# The Suzaku View of X-ray Binaries

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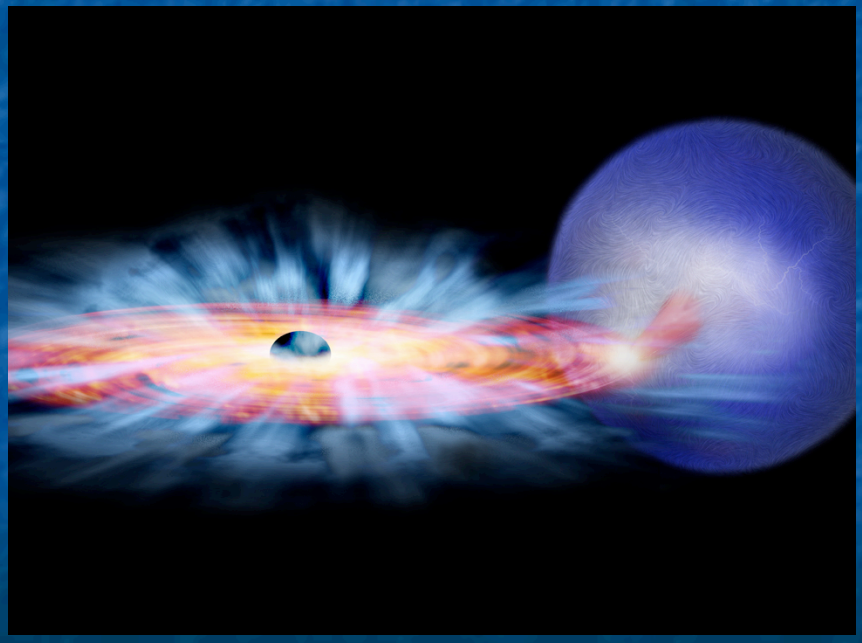
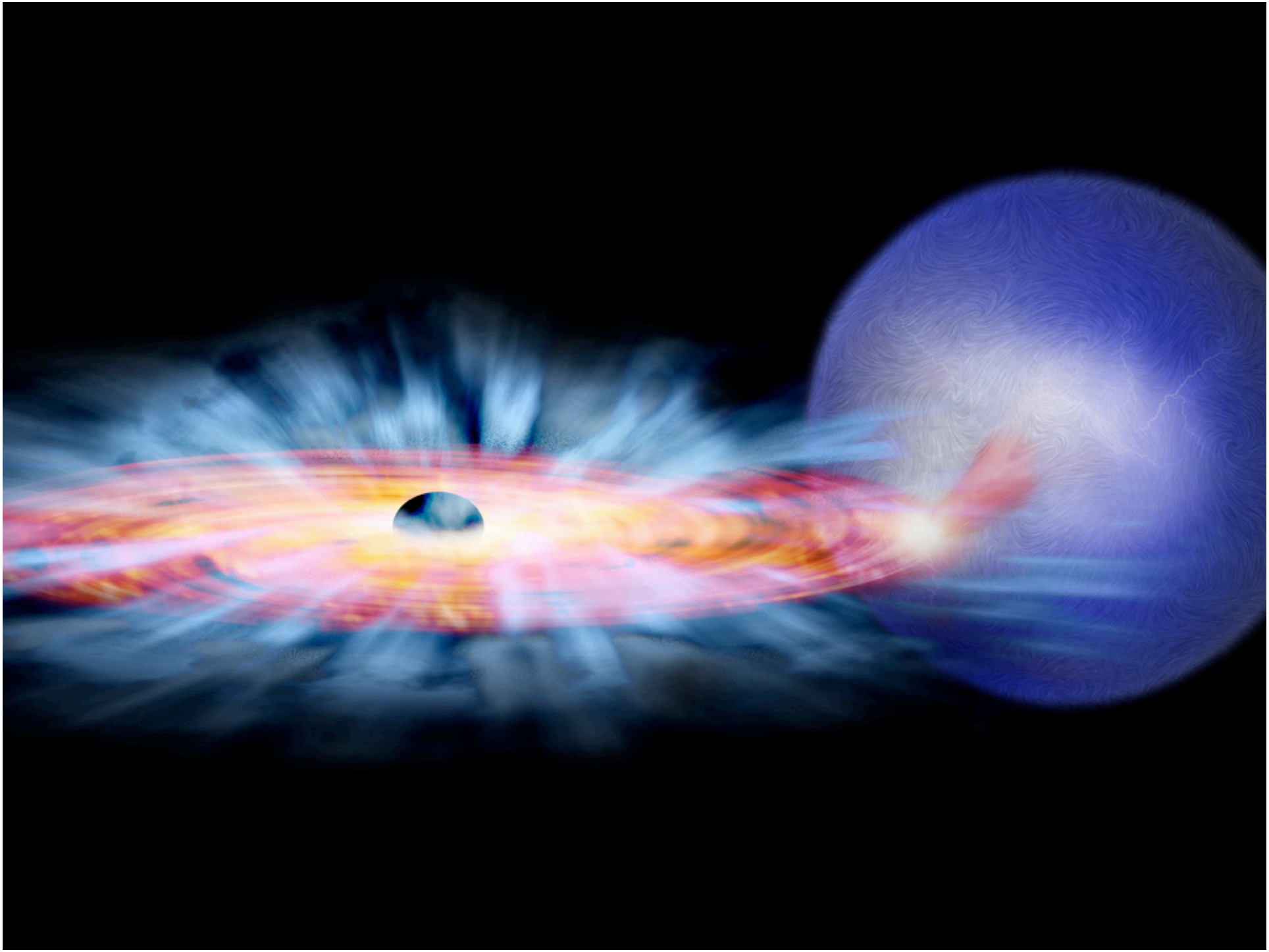
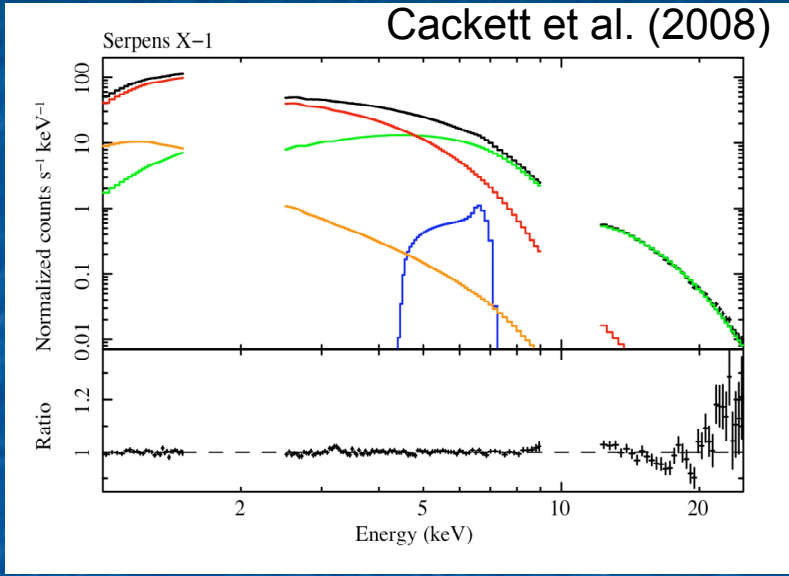




# Outline

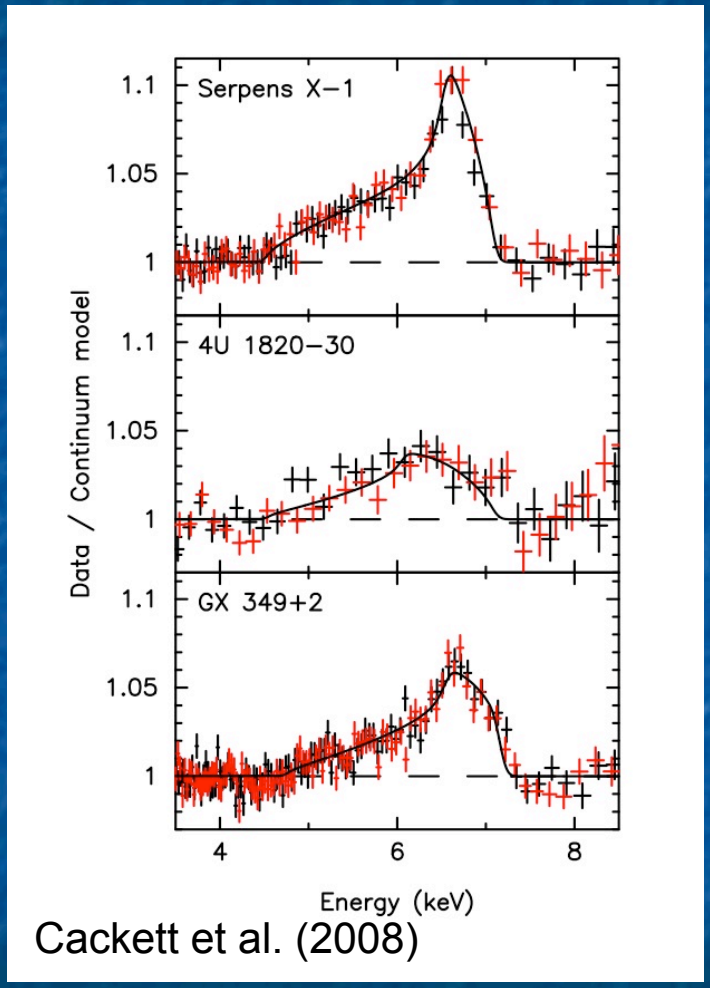
- Highlight four recent Suzaku results
  - Broad iron lines in neutron star binaries & constraints on **neutron star structure**
  - Cyclotron lines in X-ray pulsars as probes of **accretion onto magnetized neutron stars**
  - Broad iron lines in black hole binaries & the **spin of stellar mass black holes**
  - Unraveling the **structure of the accretion flow** in "low/hard" state black hole binaries
- In all cases, we see the power of broad-band spectroscopy at work

# I : Broad iron lines in neutron star binaries: a new probe of neutron star structure

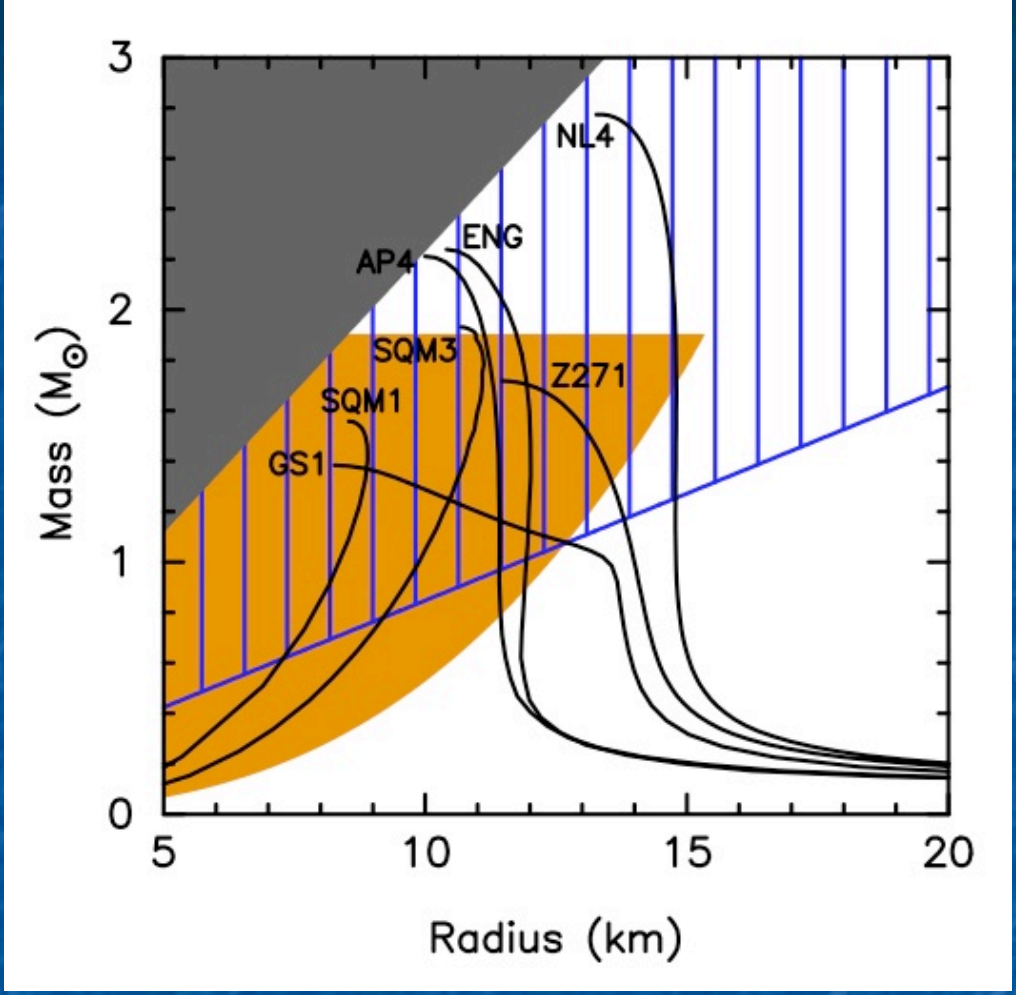



See skewed iron emission lines…

- First reported in XMM-Newton data of Serpens X-1 by Bhattacharyya & Strohmayer (2007)
- **Broad band of Suzaku useful for robust modeling of curved continuum spectrum**
- Readily interpreted as relativistically skewed lines from innermost accretion disk
- Direct constraint on M/R of innermost disk




(Lines also report in XMM/RXTE data of 4U1636-536; Pandel et al. 2008)




Cackett et al. (2008)

Iron lines constrain M/R at the inner edge of the disk… assuming $M=1.4M_{sun}$, we have

Serpens X-1 ; $R_{in}$=16±1 km
4U 1820-30 ; $R_{in}$=13.8 (+3-1.4) km
GX349+2 ; $R_{in}$=16.5±0.8 km

Iron lines constrain inclination of the inner disk… inconsistency between estimates of binary inclination (35-50 degs) and iron line inclination (<24 degs) in 4U1820-30.

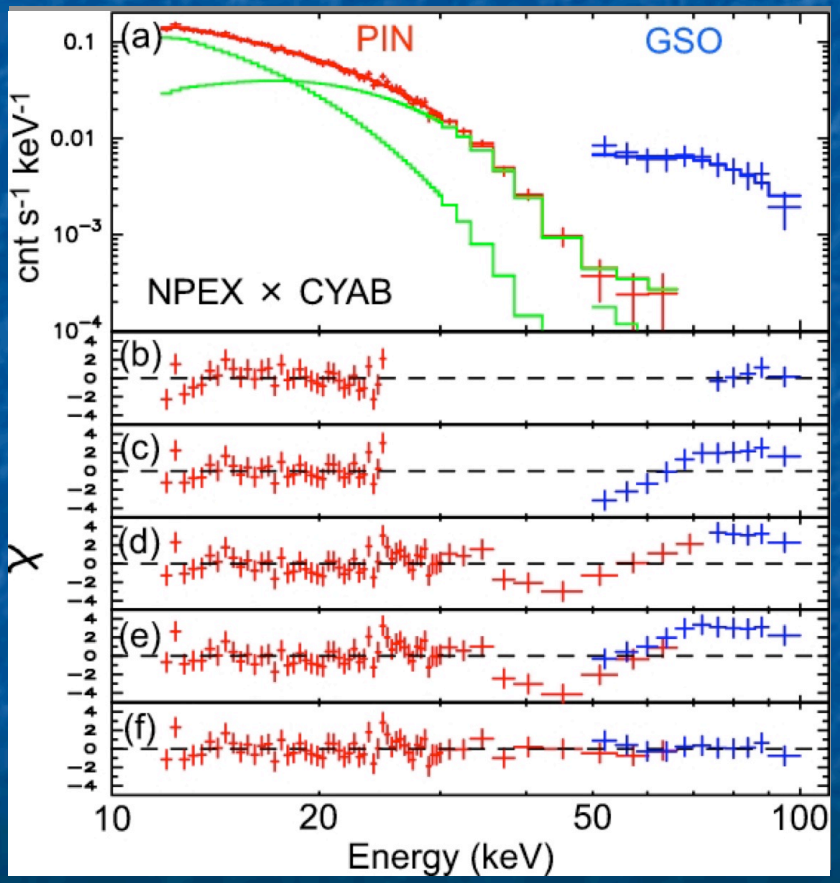
Evidence for warping of the disk away from the plane of the binary?

# II : Cyclotron resonance lines in X-ray pulsars: constraints on NS polar accretion

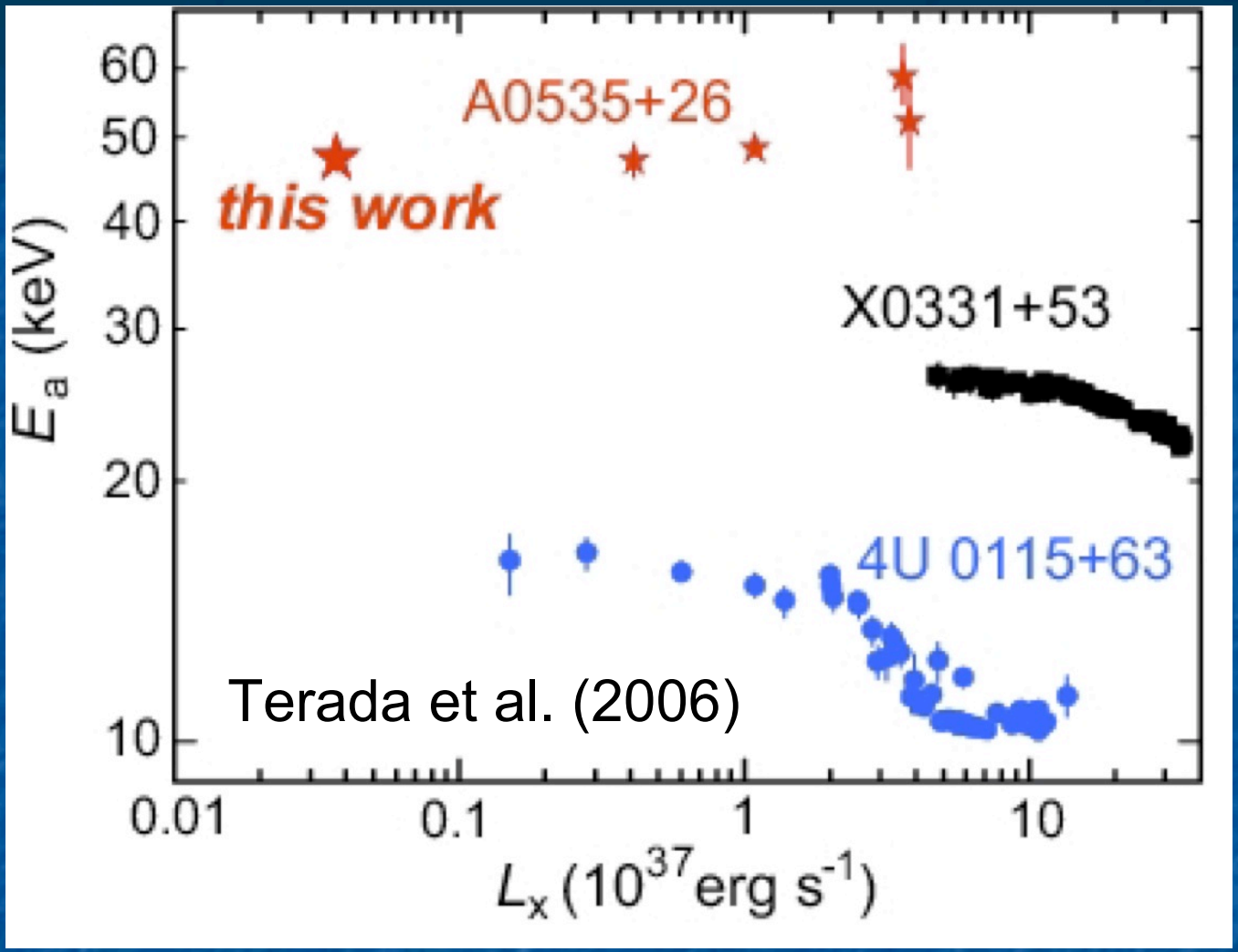
- Accretion onto highly magnetized neutron stars…
  - Can get hard X-ray absorption line due to cyclotron resonance

$$E_a = 11.6 \left( \frac{B}{10^{12} G} \right) \text{ keV}$$

  - Previously only seen in very luminous states of X-ray pulsars
  - Suzaku allowed us to push down to lower-L systems (Terada et al. 2006)

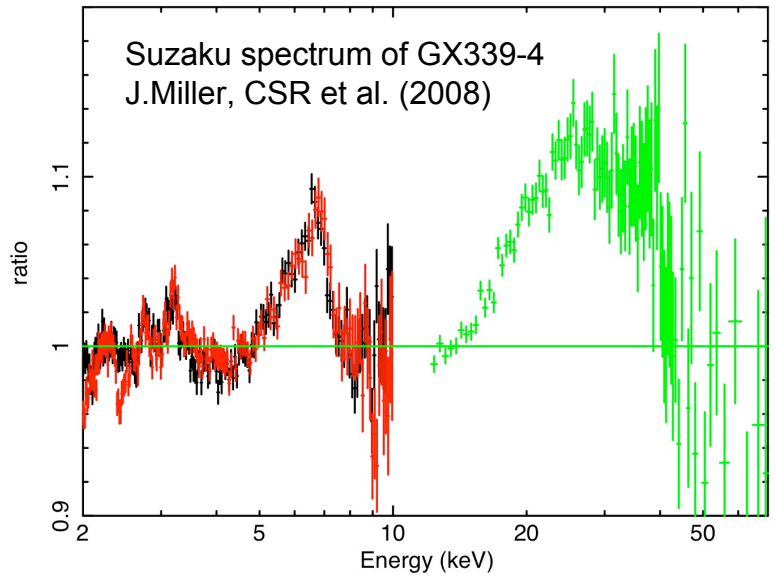



Terada et al. (2006)




Probing changes in the accretion column (and hence B-field at emission location) as a function of accretion rate

# III : Broad iron lines in black hole binaries : the spin of stellar mass black holes



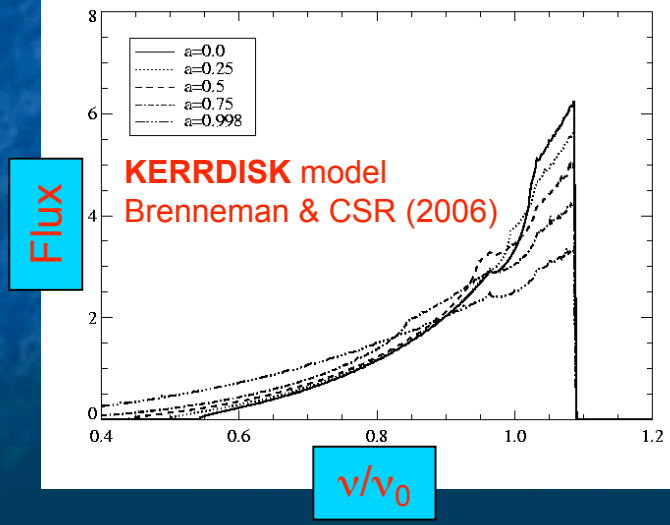

Spin of GX339-4…

a=0.89±0.04 (Suzaku alone)
a=0.93±0.01 (XMM+Suzaku)

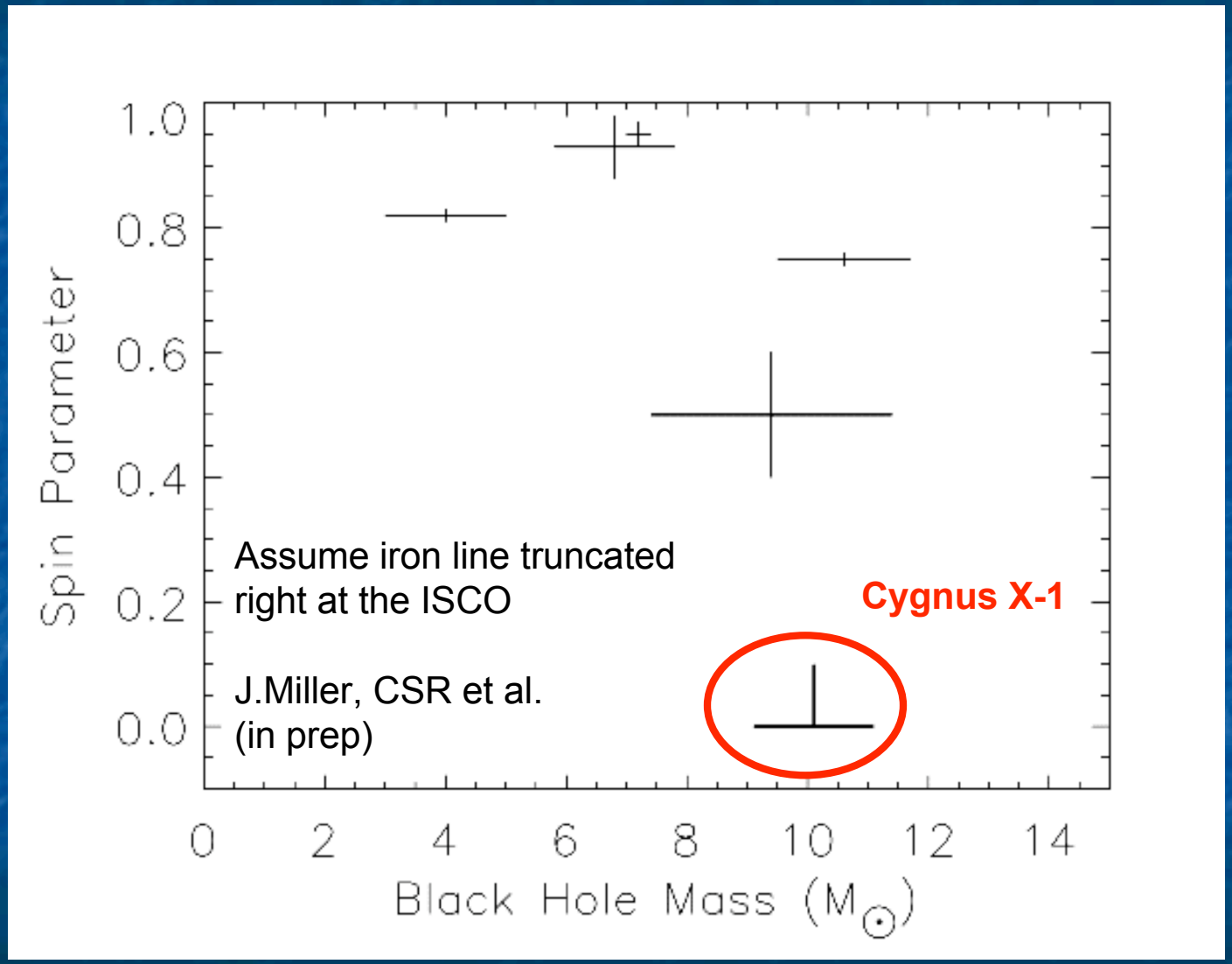
Current best estimate:
a=0.93±0.01 (stat) ±0.04 (sys)

Model continuum as thermal disk + powerlaw

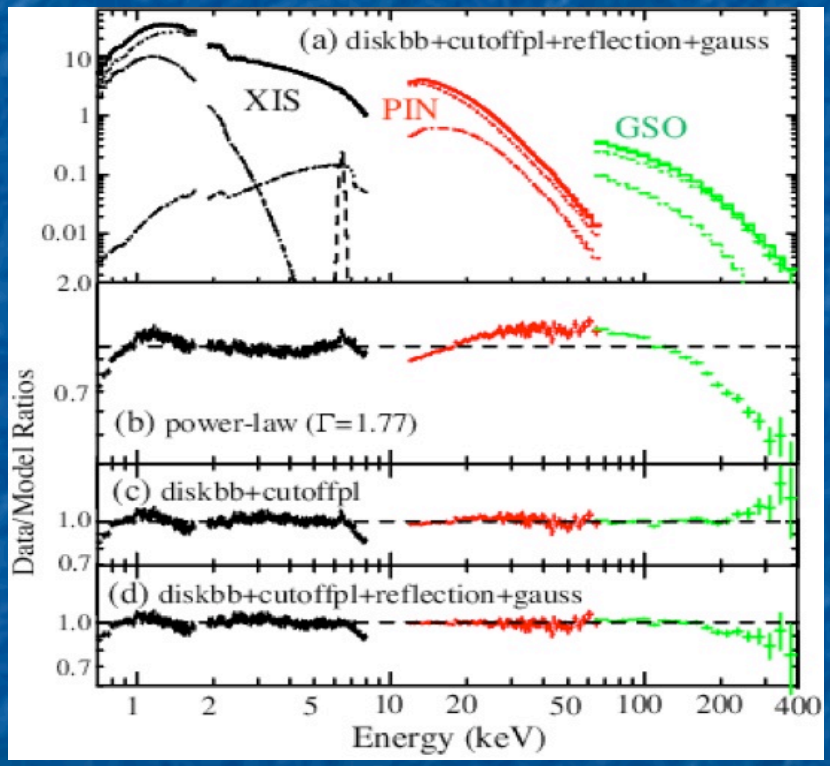
Then model relativistic blurring of the full reflection spectrum from an an ionized disk



# First results from a sample of stellar mass black holes (montage of data from various satellites & various states)



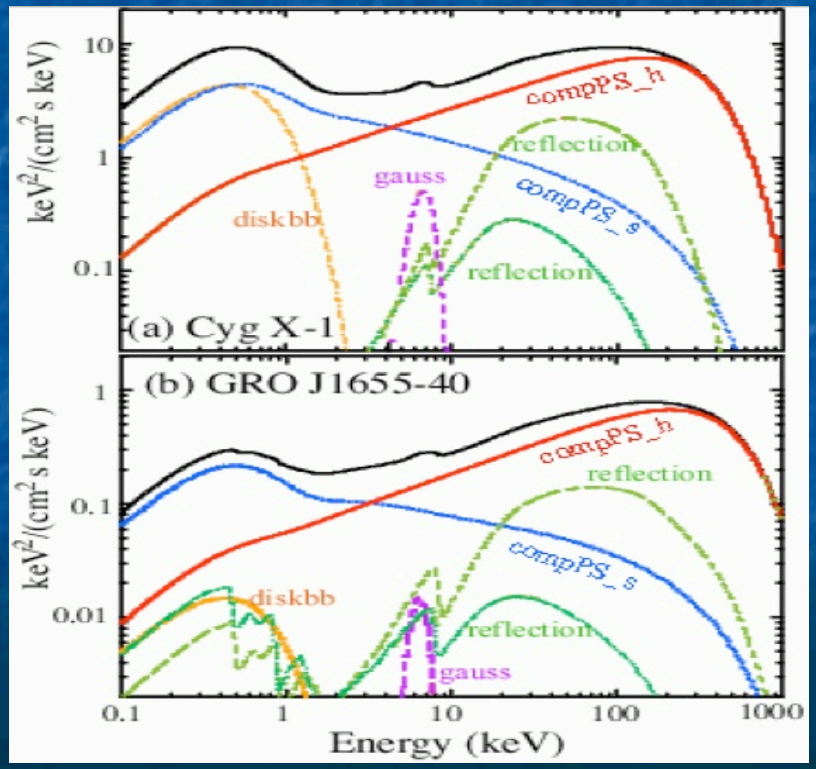
# IV: Broad-band spectroscopy of GBHCs: Unraveling the structure of low/hard state accretion flows

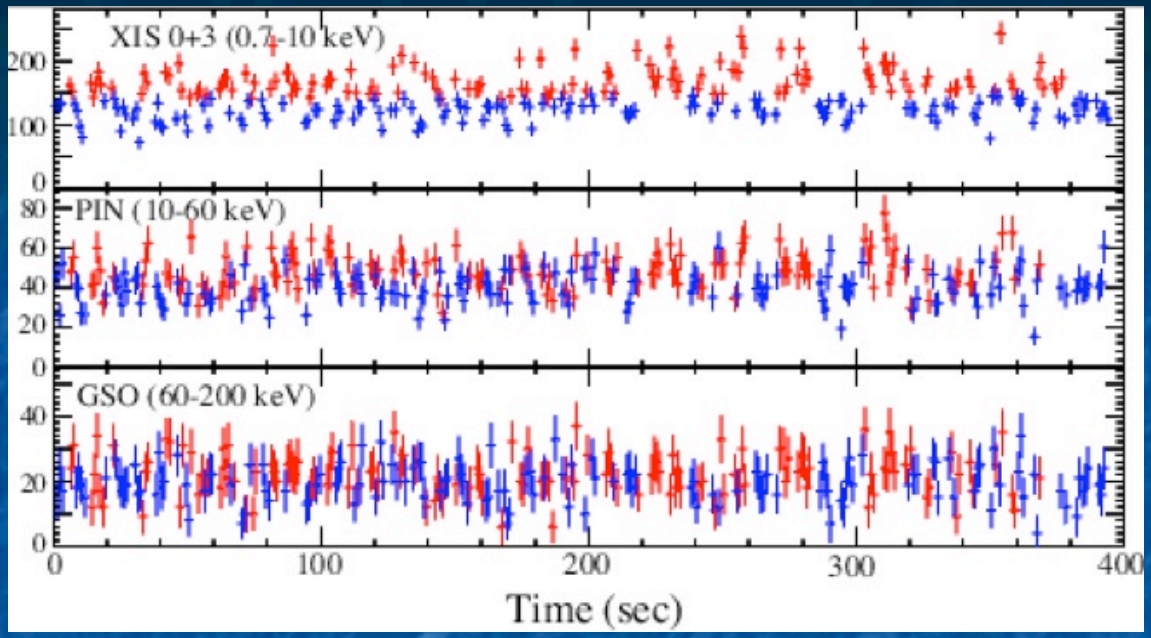



Suzaku spectrum in 0.7-400keV band

**Makishima et al. (2008)**

Needs at least two Comptonization components (also see BeppoSAX work; Frontera et al. 2001)
Iron line ⇒ cold disk at r~15-20$r_g$

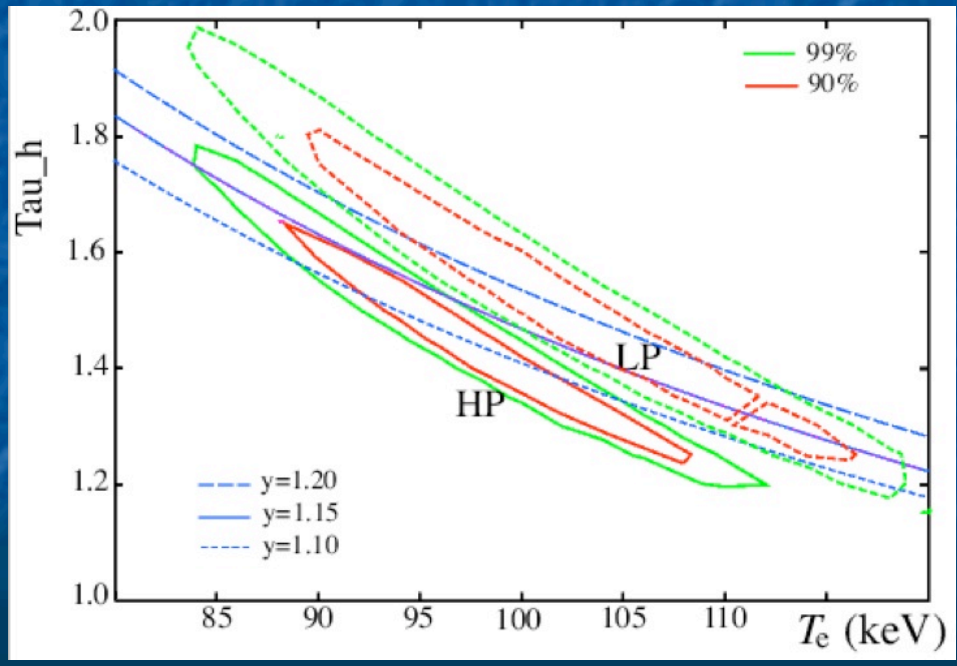





Cygnus X-1
(Makishima et al. 2008)

Detect changes in spectrum as a function of flux…

Seed photon input into Compton cloud increases… cloud cools and brightens.



# Summary

- Broad-band sensitivity of Suzaku makes it a powerful tool for probing accreting compact objects
- Highlighted four studies:
  - Broad iron line constraints on NS structure
  - Cyclotron line constraints on polar NS accretion
  - Broad iron line constraints on stellar-mass BH spin
  - Broad band continuum studies of stellar-mass BH systems and the structure of low/hard state accretion flows