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On the modeling of Si IV and C IV broad absorption troughs in BAL Quasar spectra.

A method of multicomponent analysis.

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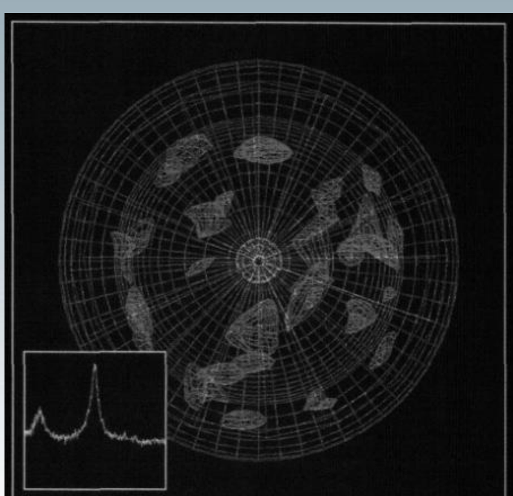
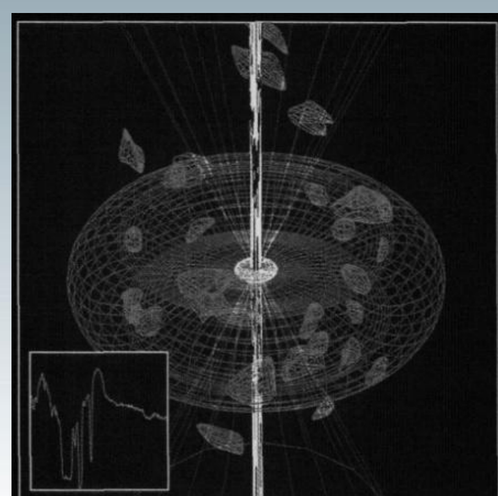
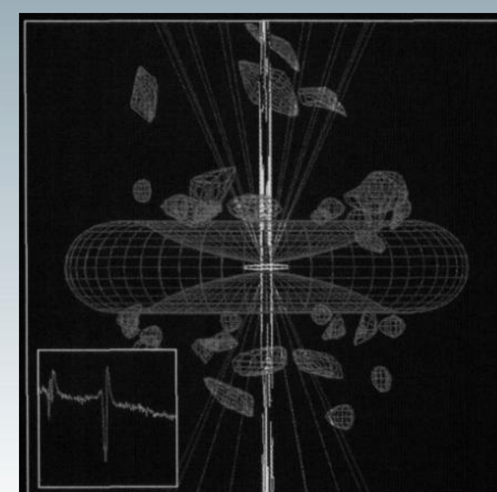
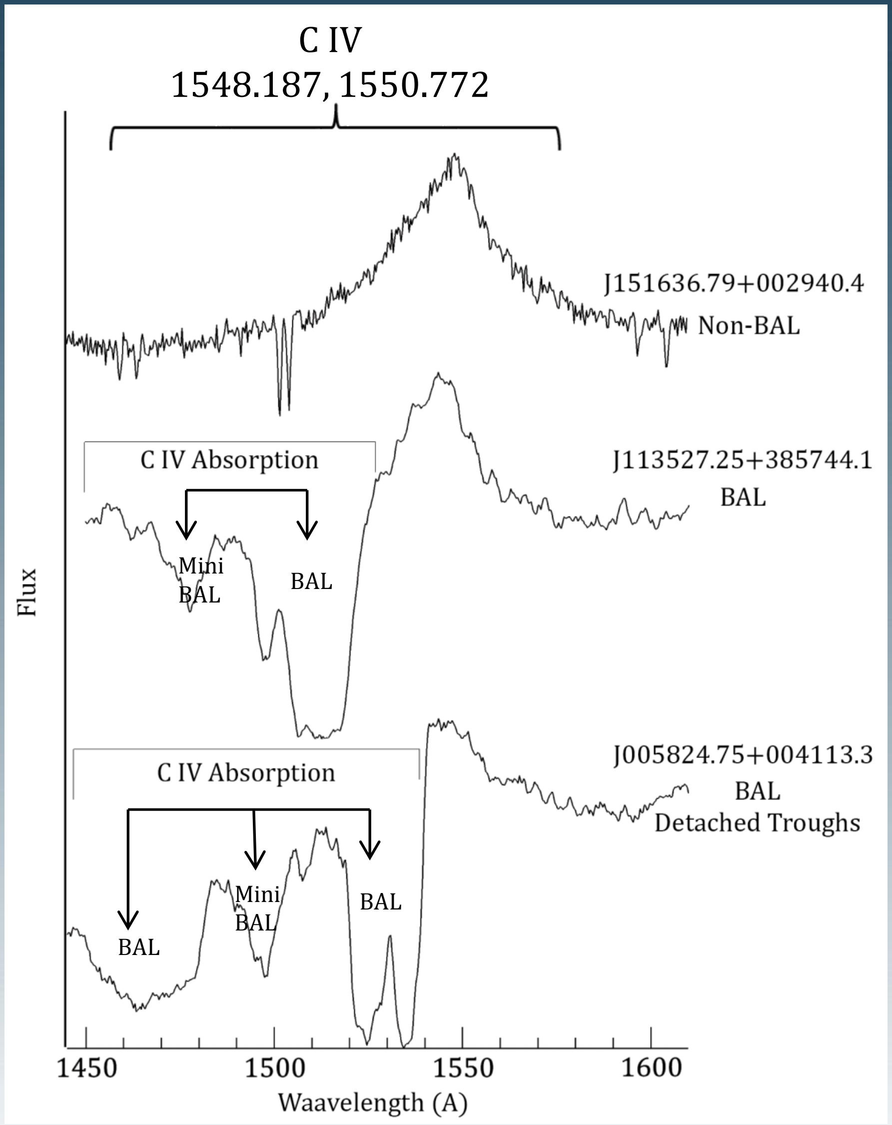






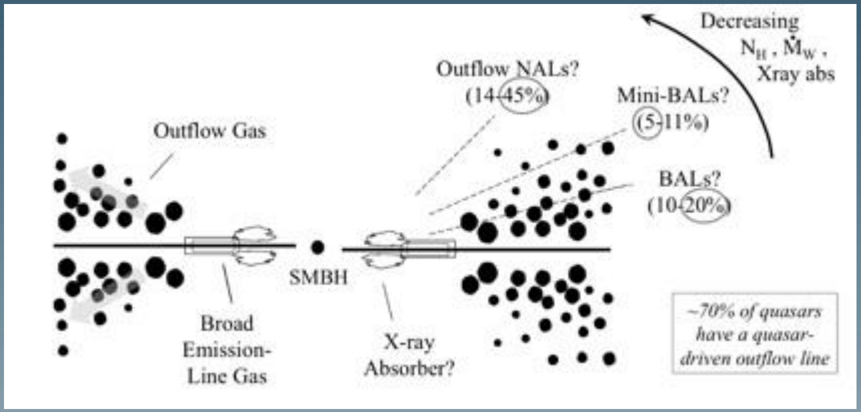
What are BALs
or
Broad Absorption Lines

BALs are Broad and complex absorption lines (FWHM: 2000 – 20000 km/s), which in the majority of cases are blueshifted relative to the AGN emission lines, implying outflow velocities from near 0 to as much as ~ 60,000 km/s (~ 0.2 c).

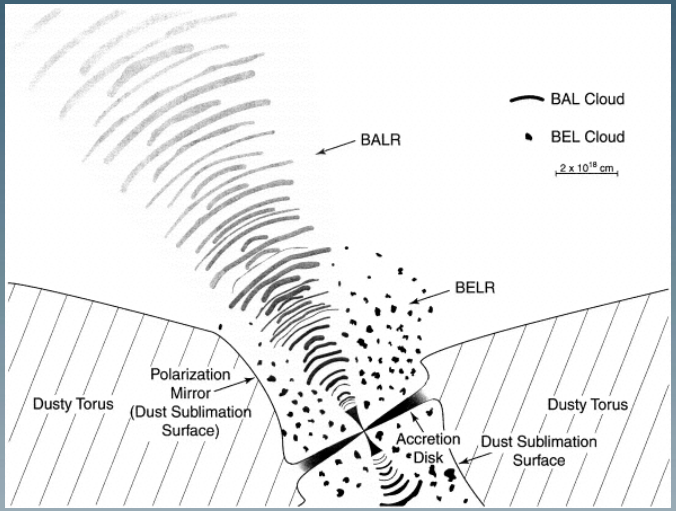


The Origin of BALs
Flow of many individual clouds

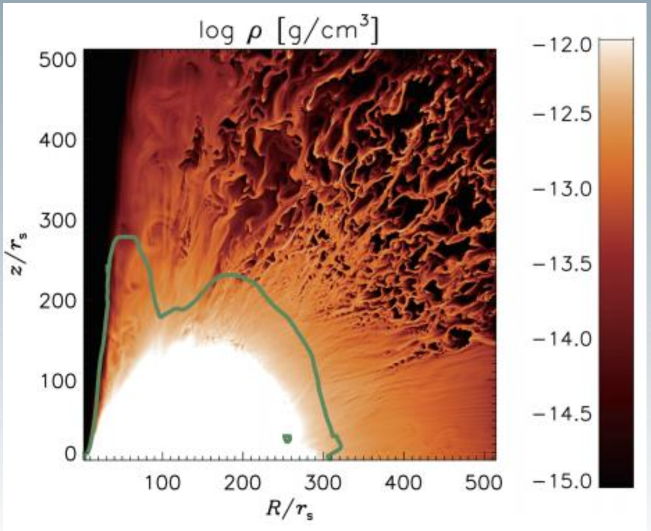
(McKee & Tarter1975, Turnshek 1984, Punsly 1999, Lyratzi et al. 2009, 2010, 2011, Takeuchi, et al. 2013, Misawa et al. 2014 Moravec et al. 2016)



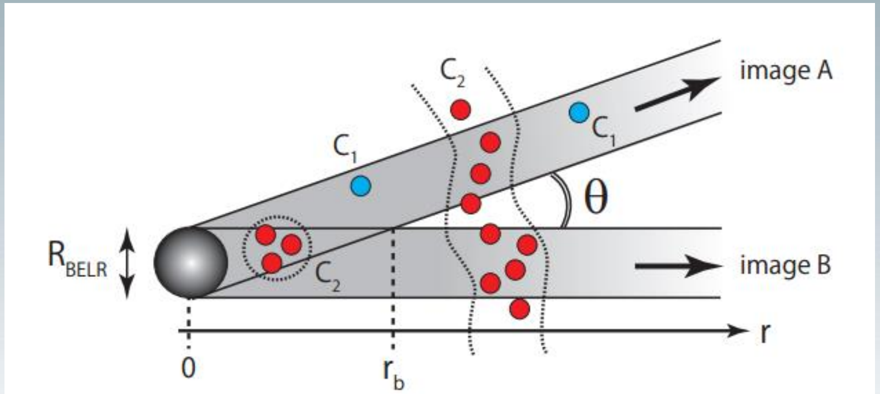
Moravec, E., et al. 2016 AAS, 227, 417.04



Punsly, B., 1999, AJ, 527, 624



Takeuchi, S., et al. 2013, PASJ,65,88



Misawa, T. et al. 2014, ApJ, 794, 20

The spectroscopic analysis is performed using the ASTA software which is based on the model of Danezis et al. 2003, 2005, 2007, Lyratzi et al. 2009

There are two major problems that we encountered trying to achieve the best fit and calculate the values of physical parameters that describe the clouds.

1. Which is the exact number of components needed to simulate accurately the BAL troughs?
2. How can we guarantee the uniqueness of the fit?

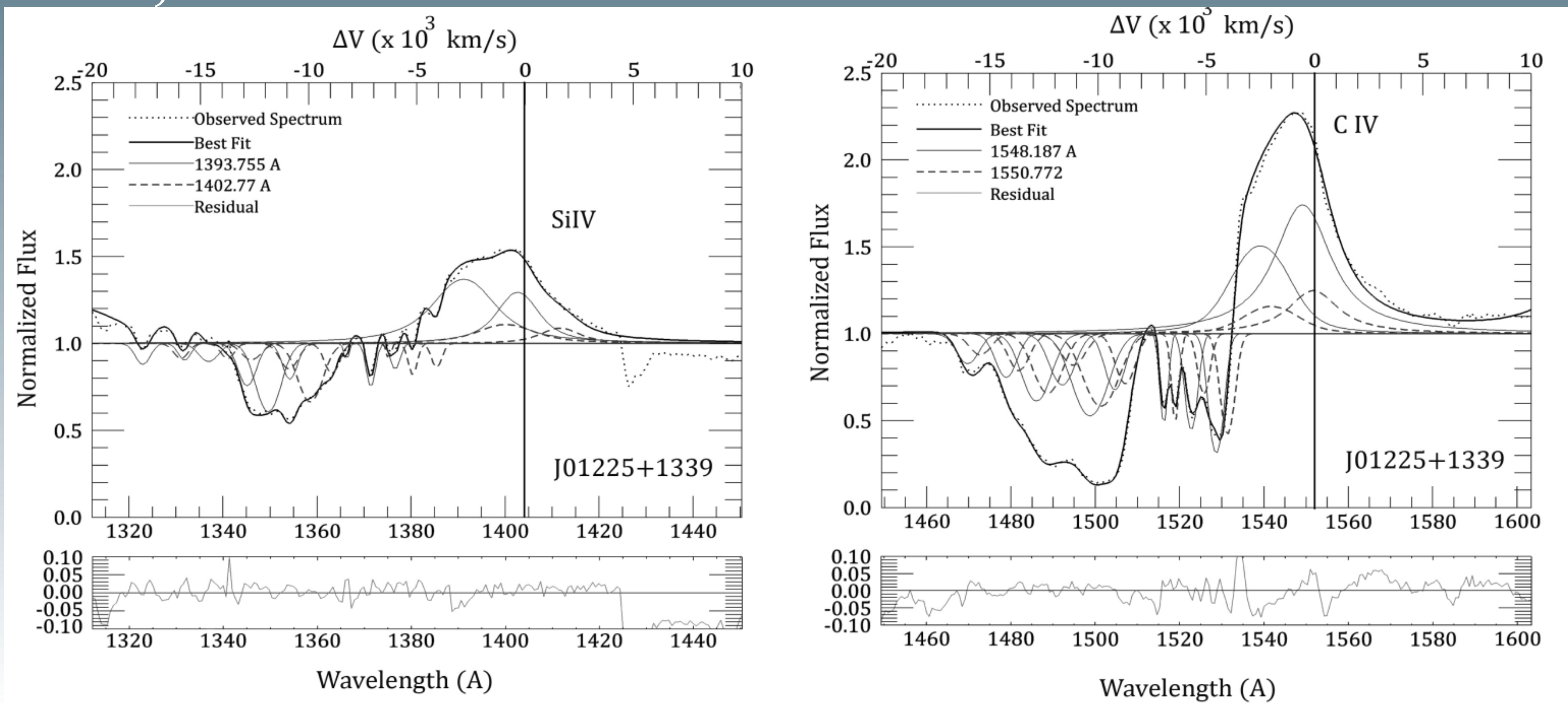
These problems were solved by introducing a number of strict criteria which are applied between the members of a doublet as well as between the two different ions i.e. Si IV and C IV.

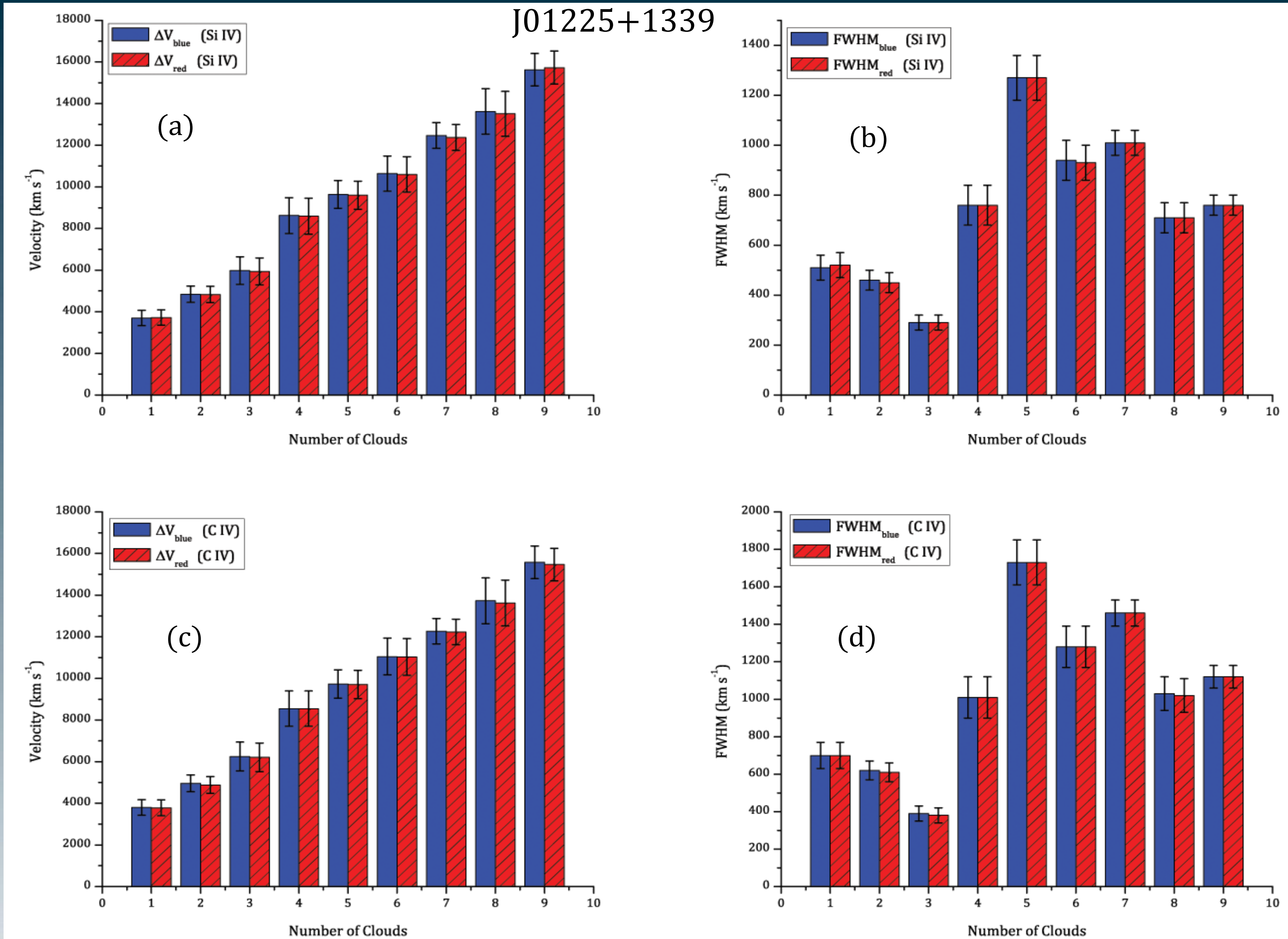
In the case of Si IV and C IV doublets we do not treat them as singlet but instead we treat each member of a doublet independently. Treating doublets as singlets introduces great uncertainties in the measured parameters, especially in the case of Si IV where the doublet separation is large.

I) Criteria between the members of a doublet

C IV λλ 1548.187, 1550.772 and Si IV λλ 1393.755, 1402.77 (Stathopoulos et al. 2015)

- The width between the blue and the red member is exactly the same.
- The velocity shift of the blue member is exactly the same as the red component shift (the difference in velocities at line center must not differ from the expected doublet separation by more than one velocity bin)
- For emission lines the ratio of optical depths between the blue and the red member is $\tau_b/\tau_r = 2$ (as dictated by atomic physics).
- For absorption lines this ratio is free to vary $1:1 \leq \tau_b/\tau_r \leq 2:1$ (to account for non-black saturation)





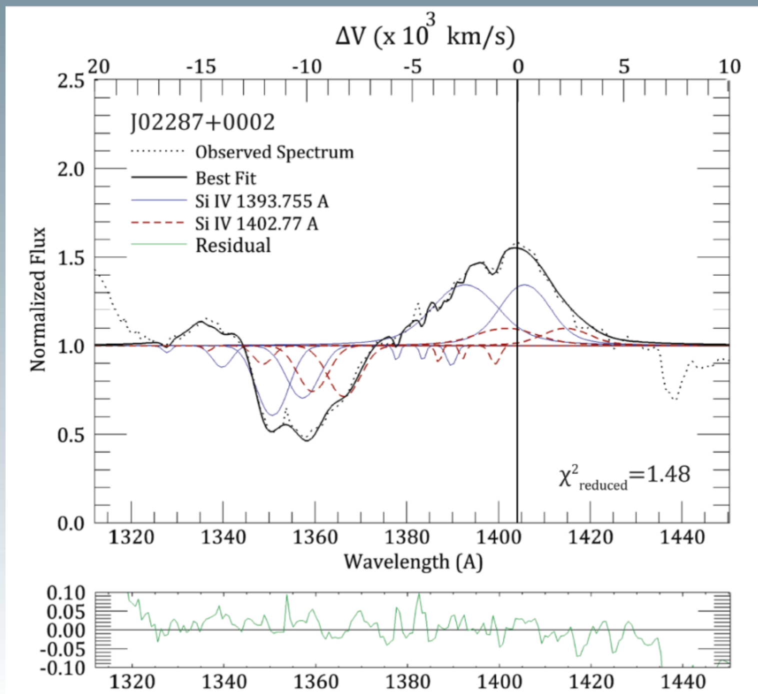
(a) ΔV of Si IV blue and red members; (b) FWHM of Si IV blue and red members; (c) ΔV of C IV blue and red member; (d) FWHM of C IV blue and red members in the case of J01225+1339.

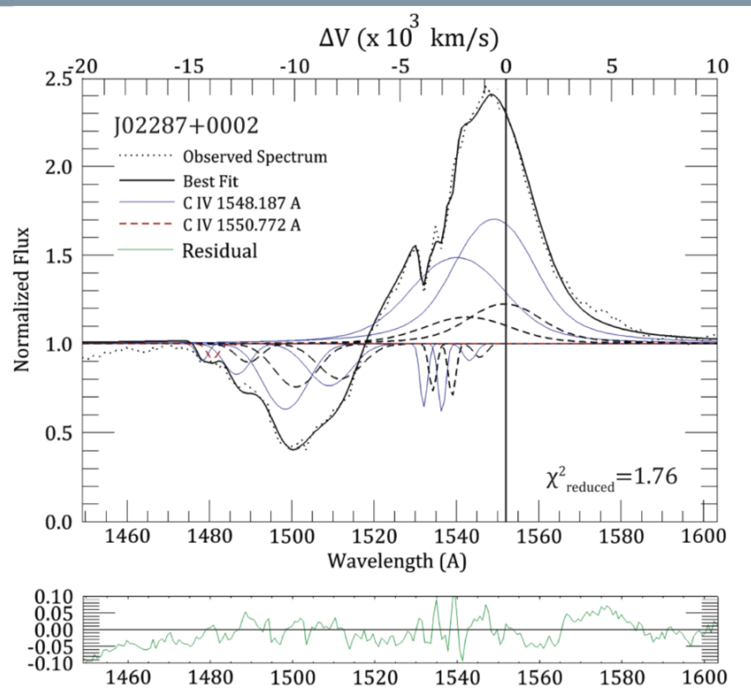
II) Criteria between C IV and Si IV components at the same outflow velocity from the emission redshift. (Stathopoulos et al. 2015)

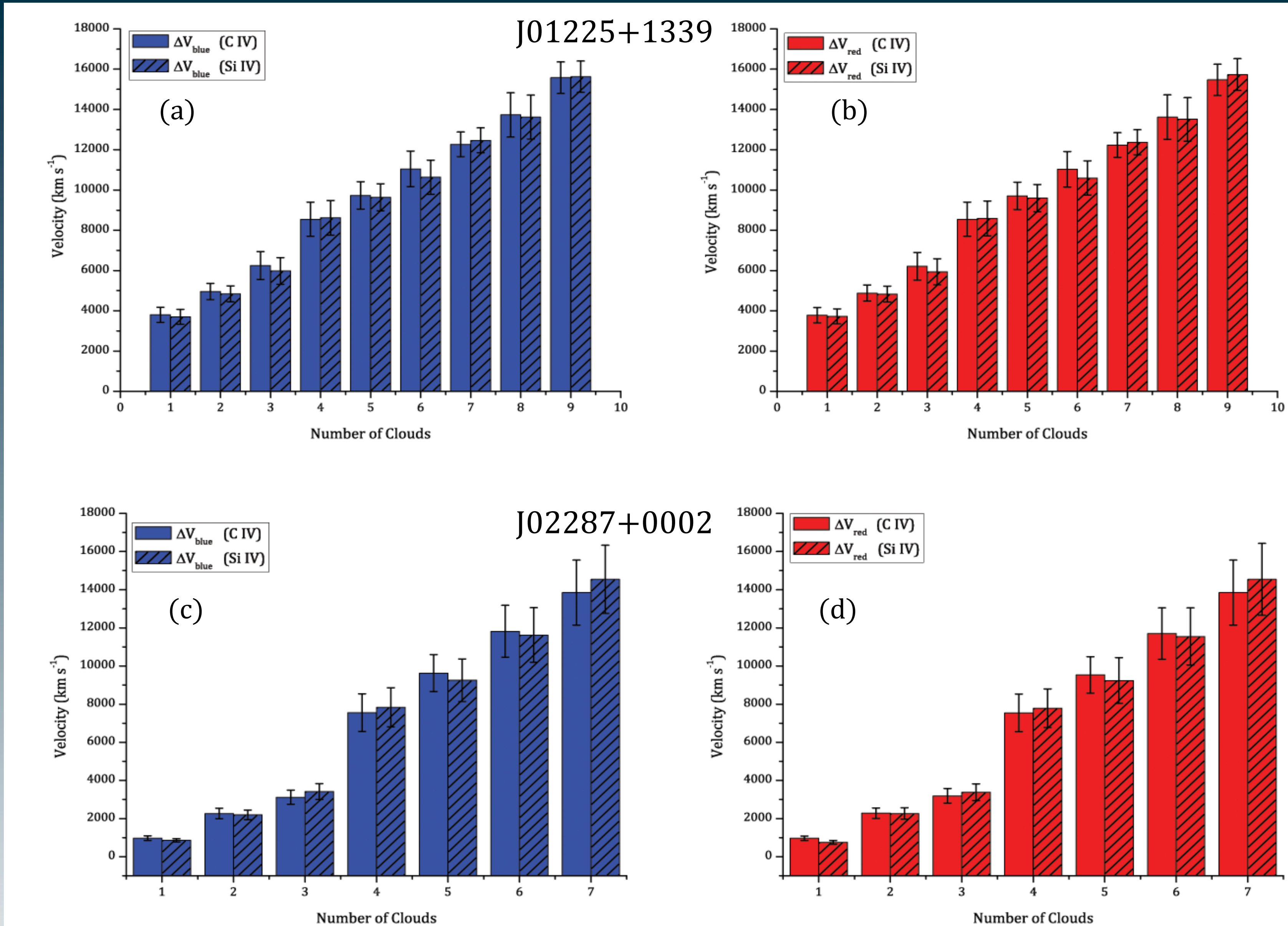
•Both C IV and Si IV BALs follow the same kinematic structure

• Each C IV doublet has its accompanying Si IV doublet at the same outflow velocity. This criterion is not restrictive as C IV might exhibit a doublet in a given velocity shift which might not be present is Si IV and vice versa (the difference in velocities at line center must not differ by more than one velocity bin).

• The ratio of optical depths for a given C IV doublet at a given velocity shift ΔV should be the same as the ratio of optical depths of the corresponding Si IV doublet at the same velocity shift ΔV.







(a) ΔV of blue members of C IV and Si IV in J01225+1339; (b) ΔV of red members of C IV and Si IV in J01225+1339; (c) ΔV of blue members of C IV and Si IV in J02287+0002; (d) ΔV of red members of C IV and Si IV in J02287+0002.