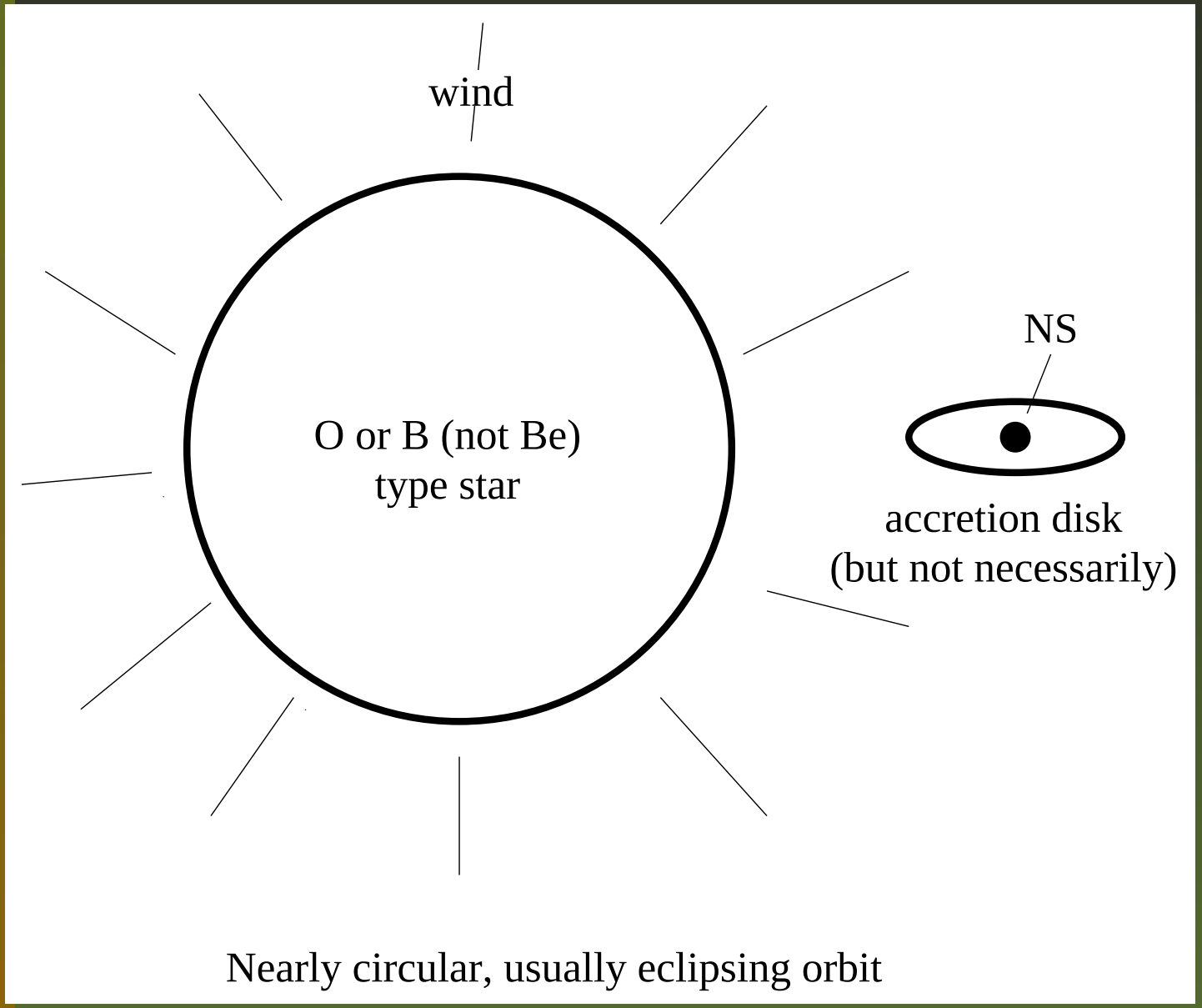
Resonant X-ray Line Scattering in the Winds of High Mass X-ray Binaries

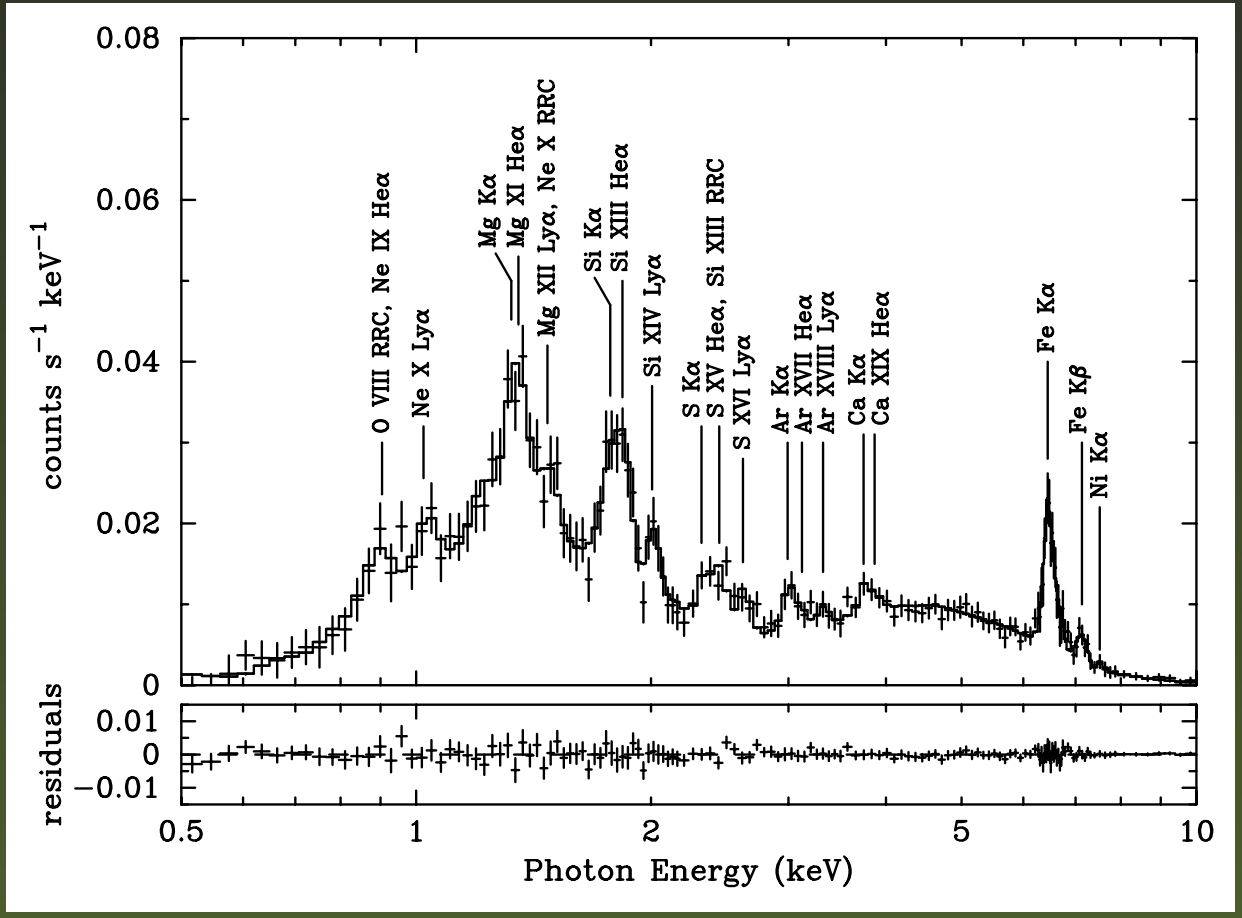
Patrick S. Wojdowski

Massachusetts Institute of Technology

OB Type High Mass X-ray Binaries

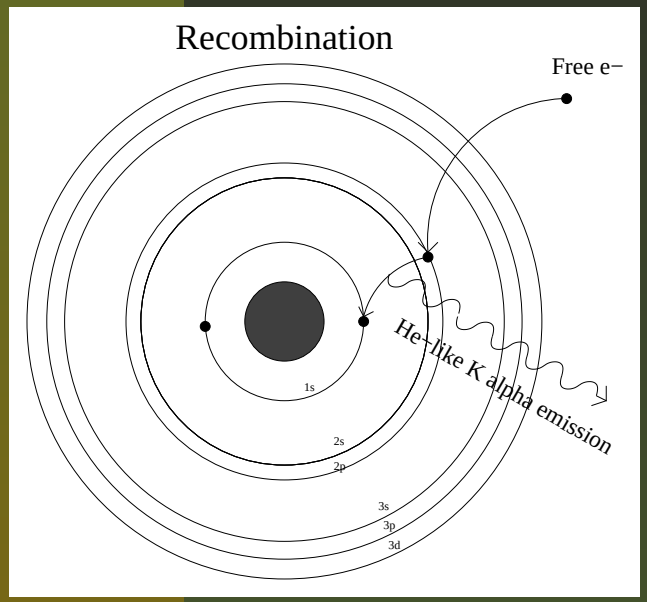


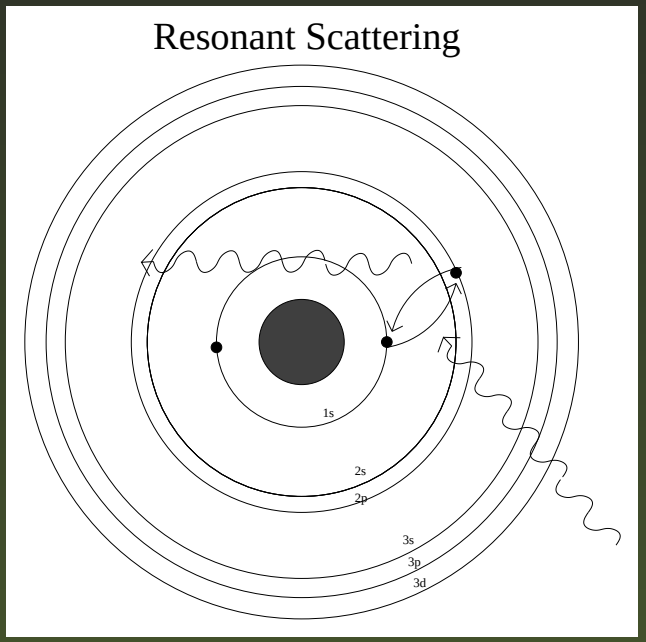
Winds with *ASCA*

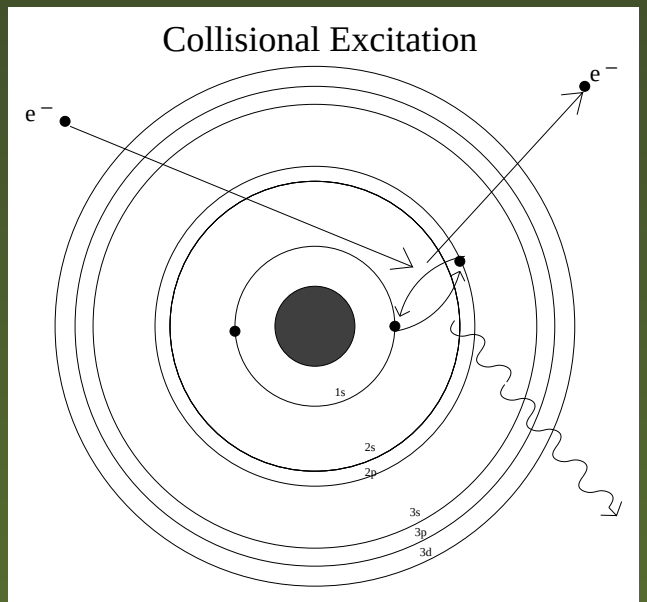


Vela X-1 in eclipse(Sako et al. 1999)

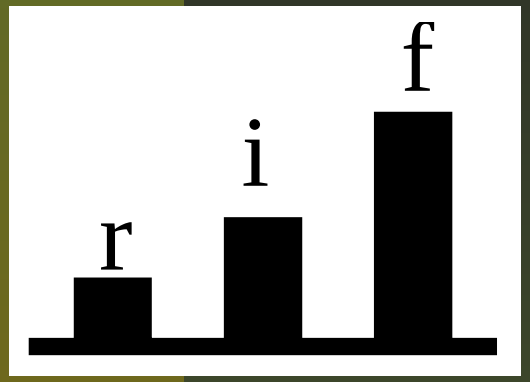
Excitation Mechanisms



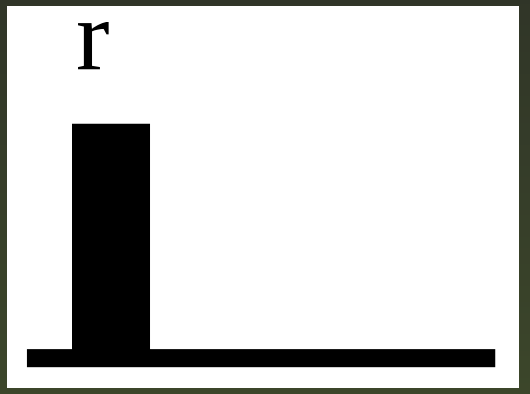




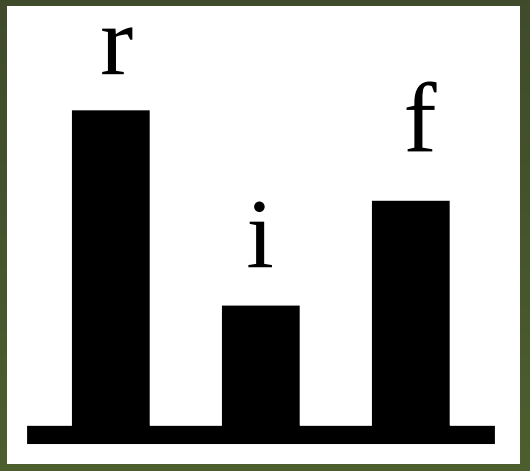
Helium-like $n = 2 \rightarrow 1$ Triplets



Recombination

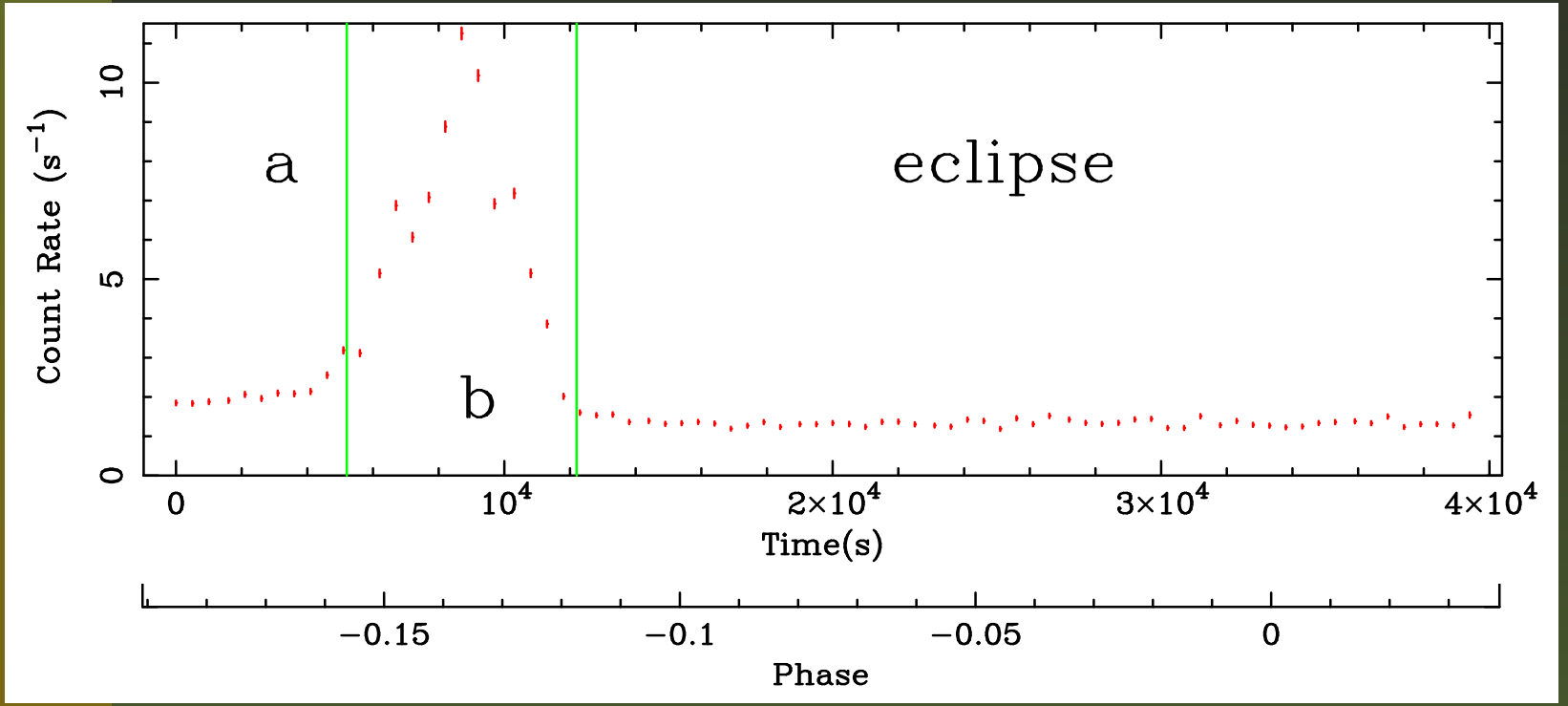


Resonant Scattering



Collisions

Chandra Observation of Cen X-3

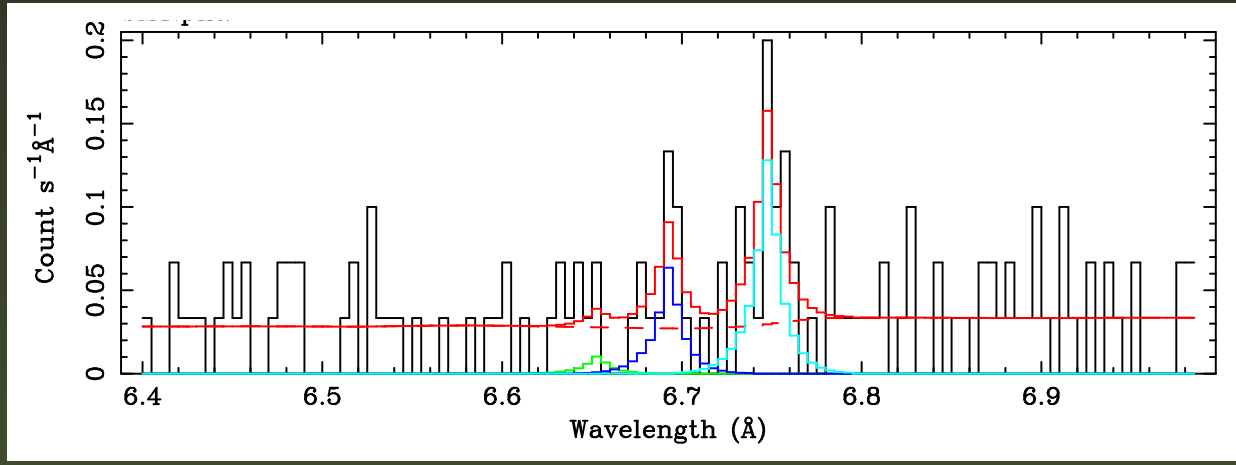


Wojdowski et al. 2003

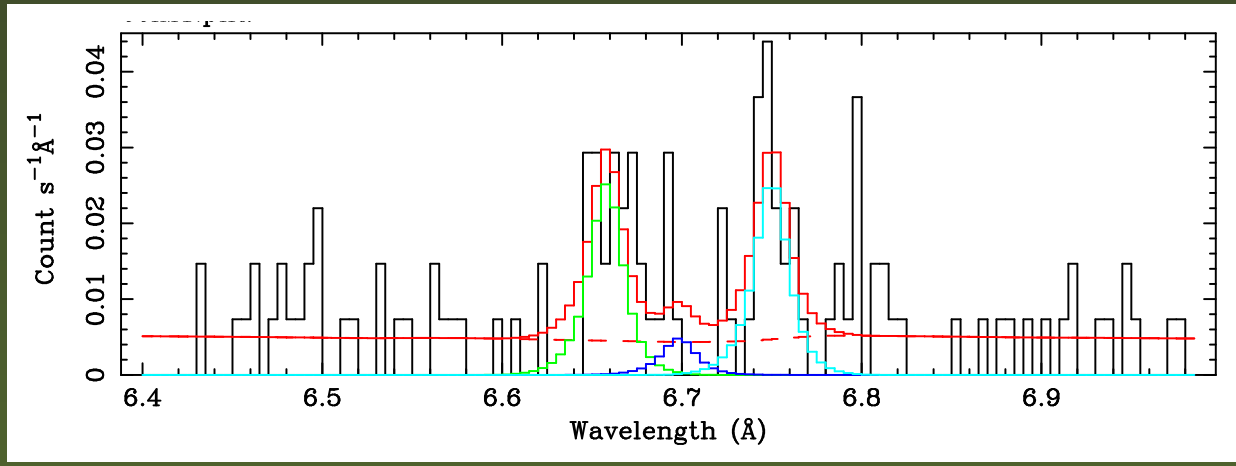
(ApJ in press, astro-ph/0206065, hereafter W03)

Observed He-like Si Triplets

Pre-eclipse(b)

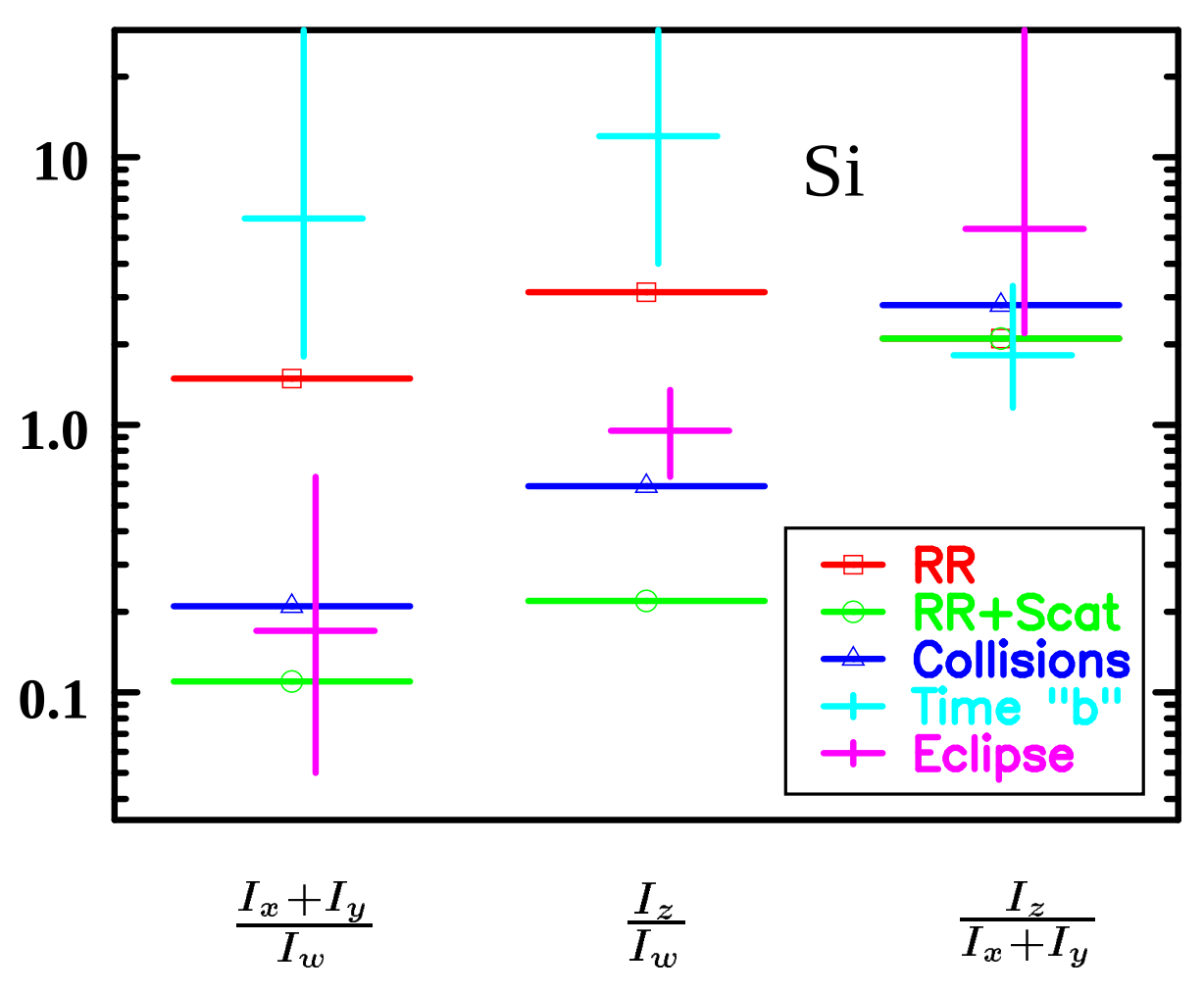


Eclipse



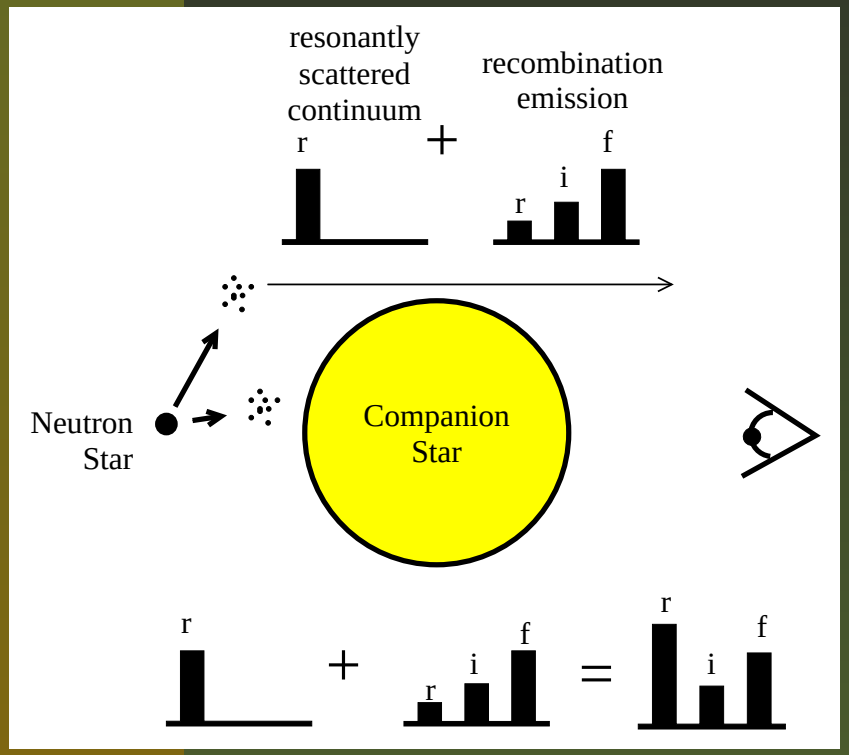
W03

Line Ratios



W03

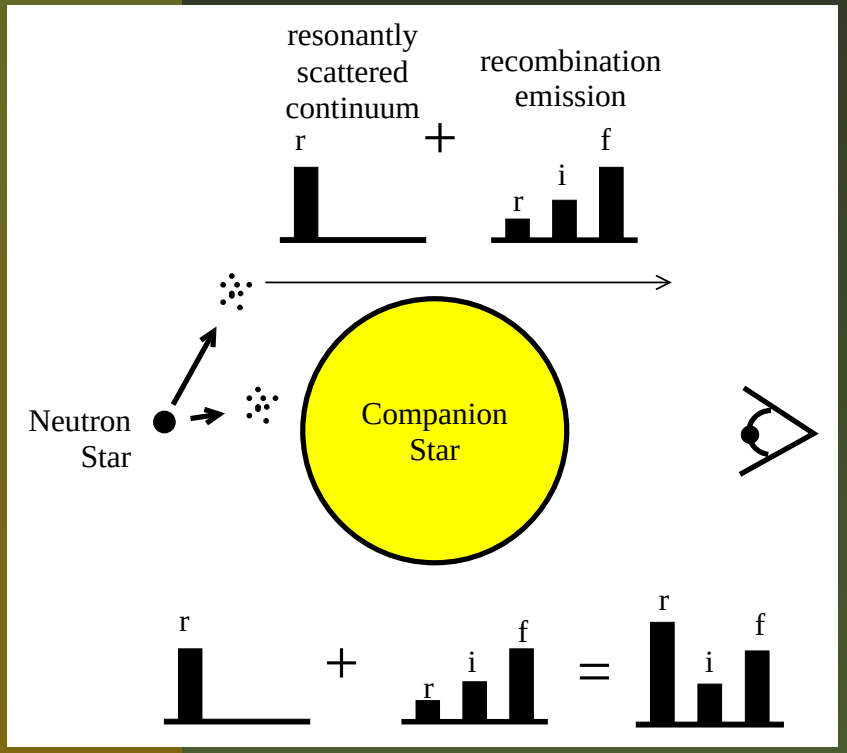
Scattering + Recombination



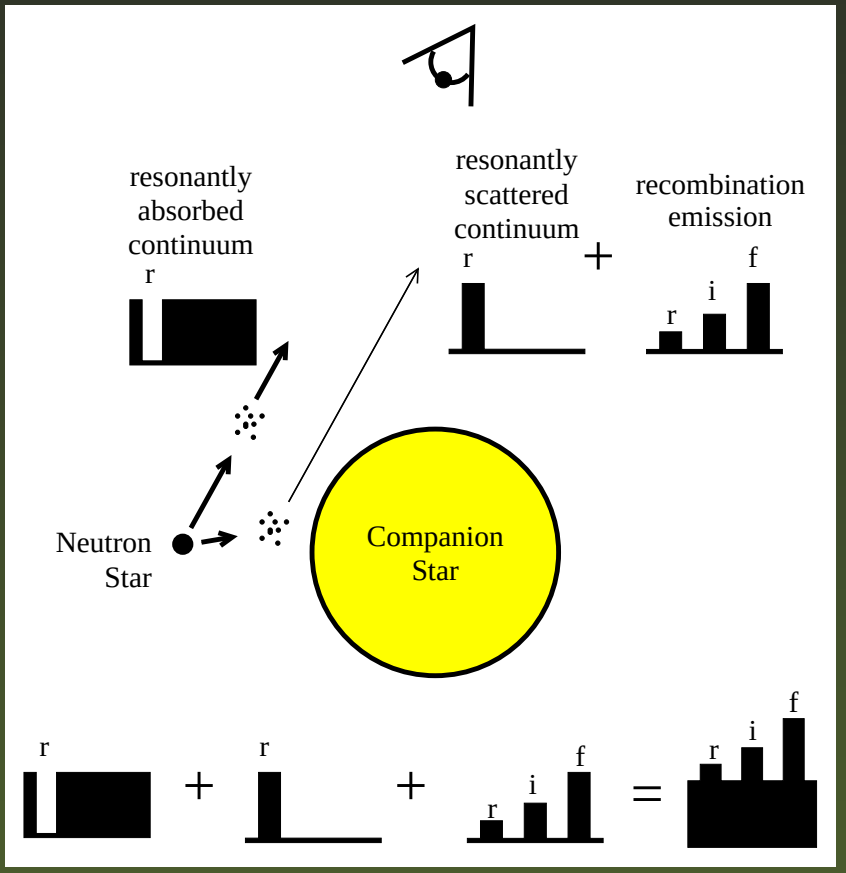
Eclipse

W03

Scattering + Recombination



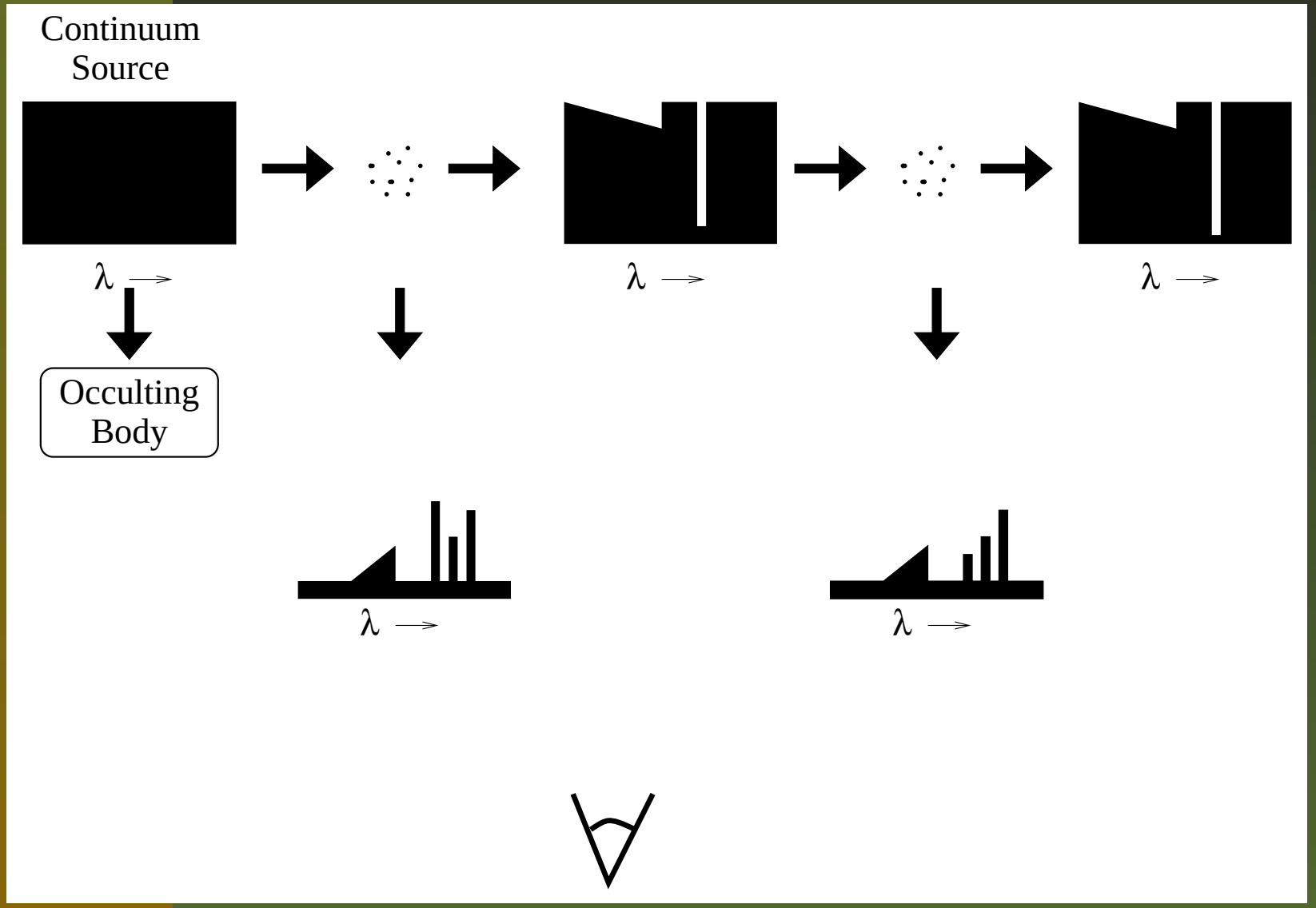
Eclipse



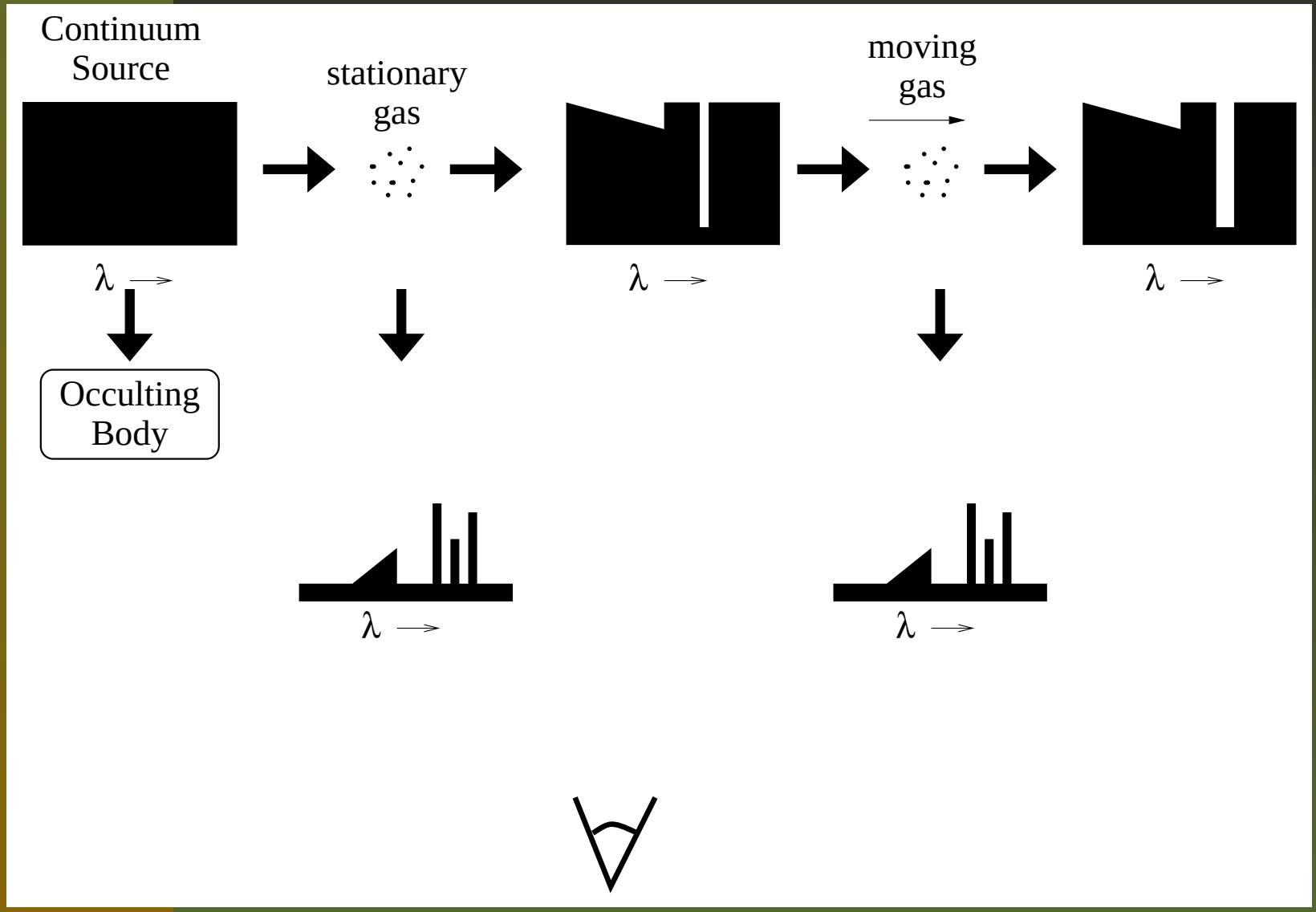
Pre-eclipse

W03

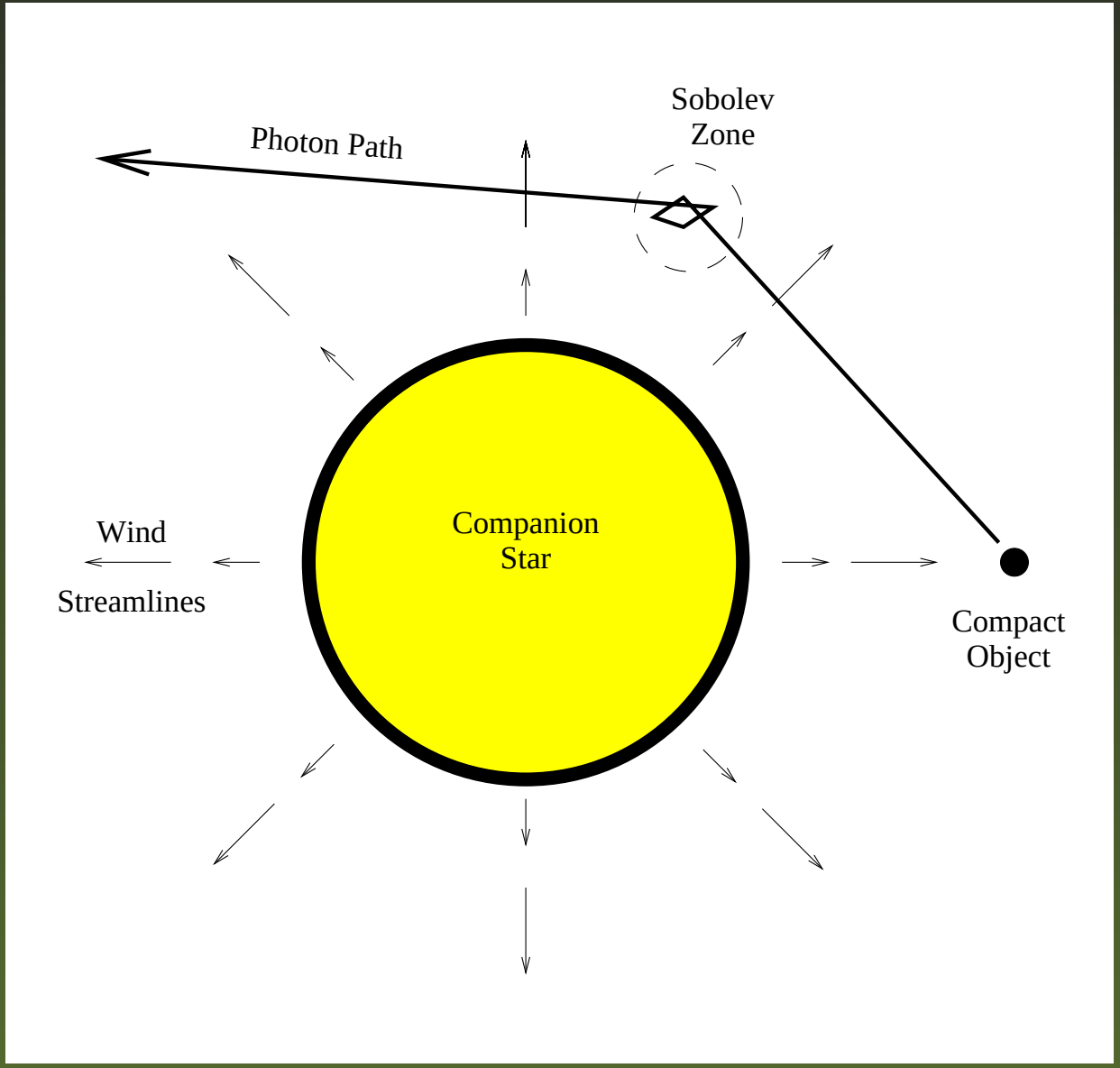
Saturation



Doppler Desaturation



Line Scattering in an HMXB



Solution of Radiative Transfer

Not too hard to derive a source function for “complete frequency and angle redistribution” :
BUT resonant line scattering:

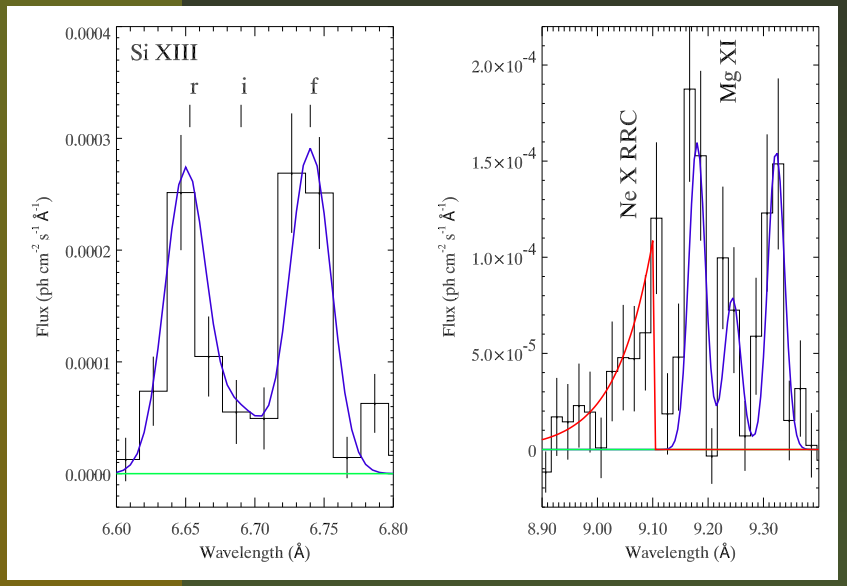
- does not completely redistribute frequencies
- does not completely redistribute angles
- is polarizing!

Monte-Carlo Approach

- Sobolev zones are independent
- Zones have only three parameters ($\hat{\mathbf{r}}$ wind radial direction)
  - τ in $\hat{\mathbf{r}}$ direction
  - τ perpendicular to $\hat{\mathbf{r}}$
  - angle to X-ray source relative to $\hat{\mathbf{r}}$
- Straightforward to include polarization

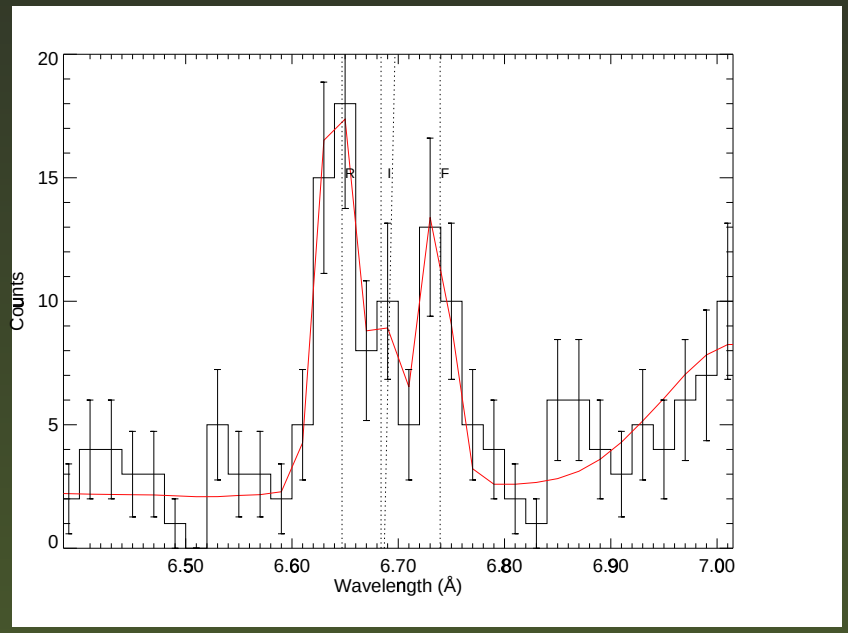
Data awaits analysis

Vela X-1 (*Chandra*)



Schulz et al. 2002

4U 1700-37 (*Chandra*)



Boroson et al. (submitted)

Conclusions

- Resonant scattering in photoionized winds is important
- Proper accounting for its effects can provide information on wind velocities
- Proper is accounting is non-trivial but possible with our Monte-Carlo approach