

A systematic study of the ~1keV emission-like feature in the spectra of X-ray binaries



Speaker:
Filippos Koliopanos

Exploring the Hot and Energetic Universe:

**The second scientific conference dedicated to the
ATHENA X-ray observatory**



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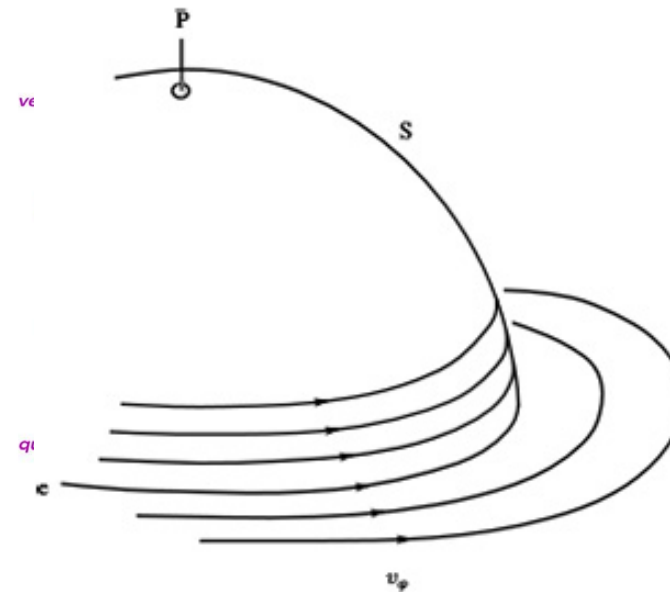
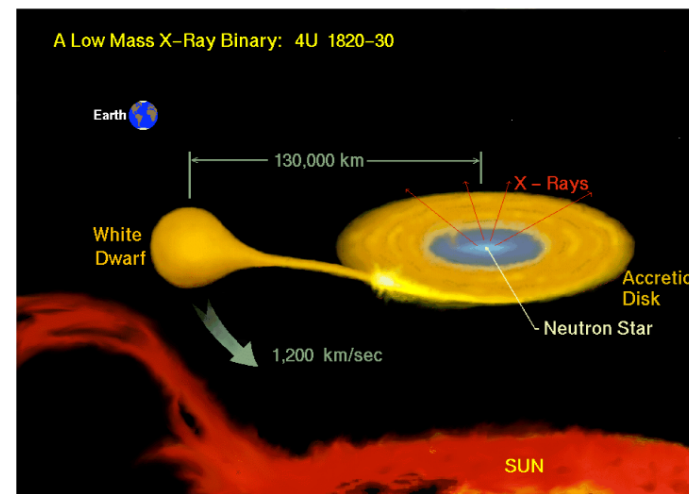


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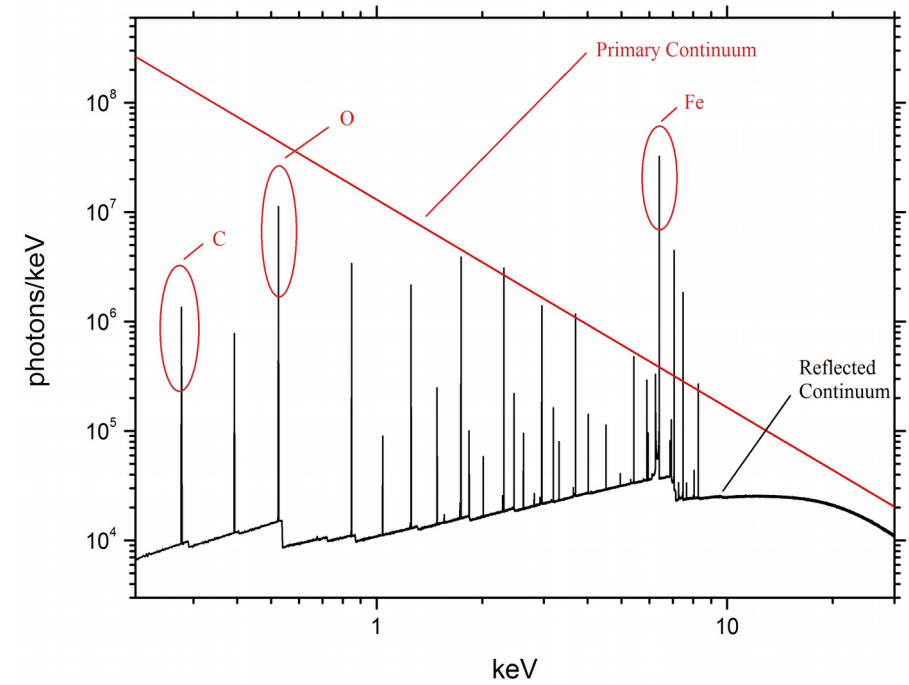
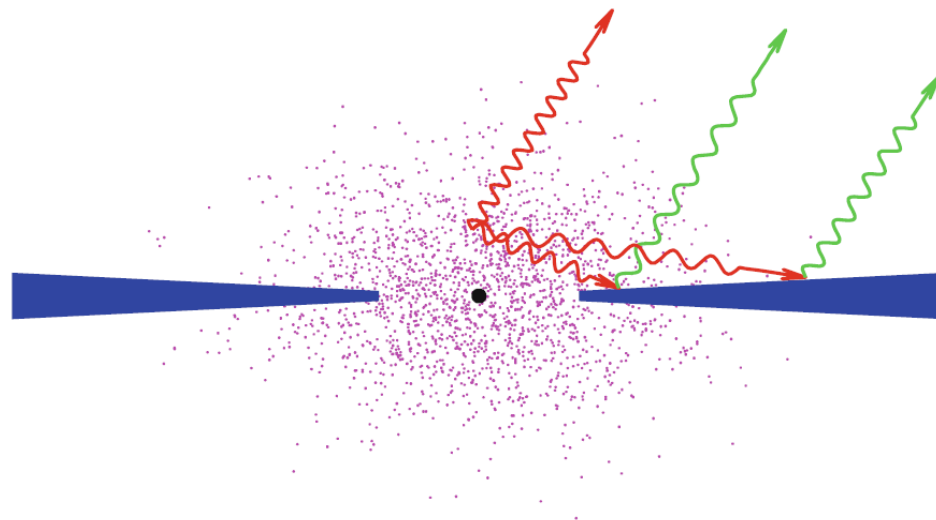




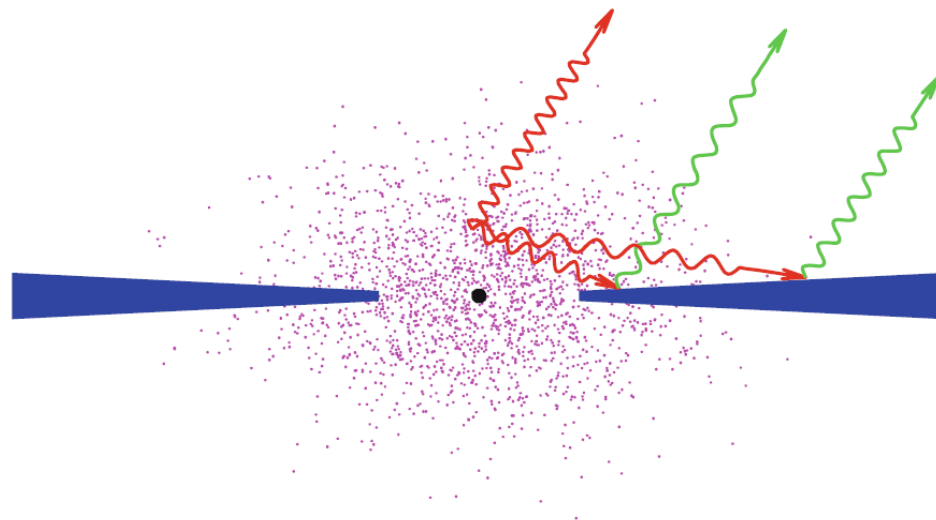
A schematic diagram of a neutron star and its surrounding environment. At the center is a sphere labeled "NEUTRON STAR" with a vertical axis and a curved arrow indicating rotation. Surrounding the star is a thick, shaded "ACCRETION DISK". Several concentric, teardrop-shaped loops represent magnetic field lines. Two wavy lines with arrows represent "PENCIL-BEAM" emissions originating from the poles of the star. A larger, shaded wedge-shaped region represents a "SHOCK". A wavy line with an arrow, labeled "FAN-BEAM", originates from the inner edge of the accretion disk. The entire diagram is set against a light gray background.

F.K. & Gilfanov 2016

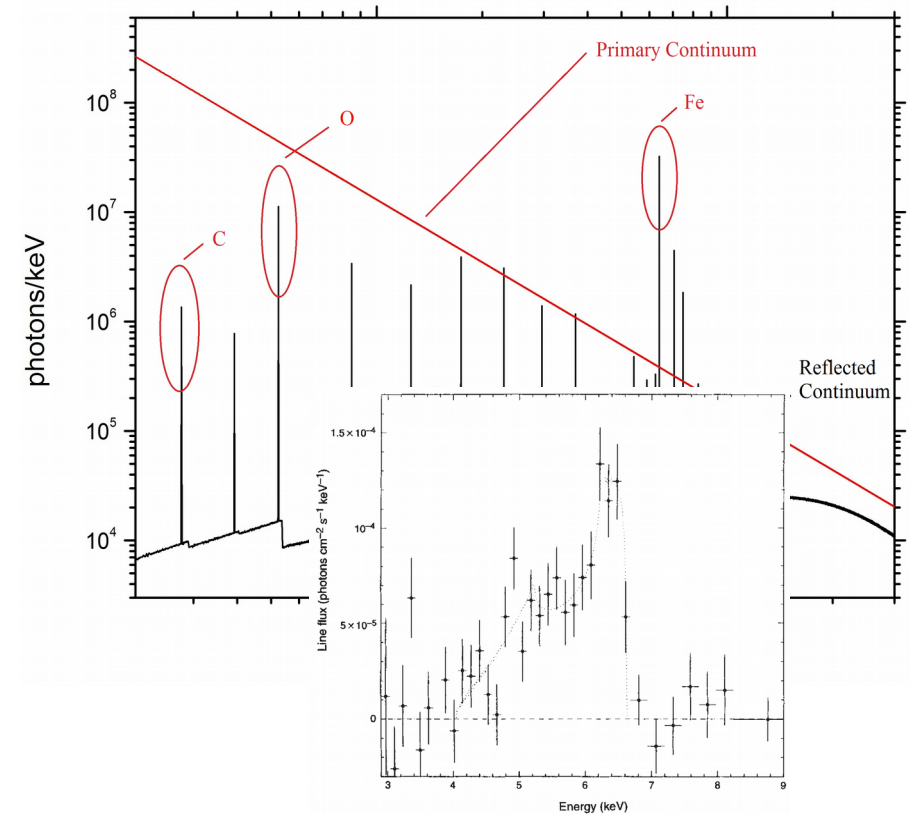
- X-ray “reflection”
- The Fe K α emission line



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- The Fe K α emission line



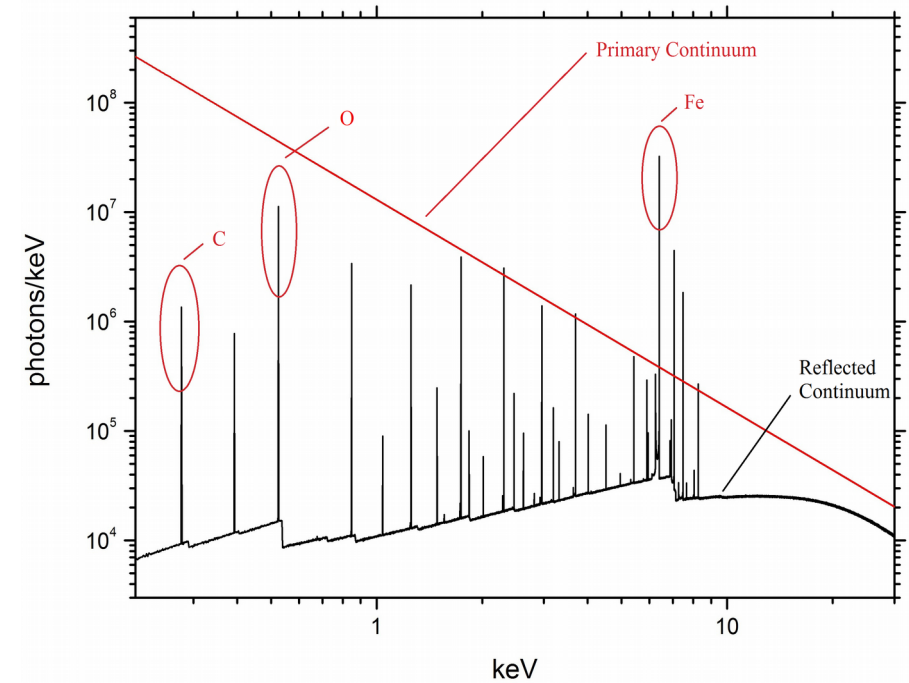
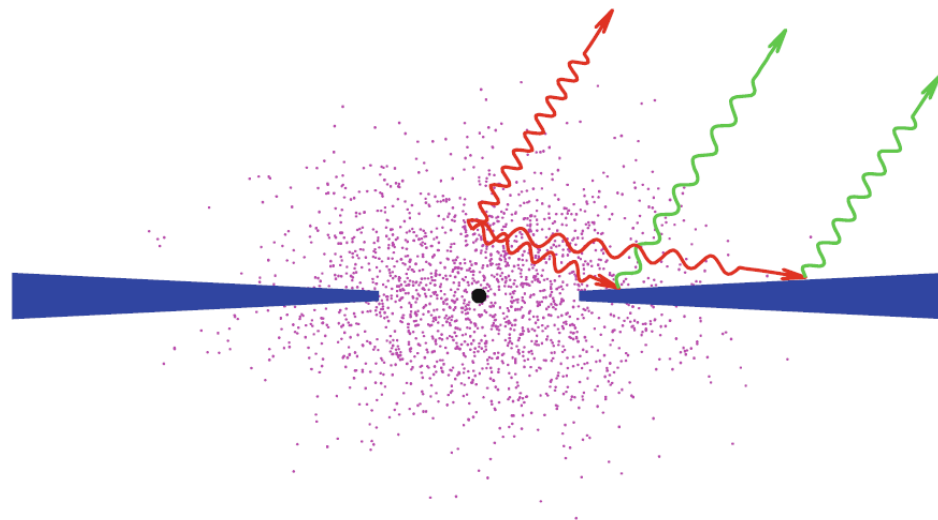
- Geometry, Temperature, Composition of disk
- Distance from compact object
- Mass compact object, spin of BH



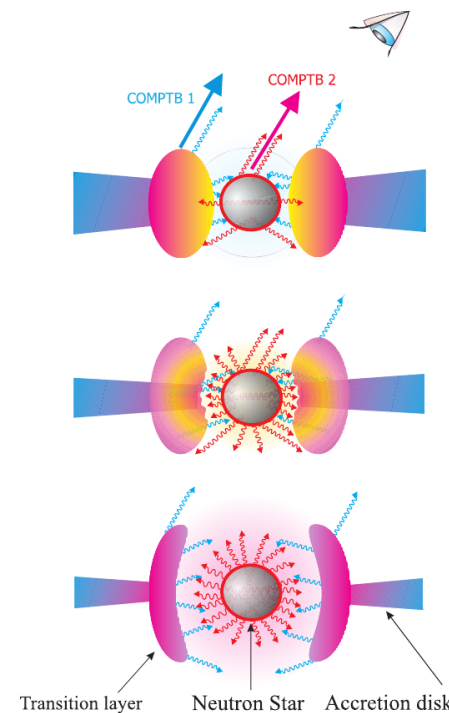
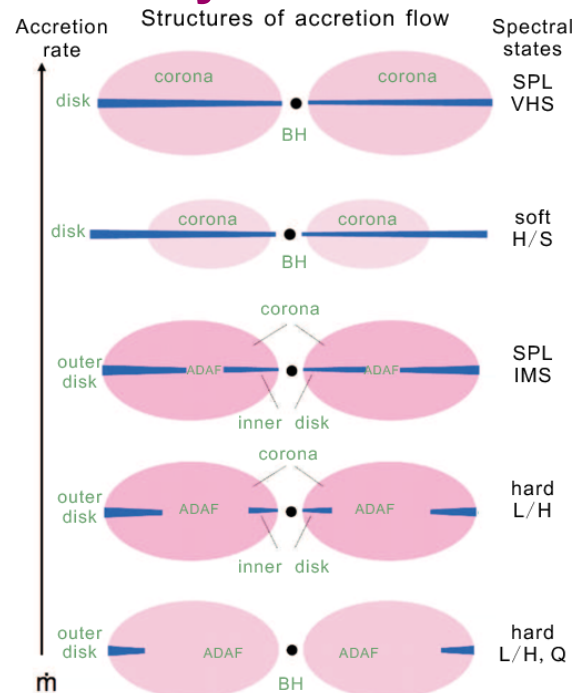
Tanaka et al. 1995

Emission processes and accretion diagnostics

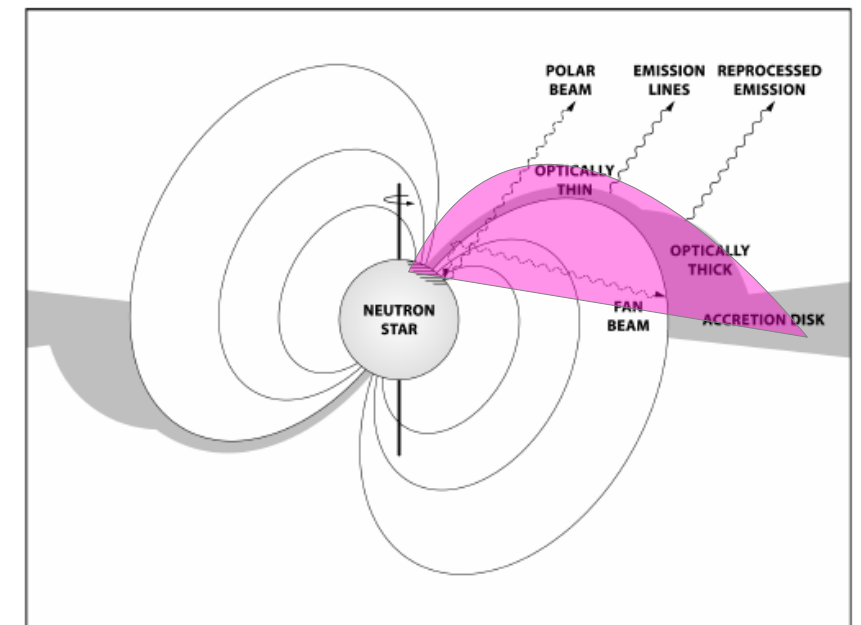
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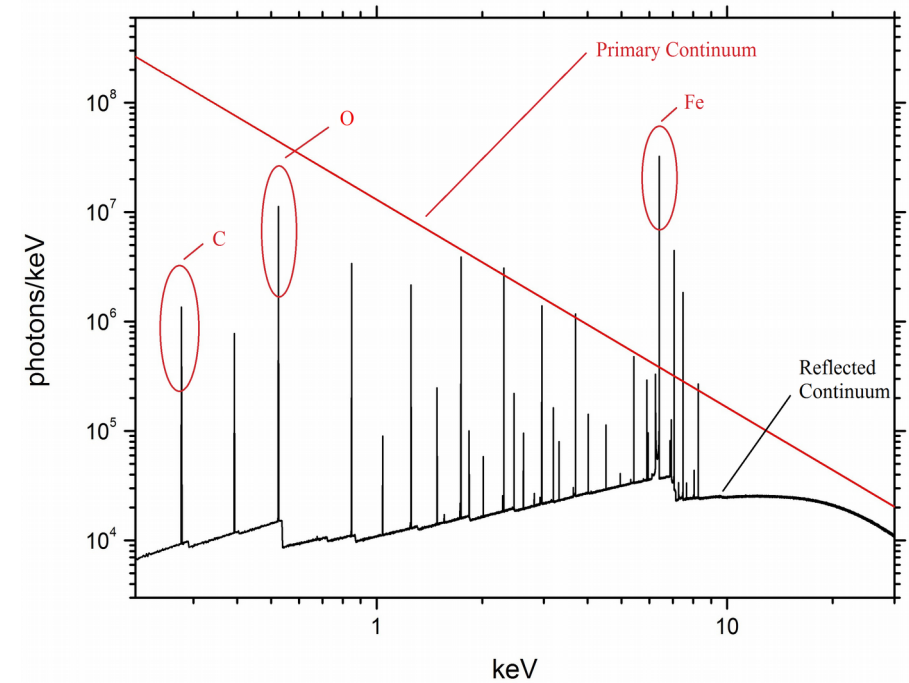
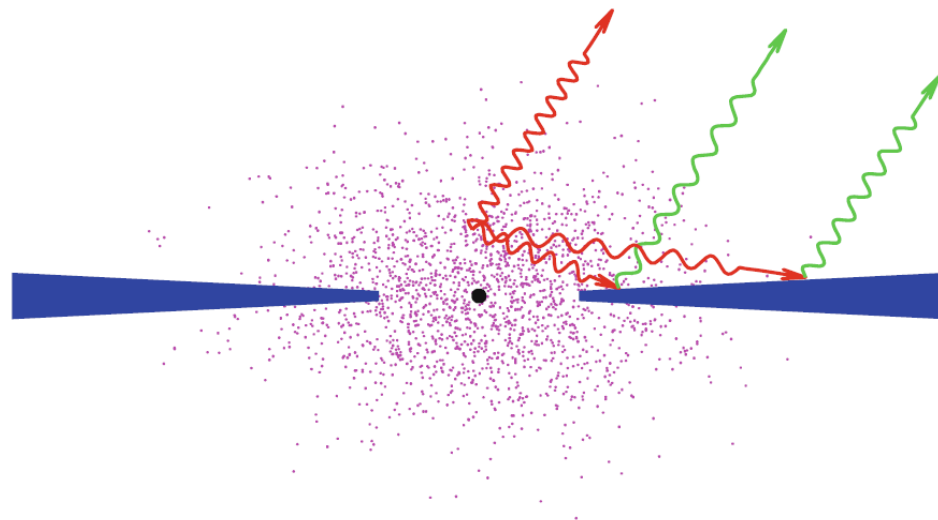
- Reality is much more complicated



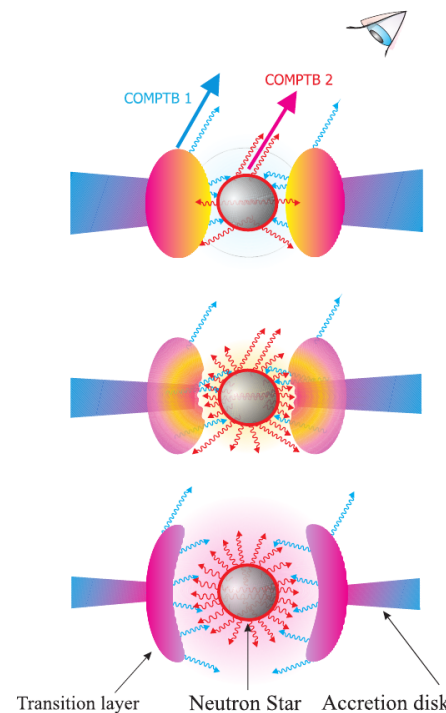
Titarchuk, Seifina, & Shrader 2014



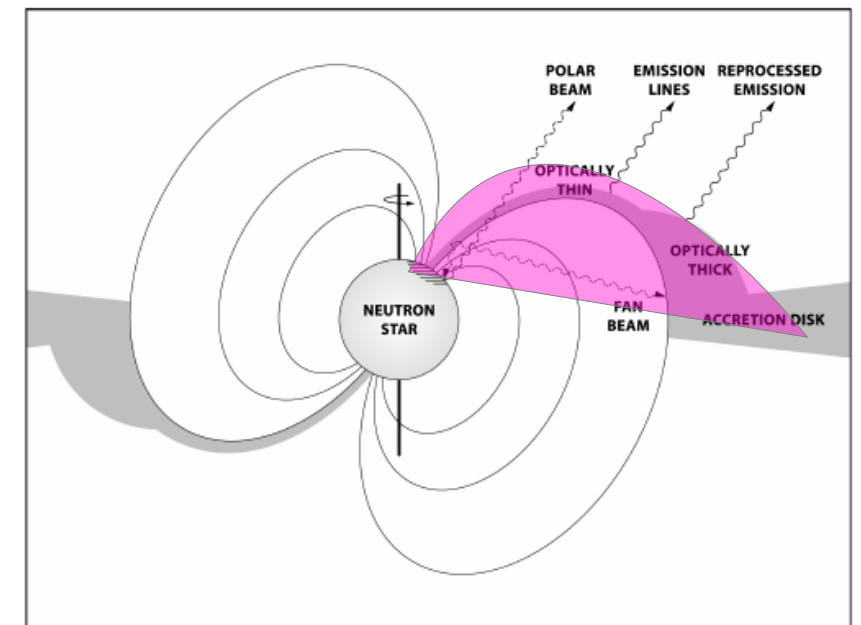
- X-ray “reflection”
- The Fe K α emission line



- Reality is much more complicated
- Emission from hot plasma
- Microscopic broadening
- Multiple emission lines



Titarchuk, Seifina, & Shrader 2014



- Broad line-like feature at $\sim 1\text{keV}$ noticed by numerous authors (e.g. Vrtillek et al. 1991; Kuulkers et al. 1997; Díaz Trigo et al. 2006; Cackett et al. 2010a; Papitto et al. 2013, van den Eijnden 2017; Degenaar 2017, F.K & Vasilopoulos 2018, Ludlam et al. 2018)
- The first systematic study of this feature using high resolution spectroscopy (XMM-Newton RGS, Chandra HETGs LETGs)

List of sources

(not final)

BH-XRBs

XTE J1650-500
GRO J1655-40
GX 339-4
Cyg X-1

NS-XRBs

XB 1254-690
4U 1916-05
EXO 0748-676
MXB 1659-298
4U 1636-536
GX 349+2
GX 9+9
4U 1735-44
Ser X-1
2S 0921-630
1A 1246-588
UW Crb
Sco X-1

MSPs

HETE J1900.1-2455
Aql X-1
Cyg X-2

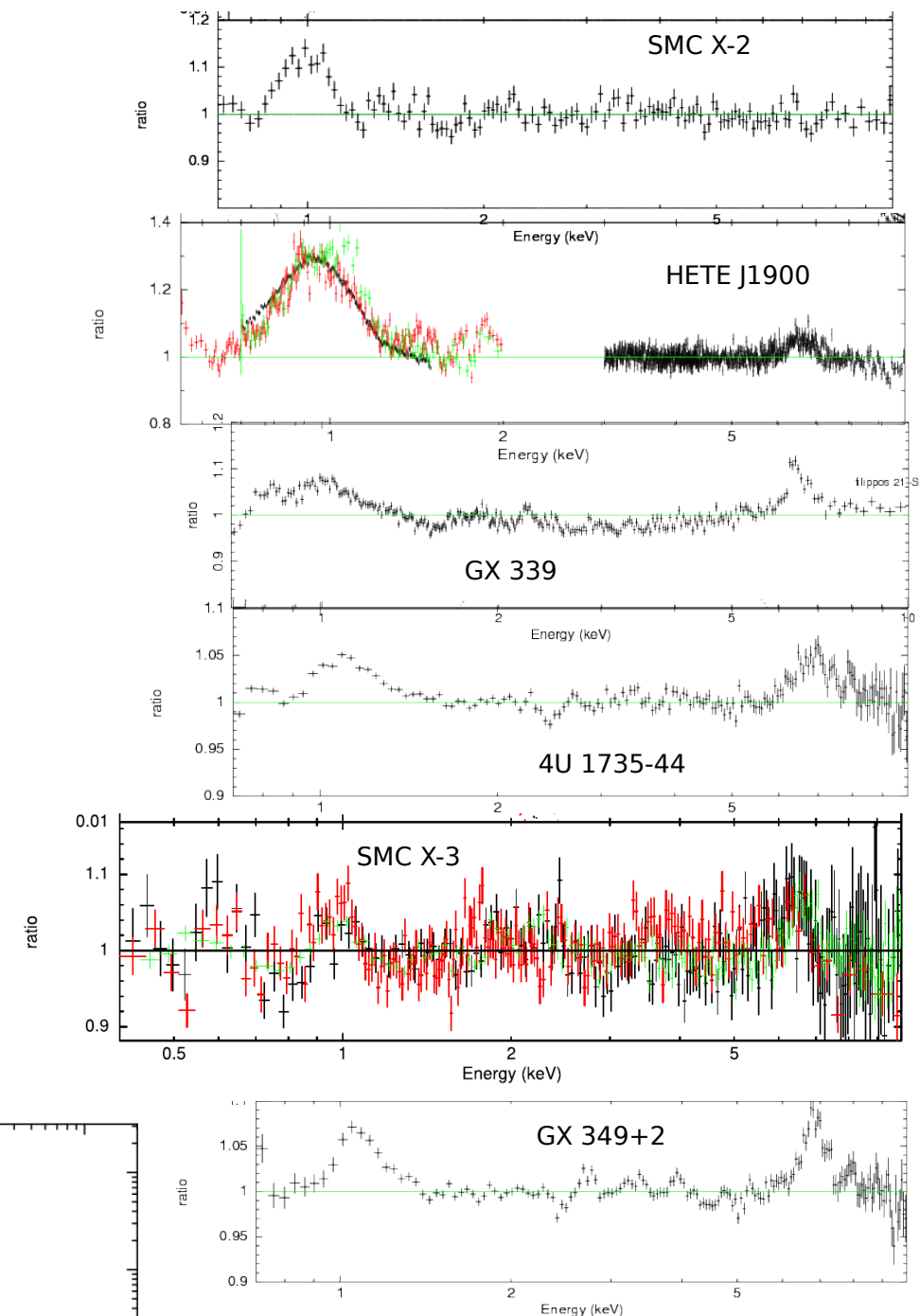
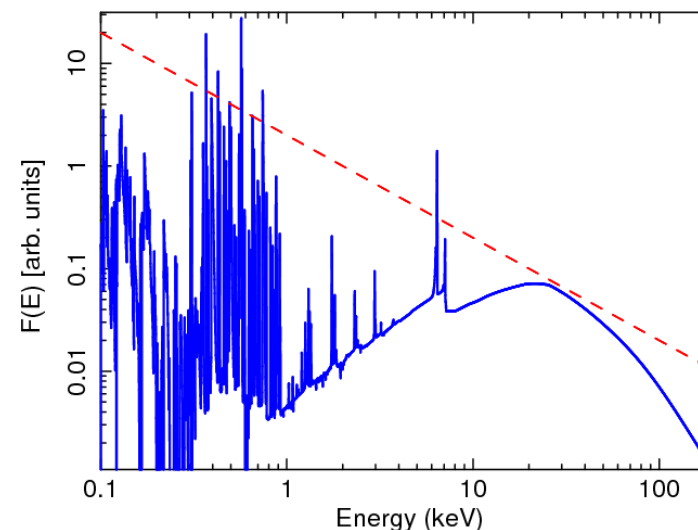
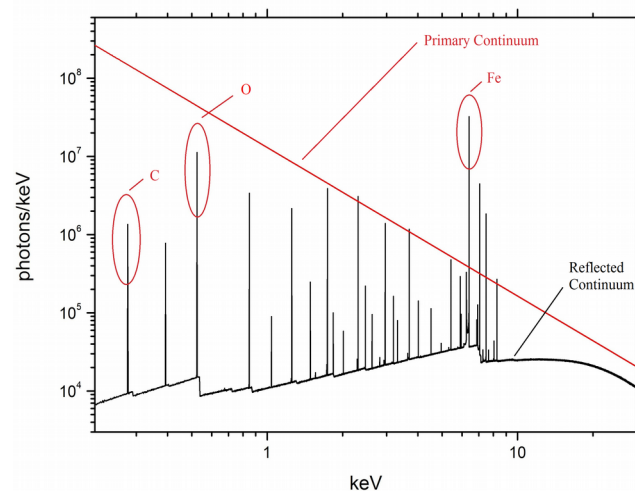
XRBs

Her X-1
SMC X-2
SMC X-3
RX J0059.2-7138
RX J0520.5-693
4U 1626-67

ULXs

Ho IX X-1
M81 X-6
M83 ULX
NGC 4736 ULX
NGC 5204 X-1
NGC 7793 P13
(low luminosity)

- **Ne IX–X K α** emission of (0.92–1.02 keV), and **Fe-L α** complex.
- Disk reflection?
 - **Broadening** $\rightarrow R \sim a \text{ few } R_s$
Consistent **Fe K α** (e.g. 4U 1735-44 and Ser X-1)
Inconsistent (e.g. 4U 1626-47, HETE J1900)
- **xiilver**, and Monte Carlo code from F.K. et al. (2013)
 - **Not single** reflection model. Overabundance of iron
 - **Not** with incident **black body**
(However Ludlam et al. 2018)
 - Overabundance of Ne ?
- Velocity & Thermally broadened plasma + reflection



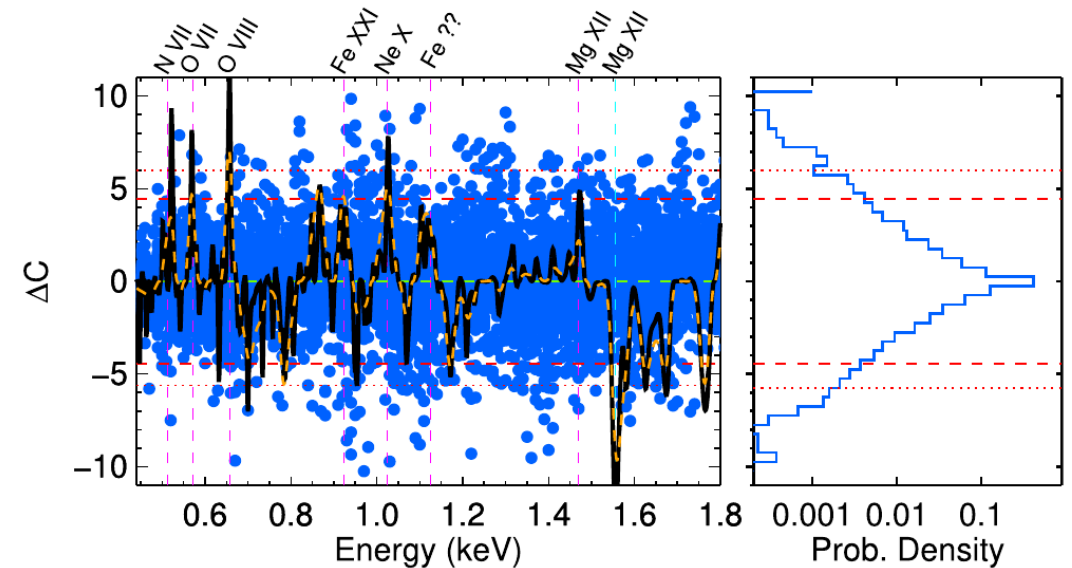
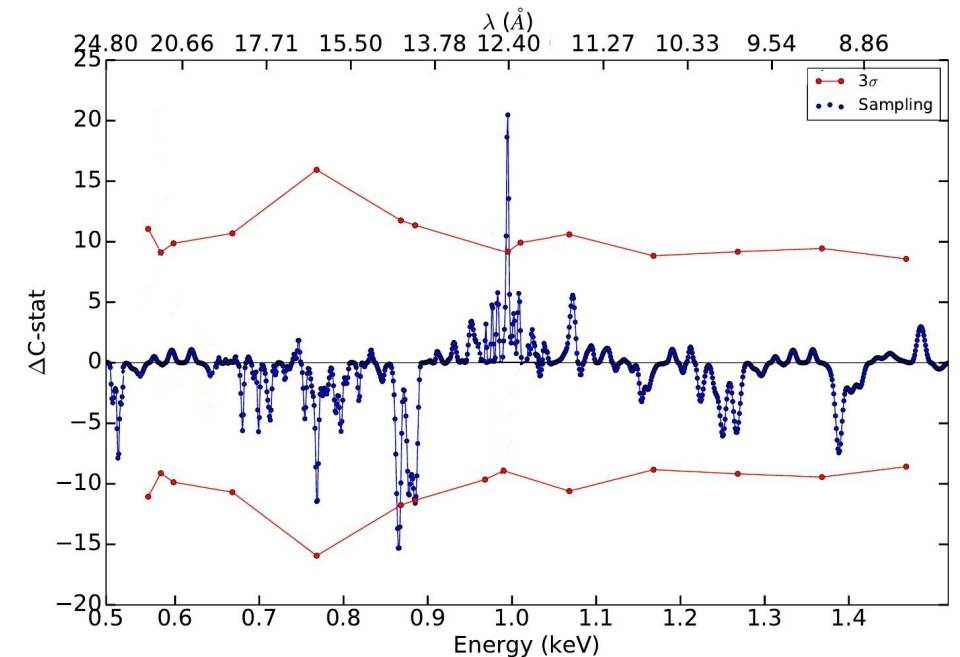
(Garcia et al., 2010, 2011, 2013)

- **Unbinned** RGS spectra. **Cash** statistics
- **Blind search**: Fixed width Gaussian
(Protassov+ 2002; Pinto+2016)
- MC simulations for significance estimation.

- **Narrow** emission lines **over broadened** continuum-like emission
- Indications of blueshift in some sources

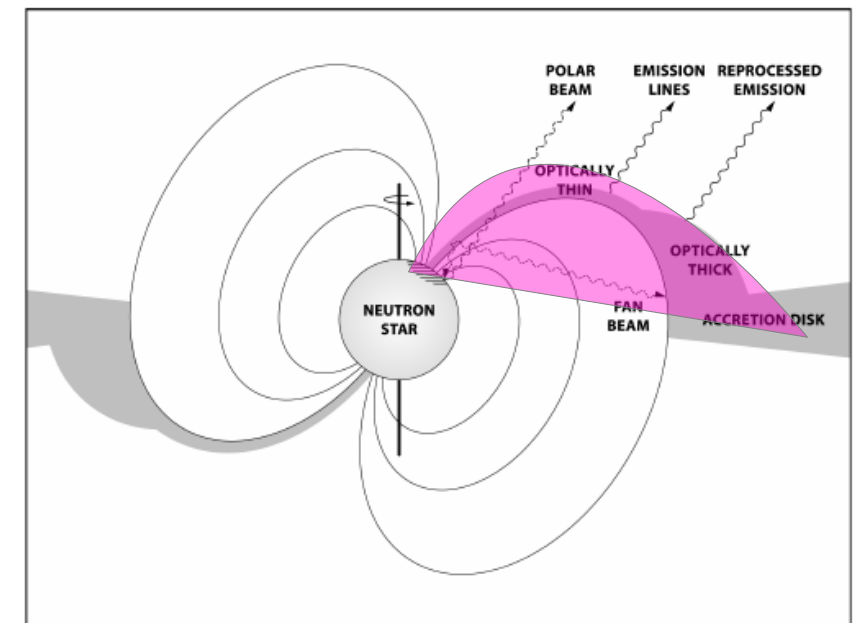
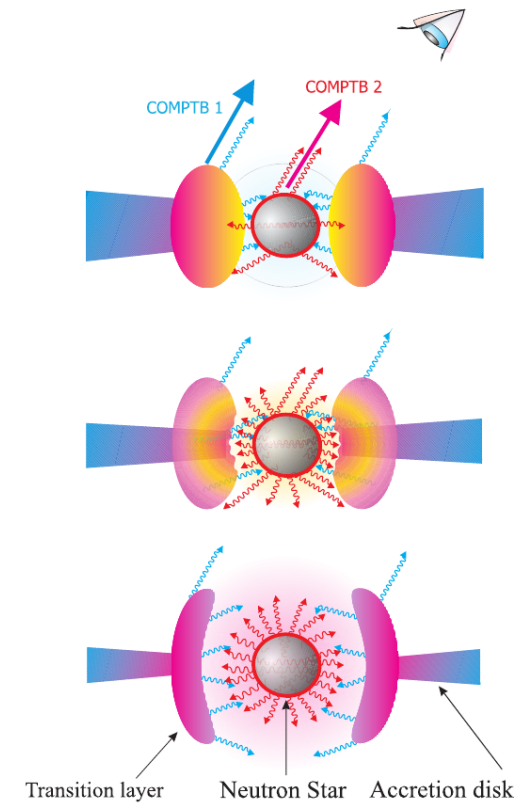
- Optically thin hot plasma
Microscopic broadening? (e.g. Basko 1980)

- **Time-resolved spectroscopy**
Indications of line flux
(and energy) variability
Low statistics



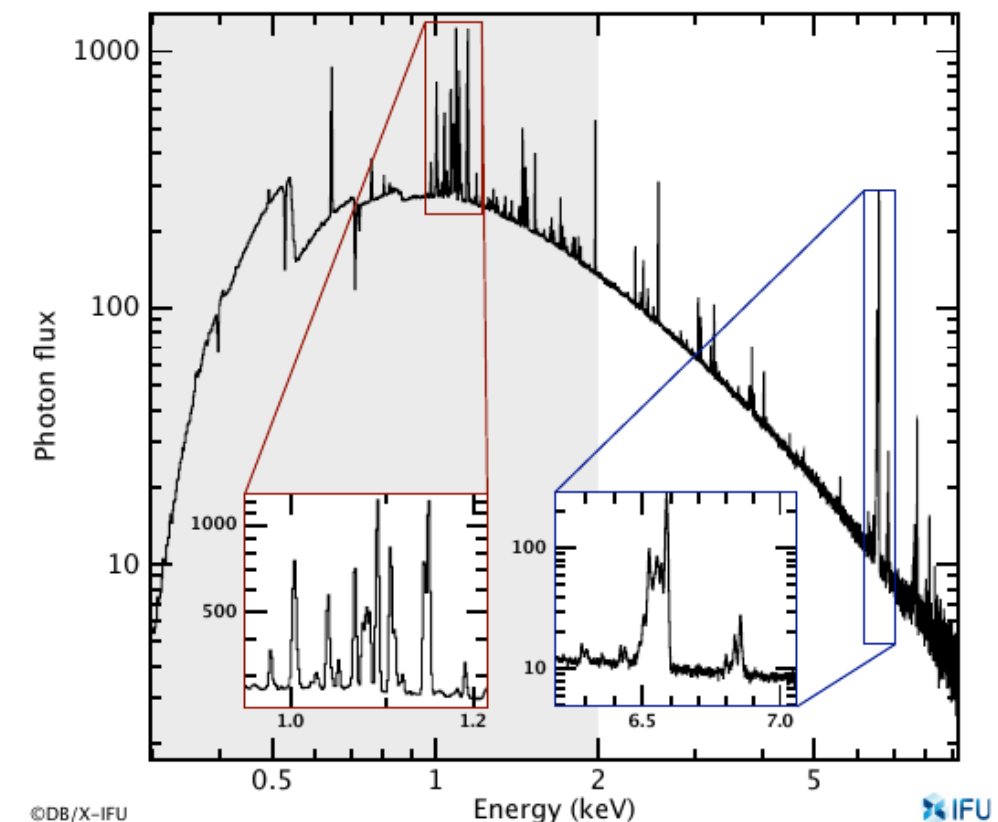
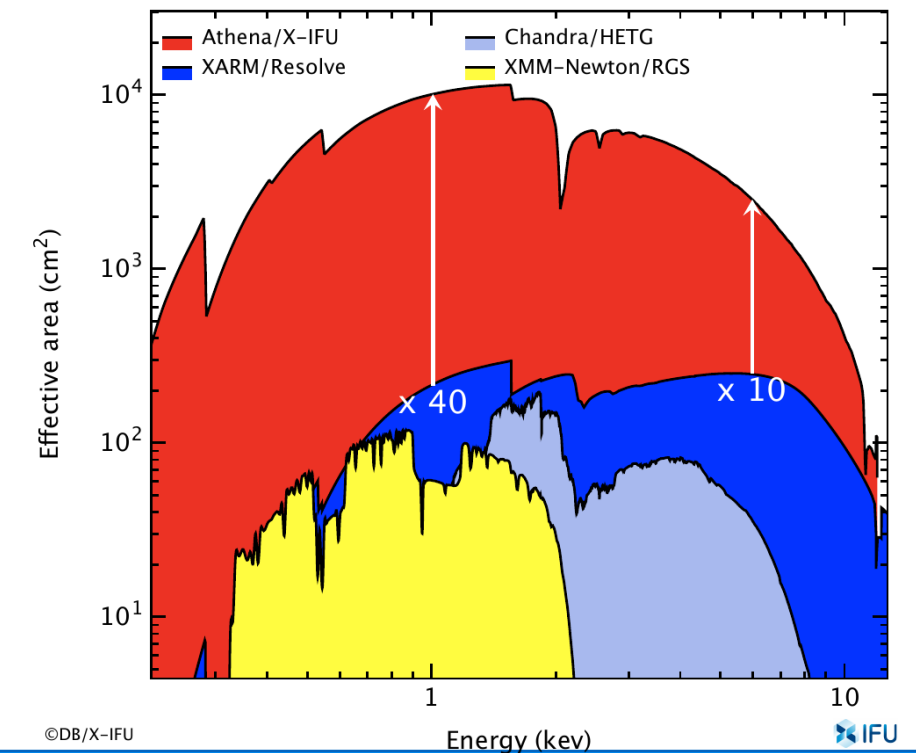
- Possible presence of surrounding hot plasma
 - A photoionized corona
(McCray & Lamb 1976; Basko 1980; Titartchuk)
- Combination of line emission and reflection?
 - Potential interpretation of the high Fe abundance issue
 - Impact on mass and spin estimations?
- Vrtilek et al. In 1991: “**RGS on XMM-Newton will enable study of the time variability of the shapes, equivalent widths, and kinematic velocities of the emission lines**”

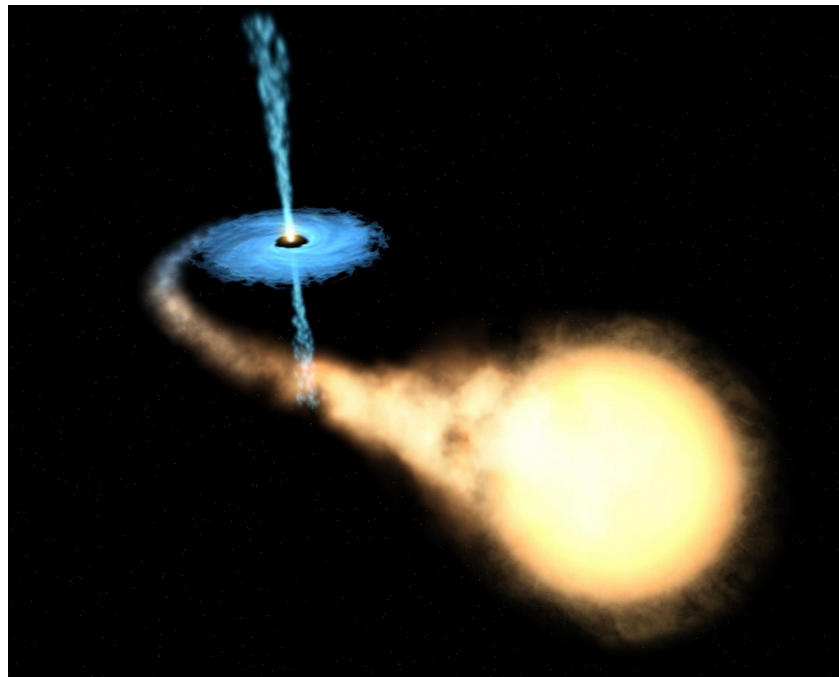
Goal: Exhaust RGS capabilities on large dataset, in preparation for ATHENA



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Accreting black holes and neutron stars:

Most **luminous** objects in the Universe

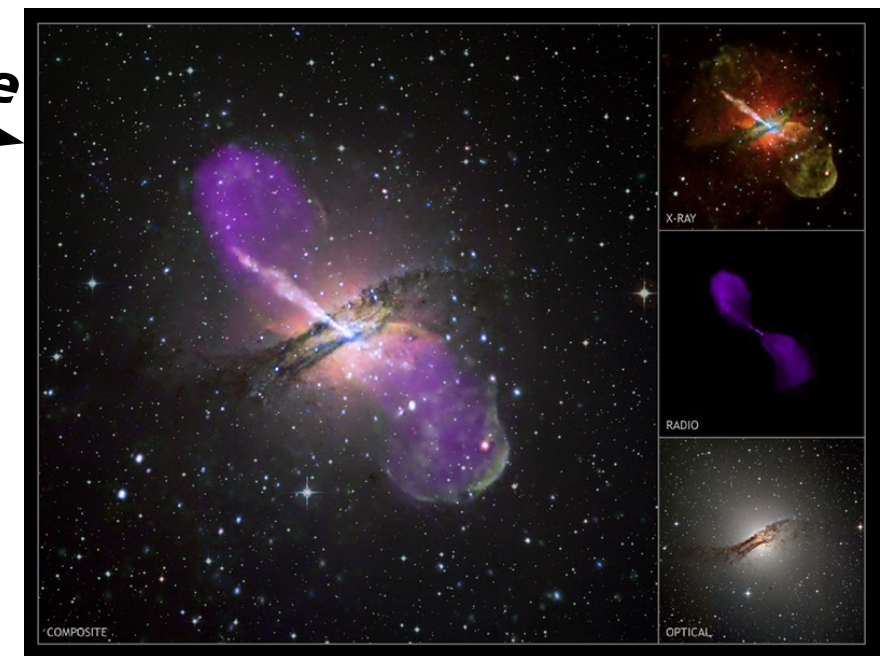
X-ray binaries : **Luminosity**
>1,000,000 L_{\odot}

Supermassive Black Holes
($>10^6 M_{\odot}$) in **MOST** Galaxies

AGN are 1000x **brighter** than **hosts!**
Massive outflows

Determine Galaxy evolution
and star formation.

scale invariance



X-ray - NASA, CXC, R.Kraft (CfA), et al.;
Radio - NSF, VLA, M.Hardcastle (U Hertfordshire) et al.;
Optical - ESO, M.Rejkuba (ESO-Garching) et al.