IXO observations of highly ionised plasmas in LMXBs

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Introduction

- What can we learn with studies of ionised plasmas in LMXBs?
- Current observational status
- Requirements for IXO
“We don’t understand how an accretion disc works”
(Nick White, yesterday)
Studies of photo-ionised plasmas in LMXBs

• Accretion discs present unique problems involving magnetised plasma dynamics, photoionisation, atomic kinetics, thermal and ionisation equilibria, general relativity and radiation transfer…

• The photoionisation of the disc plasma radically alters its equilibrium state, structure and spectrum, especially in the atmospheric and coronal disc layers.
  (Jimenez-Garate et al. 2002)
• High resolution spectra reveal emission & absorption within the accretion disc plasma
  ⇒ Information on the accretion disc structure, dynamics and physics
  ⇒ It impacts our ability to probe the physical conditions around the compact object.

• Transitions of H- and He-like ions probe the regions in the disc with the highest levels of ionisation.
Studies of photo-ionised plasmas in LMXBs

Some examples of studies you can do to understand accretion discs:

- Response of the ionised plasma to changes in the continuum
  ⇒ Implications for the emission regions in the binary
  “What is the link between disc, jet & corona?”

- Outflow velocities
  => What drives the wind?

- Simultaneous optical/UV data
  => Information about disc geometry
X-ray orbital variability as a function of inclination

Frank et al. 1987

High inclination is ideal to probe the disc!
Current observational status

Narrow spectral features from highly ionised Fe and other metals detected with *Chandra*, XMM-Newton and *Suzaku* in a growing number of X-ray binaries, mainly at high-inclination.

- Absorption lines (mainly) in dippers
- Emission lines in systems showing eclipses
Current observational status

Existence of a highly photoionised atmosphere with a flattened geometry above the disc

Jimenez Garate et al. 2002
Current observational status

GRO J1655-40 at 800 mCrab

ASCA, Ueda et al. 1998

Chandra, Miller et al. 2006

Exploring the Hot Universe with IXO, 17-19 Sept 2008, Germany
Response of the absorber to changes in the source continuum

4U 1630-472 (Kubota et al. 2007)
GRO J1655-40 (Diaz Trigo et al. 2007)
GX 13+1
Variability of the photoionised absorber with the orbital period

Boirin et al. 2005

Persistent
Variability of the photoionised absorber with the orbital period

Boirin et al. 2005

Shallow

Expanding the Hot Universe with IXO, 17-19 Sept 2008, Germany
Variability of the photoionised absorber with the orbital period

Boirin et al. 2005

Deep
A photo-ionised absorber model explains the complex spectral changes during dips.

Larger column density of neutral and ionised material plus lower ionisation of the ionised absorber explain spectral changes during dips for all the dipping sources observed with XMM (Boirin et al. 2005, Diaz Trigo et al. 2006).
EXO 0748-676: The ionised absorption & X-ray recombination emission can originate in the same region

Diaz Trigo et al. 2006

Cottam et al. 2000
Requirements for IXO

• High spectral resolution
  – Required to resolve the lines and characterise the atmospheres:
    • Number of absorbers
    • Line shifts => Outflows or static atmospheres / Doppler shifts
    • Line widths => Broadening mechanisms

• Large effective area
  – Mandatory to study dipping emission, during which count rates of <20% of the persistent count rate are reached.

BUT…

We have at least 10,000 cts/s and can reach e.g. 250,000 cts/s during BHB outbursts… !!!! (XEUS could defocus, what can IXO do?)
Requirements for IXO

• **Hard X-ray detector**
  – Important to disentangle the absorbing plasma from the underlying continuum of the source

• **Optical/UV monitor**
  – Important to understand the geometry of the system, e.g. warps and precessing discs
Simulations of 4U 1916-053 (with a microcalorimeter and of $A_{eff} = 3 \text{ m}^2$)

20 ks with IXO (or 16 ks of Persistent Emission)

80 ks with IXO (or 16 ks of Dipping emission)
Comparison to existent observations of 4U 1916-053

Chandra HETGS, 47 ks (31 ks persistent net exposure)  
Juett et al. 2006

XMM EPIC-pn, 16 ks  
(3.3 ks dip net exposure)  
Boirin et al. 2004

Suzaku, 38 ks (28 ks persistent net exposure)
Simulations of EXO 0748-676

32 ks with IXO (or 16 ks of Dipping Emission)
Comparison to existent observations

XMM EPIC-pn (8.6 ks of Dipping Emission)
Conclusions

• IXO can significantly improve our knowledge about photoionised plasmas above the accretion discs in LMXBs and consequently about accretion processes

• High spectral resolution and large effective area are necessary but we need to devise methods to observe sources with count rates $\sim 100,000$ cts/s.

• Hard X-ray band and optical/UV monitoring add important information to understand the disc.