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Modelling the spectra of (BAL)QSOs

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Overview

The problem

The code

Initial results

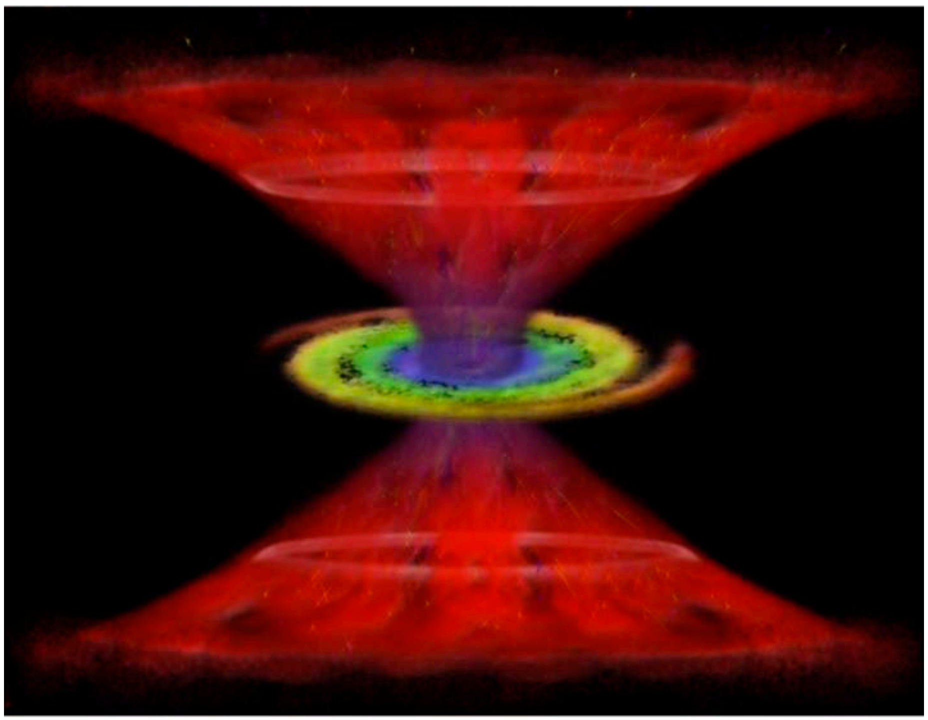
The future

BALQSOs

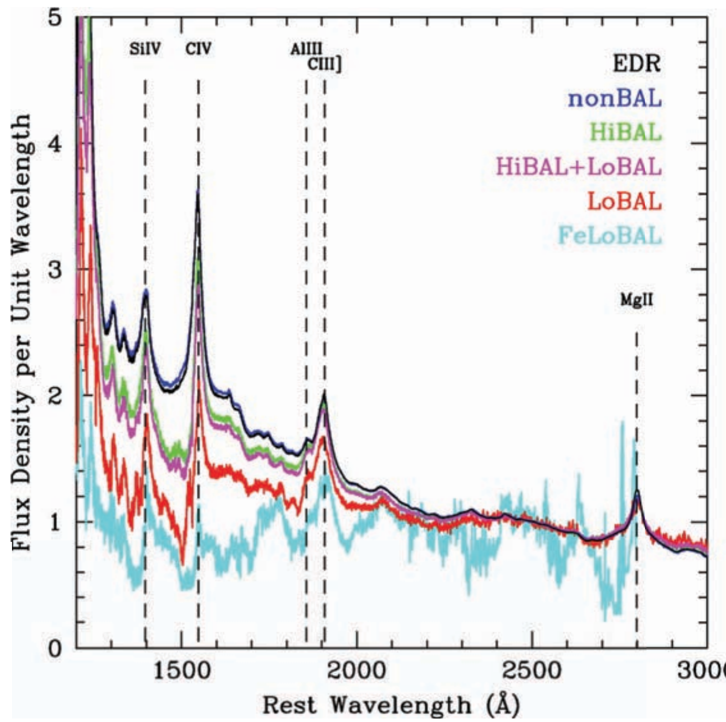
Blue shifted absorption features implying outflow velocities of

$\geq 0.1c$. (Weyman et al 1981)

Disk winds?



Martin Elvis



Reichard et al (2003)

BALQSOs – Evolution vs Orientation

About 17% of the population of QSOs exhibit BAL properties (e.g. Knigge et al [2008] and Hewett & Foltz [2003])

~~Ev[illegible]~~

- ~~[illegible] spend 17% of th[illegible] BALs~~

Orientation

- BAL Outflows cover 17% of viewing angles
- What do non-aligned BALs look like (NAL? QSO?)

Our Aims:

- Produce something that looks a little like a BAL
- Produce wind models which reproduce the observed UV spectral properties of all QSOs in the correct proportions
- Ensure those models also produce required X-ray properties
- Turn qualitative models into quantitative predictions!

Python – a 3D ionization and radiative transfer code.

Arbitrary 3D wind geometry (including input from hydrodynamical simulations)

Monte Carlo radiation treatment

Flexible Ionization Calculations

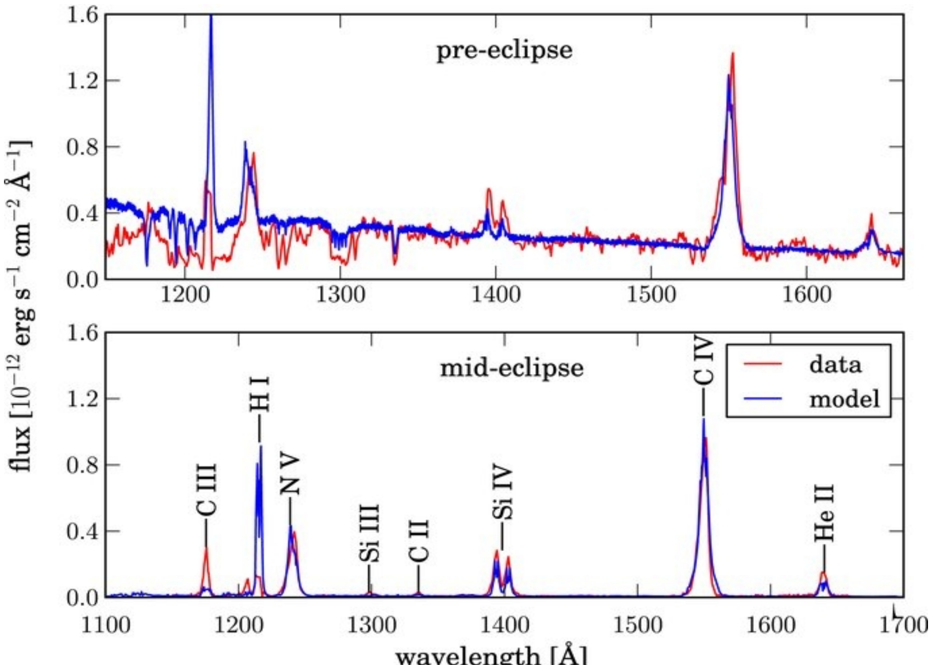
Not detailed balance ➔ fast!

Heating and Cooling

Validated against

accreting white dwarfs

Results for RW Tri, an eclipsing nova like variable. Observations carried out with HST



Noebauer et al (2010)

Setting wind parameters

- Our initial aim is to create the typical spectral features observed in BALs – this constrains
  - Which species are present (suggests ionization parameter)
  - The velocity in the wind
- Some parameters are constrained by observations
  - E.g. luminosity implies accretion rate
- Initial choices for parameters guided by existing models of X-ray observations Sim (2005), Pounds et al (2003)

An example wind model

Parameters:

CENTRAL SOURCE

- M_{BH} – $10^8 M_\odot$
- R_{BH} - 8.8×10^{13}cm ($6R_G$)

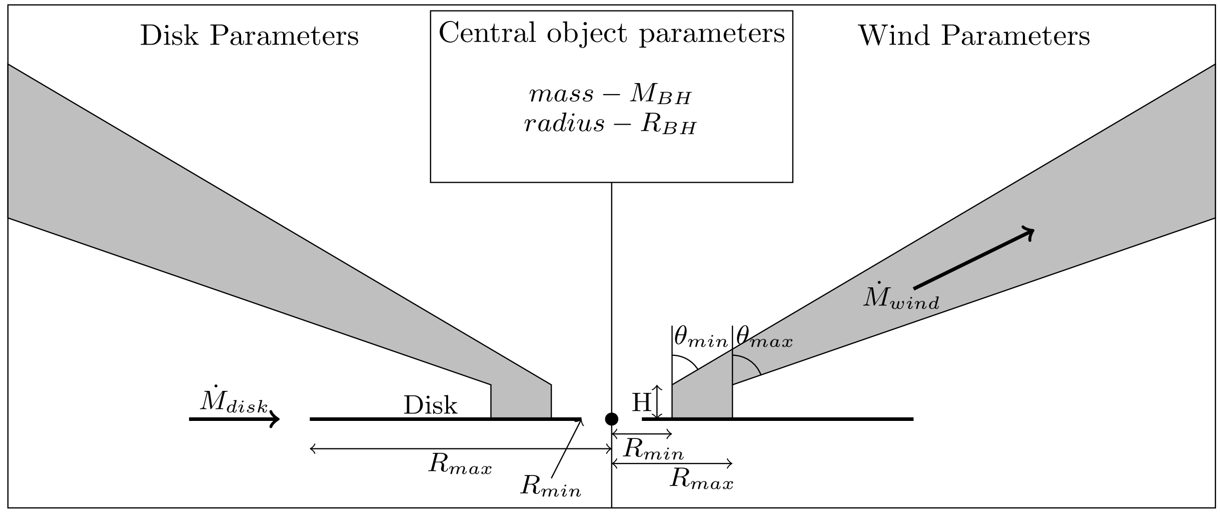
DISK PARAMETERS

- R_{min} – 8.8×10^{13}cm ($6R_G$)
- R_{max} – 5×10^{16}cm
- M_{disk} – $1.8 M_{sun}$/yr

WIND PARAMETERS

- R_{min} - 2.2×10^{15}cm ($150R_G$)
- R_{max} - 1.76×10^{16}cm ($1200R_G$)
- H - 5.7×10^{15}cm
- θ_{min} - 60°
- θ_{max} - 70°
- M_{wind} – $0.3 M_\odot$/yr
- □ -2.0
- $V_\infty = 2V_{escape}$
- R_v - 1×10^{17}cm
- α – 1.0

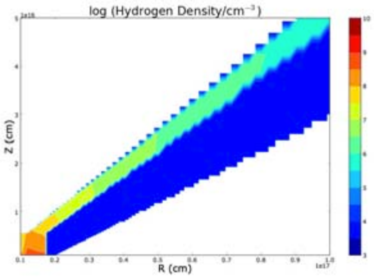
Model based on Elvis (2000)

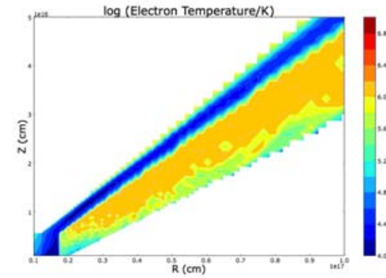


Key Parameters governing ionization state:

1. Geometry
2. Mass loss rates
3. Mass loss exponent
4. Input spectrum : Initially disk only.

Example model





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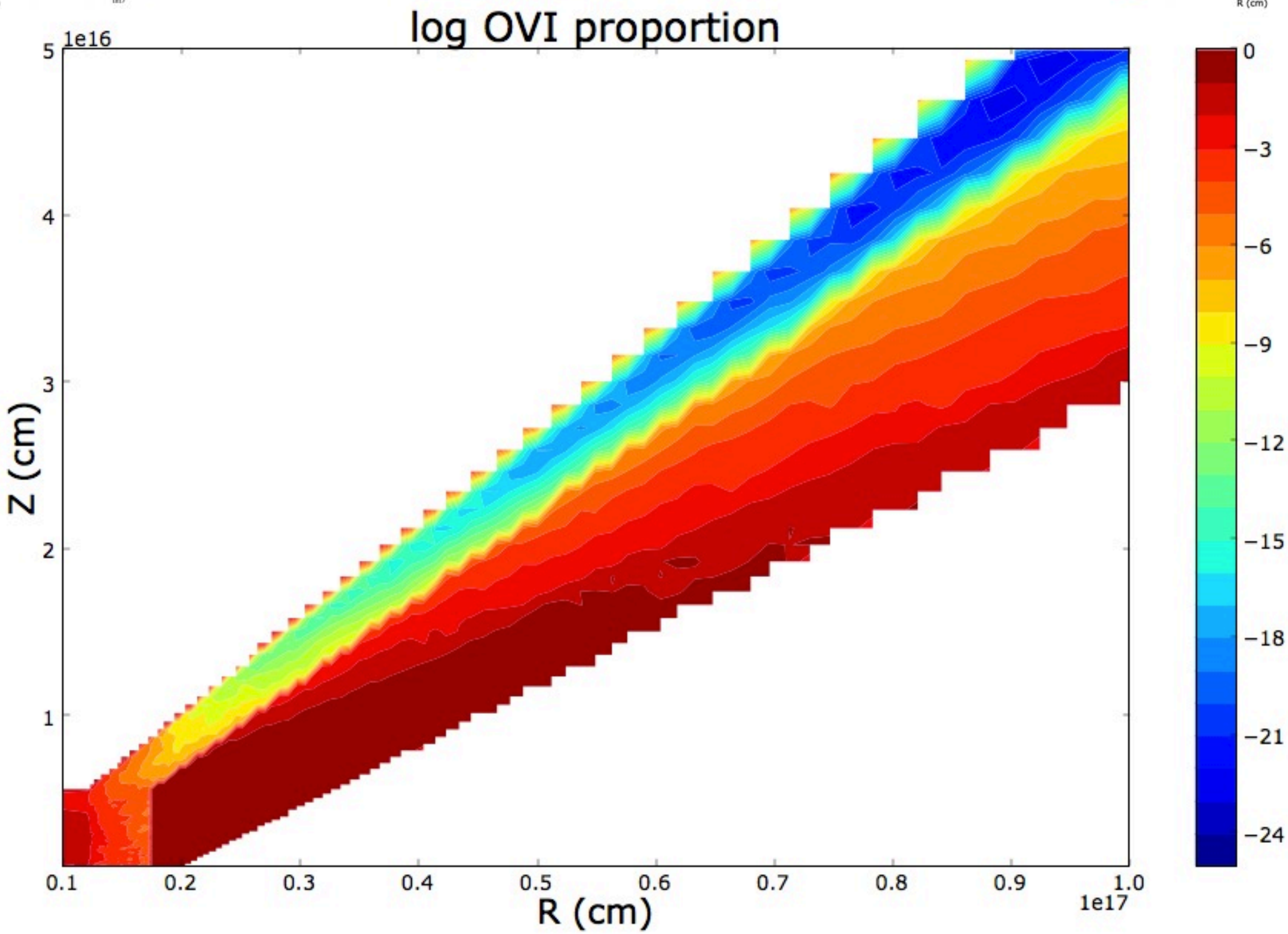
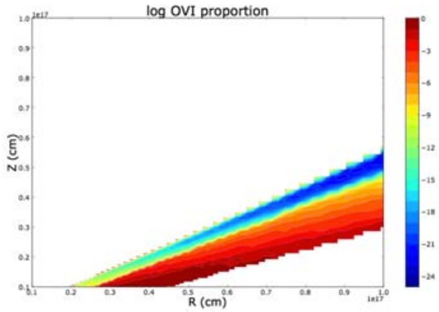
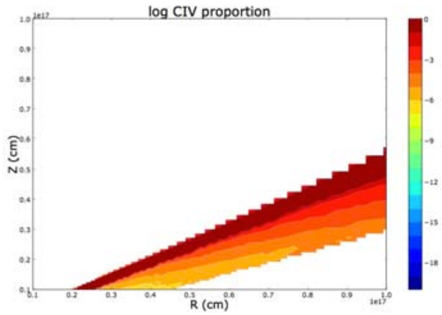
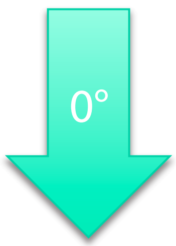
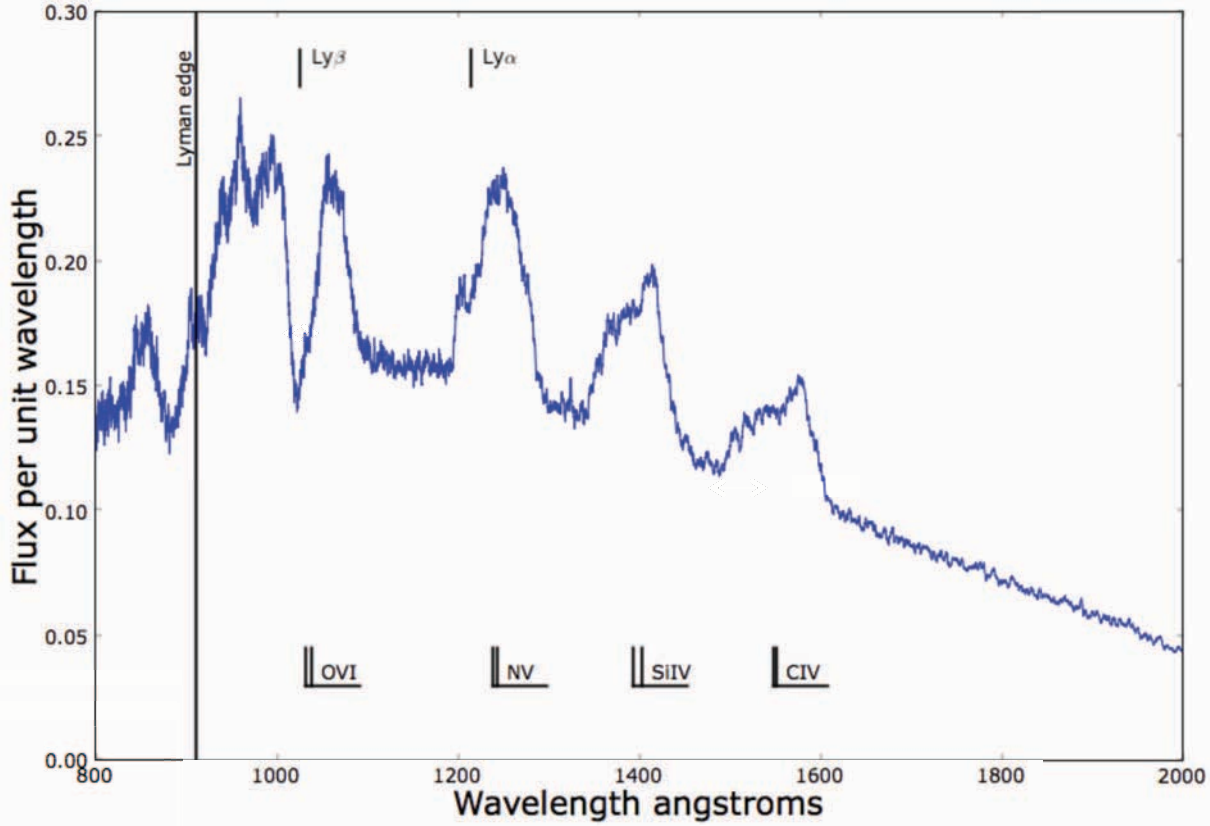


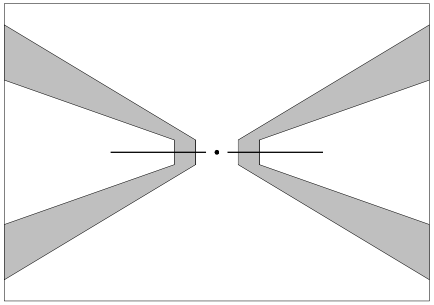
Predicted Spectra





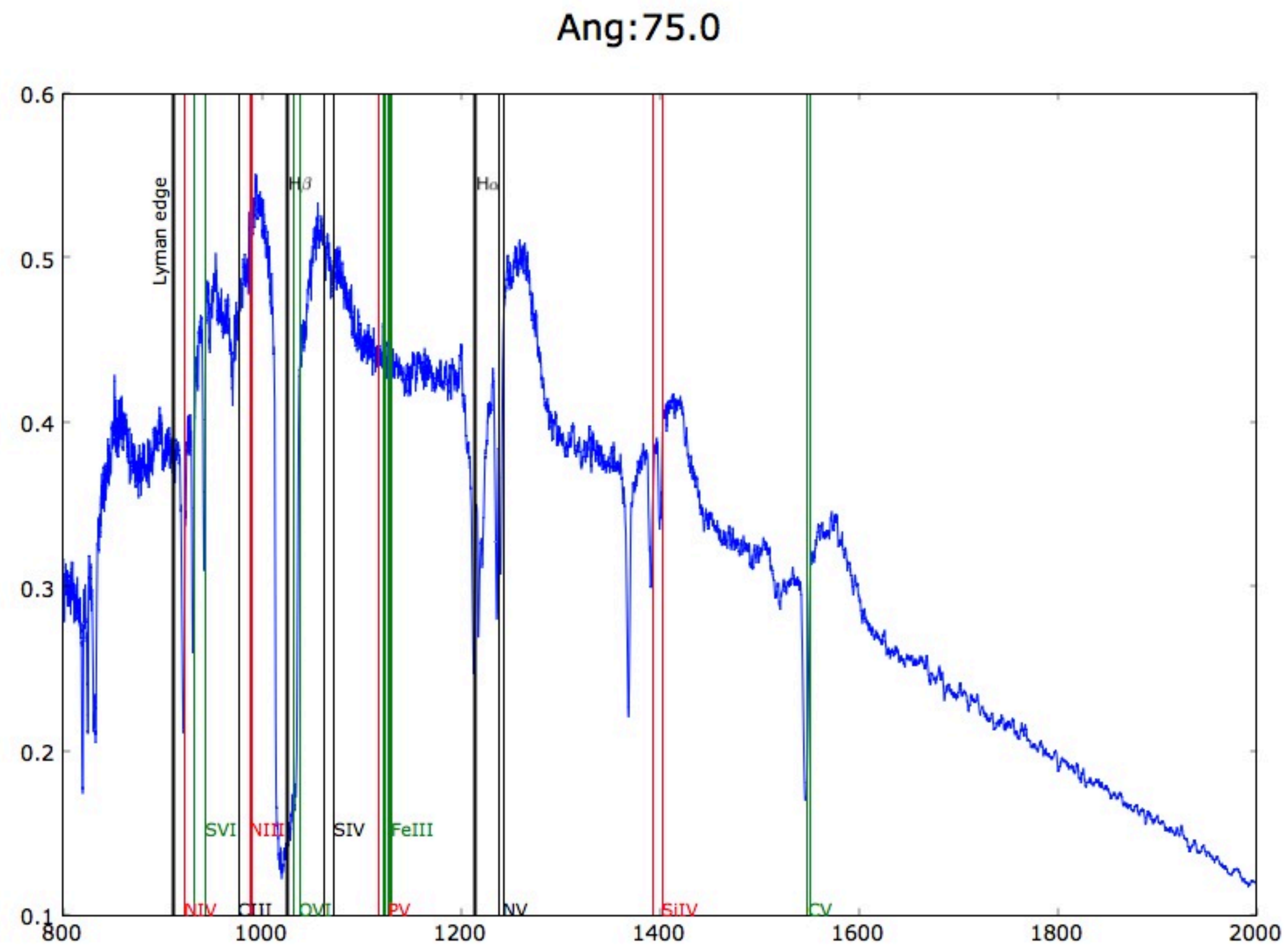






Conclusions and plans for the future

- With reasonable parameters, we have produced spectra reminiscent of those seen in BALQSOs
- Derive wind geometries that produce accurate BALQSO spectra
  - Can winds explain BAL fraction via orientation alone?
  - What should BALs look like from other angles?(QSOs hopefully!)
- Wind mass loss rates
  - Initial models agree with X-ray models in requiring outflow masses to be a significant fraction of accretion rate
  - Feedback – do BALQSO winds make a significant contribution?
- Shielding
  - Initial predictions including central X-ray sources confirm that we need some kind of compton thick shielding region
  - Location? How big? How dense?
- Thanks for your attention!



Ang:75.0
Lyman edge
Hβ
Hα
SVI
NIII
SIV
FeIII
NIV
CIII
OVI
PV
NV
SiIV
CV
0.6
0.5
0.4
0.3
0.2
0.1
800
1000
1200
1400
1600
1800
2000