Relativistic Iron Lines in Black Holes and Neutron Stars

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Cackett, Fabian, Reynolds
Homan, van der Klis, Rupen, Steeghs, Wijnands
The disk continuum

McClintock et al. 2006: $a = 0.98$ in GRS 1915+105
A Harder Look at the Continuum

Diskbb + Power-law

Diskbb + CompTT
High radius (spin) precision is impossible with disk continua
X-ray Disk Lines

Graph 1: 
- **ISCO (r_g)** vs. **Spin parameter (a/M)**
  - Schwarzchild
  - Maximal Kerr

Graph 2: 
- **Line Intensity** vs. **Energy (keV)**
  - Graph shows a peak at around 6 keV
Suzaku: GX 339-4

![Graph showing the ratio of Suzaku observations to GX 339-4 energy vs. keV.]
Suzaku: GX 339-4

Miller et al. 2008

diskbb+pow

diskpn+pow

diskbb+comptt

diskbb+pow
The continuum in stellar-mass BHs is rather simple.
No warm absorber (no means N_OVIII 10^-2 less).
Suzaku: Reflection Machine

GX 339-4, RXTE PCU2 (black) HEXTE-B (blue)
GX 339-4, RXTE PCU2 (black) HEXTE-B (blue)

Suzaku (red)
A 1.4 Msun neutron star with a radius of 10 km is about 4.5 times $GM/c^2$.

This is very similar to the 6 $GM/c^2$ ISCO expected for $a=0$ black holes.
Relativistic lines in neutron stars!

Cackett, Miller et al. 2007

$r^* < 14-16 \text{ km}$
Interesting corollary:

2.0 Msun NS
--> 3.3 GM/c^2

3.0 Msun NS
--> 2.2 GM/c^2

Massive neutron stars start to look like spinning black holes.

Indirect masses?
GX 339-4 and Serpens X-1

A game to be played with a large sample!!
Toward spin in GX 339-4

Brenneman & Reynolds line model
Assume disk always at ISCO.
Convolve line, reflection.

Suzaku only: $0.3 < a < 0.7$
XMM only: $0.7 < a < 0.98$
joint fits: $0.7 < a < 0.95$
5-10 new + 5-10 known black hole transients.

3 observations of 10 outbursts, 50 ksec each.

1.5 Msec for 15 black hole spin constraints.

12 persistent + 4 transient neutron star binaries.

3 observations of each source at 50 ksec.

2.4 Msec for 16 stellar radius limits.

5% of total time in a 10 year mission.
More Challenges

• Are disk lines present in BH high/soft states?
• Can we reveal the corona with reflection?
• At what $L_X/L_{Edd}$ do lines disappear?

• Can we see the 20-30 keV hump in a NS?
• How do lines vary through a Z/atoll track?
• How many masses can we get? (Cackett)
Summary

• Suzaku is ideal for the study of disk reflection in Galactic black holes and neutron stars.

• Relativistic lines in neutron stars have been clearly revealed, can constrain radii (Cackett).

• With broad-band spectra and new models, the time has arrived for BH spin constraints.

• *Meaningful samples only require 5% in 10 yrs.*
Iron lines are the worst way to reveal compact objects ... apart from all the others.

Winston Churchill∗

∗ not so much
The disk continuum

McClintock et al. 2006: $a = 0.98$ in GRS 1915+105
X-ray Disk Lines

(Fabian et al. 2000)

low spin (Schwarzschild)

high spin (Kerr)

(Miller et al. 2004, 2005)

Cygnus X–1

GX 339–4
Continuum \textit{In}-dependence
X-ray Disk Lines
GX 339-4 and Serpens X-1