A Synoptic Study of an X-ray Nova in Outburst

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Principal Investigator
Jeffrey McClintock

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Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

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The NASA Technical Officer for this Grant is Ronald Oliversen, Code 681, Goddard Space Flight Center, Greenbelt, MD 20771

Thus far three papers have been supported by this grant, and the above grant number appears explicitly in the acknowledgements section in each paper. In the following we give the reference for each paper and a brief synopsis of the results reported.

Title: Spectral and Timing Evolution of the Black Hole X-ray Nova
4U~1543-47 during its 2002 Outburst
Authors: S.Q. Park, J.M. Miller, J.E. McClintock, R.A. Remillard, J.A.Orosz (+6 authors)
Reference: 2004 ApJ, 610, 378 (astro-ph/0308363)

In this work, we present an X-ray spectral and timing analysis of 4U1543-47 during its 2002 outburst based on 49 pointed observations obtained using the Rossi X--ray Timing Explorer (RXTE). The outburst reached a peak intensity of 4.2 Crab in the 2--12 keV band and declined by a factor of 32 throughout the month-long observation. A \$21.9 \pm 0.6\$ mJy radio flare was detected at 1026.75~MHz two days before the X--ray maximum; the radio source was also detected late in the outburst, after the X-ray source entered the {\it hard} state. The X-ray light curve exhibits the classic shape of a rapid rise and an exponential decay. The spectrum is soft and dominated by emission from the accretion disk. The continuum is fit with a multicolor disk blackbody (\$kT_{max} = 1.04\$ keV) and a power-law (\$\Gamma \sim 2.7\$). Midway through the decay phase, a strong low-frequency quasi-periodic oscillation (QPO; \$\nu\$ = 7.3--8.1~Hz) was present for several days. The spectra feature a broad Fe K line that is asymmetric, suggesting that the line is due to relativistic broadening rather than Comptonization. Relativistic Laor models provide much better fits to the line than non--relativistic Gaussian models, particularly near the beginning and end of our observations. The line fits yield estimates for the inner disk radius that are within 6 \$GM/c^{2}\$; this result and additional evidence indicates that this black hole may have a non--zero angular momentum.

Title: The X-ray Outburst of H1743-322: High-Frequency QPOs with a 3:2 Frequency Ratio Authors:
Authors: R.A. Remillard, J.E. McClintock, J.A. Orosz and A.M. Levine
Reference: ApJ, in press (astro/ph0407025)

This is our first paper on 130 pointed observations obtained during the 2003 X-ray outburst of the black hole binary H1743-322. Based on a thorough search through the data and a careful data selection, we detected a pair of very significant high-frequency quasiperiodic oscillations with frequencies of 242 +/- 3 Hz and 166 +/- 5 Hz. The ratio of these two frequencies is consistent with a 3:2 harmonic ratio. This finding is consistent with results obtained for three other black hole systems that exhibit similar pairs of oscillations with the same 3:2 commensurate frequency ratio. We discuss our results in terms of a resonance model that invokes frequencies set by general relativity for orbital motions near a black-hole event horizon.

Title: Black Hole Binaries
Authors: J.E. McClintock and R.A. Remillard
Reference: A review chapter to appear in Compact Stellar X-ray Sources, eds. W.H.G. Lewin and M. van der Klis, Cambridge Univ. Press (astro-ph/0306213 v3)

Many entirely new RXTE results, including All-Sky Monitor light curves of 20 sources and energy spectra and power spectra of 16 sources, are contained in this extensive review. This is the first comprehensive review in a decade to define the properties of Galactic black holes, and is being widely cited. A recurring theme of the review is the importance of these black holes as potential sites for strong-field tests of general relativity.

Ongoing work: RXTE Spectral Analysis of H1743-322

The black hole source H1743-322 was in eruption throughout most of 2003 and we made 130 pointed observations using the PCA and HEXTE detectors aboard RXTE (see paper by Remillard et al. above). The source's behavior is remarkable. It displays all of the canonical X-ray states, sometimes in unusual ways. All of these spectral data (approximately 500,000 seconds) has been analyzed, and we are now preparing the results for publication. The RXTE data will be presented with coordinated Very Large Array radio monitoring data obtained by M. Rupen and V. Dhawan.