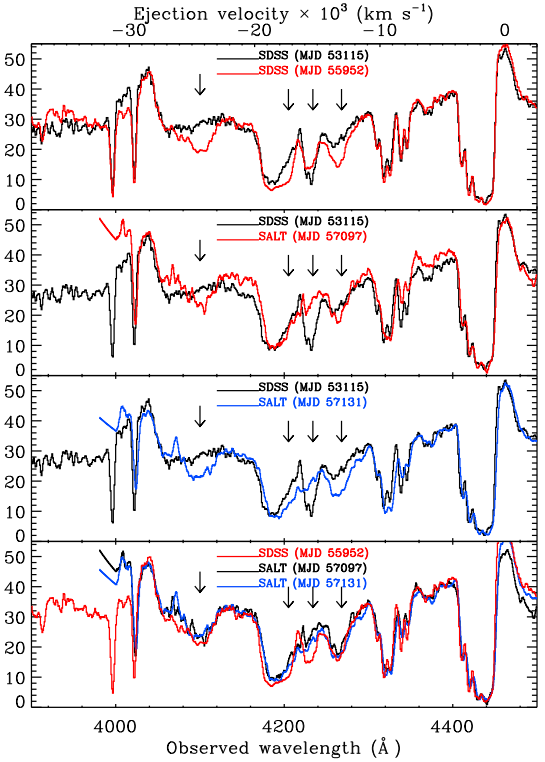
Some more examples:



J0918+0242



J1007+0340



J1044+1040

Summary from our various ongoing studies:

- $\sim 10\%$ of the radio-quiet and $\sim 20\%$ of the radio-loud BAL QSOs show signatures of emergence/disappearance when monitored over $>$ 3 years.
- These systems are not the early phases of QSO formation.
- The emergence/disappearence always occur at $v_{eje} \geq 10$ K km/s for components having shallow and broad absorption profiles.
- CRTS photometric monitoring suggests that very rarely the absorption line variability is related to ionization changes - we have found one clear case.
- Short time-scale observations are essential to distinguish between transverse motion of the cloud and disappearence due to some plasm instabilities.
- Our SALT observations show emerging systems are variable even at short time-scales. The absorption in these objects are more variable and probably originate very close to the accretion disk.
- Recurring absorption is possibly seen in one case. If confirmed this will provide vital clues on the MHD modelling of disk winds.

—-THANK YOU—-