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

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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
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 $n \sim 3 \times 10^6 \text{ cm}^{-3}$ if within $R = 10^{10} \text{ cm}$
• BUT, gives very low filling factor, $f = \frac{N_H}{nR} = 2 \times 10^{-7}$
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 $1.5 \times 10^{21}$ cm$^{-2}$ (Dickey & Lockman 90) $\Rightarrow$ 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