Identification of seven persistent low-luminosity pulsators

Ramanpreet Kaur
University of Amsterdam

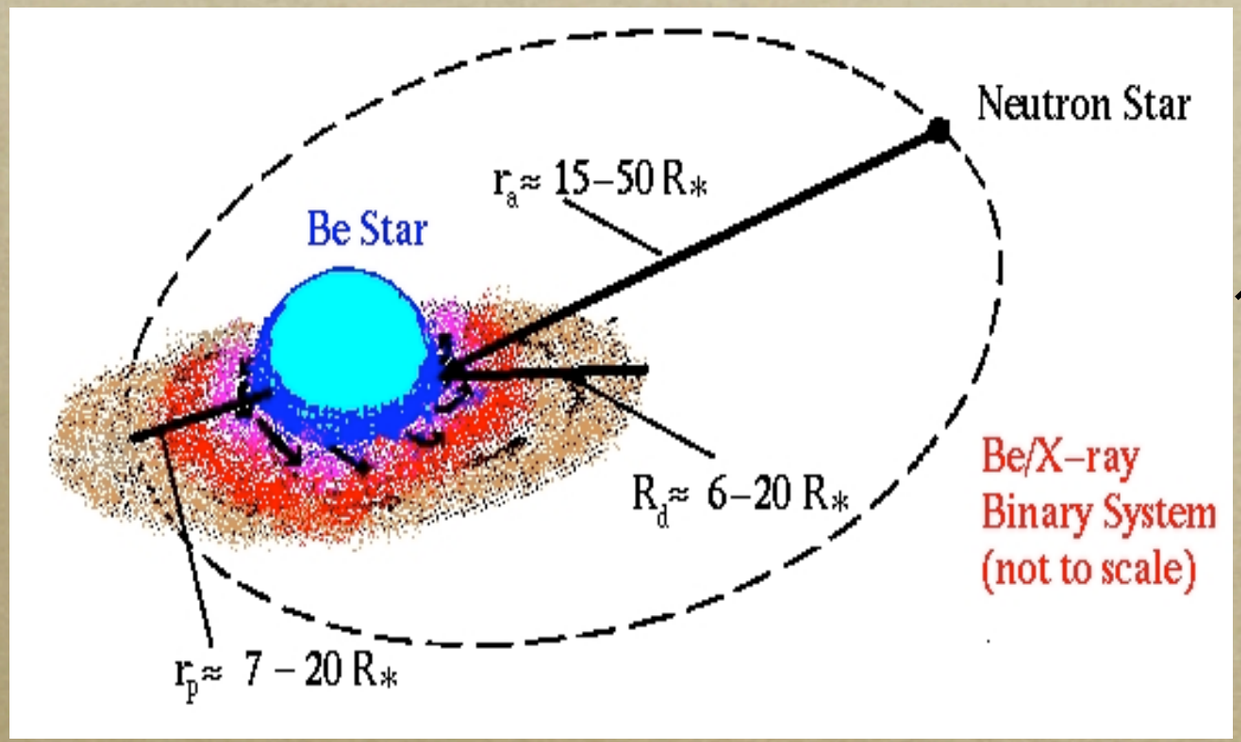
Physics of neutron stars -2011

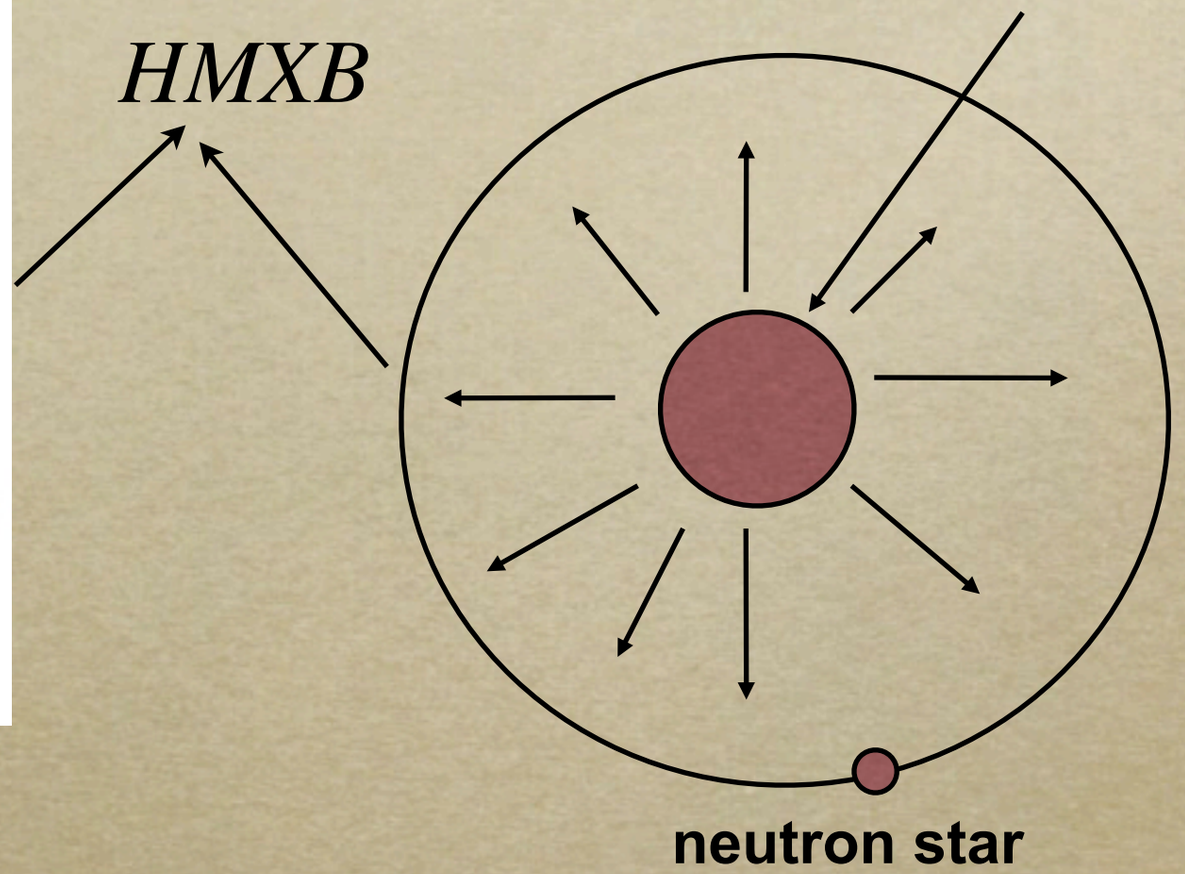
St Petersburg, Russia

Low-luminosity pulsators

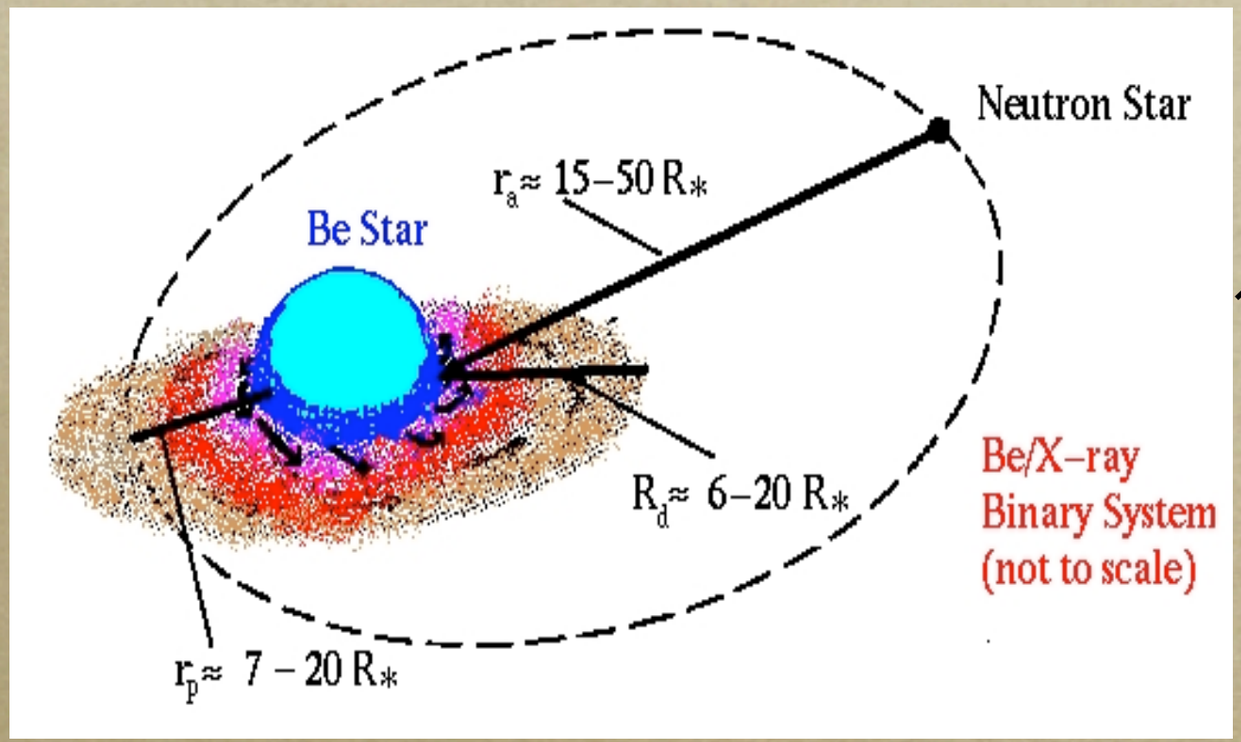
- *Slowly pulsating (Ps > 150s)*
- *Luminosity - 10^{34} - 10^{36} $ergs^{-1}$*
- *Persistent*
- *Initial studies expects them to be Be/X-ray binaries or Intermediate Polars (IPs).*
- *Present in the Galactic plane.*
- *However their nature is not yet known.*

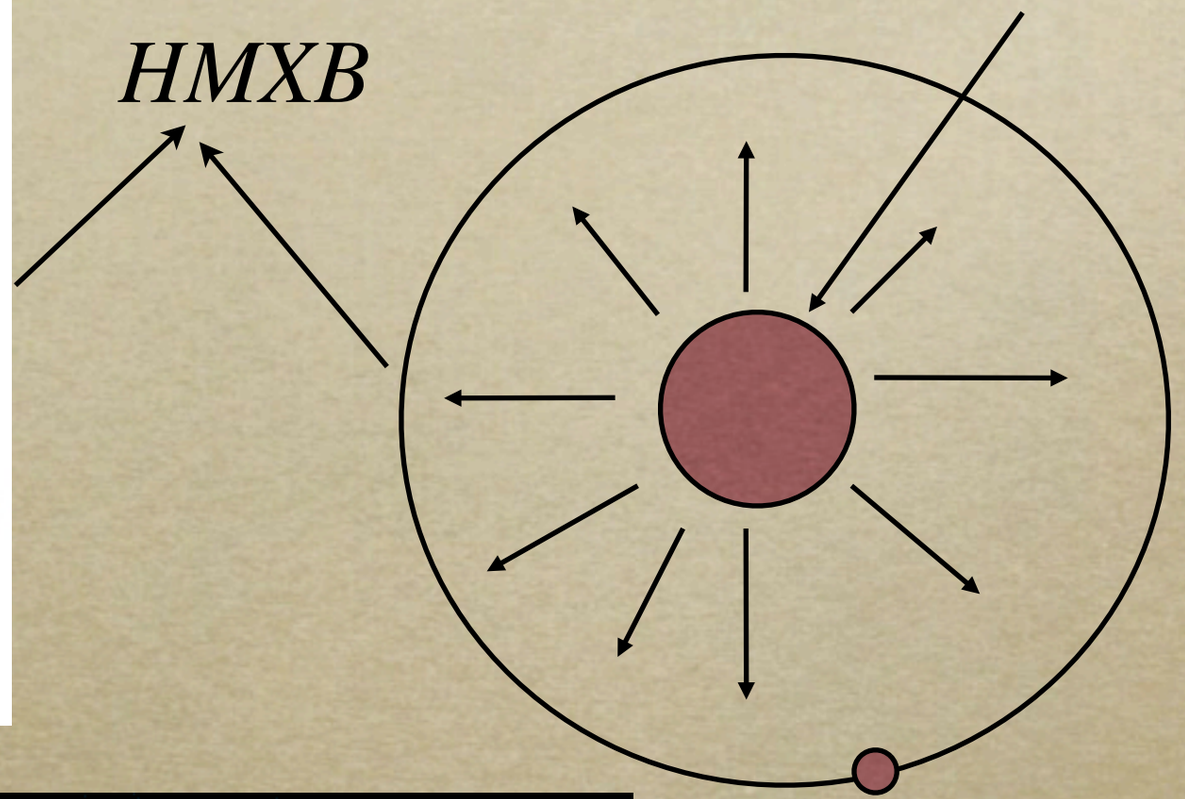
Different pulsators

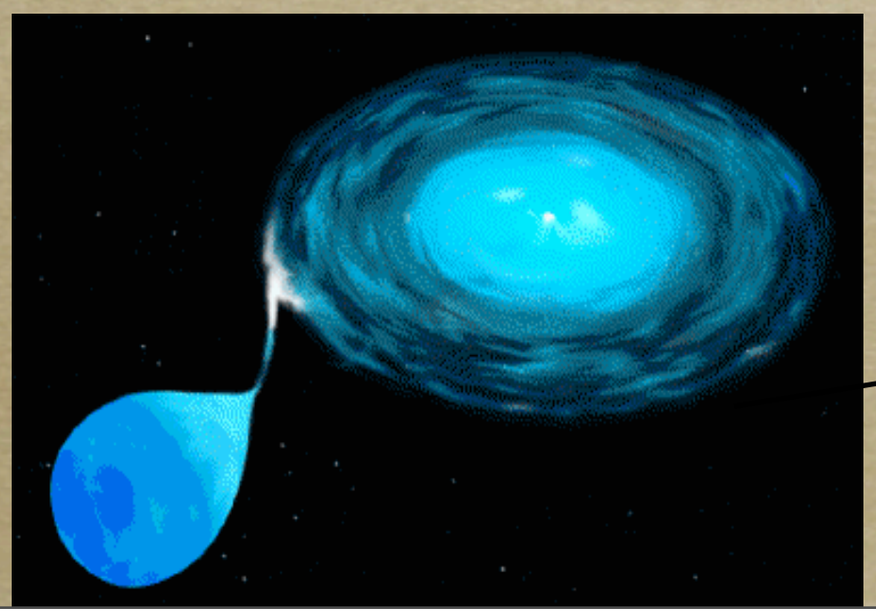




Different pulsators



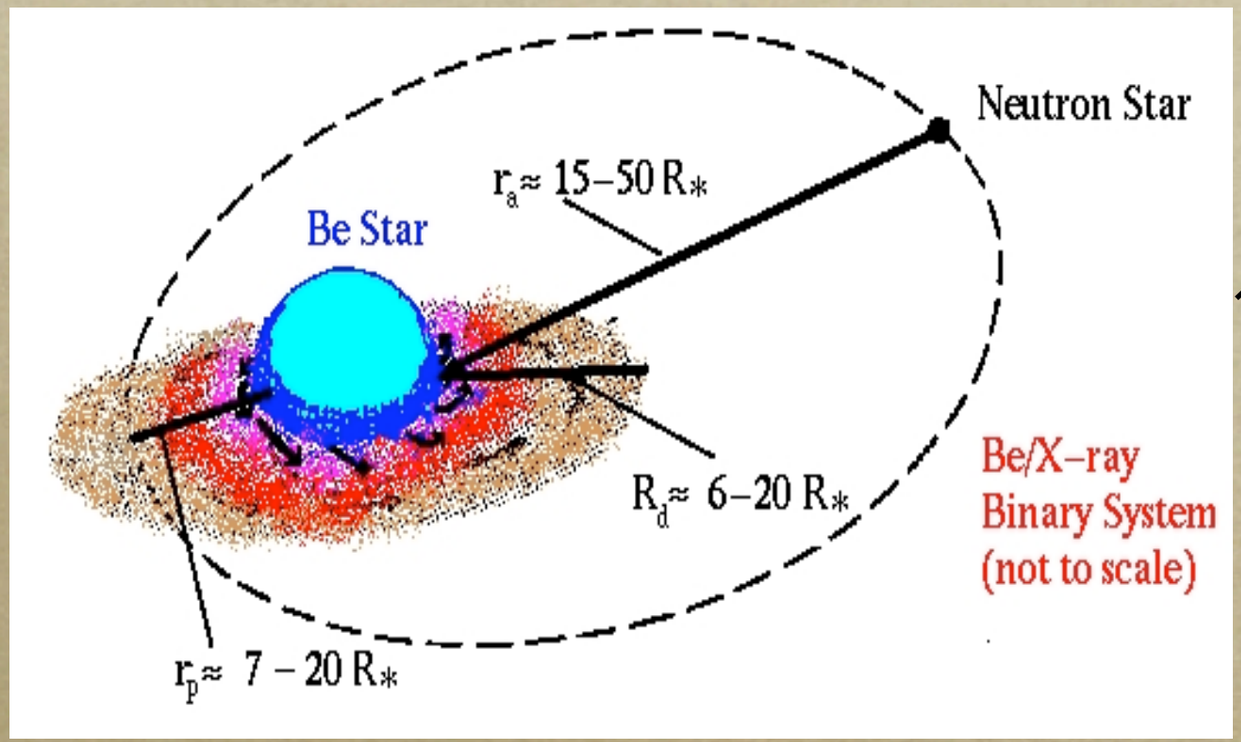




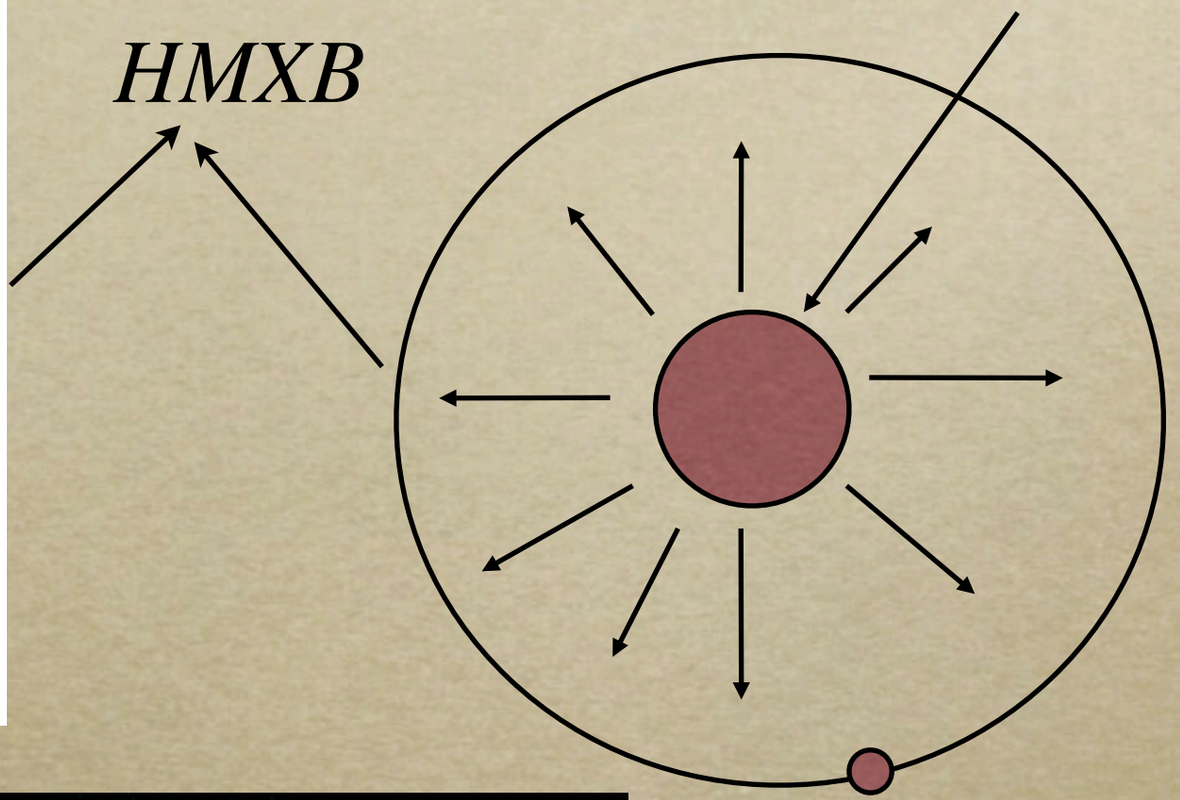
LMXB

Different pulsators

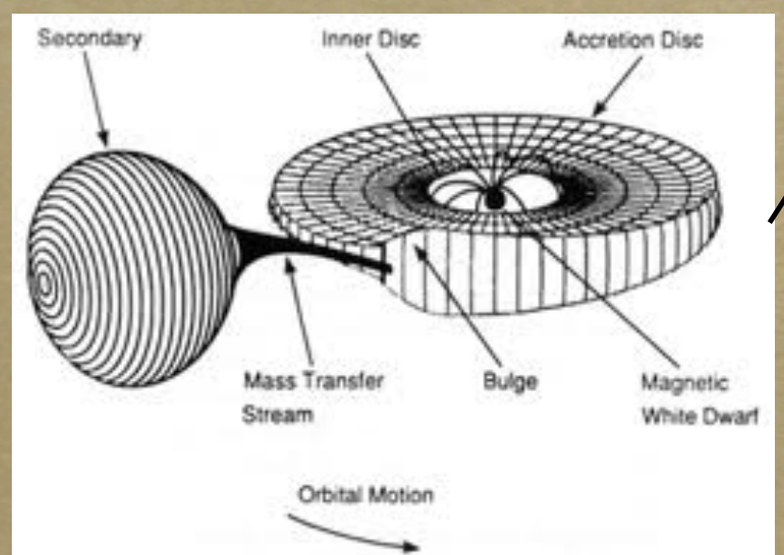
supergiant



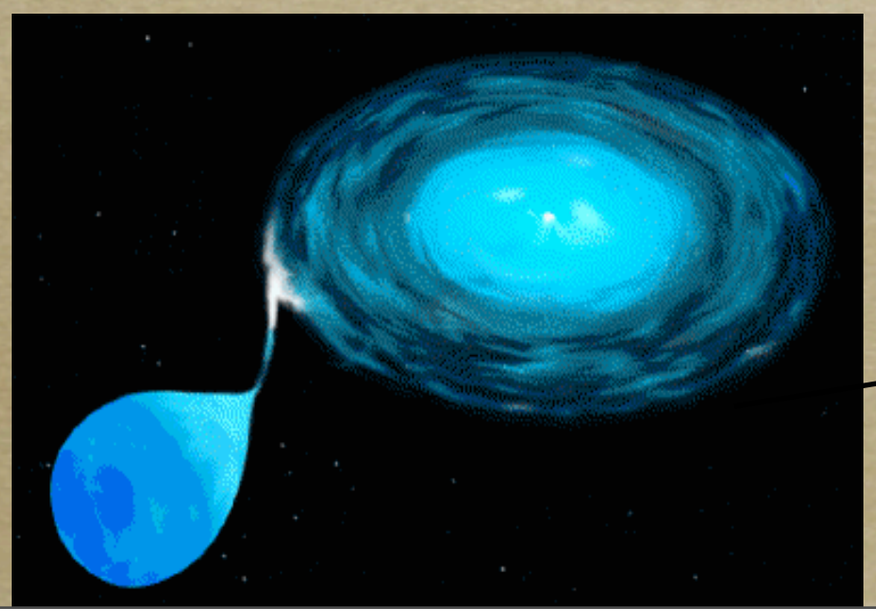
HMXB



neutron star

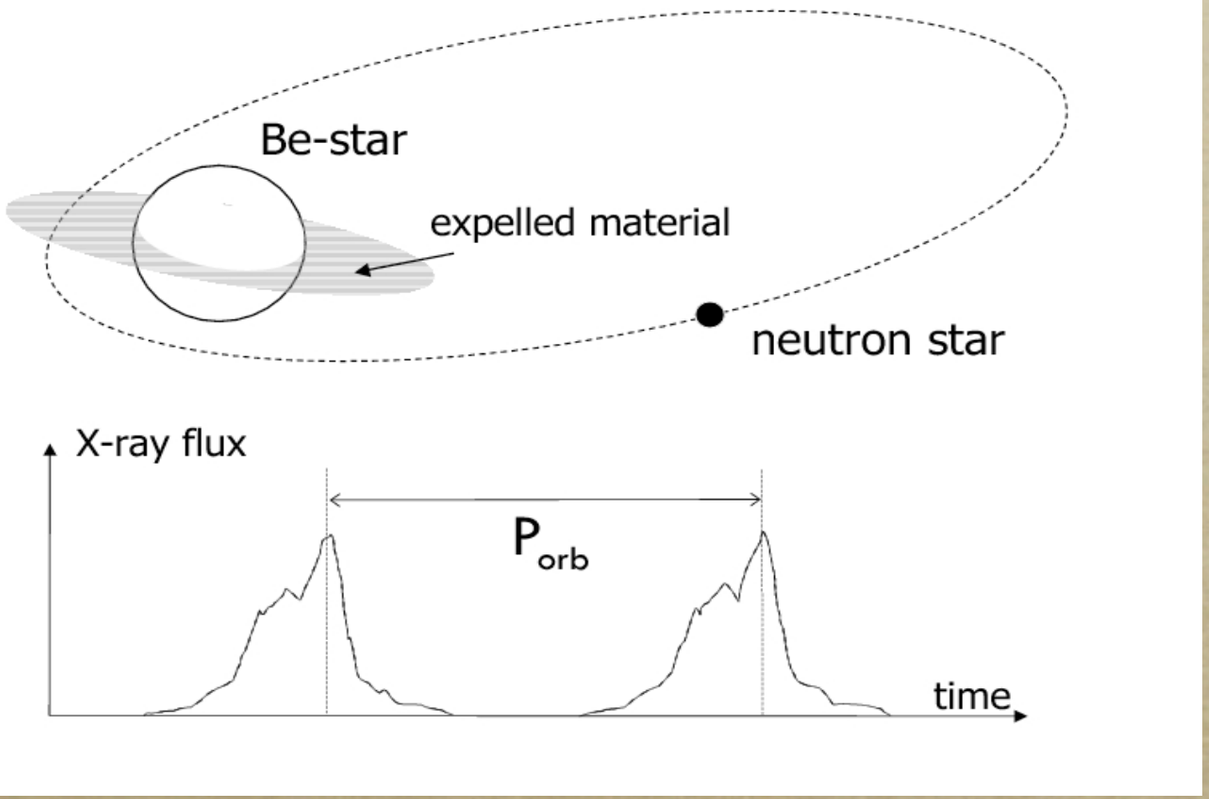


IP



LMXB

What makes these sources special ?



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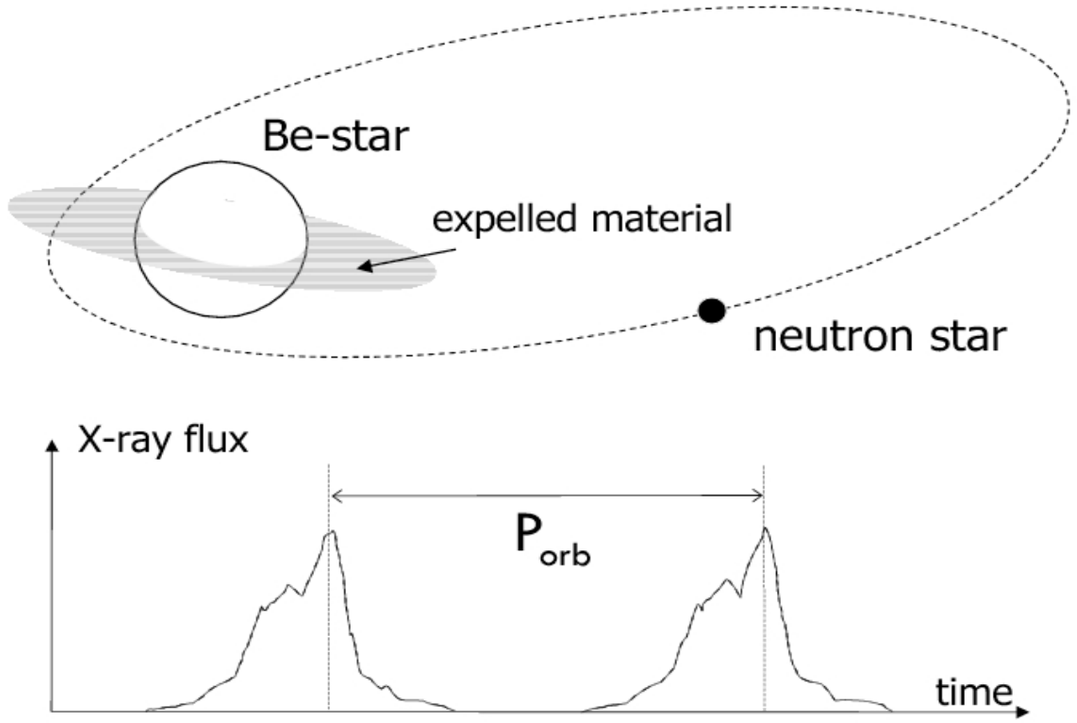
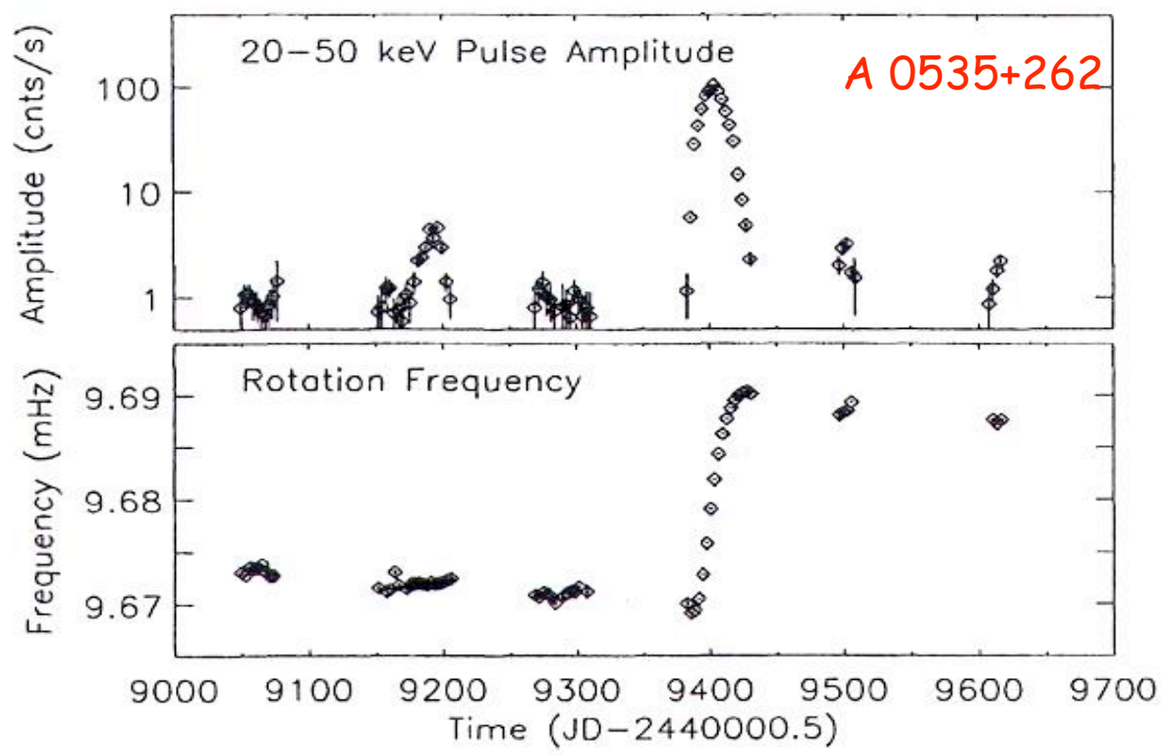
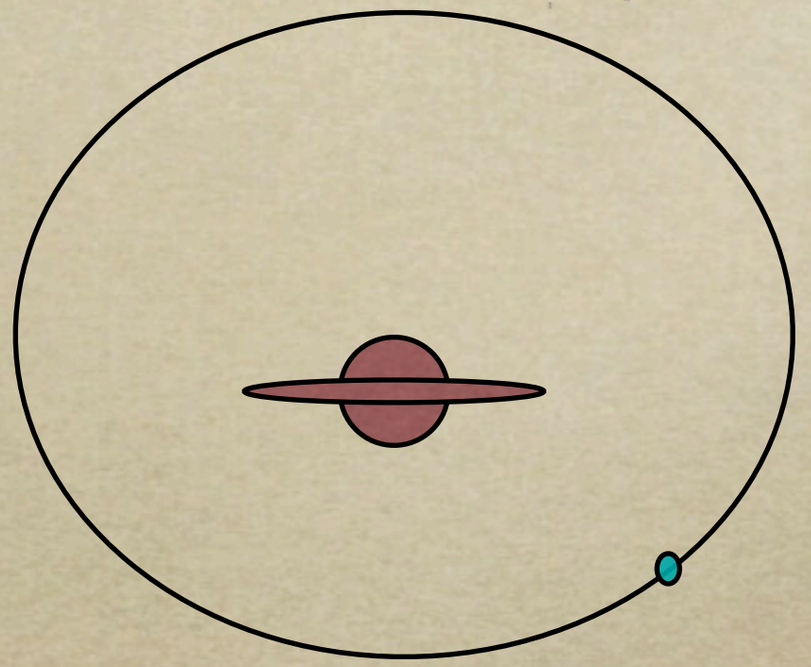


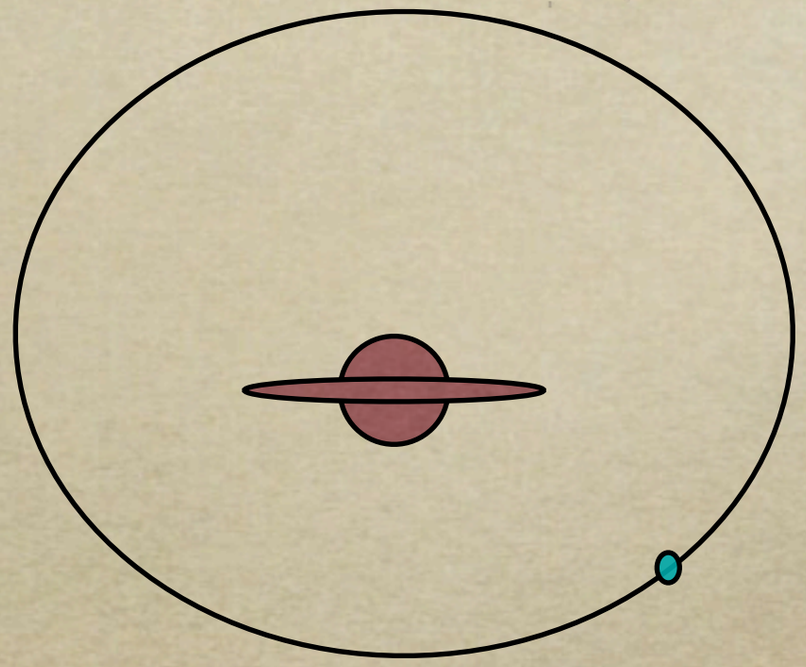


What makes our sources special ?



What makes our sources special ?

- *Classical Be/X-ray binaries have moderately eccentric orbits (e> 0.3).*
- *Pfahl et al. (2002) proposed a class of Be/X-ray binaries which has low-eccentricities (e<0.2) and long orbital periods (> 30 d).*
- *It is possible only if these eccentricities are primordial.*
- *Which means that these sources would have formed in a different type of supernova explosion without or with a small kick to the neutron star.*
- *e.g. X-Per/4U0352+309 (837s).*
- *Proposed sources - RXJ0146.9+6121 (Haberl et al. 1998a, 1998b), RX J1037.5-5647, RX J0440.9+4431 (Reig et al. 1999).*



Source name	Pulse period
SAX J1324.4-6200	171s
SAX J1420.8-5949	437s
AX J1700.1-4157	714s
AX J1740.1-2847	729s
AX J1749.2-2725	220s
AX J1820.5-1434	152s
AX J1832.3-0840	1549s

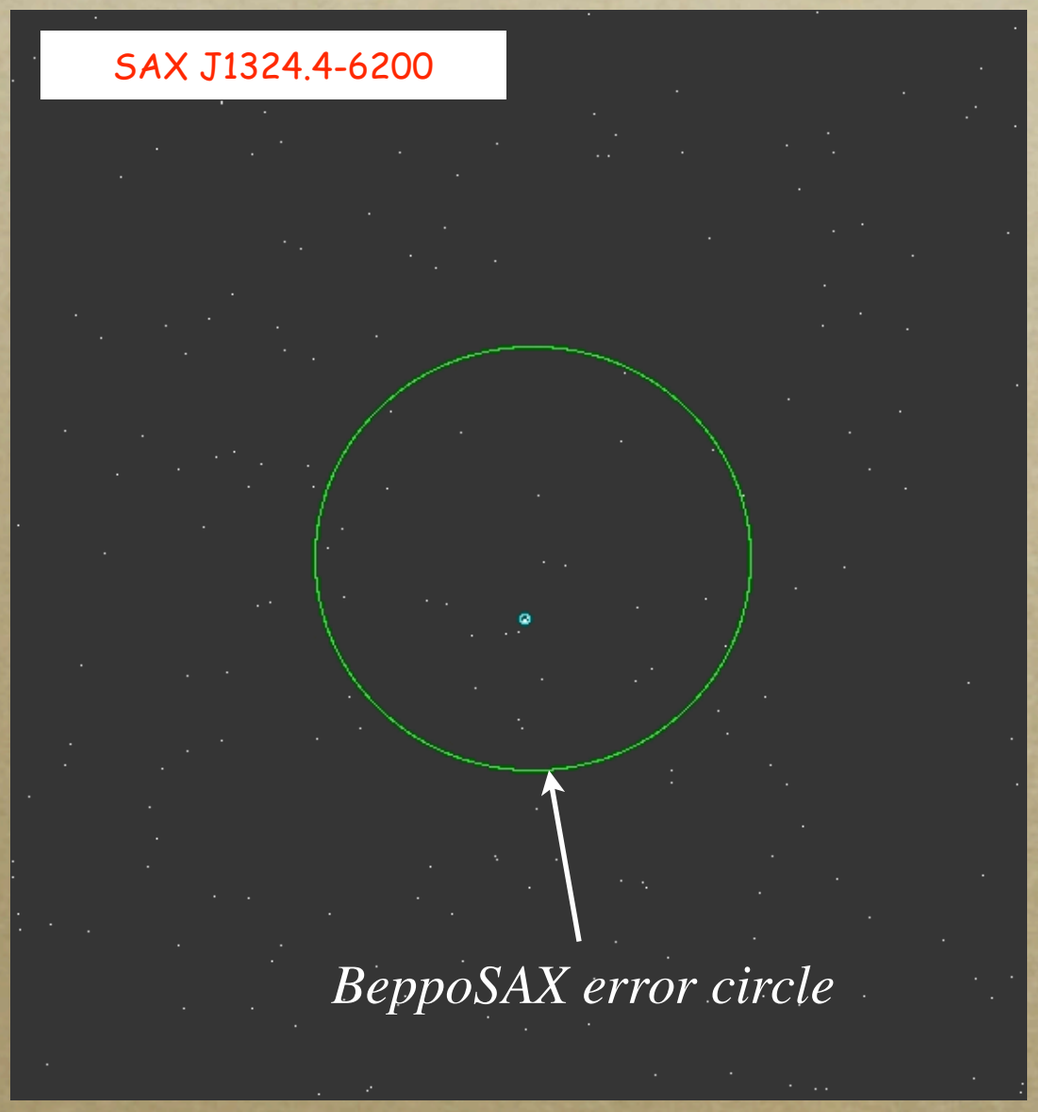
Selection criterion

- *ASCA and BeppoSAX Galactic plane surveys*
- *Pulse periods > 150s*
- *Hard X-ray spectrum ($\Gamma \sim 1.0$)*
- *X-ray luminosity = 10^{34} - 10^{36} $ergs^{-1}$*
- *These selections helped us to exclude anomalous X-ray pulsars, LMXB pulsars and to some extend IPs also.*

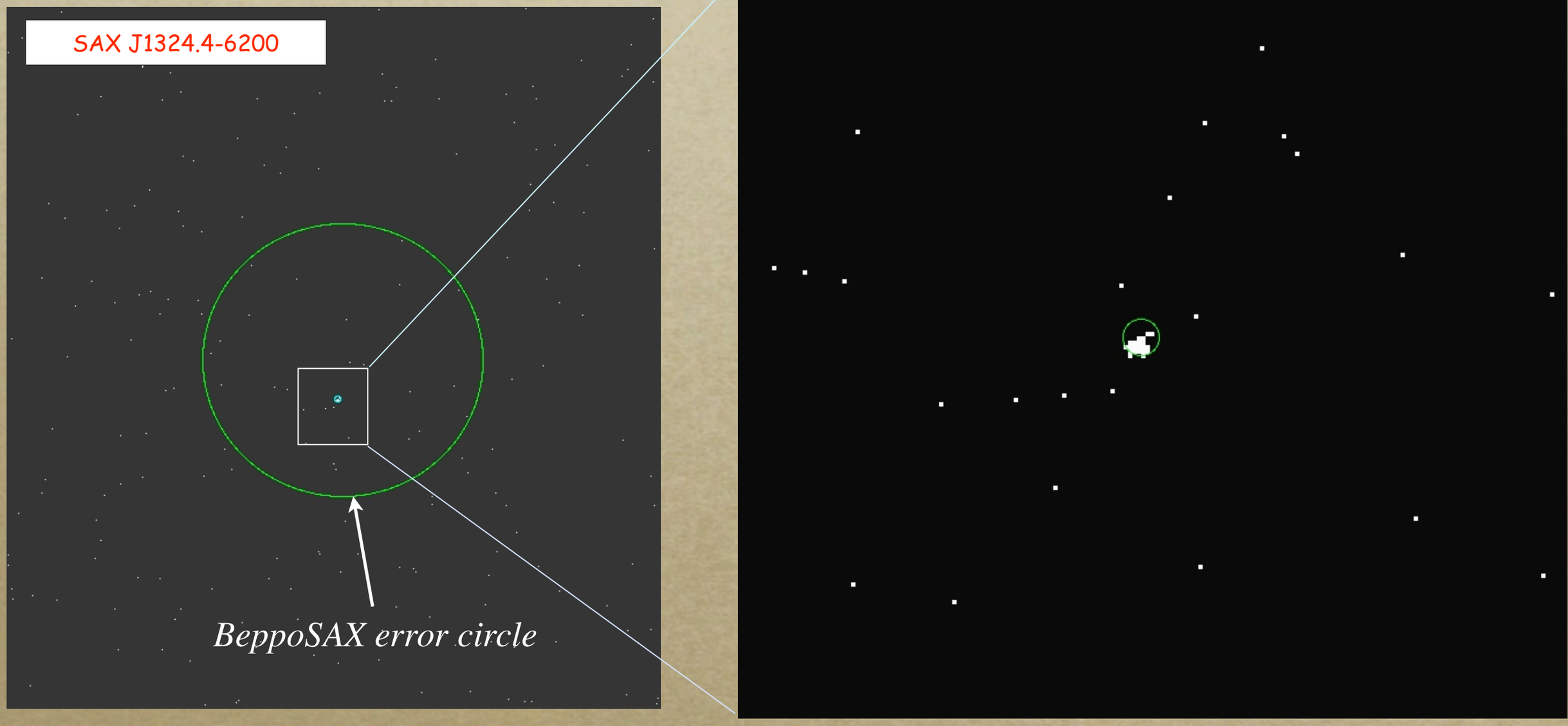
Observations

- ***Chandra*** *- to identify X-ray counterparts*
- ***XMM-Newton*** *- spectral and timing analysis*
- ***ESO-NTT imaging*** *- to identify near-infrared counterparts*
- ***ESO-VLT nir spectroscopy*** *- to study the near-infrared counterparts.*

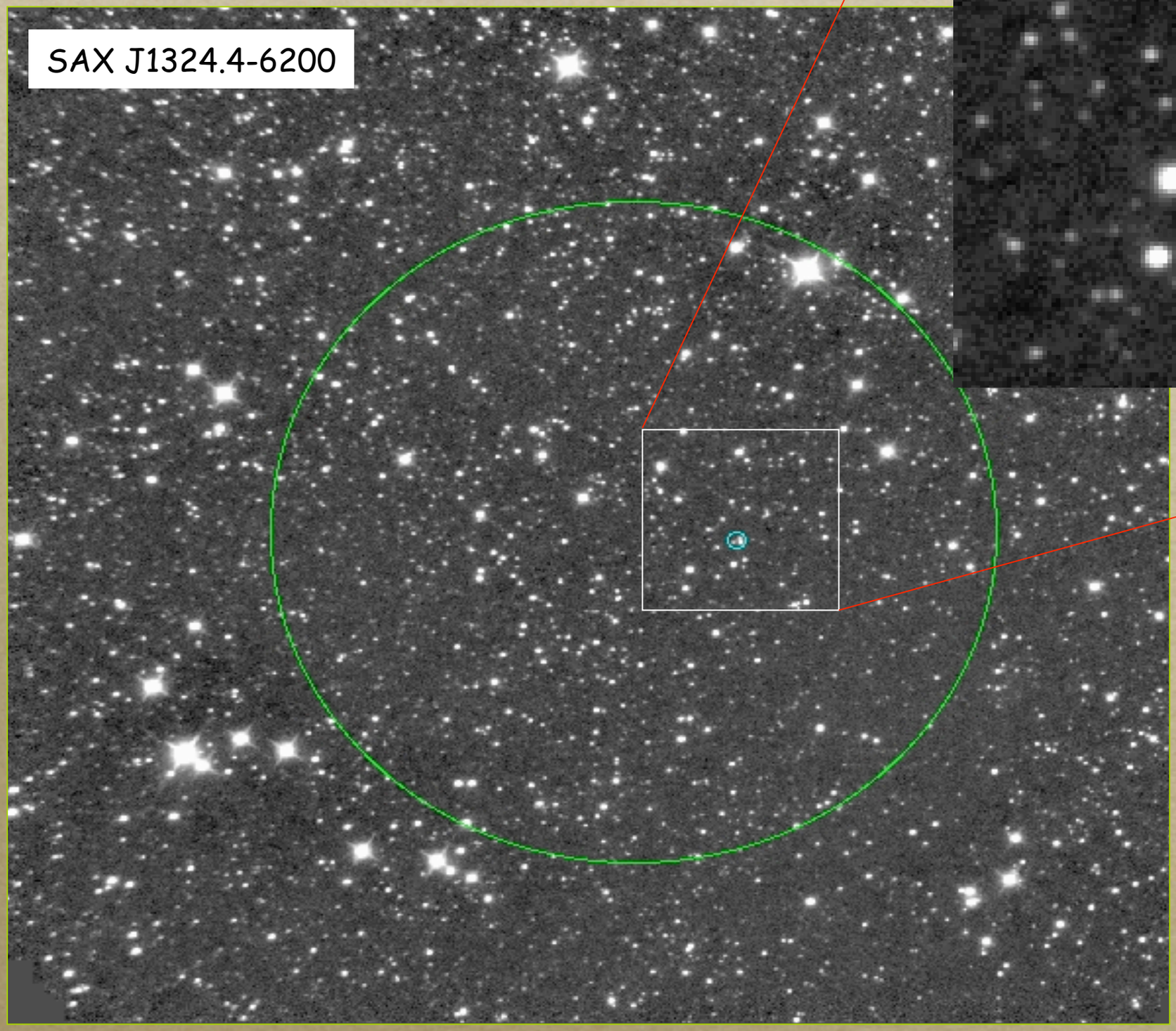
Chandra

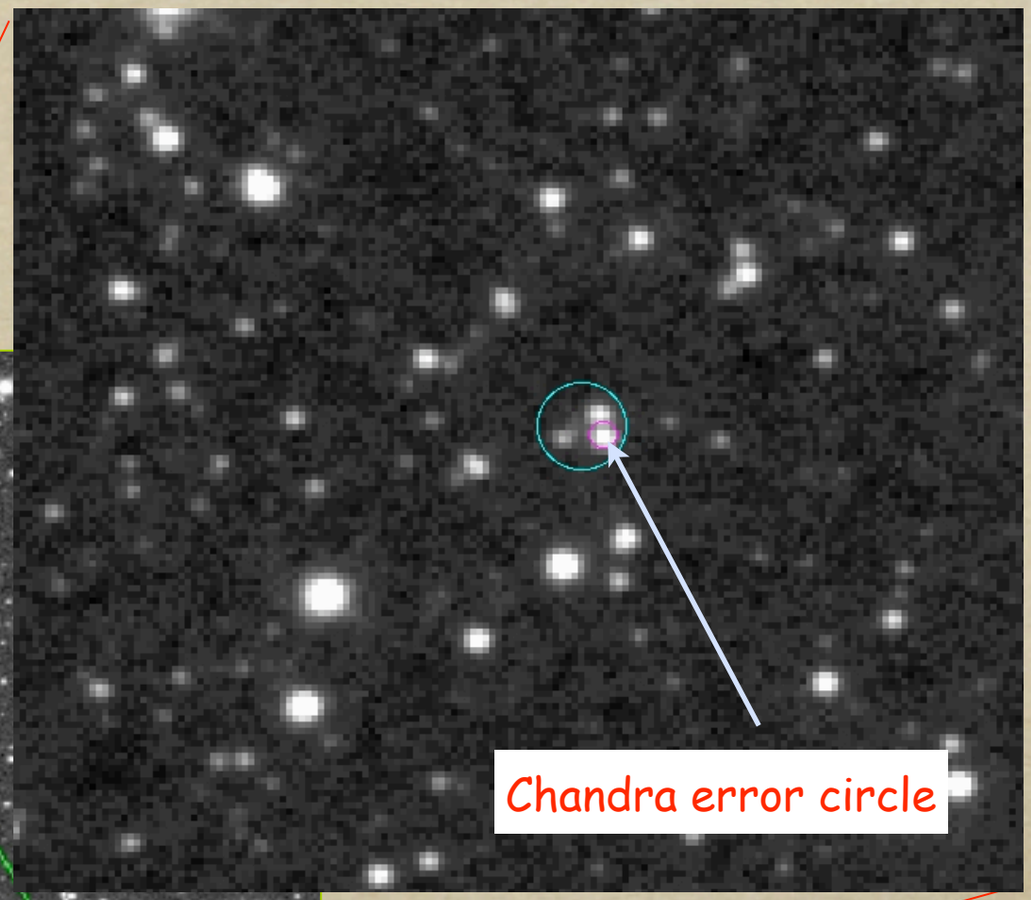


Chandra



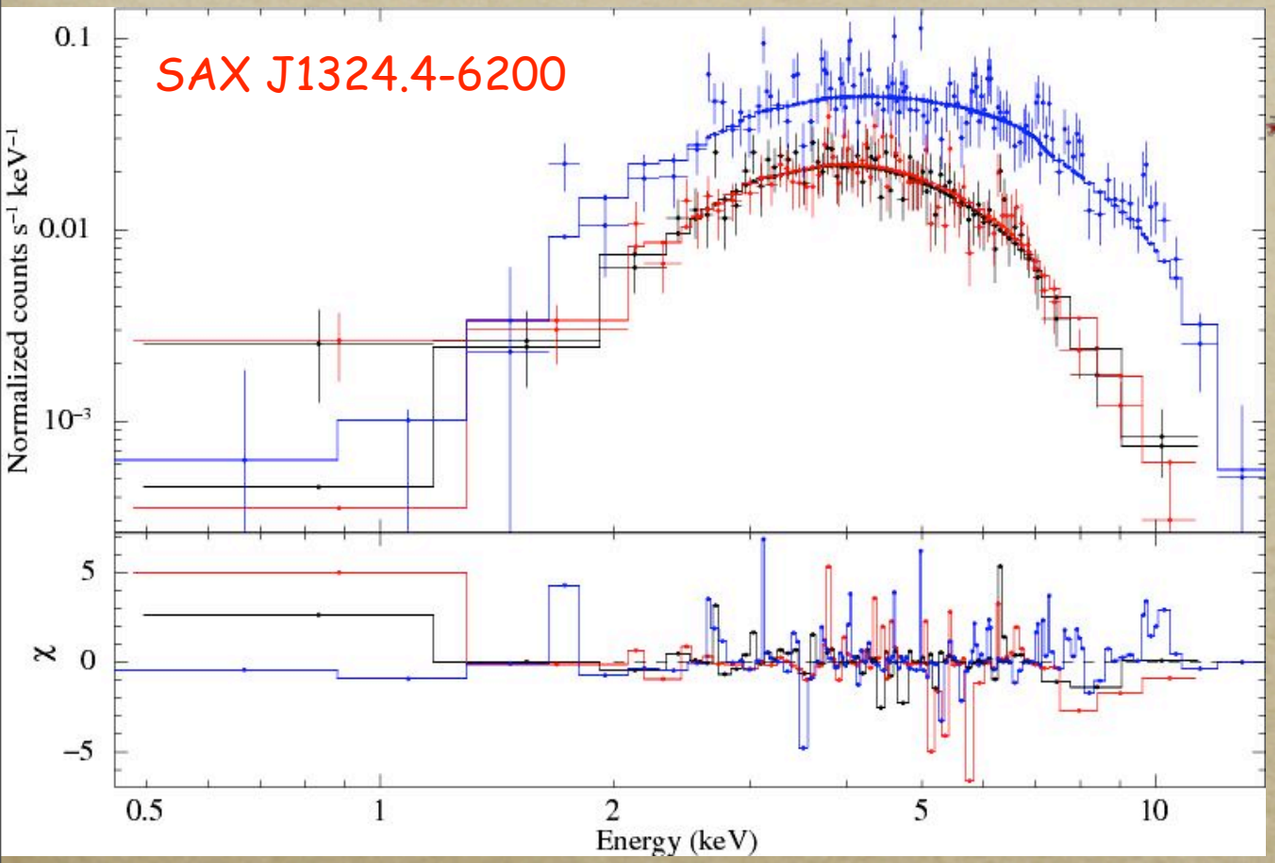
ESO-NTT (NIR)



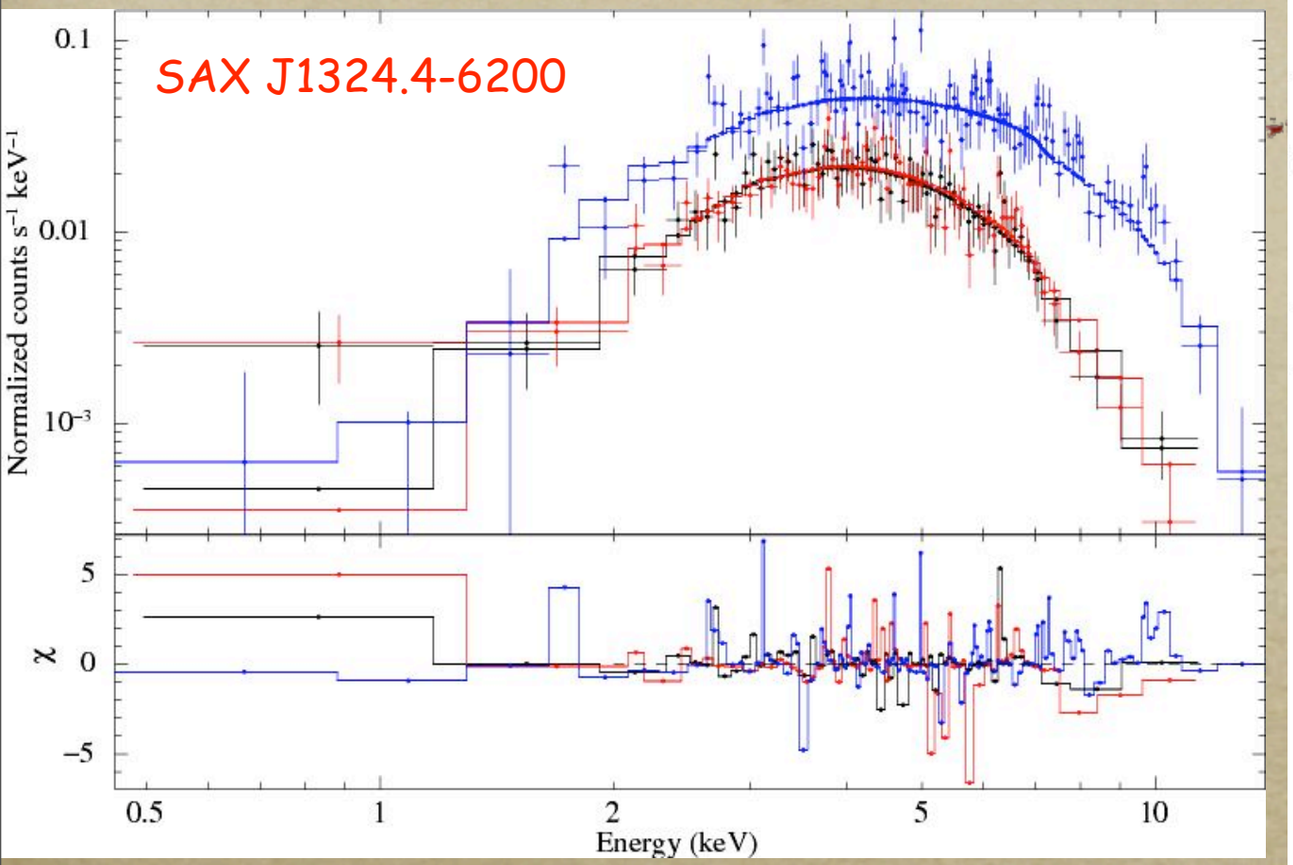


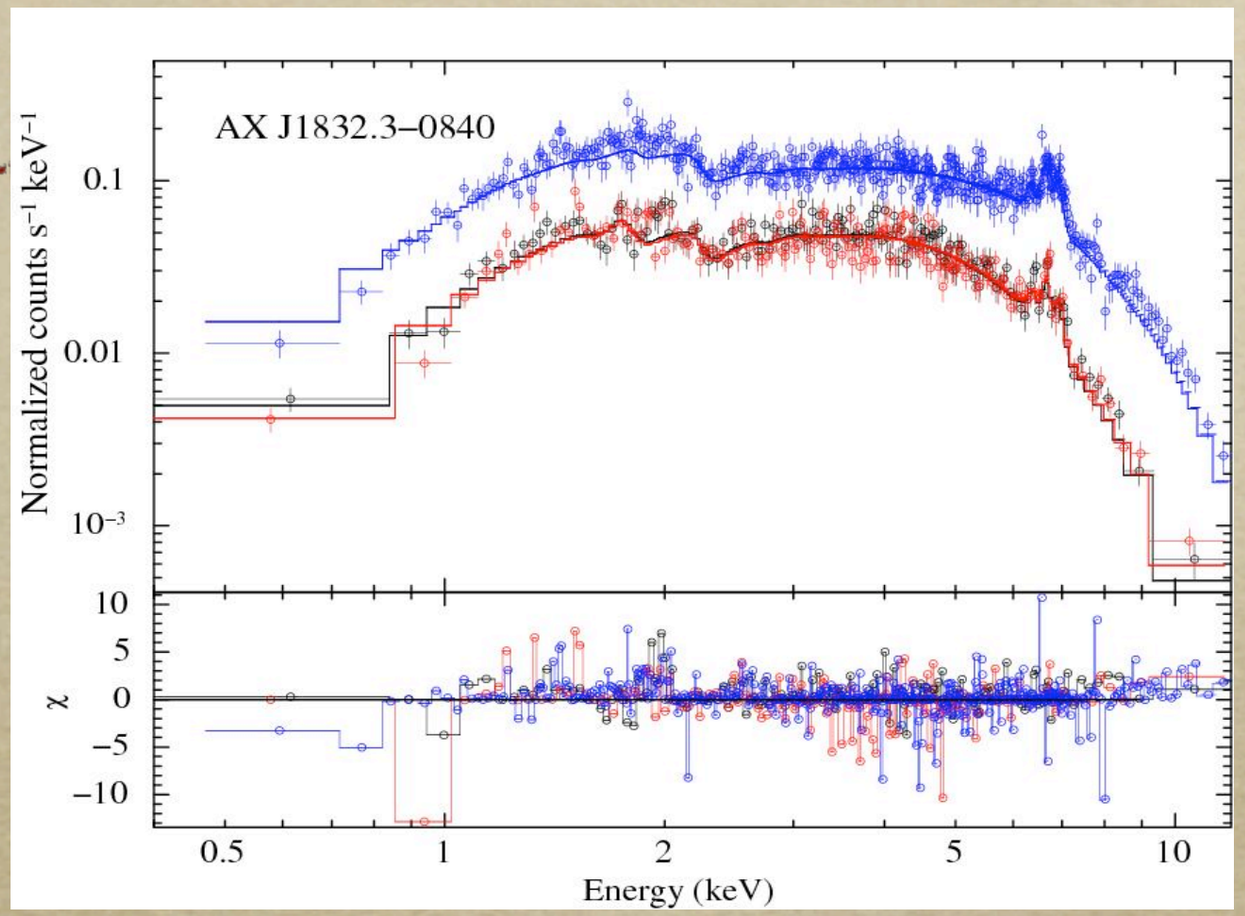
XMM-Newton

XMM-Newton

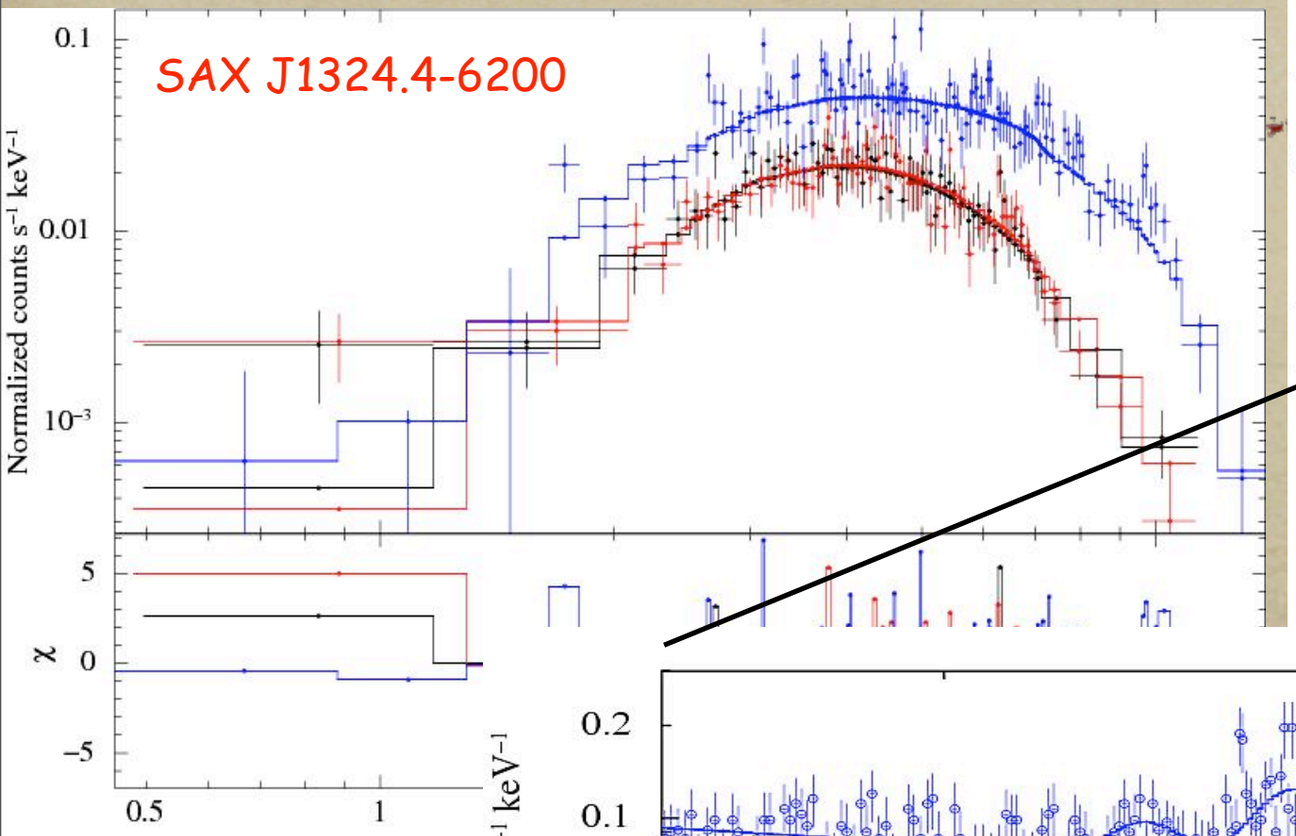

SAX J1324.4-6200
0.1
0.01
10^{-3}
Normalized counts s^{-1} keV^{-1}
5
0
−5
χ
0.5
1
2
5
10
Energy (keV)

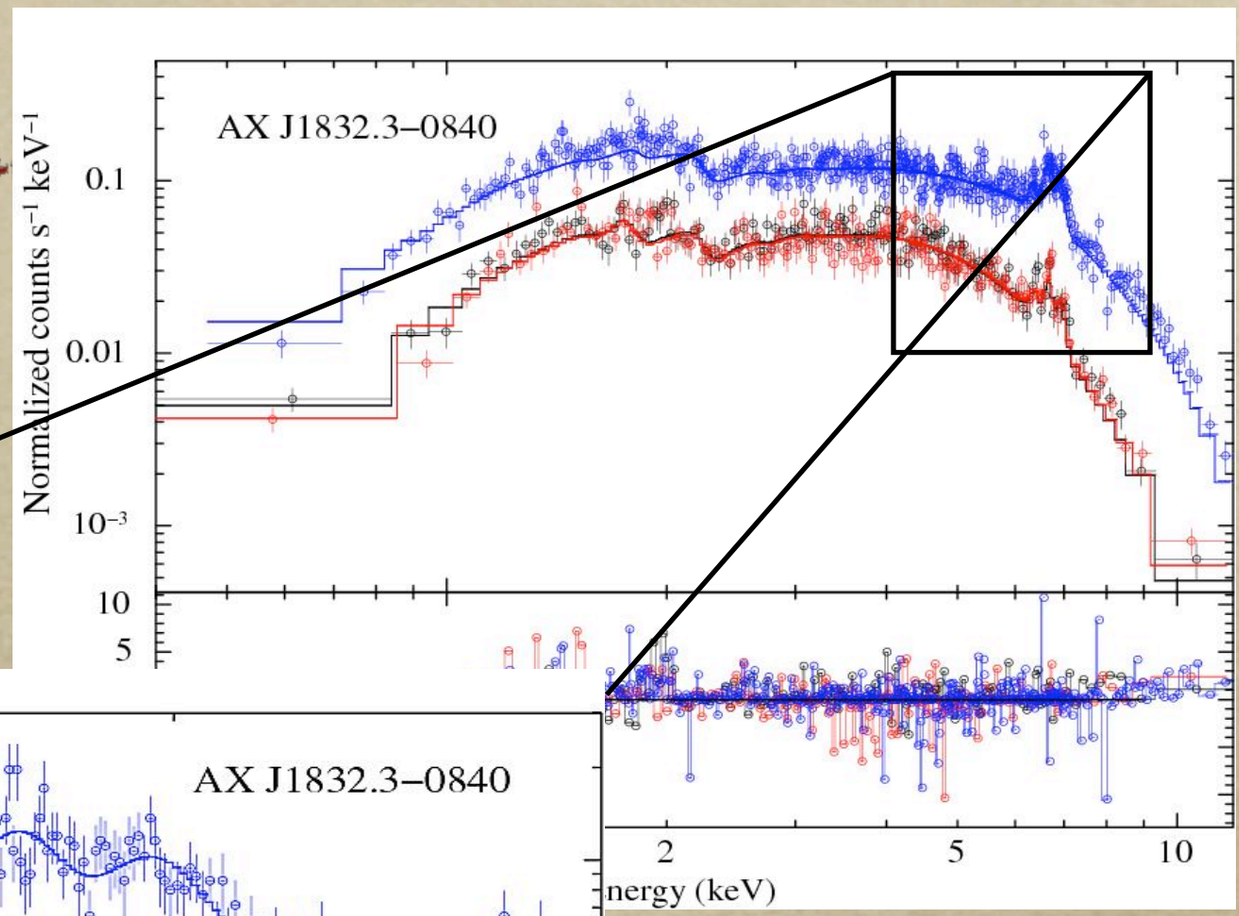
XMM-Newton

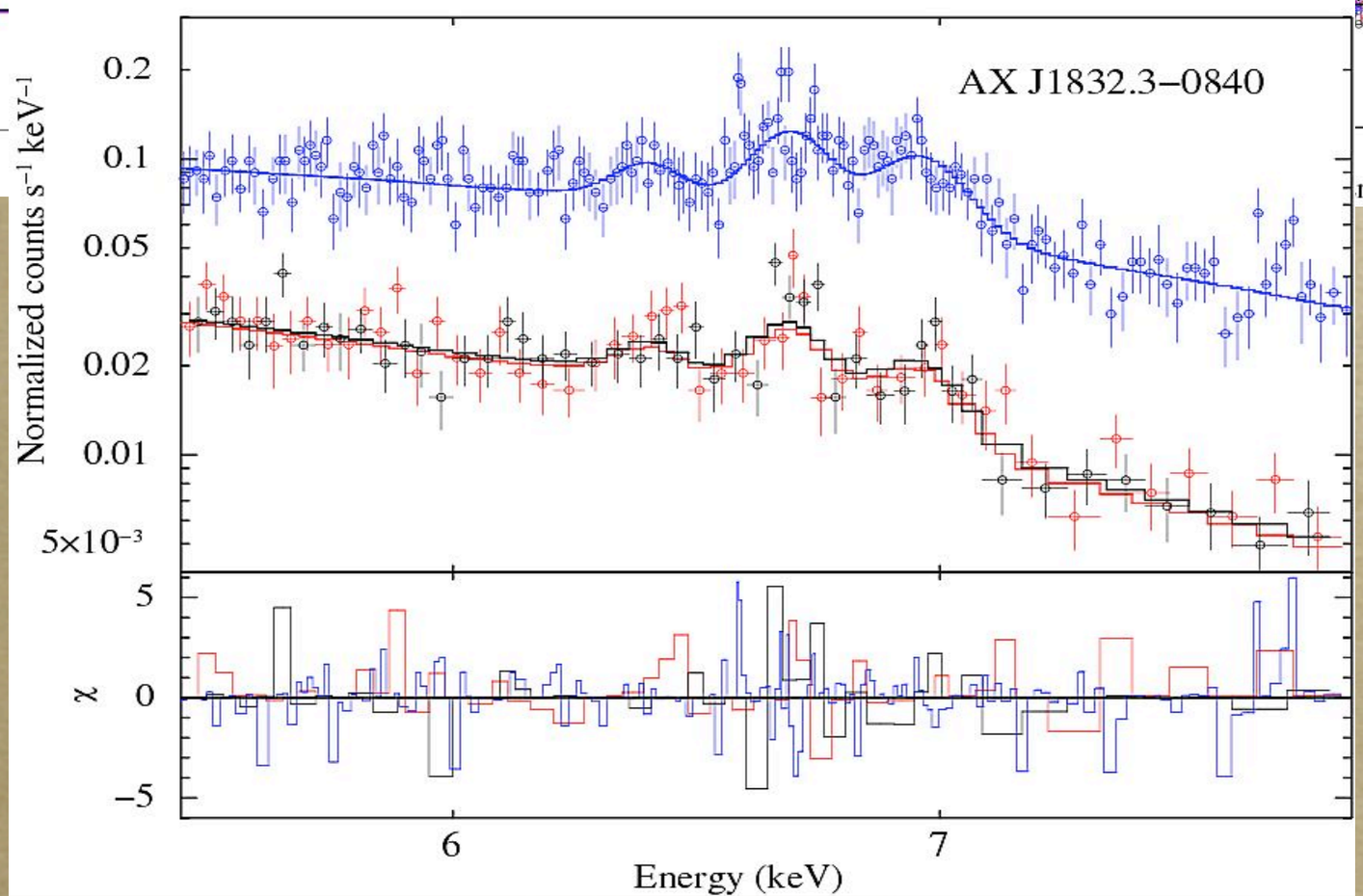

SAX J1324.4-6200
Normalized counts s⁻¹ keV⁻¹
0.1
0.01
10⁻³
χ
5
0
−5
0.5
1
2
5
10
Energy (keV)


AX J1832.3−0840
Normalized counts s⁻¹ keV⁻¹
0.1
0.01
10⁻³
χ
10
5
0
−5
−10
0.5
1
2
5
10
Energy (keV)

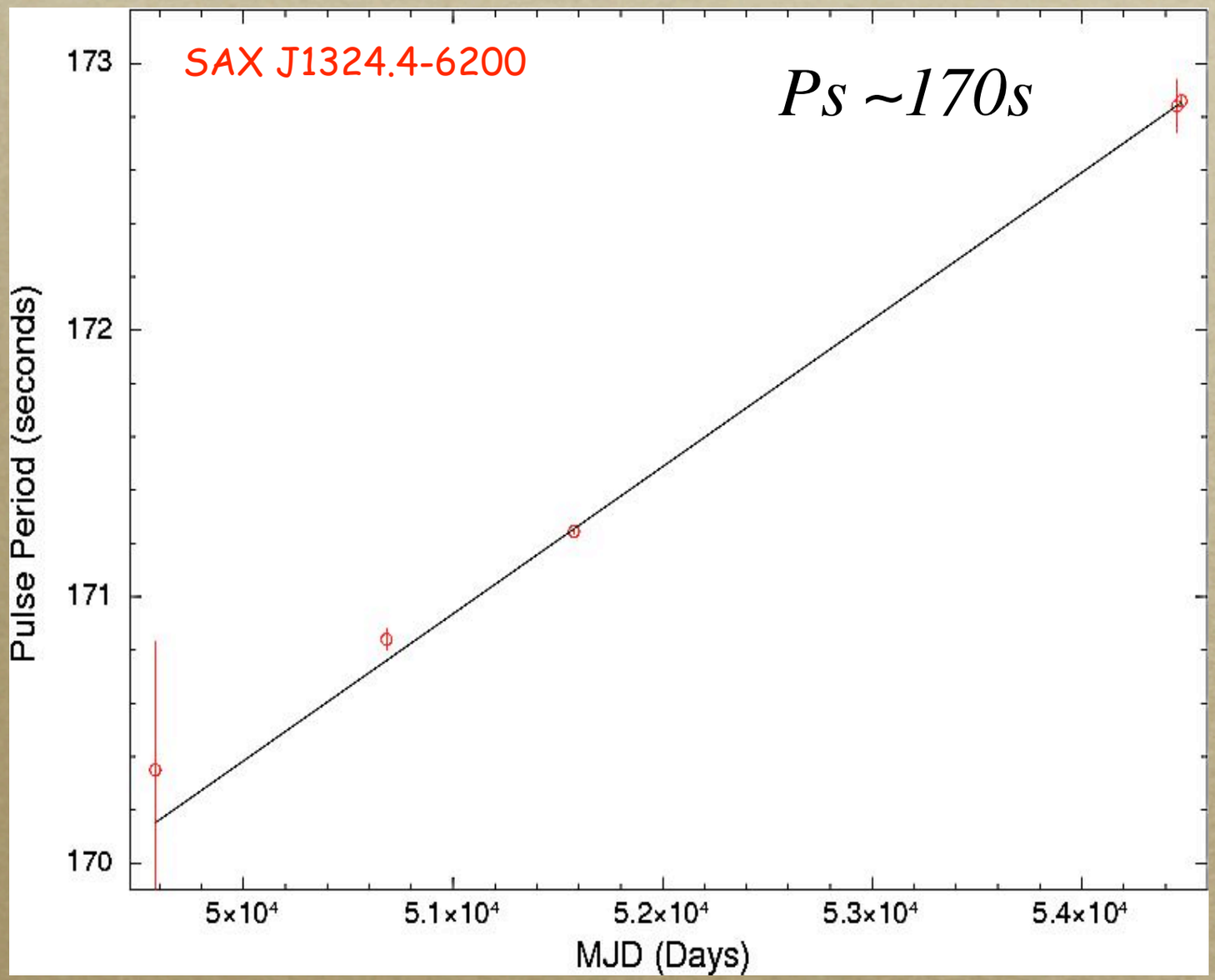
XMM-Newton


SAX J1324.4-6200
Normalized counts s⁻¹ keV⁻¹
0.1
0.01
10⁻³
χ
5
0
−5
0.5
1


AX J1832.3−0840
Normalized counts s⁻¹ keV⁻¹
0.1
0.01
10⁻³
10
5
2
5
10
nergy (keV)

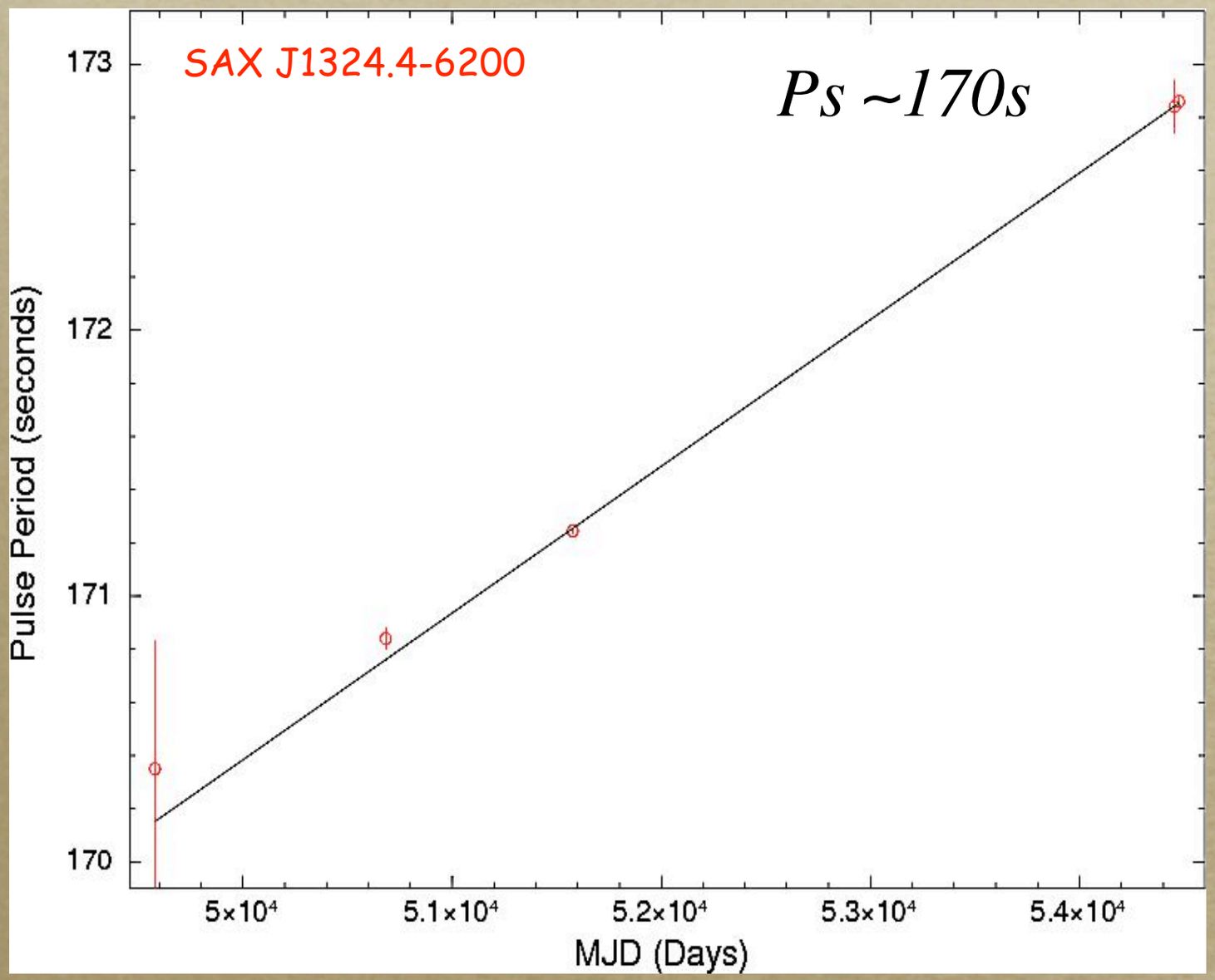

AX J1832.3−0840
Normalized counts s⁻¹ keV⁻¹
0.2
0.1
0.05
0.02
0.01
5×10⁻³
χ
5
0
−5
6
7
Energy (keV)

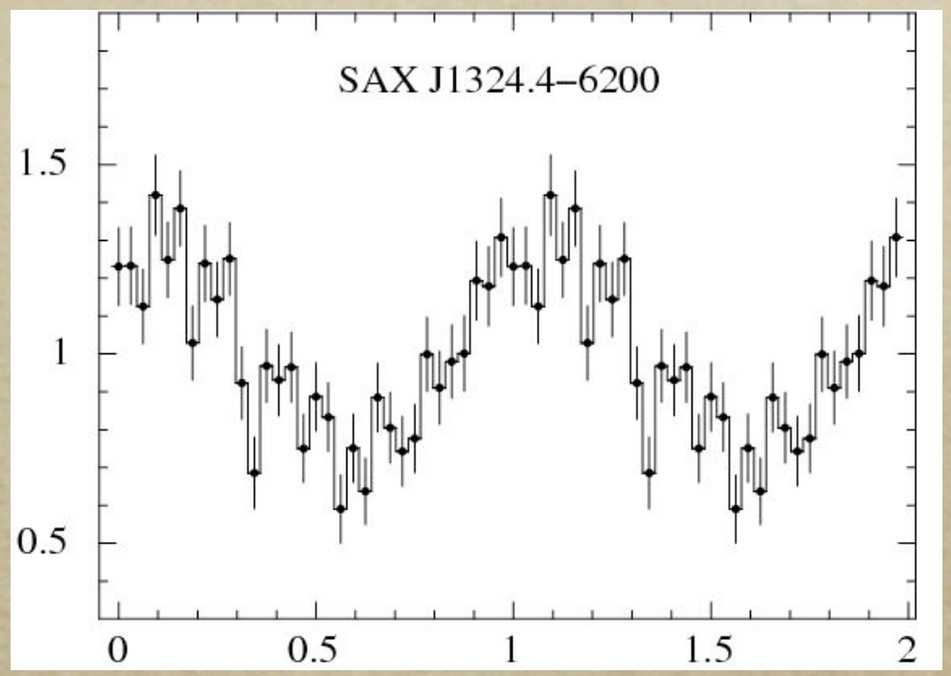
X-ray timing

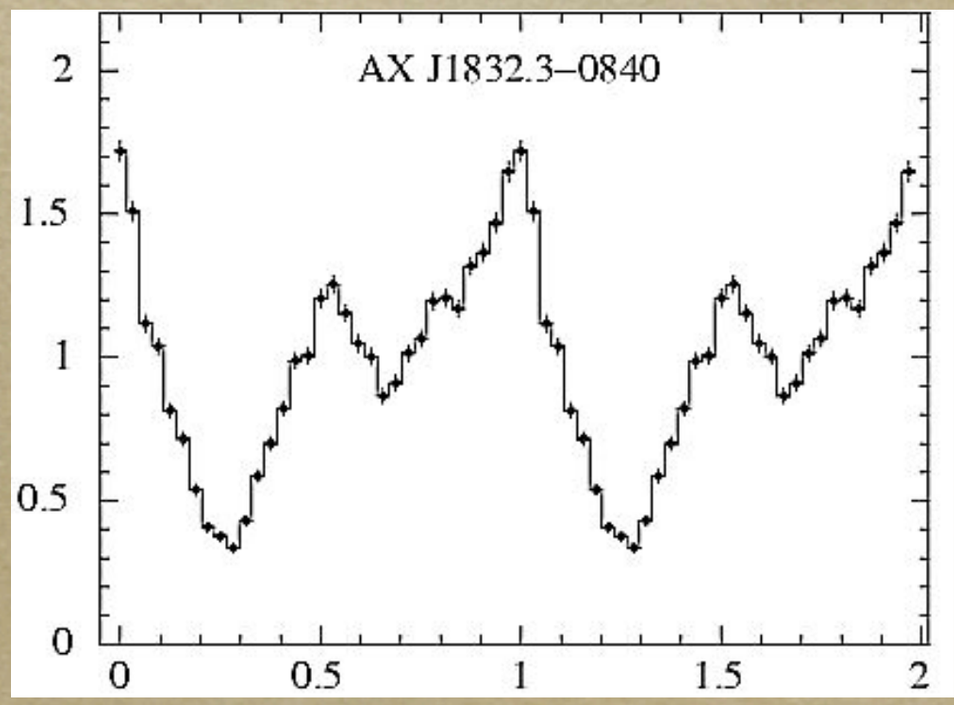


Spin period derivative = 6.34 x 10^{-9} s/s

X-ray timing







Spin period derivative = 6.34 x 10^{-9} s/s

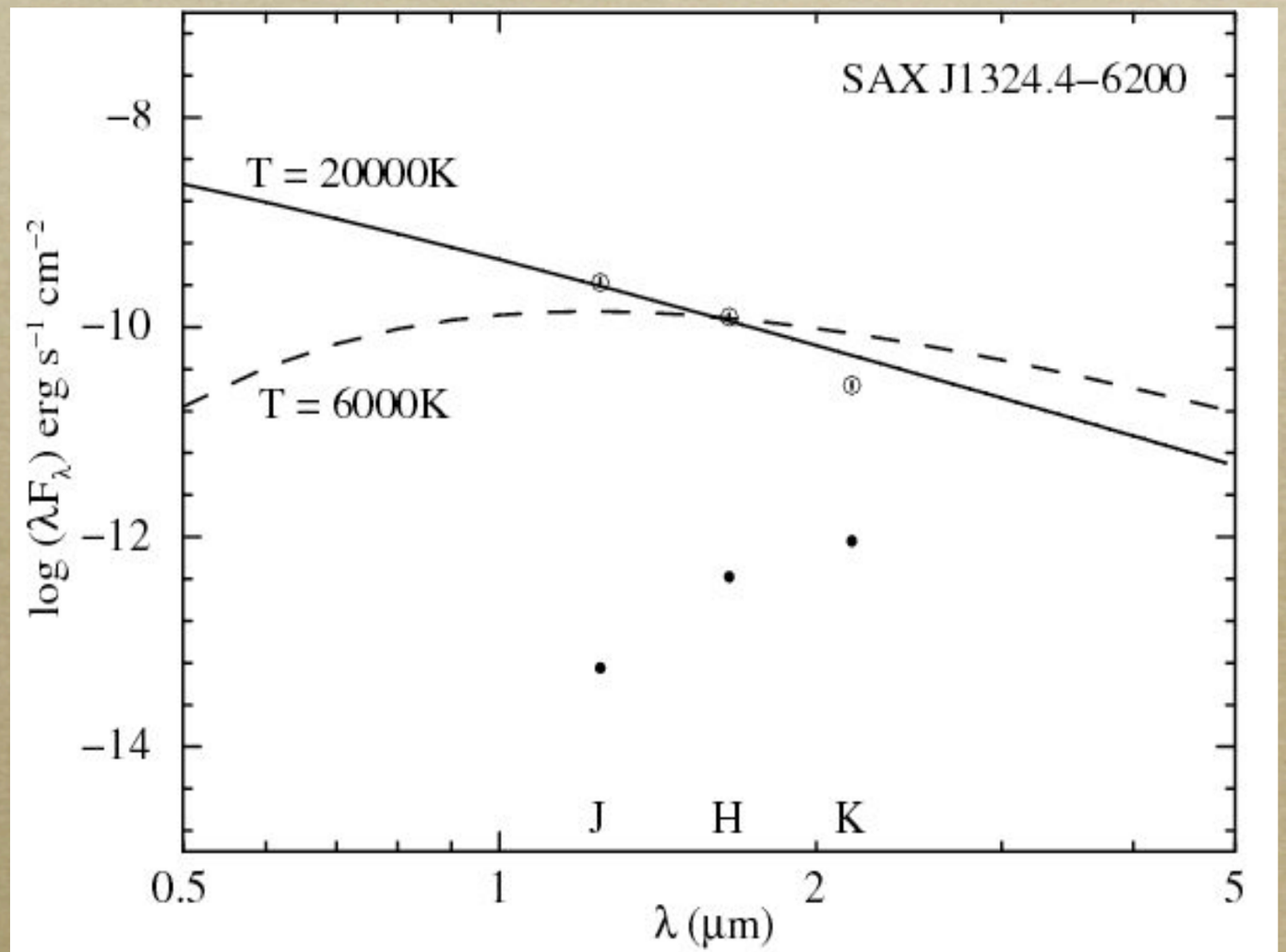
SAX J1324.4-6200 - NIR imaging

- Supergiant or a O-type star - > outside the Galaxy
- late-type ms star

  < 1.3 kpc.
- ms B-type star - >

  4 - 9 kpc.
- late-type giant - >

  2 - 11 kpc.



SAX J1324.4-6200

	Spin period	Ps derivative	X-ray spectra	Spectral type
LMXB				
HMXB				
IPs				

SAX J1324.4-6200

	Spin period	Ps derivative	X-ray spectra	Spectral type
LMXB	√			
HMXB	√			
IPs	√			

SAX J1324.4-6200

	Spin period	Ps derivative	X-ray spectra	Spectral type
LMXB	√	√		
HMXB	√	√		
IPs	√	×		

SAX J1324.4-6200

	Spin period	Ps derivative	X-ray spectra	Spectral type
LMXB	√	√	×	
HMXB	√	√	√	
IPs	√	×	×	

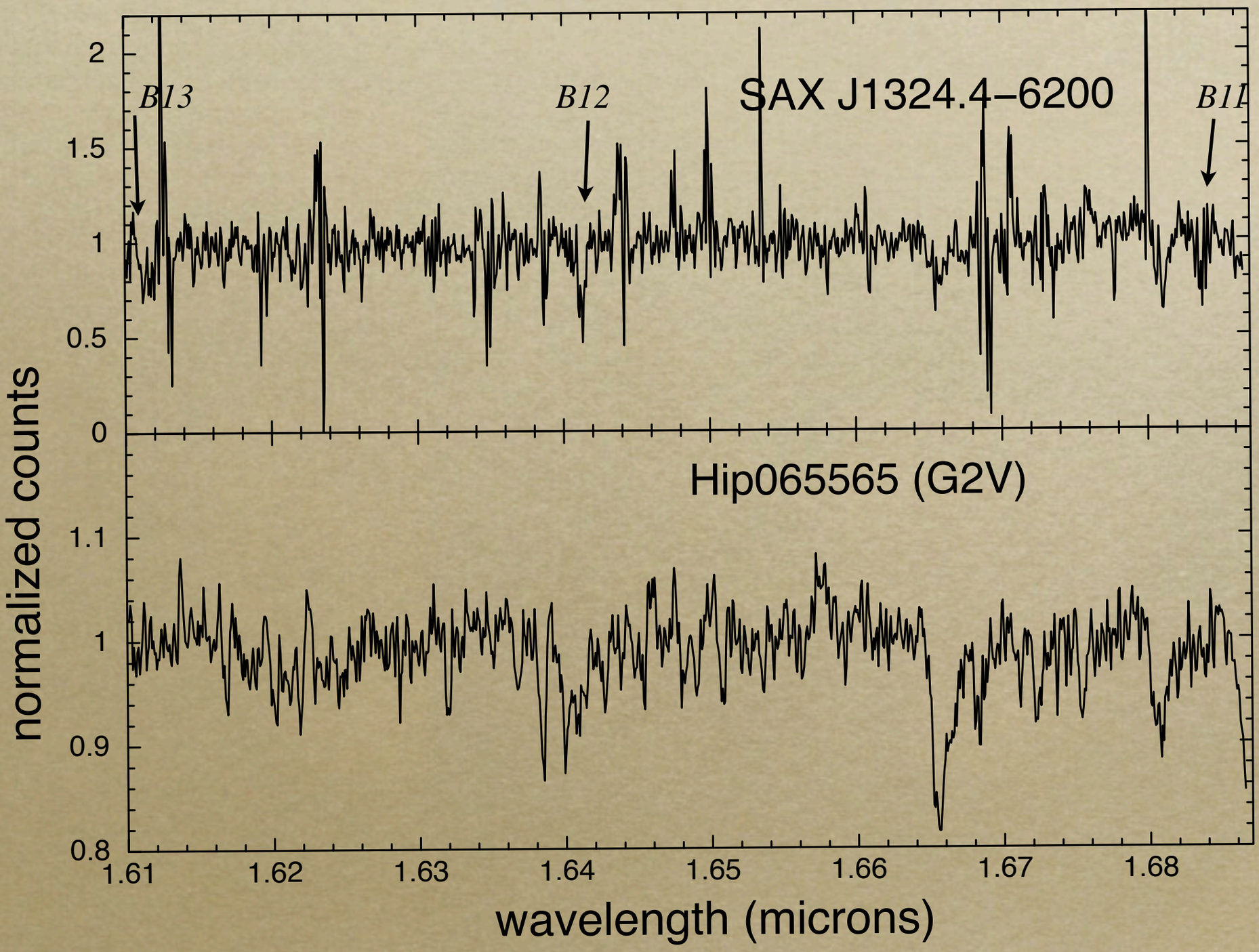
SAX J1324.4-6200

	Spin period	Ps derivative	X-ray spectra	Spectral type
LMXB	√	√	×	√
HMXB	√	√	√	√
IPs	√	×	×	√

AX J1832.3-0840

	Spin period	Ps derivative	X-ray spectra	Spectral type
LMXB	×	√	×	√
HMXB	√	√	×	×
IPs	√	√	√	√

SAX J1324.4-6200



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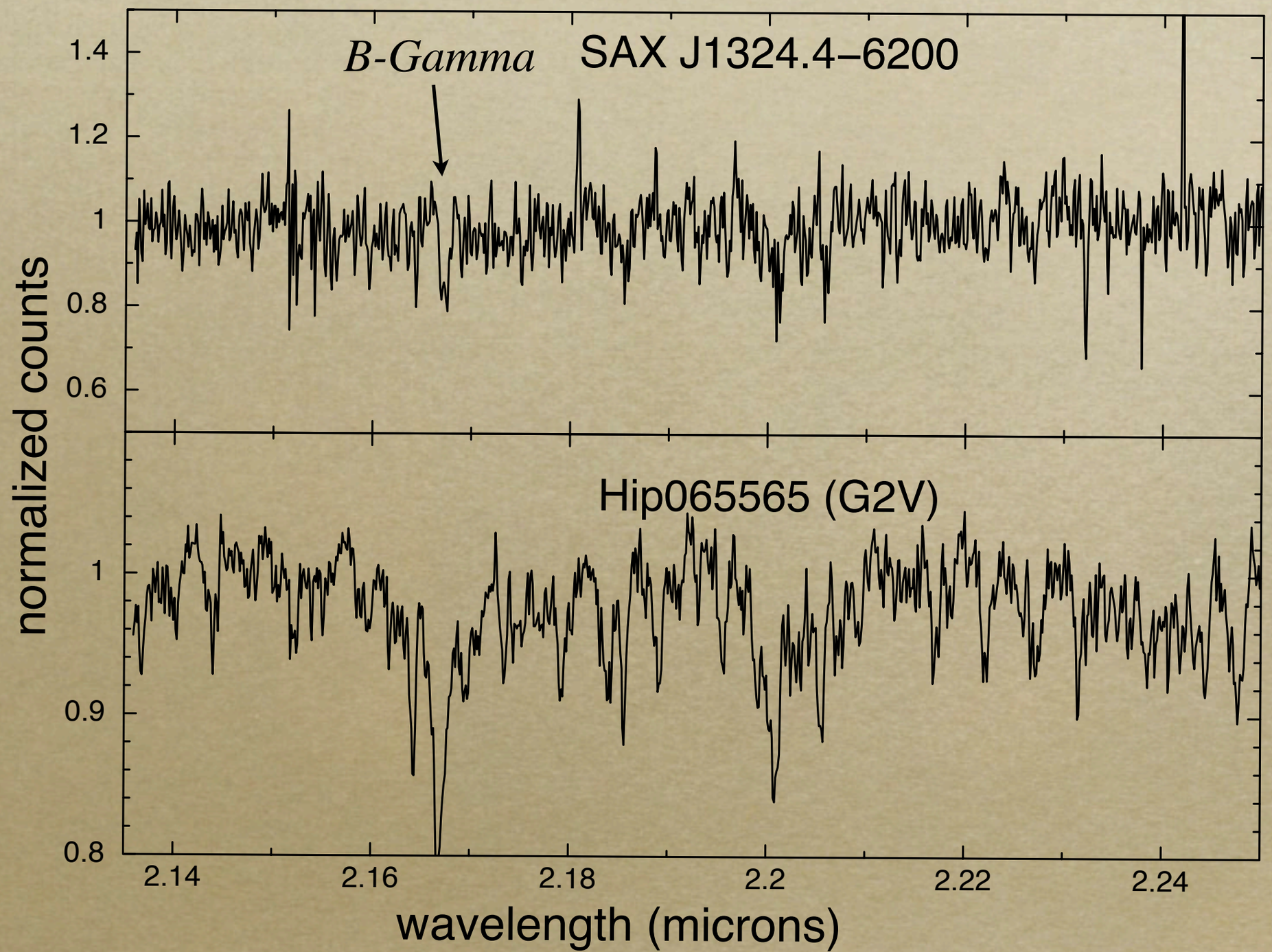
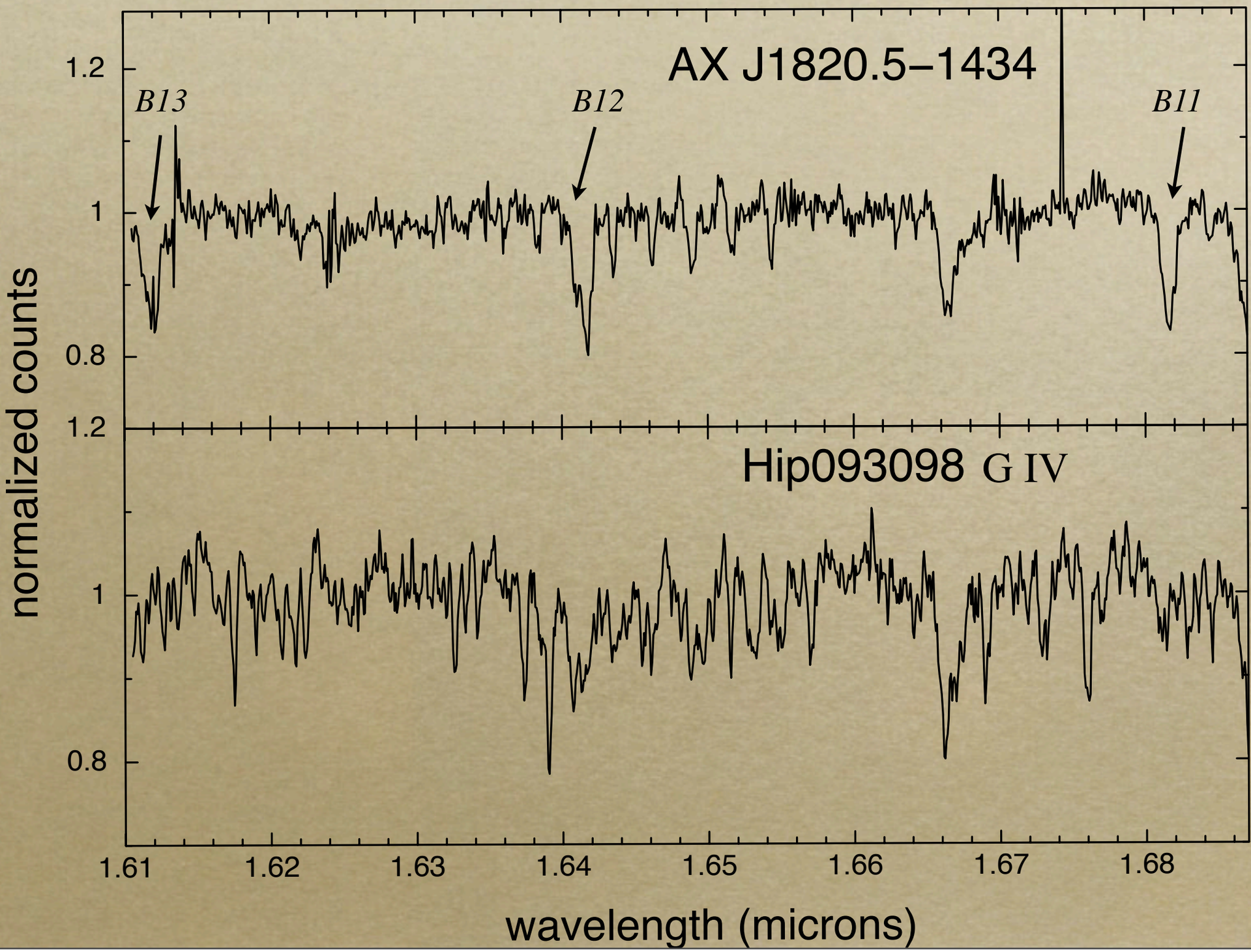


AX J1820.5-1434



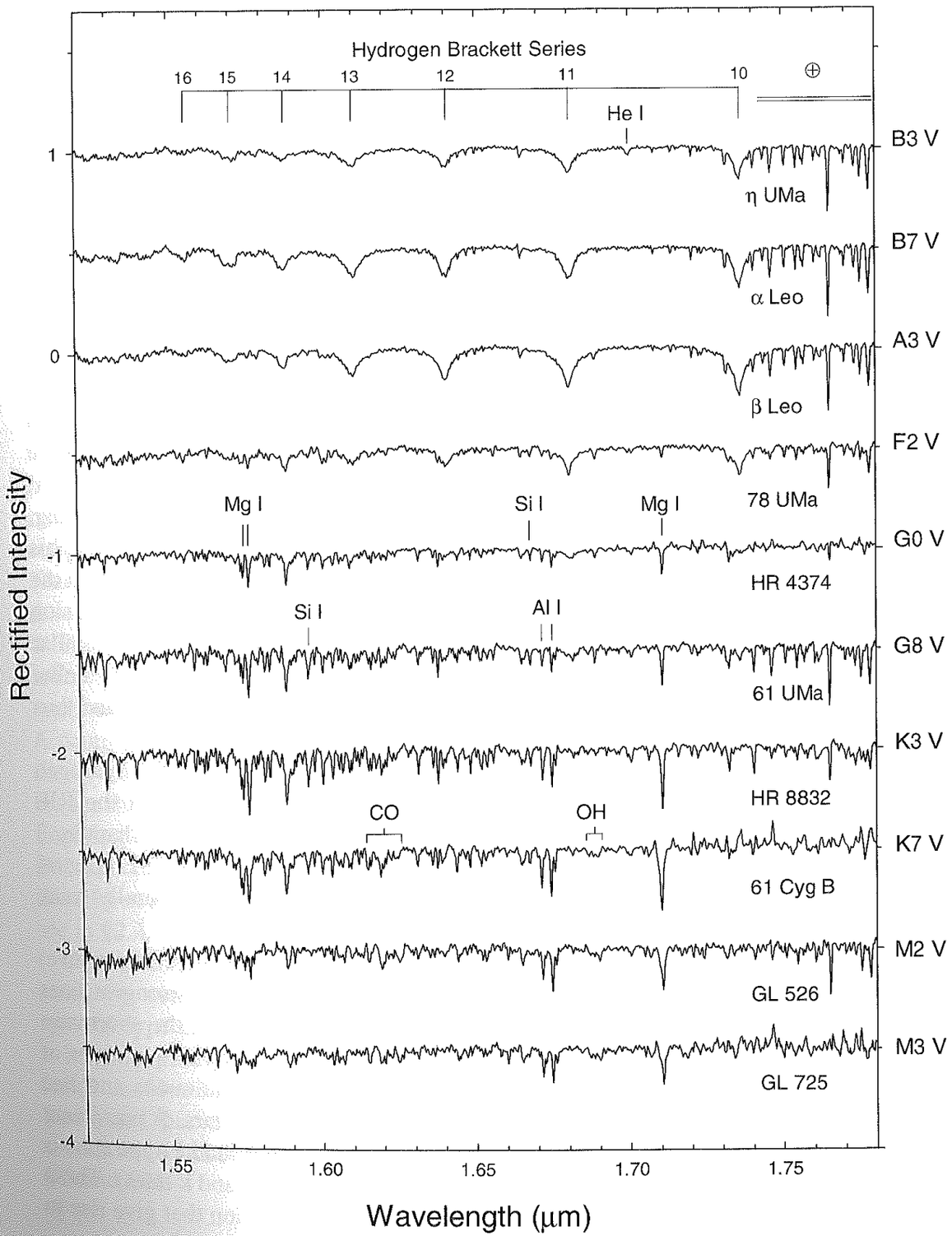


Figure 2.7 The Main Sequence in the H-band infrared. The spectra in this figure are from Meyer et al. (1998) and have been rectified. They have been given half-integer vertical offsets.

Stellar spectral classification

- Richard O. Gray and Christopher J. Corbally

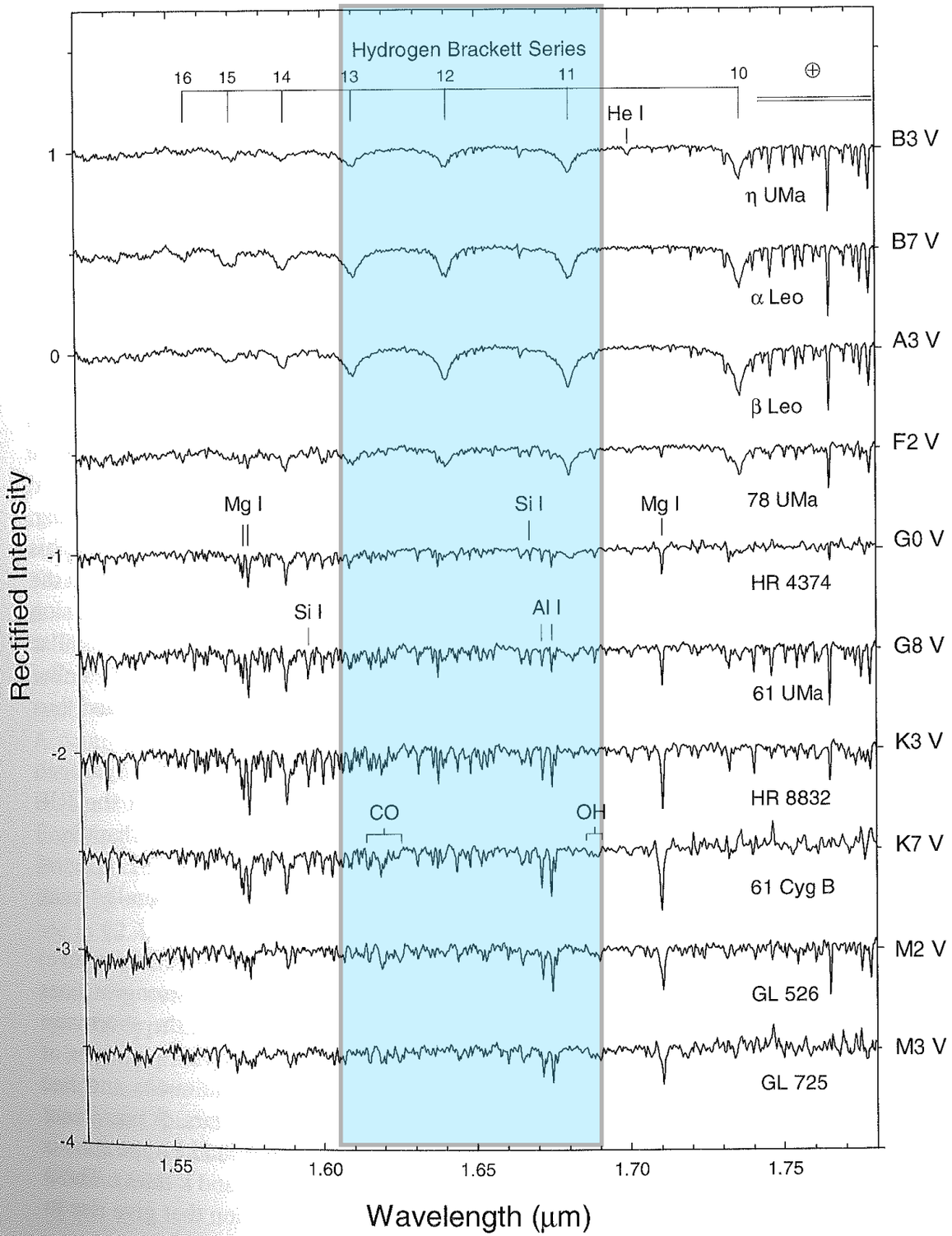


Figure 2.7 The Main Sequence in the H-band infrared. The spectra in this figure are from Meyer et al. (1998) and have been rectified. They have been given half-integer vertical offsets.

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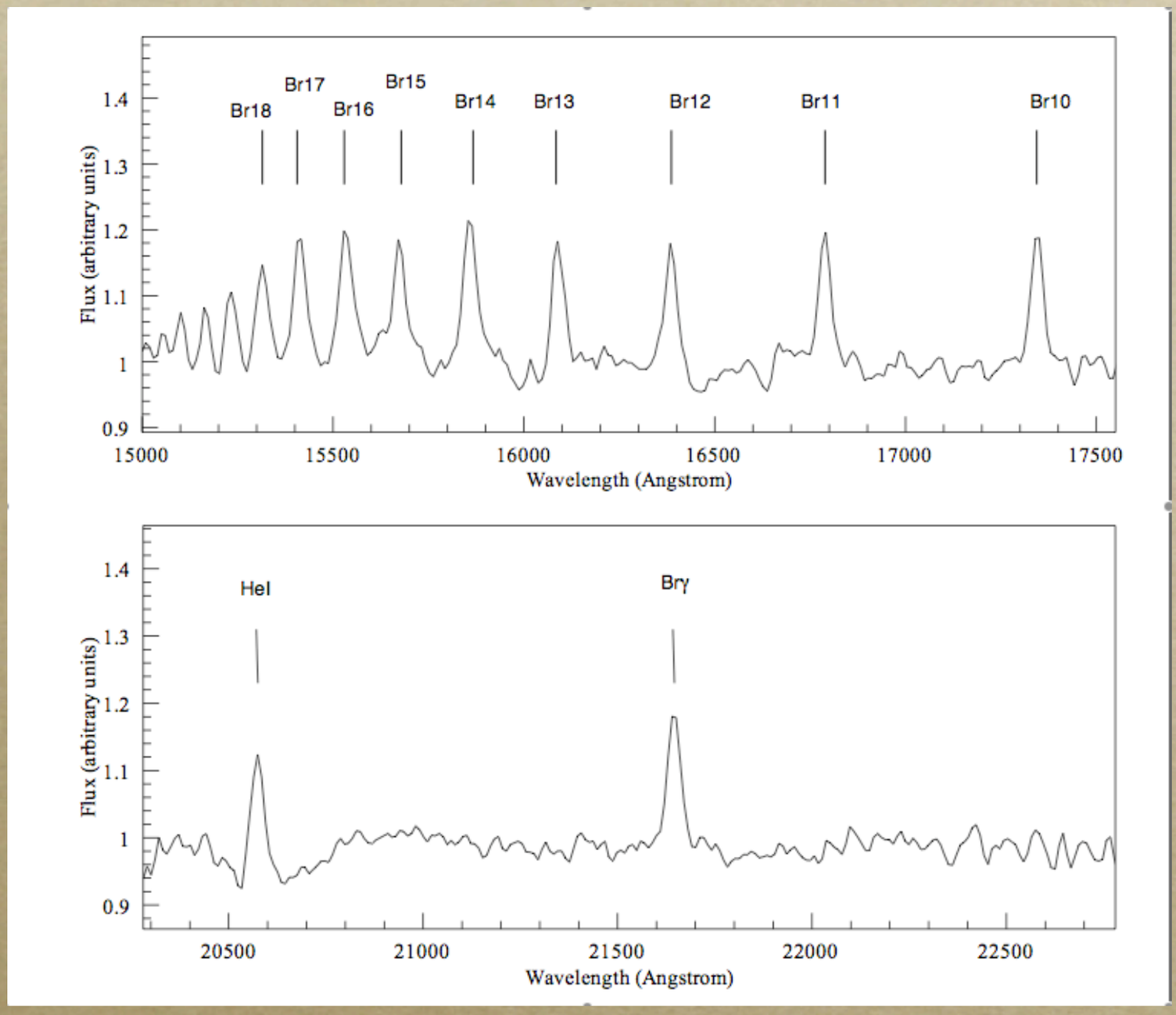
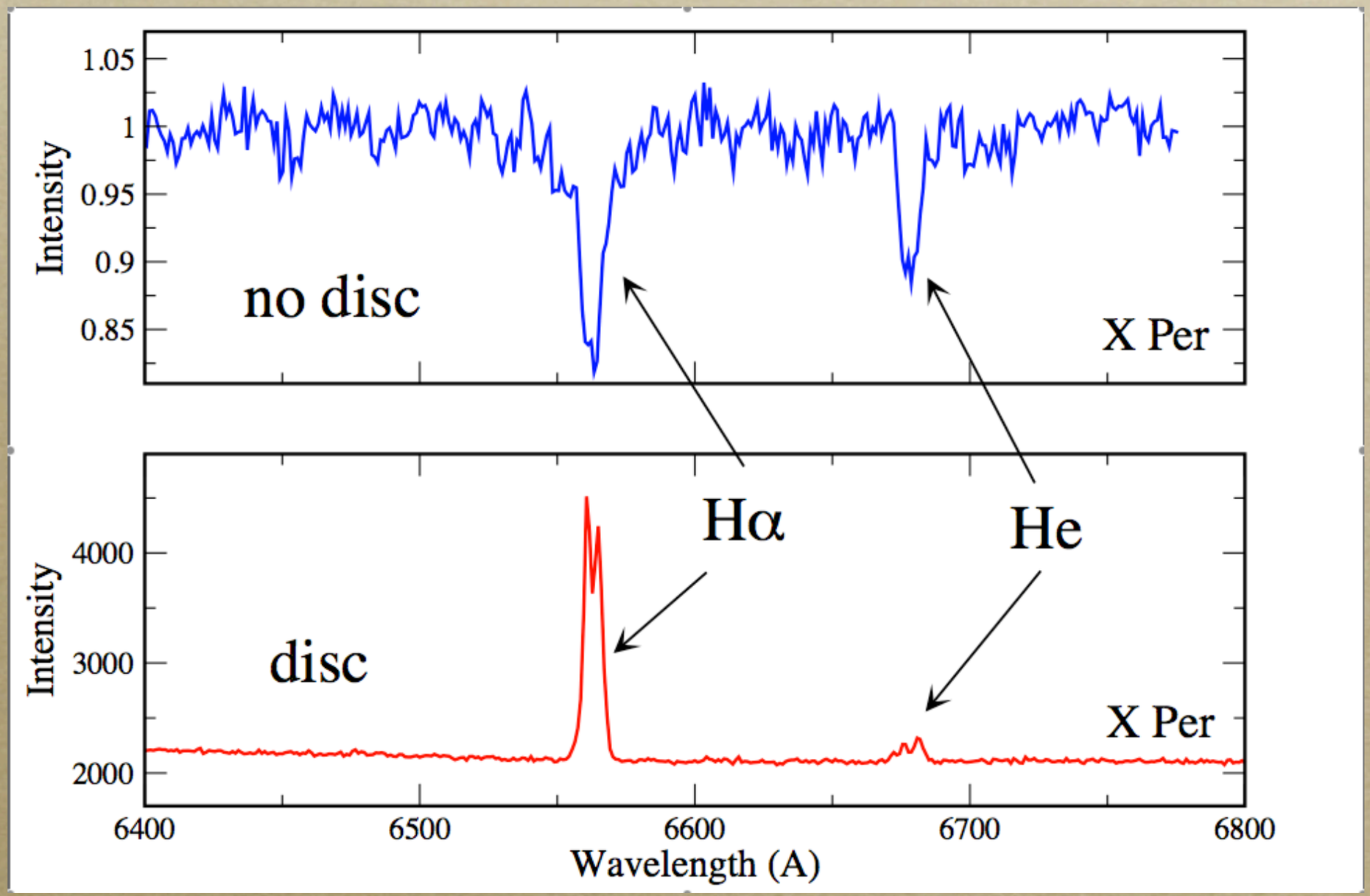
Be/X-ray binary



Be/X-ray binary



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Conclusions.

- Sources (SAX J1324.4-6200, AX J1820.5-1434) which showed H absorption lines are either HMXBs or IMXBs.
- AX J1749.2-2725 is likely HMXBP.
- Three of our sources (AX J1700.1-4157, AX J1740.1-2847, AX J1832.3-0840) are likely IPs.
- SAX J1452.8-5949 - *likely IP or LMXB*.
- *It is possible that the three HMXBs belong to the persistent Be/X-ray binaries class. However they could also well be members of some other unexplored class of sources at low-luminosities.*