Investigating the Nature of Absorption Lines in the Neutron Star LMXB 4U 1820-30

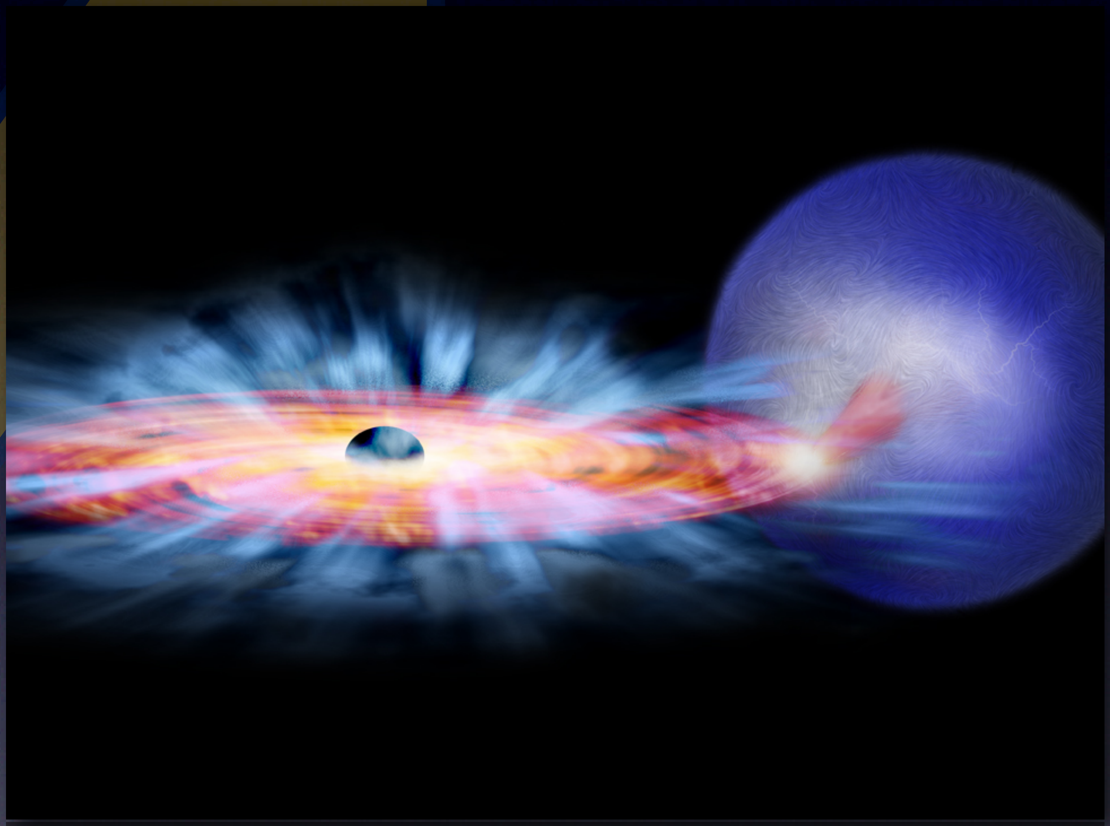
Ed Cackett
ecackett@umich.edu
Chandra Fellow, University of Michigan

see Cackett et al., 2008, ApJ, 677, 1233

Jon Miller, John Raymond, Jeroen Homan, Michel van der Klis,
Mariano Méndez, Danny Steeghs, Rudy Wijnands

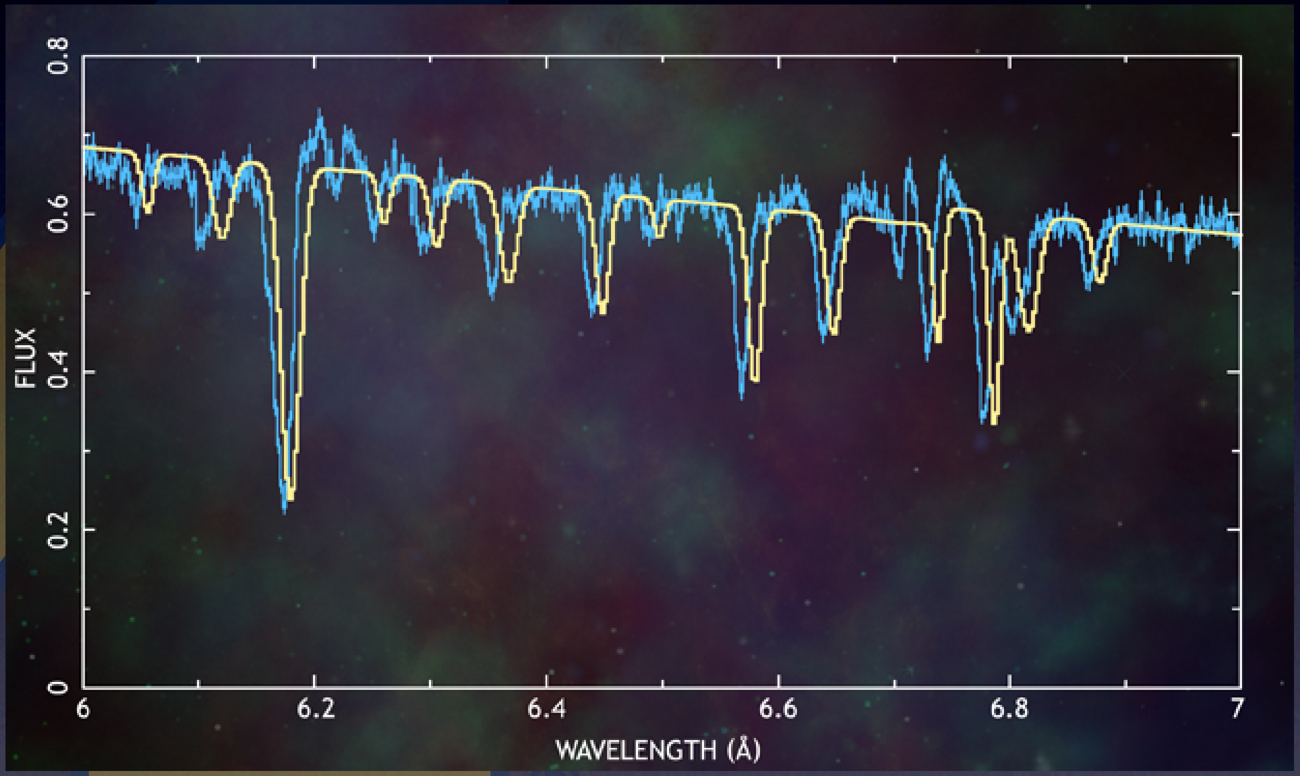
Outline

- Context: Absorption lines & disk winds in stellar mass black holes
- 4U 1820-30: an ultra-compact binary
- Results: ISM or disk wind?



Absorption lines in stellar-mass BHs

- Most outstanding case is GRO J1655-40 (Miller et al. 2006, 2008)
- line-rich spectrum (90 lines at 5σ)
- Blueshifted (300-1600 km/s)
- CLOUDY, XSTAR modeling give high density, high ionization parameter
- Implied launching radius 10 times closer to BH than predicted by thermal models....magnetic driving may be important



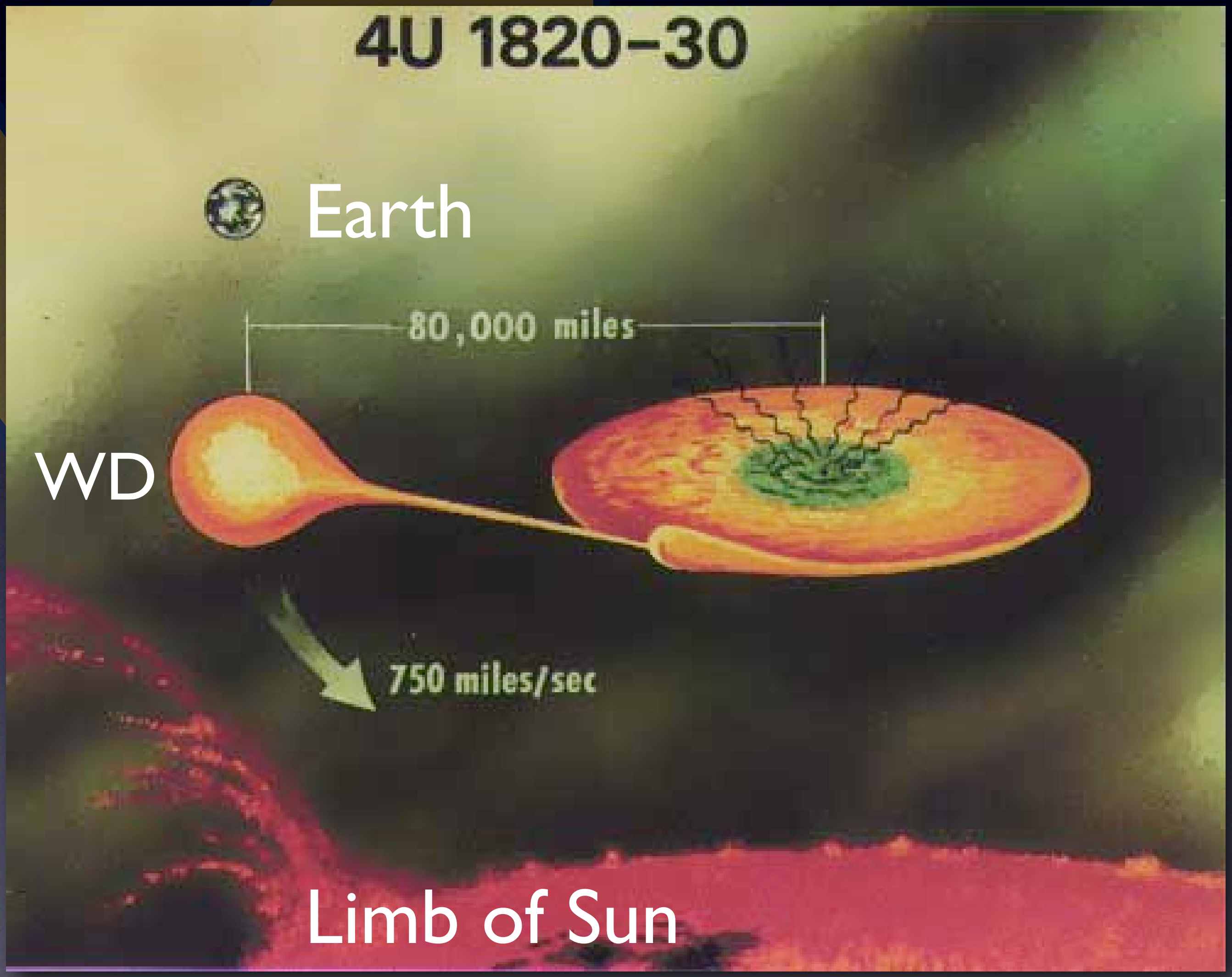
Chandra HETG spectrum of GRO J1655

Absorption lines in neutron star LMXBs

- Nothing like GRO J1655 seen in neutron stars!
- In dipping sources (where inclination is edge on) often see rich absorption spectrum (e.g. Sidoli+01, Parmar+02, Boirin+05)
- Other sources have only a few weak lines (e.g. Yao & Wang 05, Juett+06) which are consistent with absorption by hot (~10^6 K) ISM

4U 1820-30: an ultra-compact binary

- 11 min orbit (!!)
- Companion: He white dwarf
- Ideal source for testing origin of lines - we know how big the system is!



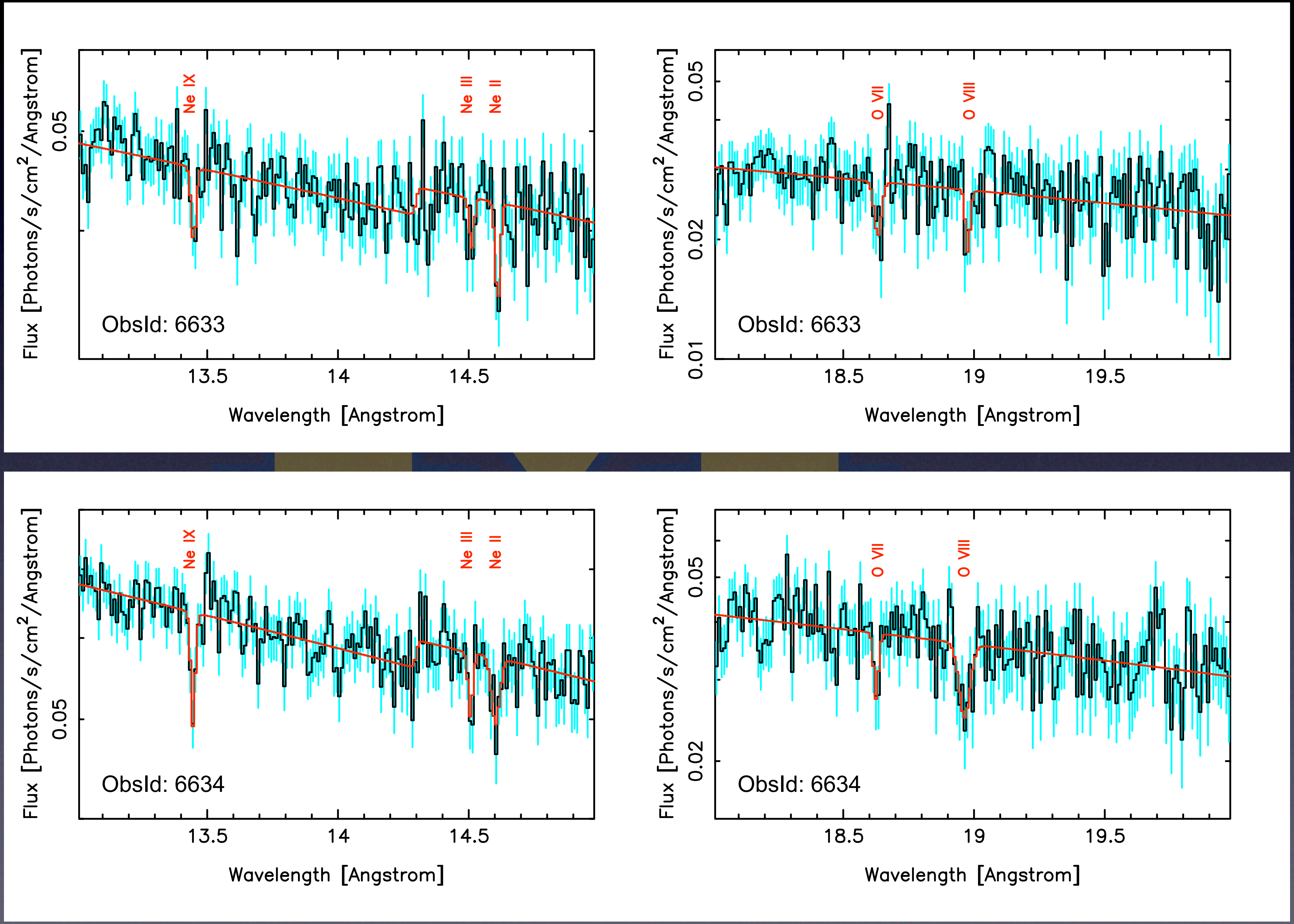
Chandra observations of 4U 1820-30

- We obtained 2 HETG obs in CC-mode (~25 ksec each)
- 2 previous HETG obs (~10 ks each; Juett +04,06; Yao & Wang 05,06)
- Multiple epochs: can look for variability - which would indicate local origin

Chandra HETG spectra

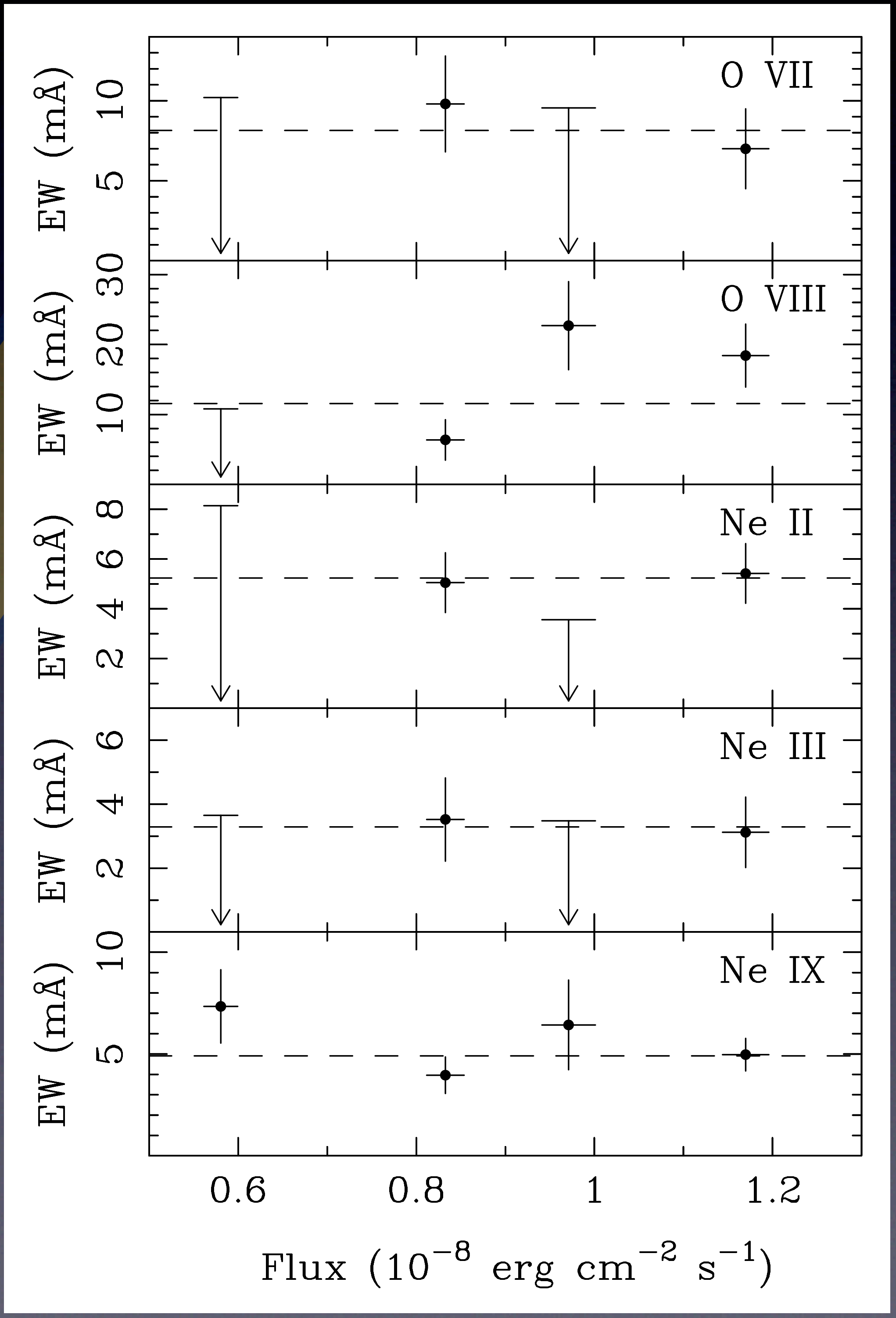
Obs. 1

Obs. 2



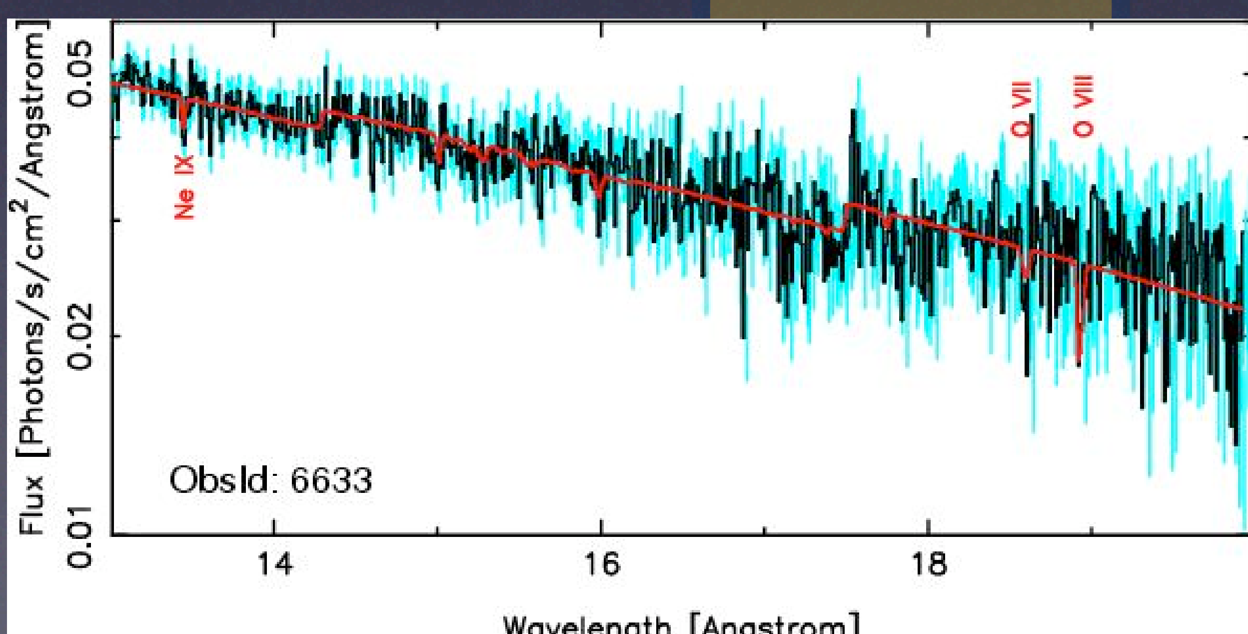
Searching for variability

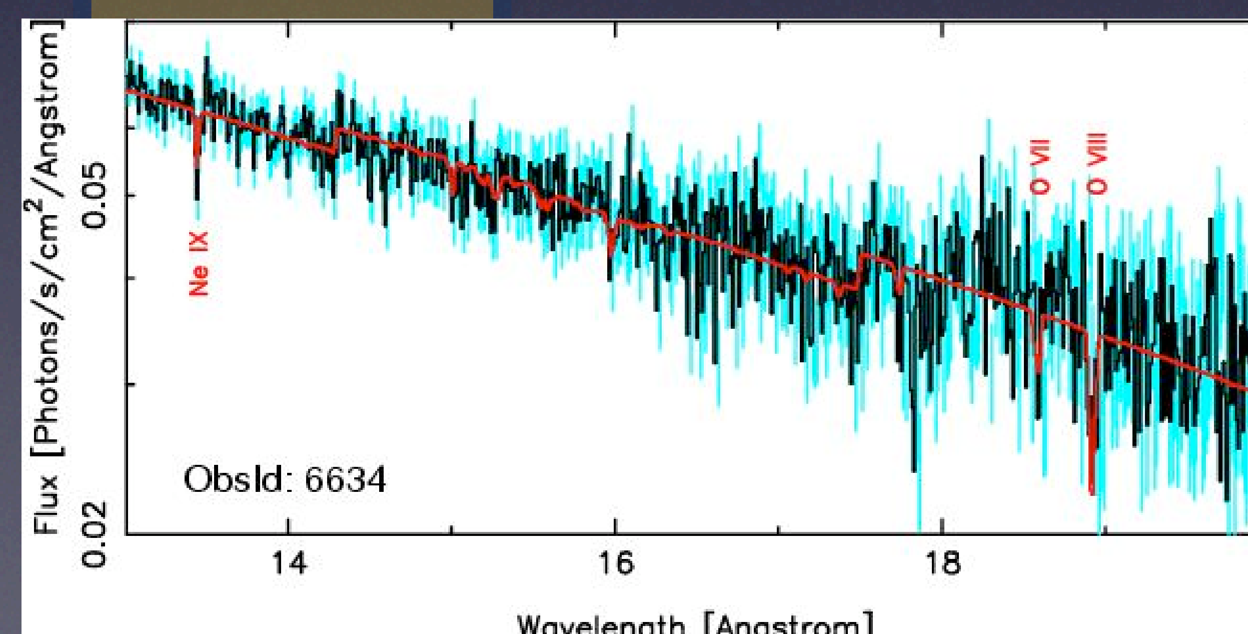
- Looked at all 4 observations
- Lines not detected in all obs.
- Only tentative variability in OVIII, but low significance



Testing local absorption origin

- Ran grids of XSTAR models, for a range of column densities and ionization parameters
- Can reproduce observed spectrum well
- Implies $n \sim 3E16\ cm^{-3}$ if within $R = 10^{10}$ cm
- BUT, gives v. low filling factor, $f = N_H/nR = 2E\text{-}7$





Testing hot ISM origin

- Assume a range of Doppler parameters, use observed EW and known oscillator strengths to determine column density for species
- Convert to equivalent H column (determine T and ionic fraction)
- N_H values all less than 1.5E21 cm^{-2} (Dickey & Lockman 90) → hot ISM origin ok

Conclusions

- So, both ISM and disk wind can both explain the spectrum though
  - ➡ no blueshifts
  - ➡ little (or no) variability
  - ➡ and extreme parameters would be needed for a local origin
- all point to hot ISM as most likely origin