Chandra Observations of Faint LMXBs

Colleen A.Wilson, S.K. Patel, C. Kouveliotou (NSSTC), M. van der Klis(U. Amsterdam), T.Belloni(Brera Observatory, Italy), W.H.G. Lewin(MIT), P. Jonker(Cambridge)

Abstract

There exists a group of persistently faint galactic X-ray sources that based on their location in the galaxy, high Lx/Lopt, association with X-ray bursts, and absence of X-ray pulsations are thought to be low-mass X-ray binaries (LMXBs). We present results from Chandra observations for 7 of these systems: 1708-408, 1711-339, 1735-269, 1736-297, 1746-331, 1746.7-3224, and 1812-12. Improved locations for all sources, excluding 1736-297 and 1746-331 (which were not detected) are presented. Our observations are consistent with previously reported transient behavior of 1736-297, 1746-331, and 1711-339 (which we detect in one of two observations). Energy and power spectra are presented for 1735-269, 1711-339, and 1746.7-3224. The energy spectra are hard, consistent with typical faint LMXB spectra. Further, we present a newly discovered source, a very faint, soft, source, separated by 2.7' from 1746.7-3224.

Why Study These Objects?

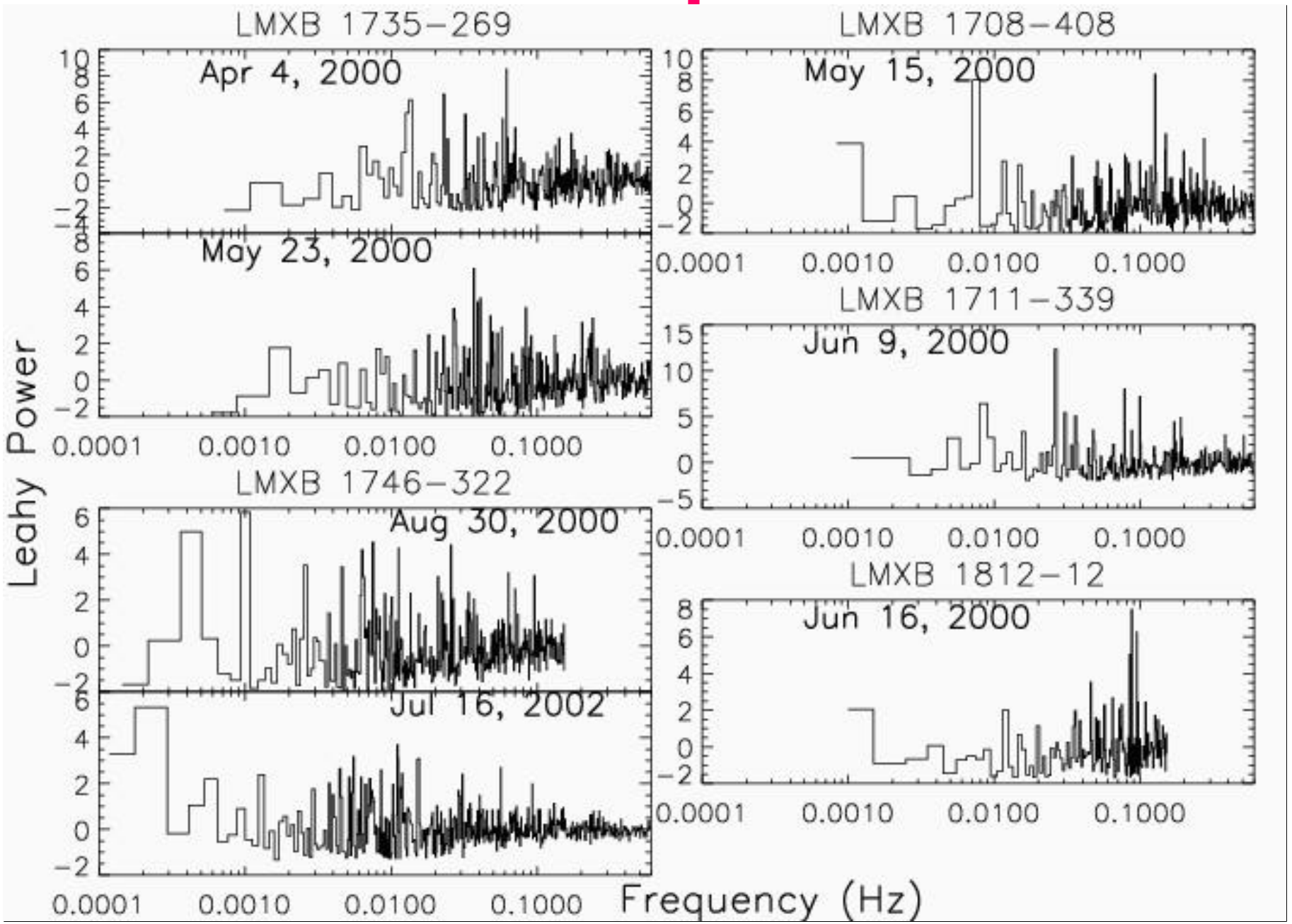
- They are thought to be the faintest LMXBs.
- Previous instruments were not sensitive enough to study them.
- Arc second locations are needed for optical identifications.
- They provide a probe of the physics of accretion at lower accretion rates than previously studied.

Source	Date	R.A. (Error Radius 90 % confidence,	Declination = 0.6“, on axis)
1708-408	5/15/2000	17h12m23.83s	-40°50’34.0"
1711-339	6/9/2000	17h14m19.78s	-34°02’47.3"
	3/12/2002	Not Detected.	
1735-269	4/4/2000	17h38m17.12s	-26°59’38.6"
	5/23/2000		
1736-297	5/31/2000	Not Detected.	
1746.7-3224	8/30/2000	17h50m03.90s	-32°25’50.4"
	7/16/2002		
1746-331	6/9/2000	Not Detected.	
1812-12	6/16/2000	18h15m06.18s	-12°05’47.1"

N_H* (10^{22} cm^{-2})	Photon Index*	α (pileup parameter)*	Flux (erg cm^{-2} s^{-1}, 1-10 keV)
3.5±0.5	2.0±0.3	Trailed image	8.9´10^{-10}
1.4±0.4	1.9±0.5	0.64±0.03	4.2 ´10^{-11}
1.70±0.05 2.2±0.5	2.07±0.04 2.6±0.5	CC mode Trailed image	1.9´10^{-10} 1.6´10^{-10}
Not Detected.			
2.2±0.2 1.3±0.1	1.66±0.07 1.0±0.1	0.91±0.02 0.63±0.01	1.6´10^{-11} 3.9´10^{-11}
Not Detected.			
0.9±0.2	1.4±0.3	Trailed image	3.5´10^{-10}

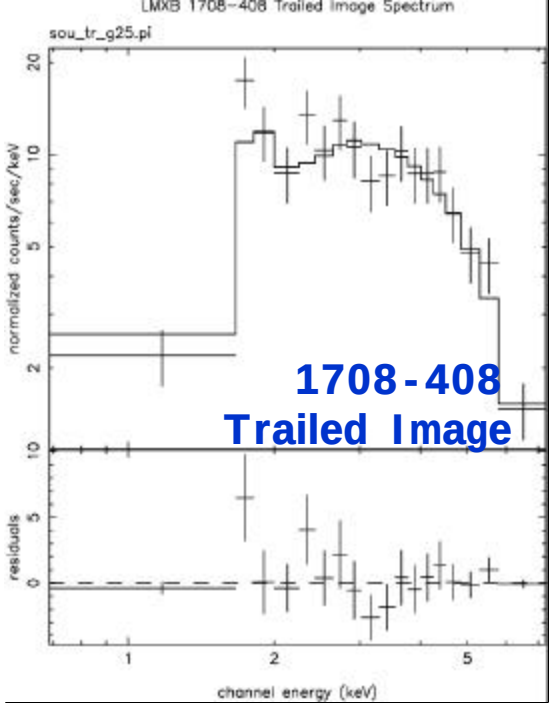
*Errors on spectral fitting parameters are 1s

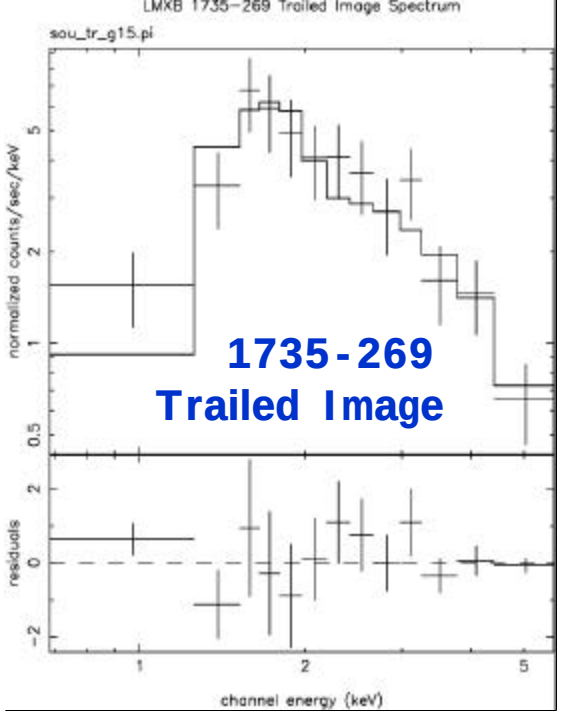
Power Spectra

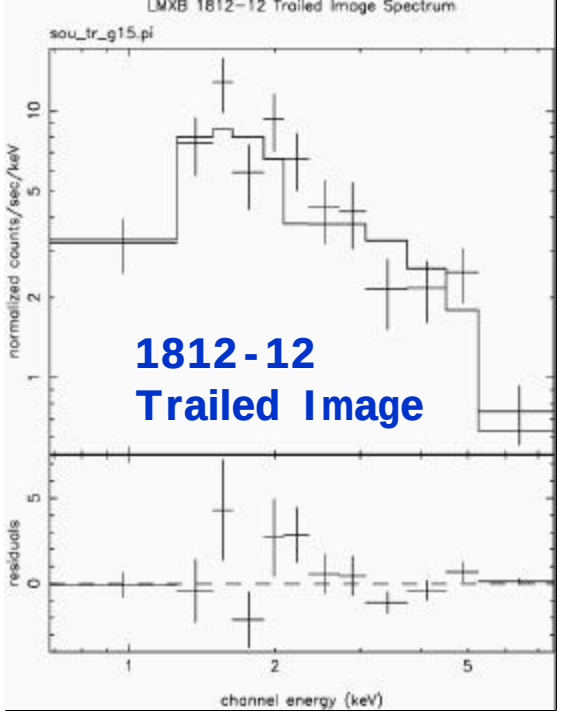


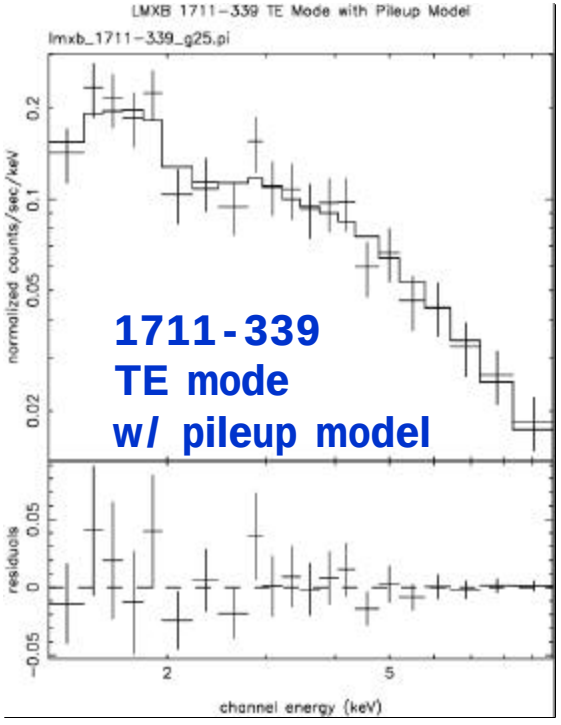
Power Spectra

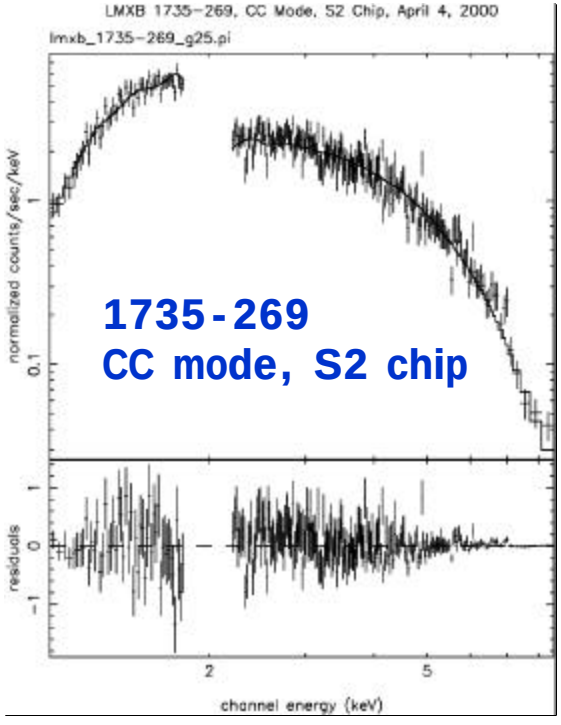
- Prior observations of LMXBs have shown increasing X-ray variability with decreasing accretion rates and hard energy spectra.
- Power spectra from our Chandra observations shown very little X-ray variability, with no significant peaks or noise.
- The average power > 0.1 Hz has been subtracted from each power spectrum as an estimate of the Poisson level.

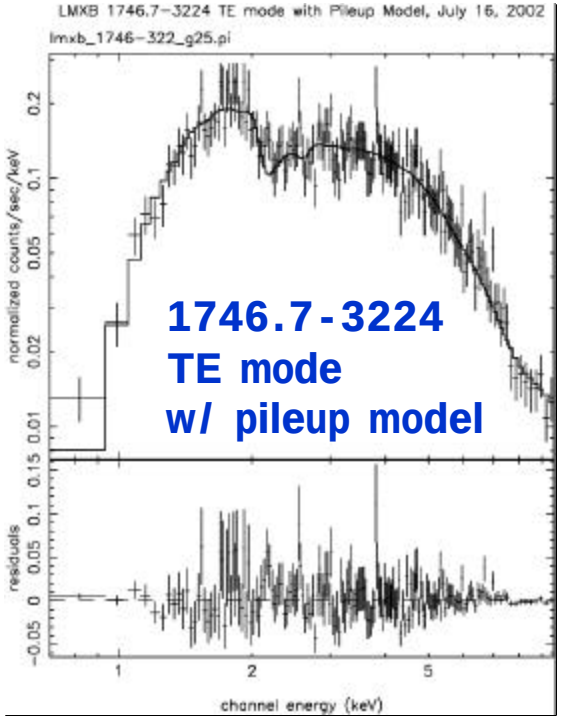

LMXB 1708-408 Trailed Image Spectrum
sou_tr_g25.pi
normalized counts/sec/keV
residuals
channel energy (keV)
1708-408
Trailed Image


LMXB 1735-269 Trailed Image Spectrum
sou_tr_g15.pi
normalized counts/sec/keV
residuals
channel energy (keV)
1735-269
Trailed Image


LMXB 1812-12 Trailed Image Spectrum
sou_tr_g15.pi
normalized counts/sec/keV
residuals
channel energy (keV)
1812-12
Trailed Image


LMXB 1711-339 TE Mode with Pileup Model
lmxb_1711-339_g25.pi
normalized counts/sec/keV
residuals
channel energy (keV)
1711-339
TE mode
w/ pileup model

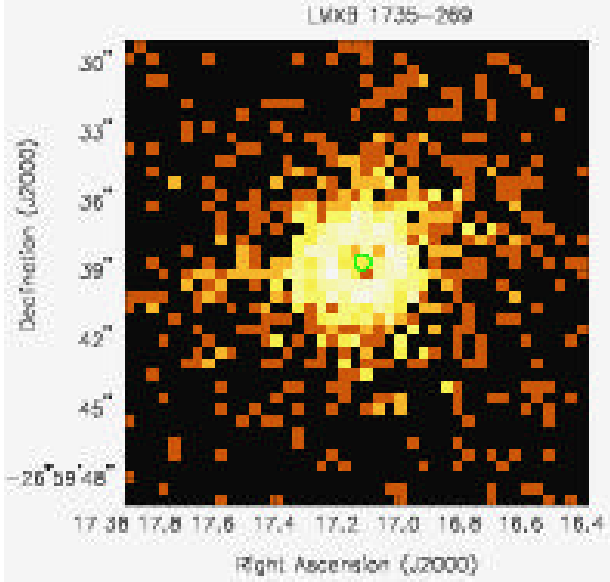

LMXB 1735-269, CC Mode, S2 Chip, April 4, 2000
lmxb_1735-269_g25.pi
normalized counts/sec/keV
residuals
channel energy (keV)
1735-269
CC mode, S2 chip

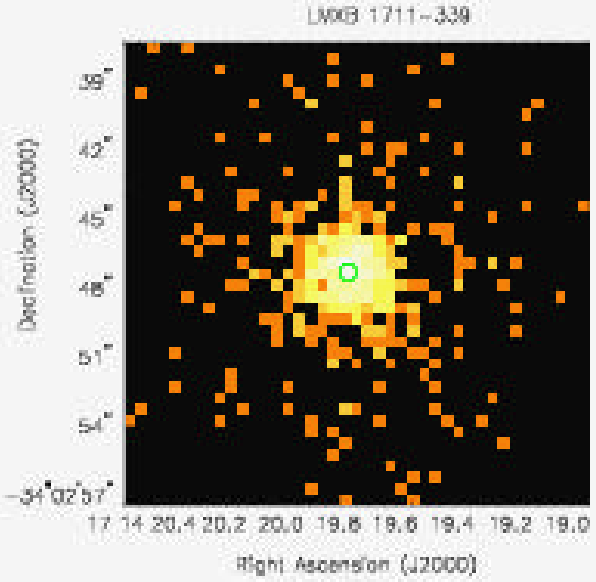

LMXB 1746.7-3224 TE mode with Pileup Model, July 16, 2002
lmxb_1746-322_g25.pi
normalized counts/sec/keV
residuals
channel energy (keV)
1746.7-3224
TE mode
w/ pileup model

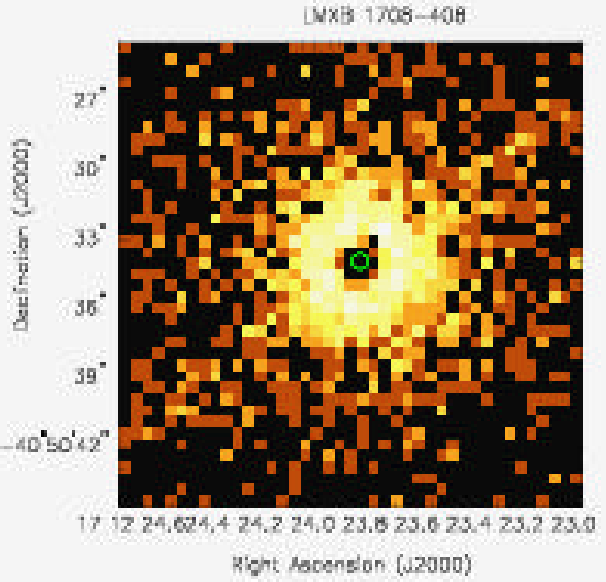
Energy Spectra

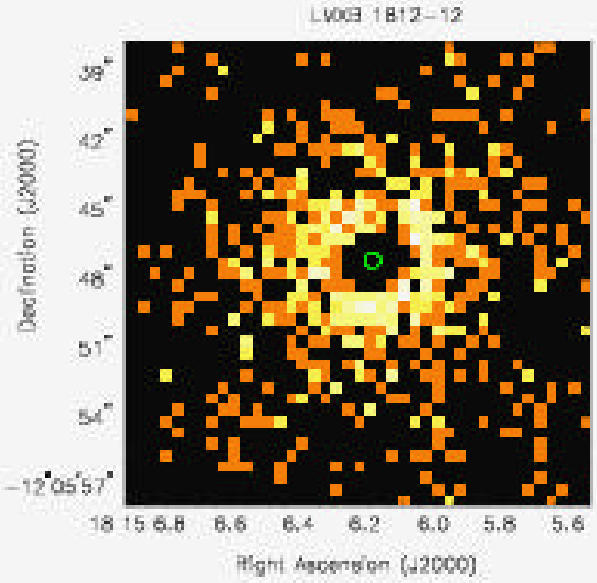
- Typical LMXB energy spectra are hard when faint and soft when bright.
- An absorbed power law was fitted to
  - trailed image TE mode spectra for 1708-408 (top left), 1711-339 (not shown), 1735-269 (top center), 1746.7-3224 (not shown) and 1812-12 (top right).
  - CC-mode spectra for 1735-269 (bottom center)
  - TE mode spectra for 1711-339 and 1746.7-3224 (bottom left & right), using the pileup model. These fits were approximately consistent with fits to trailed image spectra, but tended to predict higher fluxes.

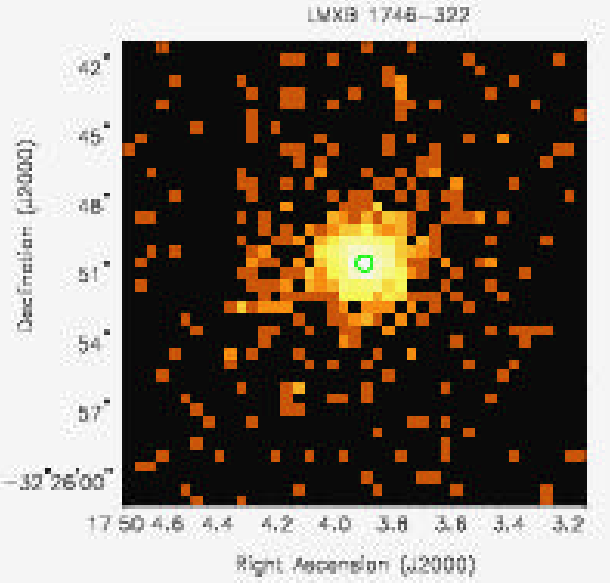
Locations


LMXB 1735−269
Declination (J2000)
Right Ascension (J2000)


LMXB 1711−339
Declination (J2000)
Right Ascension (J2000)


LMXB 1708−408
Declination (J2000)
Right Ascension (J2000)


LMXB 1812−12
Declination (J2000)
Right Ascension (J2000)


LMXB 1746−322
Declination (J2000)
Right Ascension (J2000)

Locations

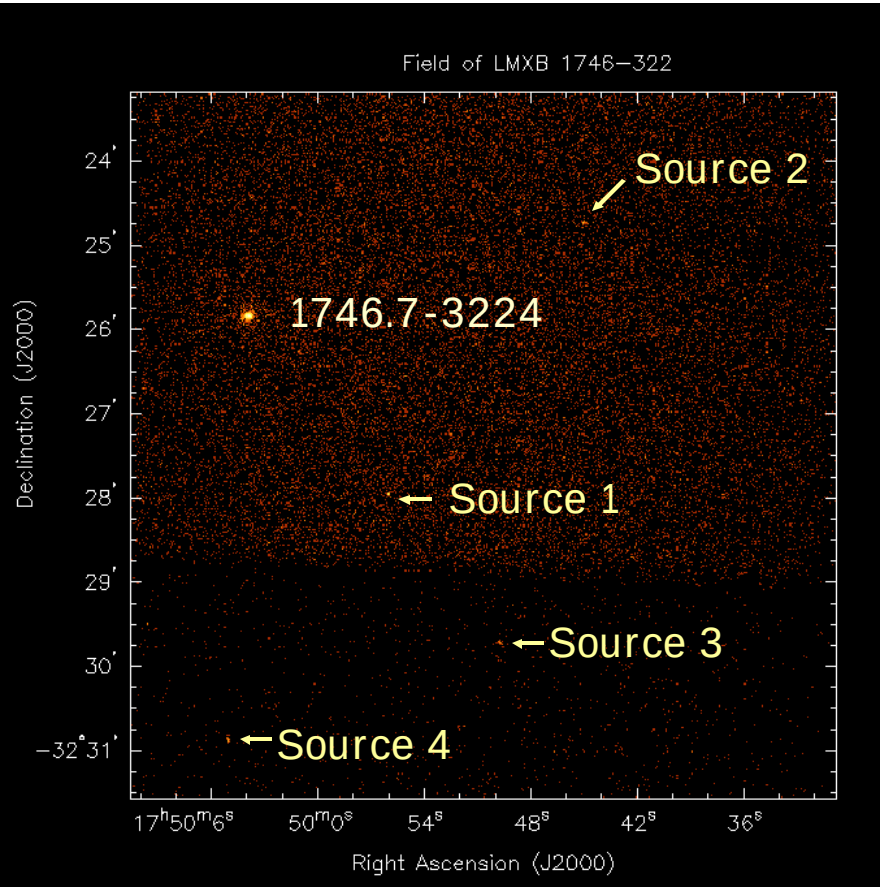
- Shown is a mosaic of images with location error circles overlaid.
- The 90% confidence error radius is 0.6” for all on axis sources.
- The Ciao tool *wavdetect* was used to locate 1711-339, 1735-269, and 1746.7-3224.
- A Gaussian+hyperbolic tangent model was fitted to determine locations for the highly piled up sources 1708-408 and 1812-12.

Conclusions

- **All 5 detected objects appear to be in the same state - most likely the faint hard state – with power law indices of 1.3-2.0.**
- **X-ray variability in all 5 sources was surprisingly low in the Chandra observations; however, significant noise in 1735-269[1,2] and 1812-12 was detected with RXTE.**
- **1711-339, 1736-297, and 1746-331 went undetected in at least 1 observation, consistent with prior reports of transient behavior.**
- **Arc second locations should lead to optical identifications and orbital period determinations which in turn may tell us why these objects are so faint.**

1 Wijnands & van der Klis 1999, A&A, 345, L35
2 Belloni, Psaltis, & van der Klis 2002, ApJ, 572, 392

Serendipitous Sources



- Aug 30, 2000 observation.
- Only field of 8 with highly significant detections of serendipitous sources.
- Most fields were very small (subarrays.)

#	R.A. (J2000)	Decl. (J2000)	Signif (s)	Net Cnts (0.3-8keV)	Off Axis Dist
1	17h49m56.02s	-32°27'57.1"	11.9	42±7	1.8'
2	17h49m44.97s	-32°24'43.7"	6.2	21±5	4.5'
3	17h49m49.74s	-32°29'42.7"	7.0	18±4	3.9'
4	17h50m05.08s	-32°30'52.3"	10.0	25±5	3.9'

- Sources located using *wavdetect*
- 90% confidence error radius £ 1" for all sources.
- All new sources not in July 16, 2002 observation (outside of subarray.)
- Most significant source #1
  - Fitted with a blackbody model
  - kT = 0.27±0.04 keV
  - Flux=1.7´10^{-14} erg cm^{-2} s^{-1}, 0.4-0.7 keV