

High Resolution Spectroscopy of X-ray Binaries

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1. Stellar wind dynamics and mass loss in massive binaries: GX301-2, Vela X-1
2. Absorption spectroscopy of the ISM and IGM
3. Photospheric spectroscopy of EXO0748-676

MSSL workshop, March 2006

Stellar wind dynamics and mass loss: GX301-2

Full Compton-recoil
spectrum on Fe $K\alpha$!
(*Chandra* HETGS)

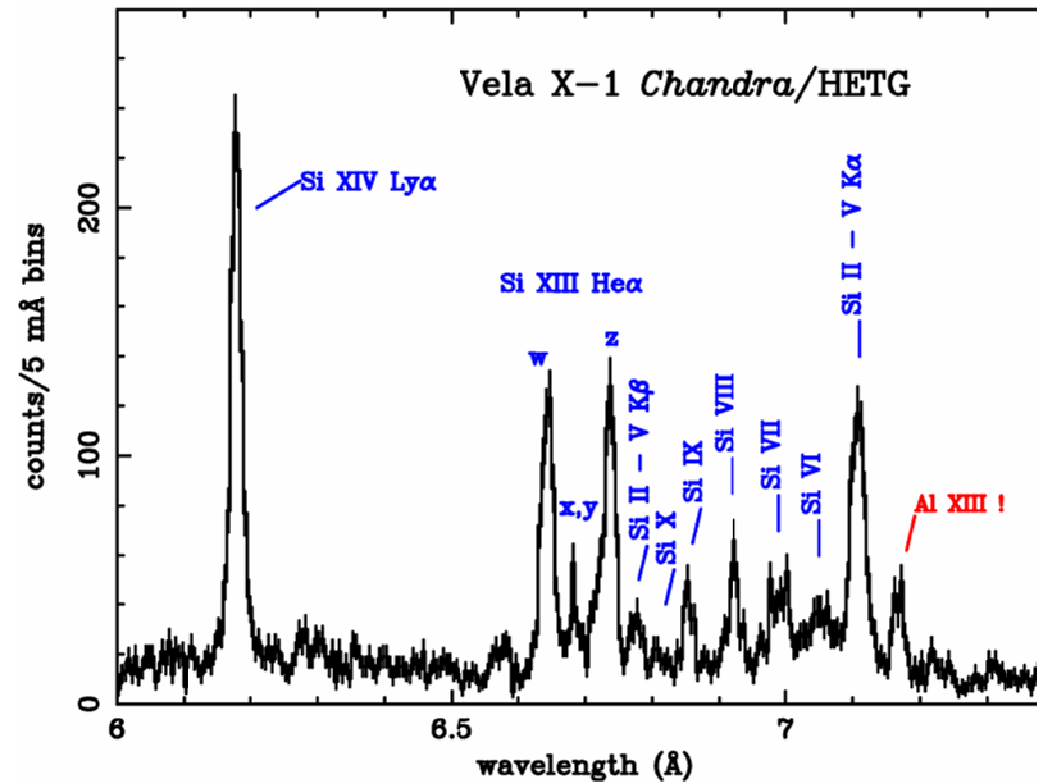
- column density,
metallicity ($\tau_C \sim 1$)
- medium **cold**:
 $kT < 3.4, 0.6$ eV

Actually see effects
of multiple scattering!

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Watanabe, Sako, et al. 2003, *ApJ(Letters)*

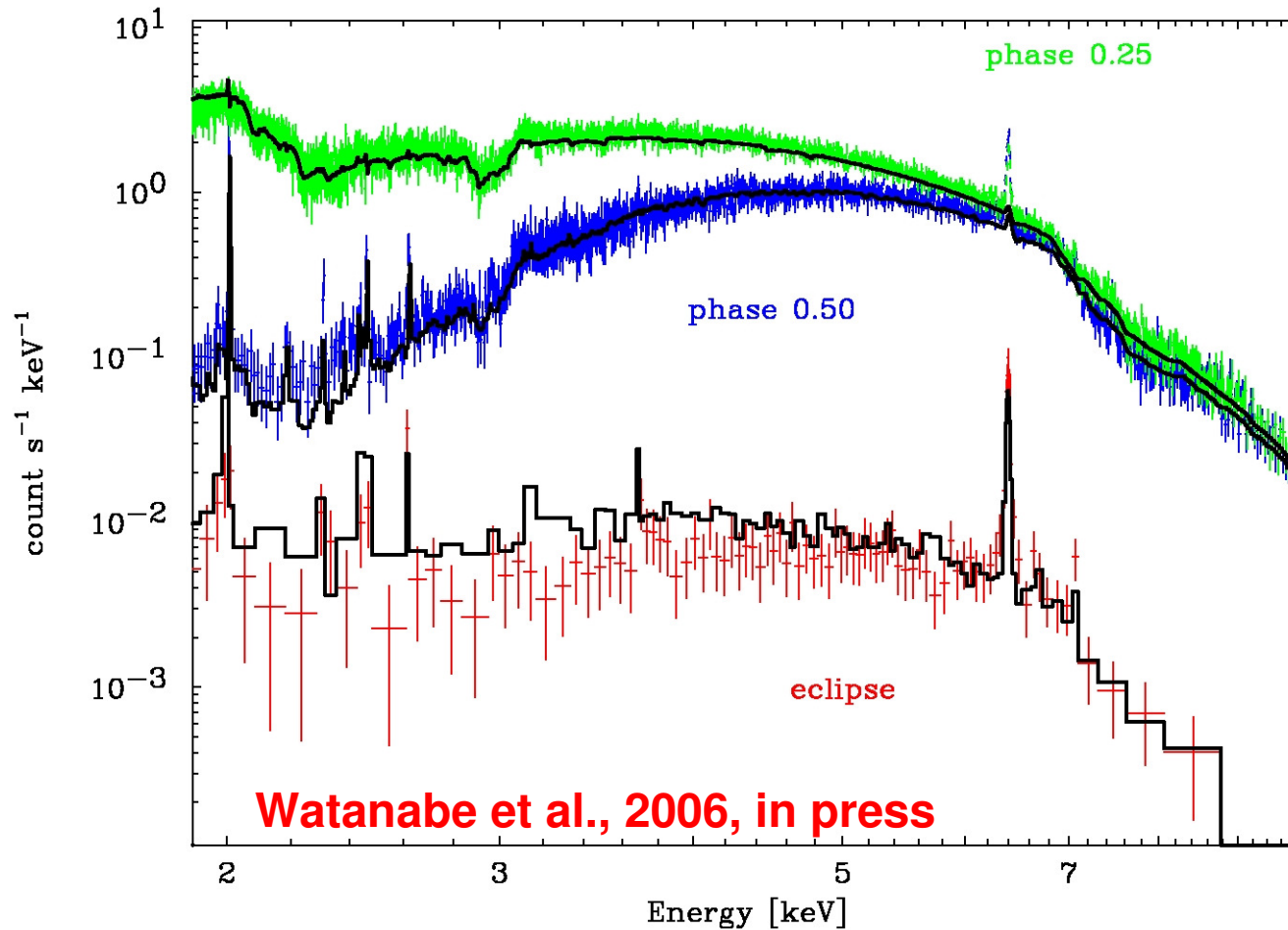
Stellar wind dynamics and mass loss: Vela X-1



Perhaps the bizarrest (binary) spectrum in X-ray astronomy:
Vela X-1 in eclipse- the full K spectrum of Si!

Unique tracer of flow in companion stellar wind (better than UV!)

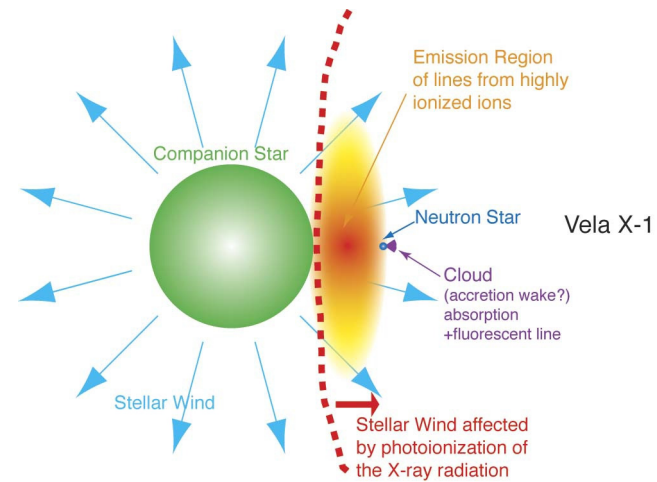
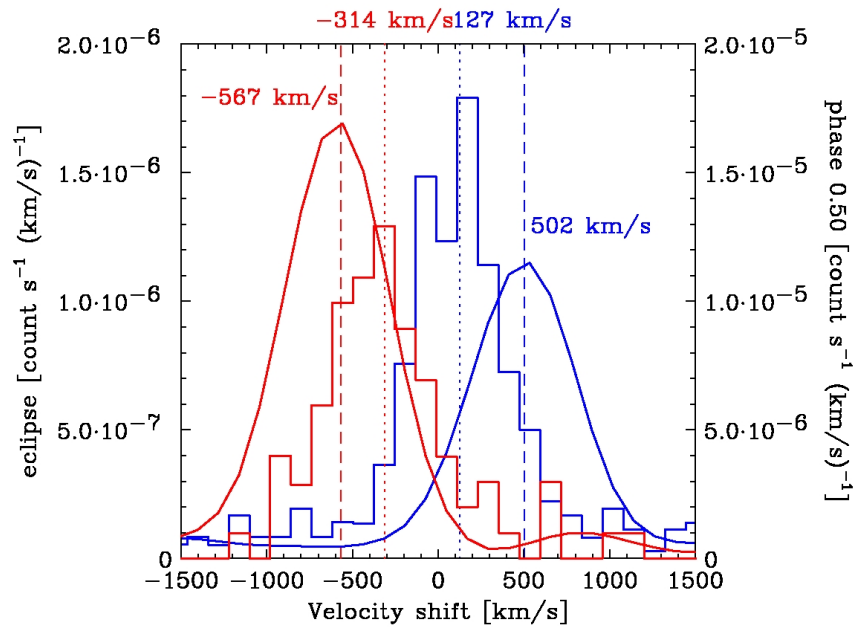
Stellar wind dynamics and mass loss: Vela X-1



- emission clearly recombination in X-ray photoionized wind
- 3 binary phases, full Monte Carlo wind model (CAK wind)
- see geometric distribution, measure v-field, mass loss rate

Stellar wind dynamics and mass loss: Vela X-1

How good is the CAK wind?



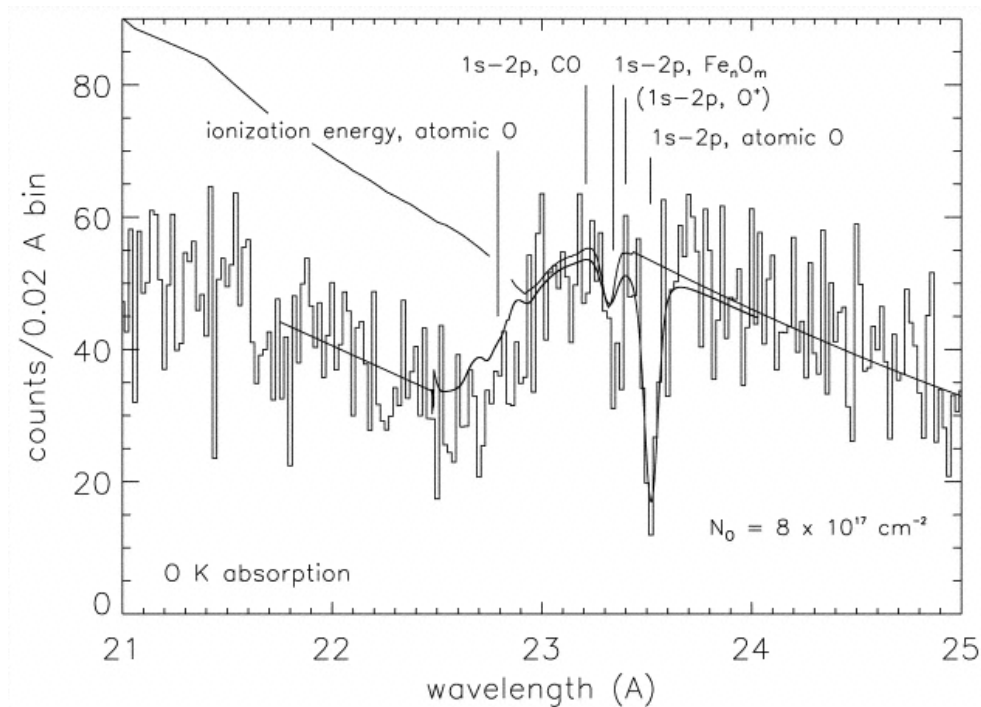
Clearly observe loss of acceleration:
X-ray photoionization erases
radiative force in CNO UV resonance lines!

See excess Fe fluorescence
outside eclipse: small, dense
region near NS: wake?

Absorption spectroscopy of the ISM and IGM

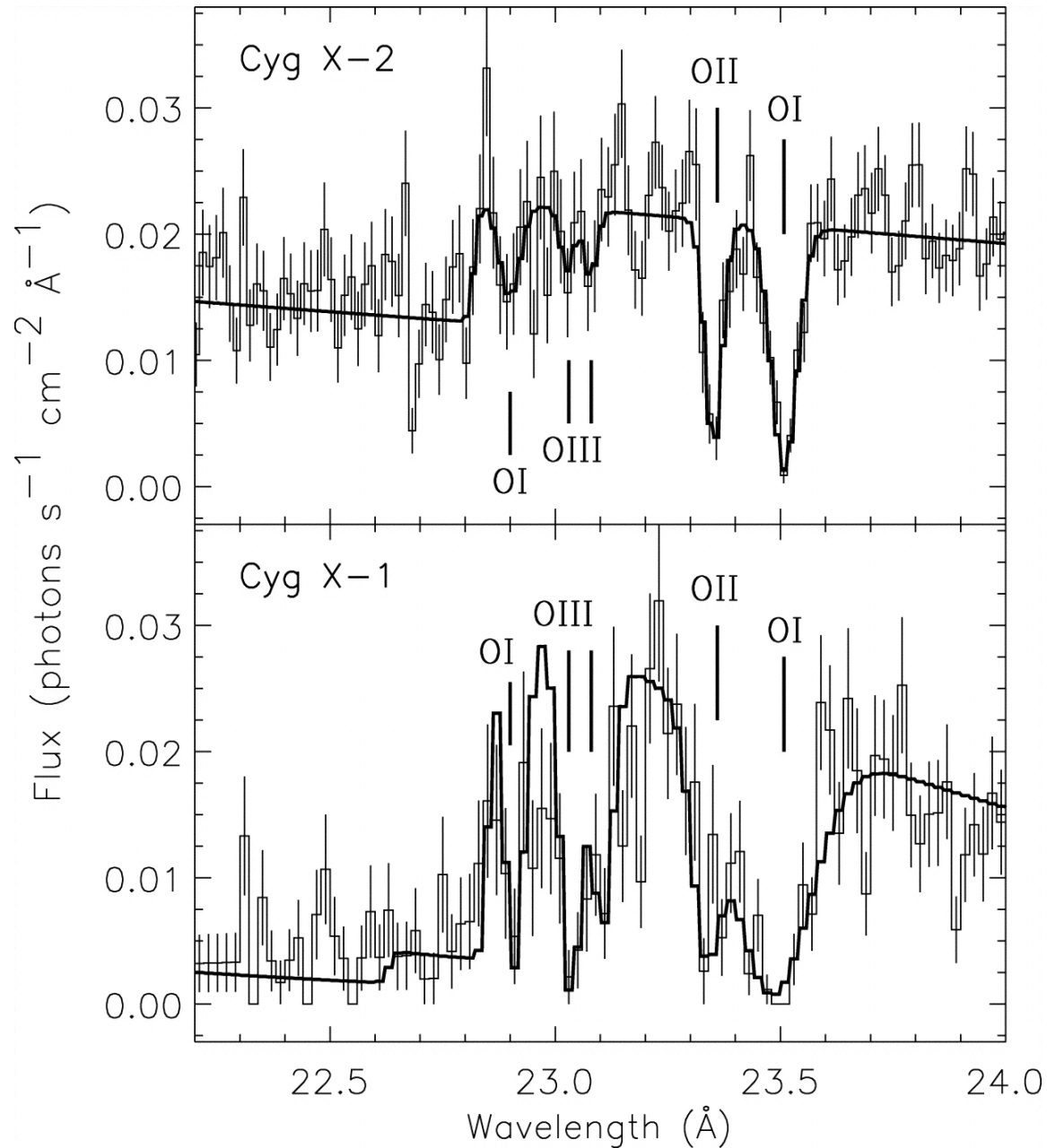
X-ray band contains the spectra of all charge states,
molecular forms of the abundant elements:

Can do physical chemistry of ISM all in one go



Early attempt: X0614+091, *Chandra* LETGS

Absorption spectroscopy of the ISM and IGM



New calculations
for higher
ionization states:
really works!

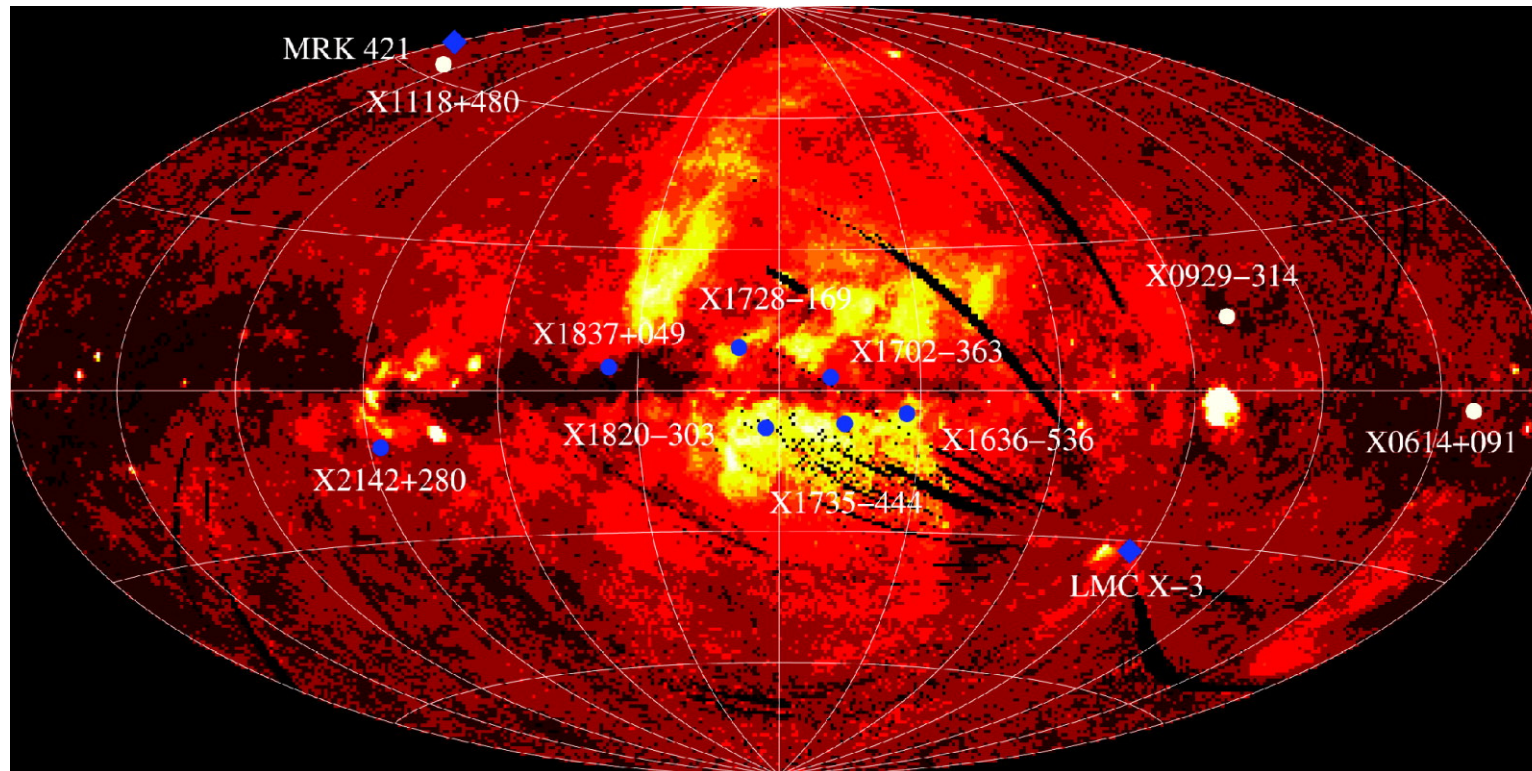
(still want to see
chemical shift!)

Chandra HETGS
Juett et al. 2004

Absorption spectroscopy of the ISM and IGM

Now also detect high ionization species: O VII, VIII; Ne IX, X
(Yao and Wang; Galactic sources; LMC X-3)

Yao & Wang, 2005, ApJ

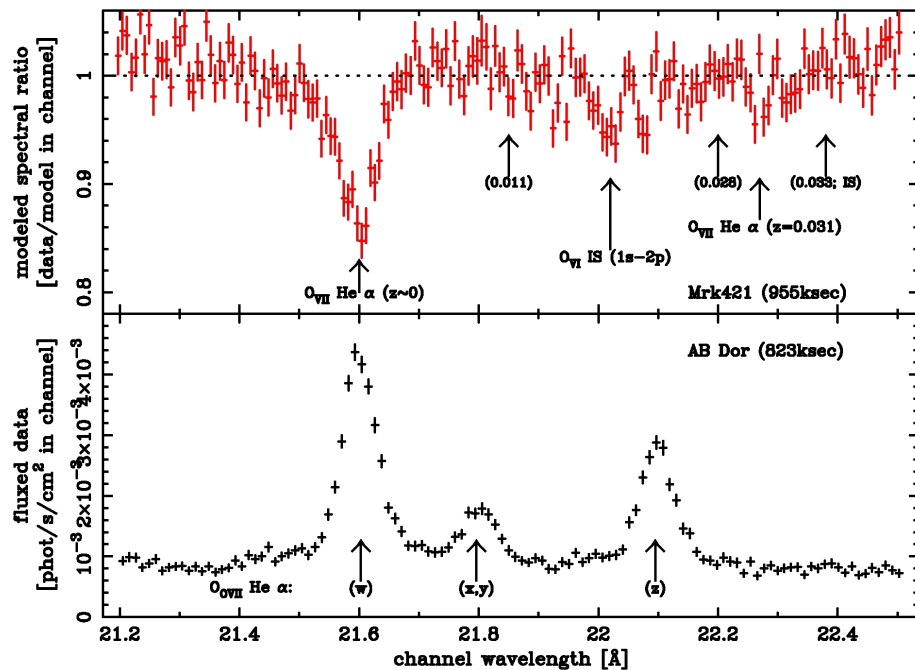


Blue symbol: discrete absorption detected

**See absorption from the same gas that dominates
the low energy diffuse emission (the '1 MK ISM')**

Absorption spectroscopy of the ISM and IGM

O VII resonance absorption also seen towards LMC;
important for interpretation of $z=0$ absorption
spectra of extragalactic sources (Local Group IGM?)



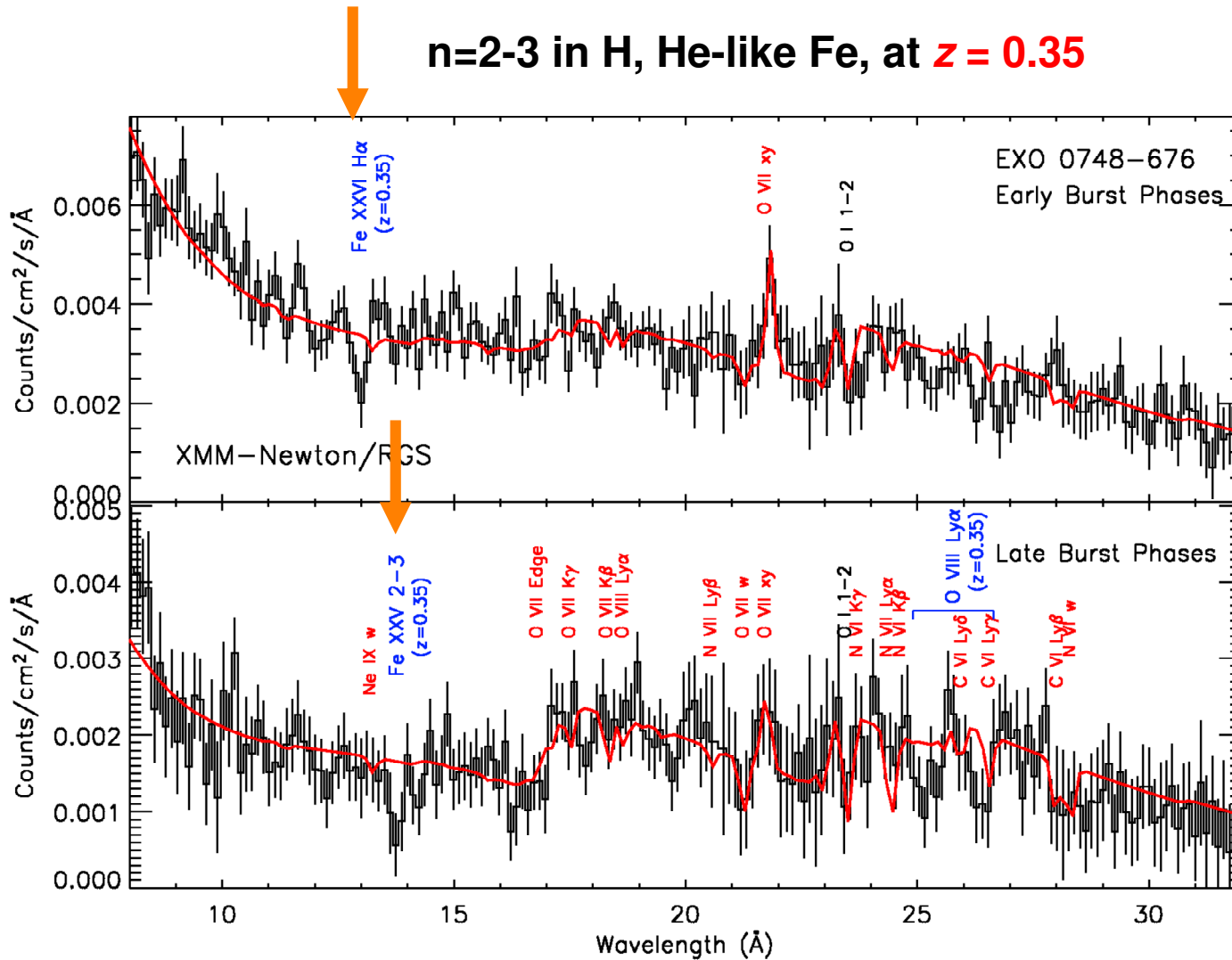
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Mkn 421; Rasmussen et al. 2006

LMC X-3; Wang et al. 2005

Photospheric spectroscopy of neutron stars

XMM/RGS Spectroscopy of the burst spectrum of EXO0748-676

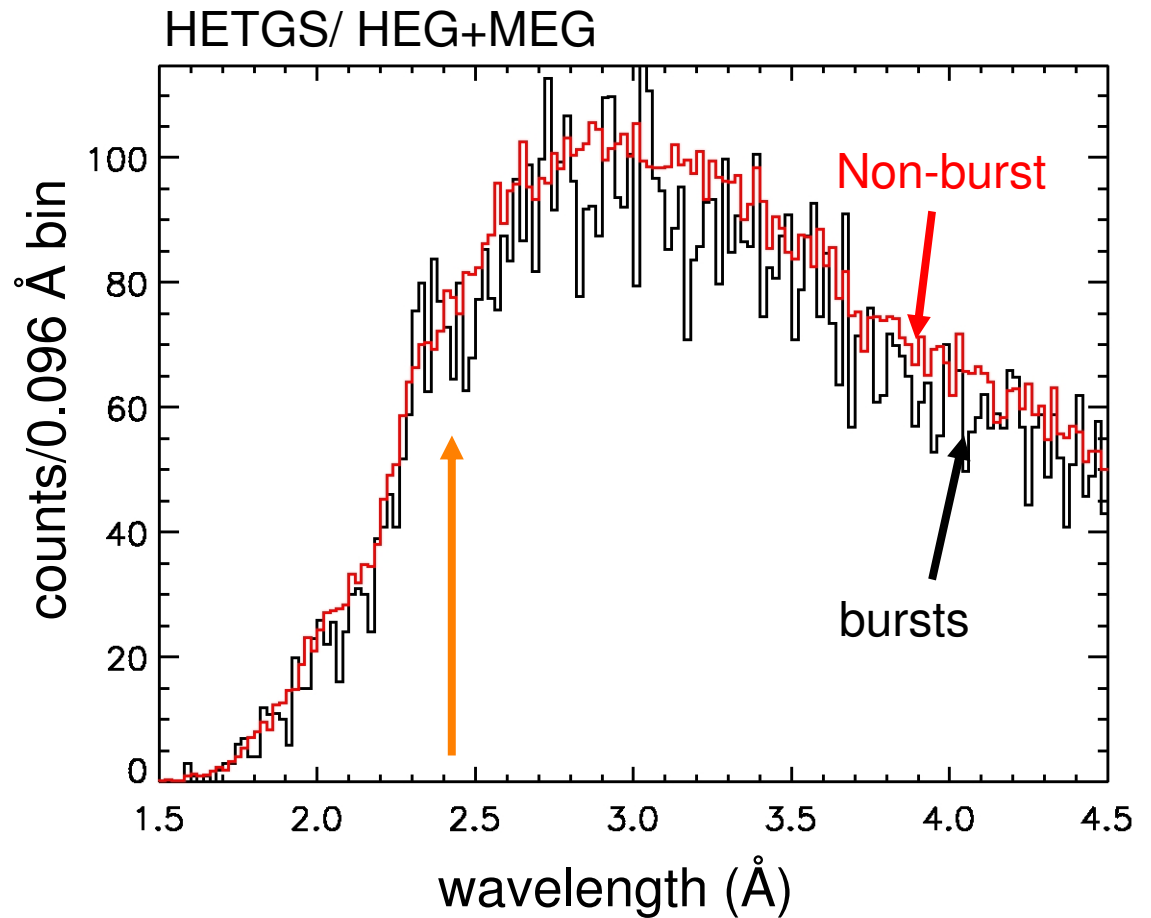
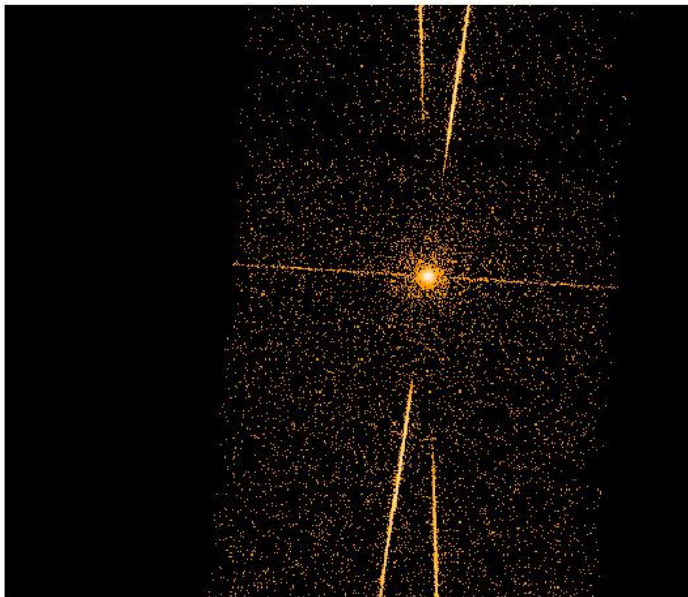


Cottam, Paerels, Mendez, 2002

Photospheric spectroscopy of neutron stars

Fe Lyman Spectroscopy with Chandra HETGS

300 ksec exposure;
Continuum not BB!
Focus on Fe Ly band



H-like Fe Ly α ,
 $1.778\text{\AA} \times 1.35 = 2.400\text{\AA}$