# The 2005 Outburst of the Halo Black Hole X-Ray Transient XTE J1118+480

The Harvard community has made this article openly available. Please share how this access benefits you. Your story matters

| Citation       | Zurita, C., M. A. P. Torres, D. Steeghs, P. Rodriguez#Gil, T. Munoz#Darias, J. Casares, T. Shahbaz, et al. 2006. “The 2005 Outburst of the Halo Black Hole X-Ray Transient XTE J1118+480.” The Astrophysical Journal 644 (1): 432–38. https://doi.org/10.1086/503286. |
|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Citable link   | http://nrs.harvard.edu/urn-3:HUL.InstRepos:41399946                                                                                                                                                                                                                                                                                  |
| Terms of Use   | This article was downloaded from Harvard University’s DASH repository, and is made available under the terms and conditions applicable to Other Posted Material, as set forth at http://nrs.harvard.edu/urn-3:HUL.InstRepos:dash.current.terms-of-use#LAA                                                                                     |
THE 2005 OUTBURST OF THE HALO BLACK HOLE X-RAY TRANSIENT XTE J1118+480

C. Zurita
Instituto de Astrofísica de Canarias, 38200 La Laguna, Tenerife, Spain; czurita@iac.es

M. A. P. Torres and D. Steeghs
Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138

P. Rodríguez-Gil, T. Muñoz-Darias, J. Casares, and T. Shahbaz
Instituto de Astrofísica de Canarias, 38200 La Laguna, Tenerife, Spain

I. G. Martínez-Pais
Instituto de Astrofísica de Canarias, 38200 La Laguna, Tenerife, Spain; and Departamento de Astrofísica, Universidad de La Laguna, E-38206 La Laguna, Tenerife, Spain

P. Zhao and M. R. Garcia
Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138

A. Piccioni, C. Bartolini, and A. Guarnieri
Dipartimento di Astronomia, Università di Bologna, Via Ranzani 1, Bologna, Italy

J. S. Bloom
Astronomy Department, University of California, Berkeley, CA 94720

C. H. Blake, E. E. Falco, and A. Szentgyorgyi
Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138

AND

M. Skrutskie
University of Virginia, Department of Astronomy, P.O. Box 3818, Charlottesville, VA 22903

Received 2005 October 7; accepted 2006 February 8

ABSTRACT

We present optical and infrared monitoring of the 2005 outburst of the halo black hole X-ray transient XTE J1118+480. We measured a total outburst amplitude of $\sim 5.7 \pm 0.1$ mag in the $R$ band and $\sim 5$ mag in the infrared $J$, $H$, and $K_s$ bands. The hardness ratio $HR2$ ($5-12$ keV : $3-5$ keV) from the RXTE ASM data is $1.53 \pm 0.02$ at the peak of the outburst, indicating a hard spectrum. Both the shape of the light curve and the ratio $L_x(1-10$ keV)/$L_{opt}$ resemble the minioutbursts observed in GRO J0422+32 and XTE J1859+226. During early decline, we find a $0.02$ mag amplitude variation consistent with a superhump modulation, like the one observed during the 2000 outburst. Similarly, XTE J1118+480 displayed a double-humped ellipsoidal modulation distorted by a superhump wave when settled into a near-quiescence level, suggesting that the disk expanded to the $3^{rd}$ resonance radius after outburst, where it remained until early quiescence. The system reached quiescence at $R = 19.02 \pm 0.03$, about 3 months after the onset of the outburst. The optical rise preceded the X-ray rise by at most 4 days. The spectral energy distributions (SEDs) at the different epochs during outburst are all quasi–power laws with $F_{\nu} \propto \nu^{\alpha}$ increasing toward the blue. At the peak of the outburst, we derived $\alpha = 0.49 \pm 0.04$ for the optical data alone and $\alpha = 0.1 \pm 0.1$ when fitting solely the infrared. This difference between the optical and the infrared SEDs suggests that the infrared is dominated by a different component (a jet?), whereas the optical is presumably showing the disk evolution.

Subject headings: accretion, accretion disks — binaries: close — stars: individual (XTE J1118+480, KV UMa) — X-rays: stars

1. INTRODUCTION

X-ray transients (XRTs) are a class of low-mass X-ray binaries in which long periods of quiescence (typically decades) are interrupted by dramatic outbursts, when the X-ray luminosity suddenly increases by up to a factor of $10^6$ (e.g., Charles & Coe 2006). During the outburst, XRTs usually reach a state in which the X-ray emission is dominated by thermal emission from the hot inner accretion disk (i.e., the high/soft [HS] or thermal-dominated state). There are, however, a few of these systems (see, e.g., Brocksopp et al. 2004) that are instead dominated by a hard nonthermal power-law component, likely produced by thermal Comptonization of seed photons in the vicinity of the accreting black hole (i.e., the low/hard [LH] state). At even lower accretion rates, XRTs reach quiescence, which may be just an extreme example of the LH state. To explain the LH (and quiescent) state, a standard disk truncated at some large inner radius is assumed. The interior volume is filled with a hot, optically thin, quasi-spherical accretion flow, where most of the energy released via viscous dissipation remains in this flow rather than being radiated away (as in a disk) to be finally advected by the object (e.g., Narayan et al. 1996). This model, called advection-dominated accretion flow (ADAF), is the most widely discussed picture, although other alternatives have also been invoked. For instance, the accretion disk corona model assumes a cool thin disk embedded in a hot corona powered by magnetic flares (e.g., Merloni & Fabian 2001). It has also been proposed that emission from jets (which are believed to be associated with
2005 OUTBURST OF XTE J1118+480

The XRT XTE J1118+480 was discovered by the All-Sky Monitor (ASM) on board of the Rossi X-ray Timing Explorer (RXTE) on 2000 March 29 (Remillard et al. 2000) as a weak, slowly rising X-ray source. Retrospective analysis of the ASM database revealed a previous outburst episode in 2000 January. The precursor was shorter than the main outburst, although both reached similar brightness (e.g., Uemura et al. 2000). XTE J1118+480 is one of the few XRTs that remained in a LH state throughout the outburst and failed to reach the HS state. This object is also important for several reasons. It is a secure case of a black hole accretion flows onto black holes and the mechanisms involved.

Infrared photometry was obtained with the 1.3 m PAIRITEL\(^2\) robotic telescope at FLWO. The camera is the Two Micron All Sky Survey (2MASS) South instrument, which images simultaneously in J, H, and K\(_s\), covering a field of view of 8.5' x 8.5'.

3. LONG-TERM LIGHT CURVE

We discovered an optical rebrightening of J1118 ~5 yr after its first reported outburst (Zurita et al. 2005). We then embarked on a new campaign of systematic monitoring of the outburst light curve in the optical and infrared bands. The source reached \( R = 13.37 \pm 0.01 \) at the outburst peak, \( 5.7 \pm 0.01 \) mag above the mean quiescent level. In the infrared, we measured total outburst amplitudes of \( 4.9 \pm 0.1, 5.0 \pm 0.1, \) and \( 4.8 \pm 0.1 \) mag in \( J, H, \) and \( K_s \), respectively. Although the optical brightness is similar to that observed during the 2000 outburst, the current event did not power the source above ~25 mcrab in X-rays. Similarly, the 2000 outburst, although also faint in X-rays, reached a peak of ~45 mcrab (Wood et al. 2001). In Figure 1 we present our overall optical and infrared light curve of the 2005 outburst. The light curve morphology of both the X-ray and the optical emission is not the “canonical” fast rise and exponential decay (FRED; Chen, et al. 1997). In comparison, the precursor X-ray light curve for the 2000 outburst shows a FRED, and the March outburst (X-ray and optical) showed a plateau morphology (see the 2000 outburst light curves in, e.g., Wren et al. 2001).

We note, however, that neither the sources that remained in a LH state nor a large number of those that reach the HS state are FRED shaped. We calculated the hardness ratio HR2 (5–12 keV : 3–5 keV) from the RXTE ASM data. Although only a few measurements were possible due to statistical limitations (see Fig. 1), we found HR2 = 1.53 \pm 0.02 at the peak of the outburst (from HJD – 2,453,300 = 83 to 86). This value of HR2 is consistent with a hard spectrum, supporting that J1118 likely remained in the LH state throughout the outburst (e.g., McClintock & Remillard 2006).

The shape of the 2005 outburst light curve is remarkably similar to that of the “minoutbursts” observed in GRO J0422+32 (Chevalier & Ilovaisky 1995) and XTE J1859+226 (Zurita et al. 2002b).

1 IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

2 See http://www.pairitel.org.
curve displays a small bump just before the system definitely settled down into quiescence. This type of behavior was also found during the minioutbursts of both GRO J0422+32 and XTE J1859+226 (see Fig. 2). These light curves have comparable length and brightness, and the X-ray–to–optical ratio measured in J1118 is also similar to what has been seen in minioutbursts, i.e., it is much lower than in normal outbursts (e.g., Zurita et al. 2002b). These facts support the suggestion of Hynes et al. (2000) that the outbursts in J1118 are indeed minioutbursts rather than full XRT events.

4. OPTICAL MODULATION DURING EARLY DECLINE AND NEAR QUIESCENCE

Example light curves of J1118 at different outburst epochs are presented in Figure 3. The data have been phase folded on the orbital ephemeris of Torres et al. (2004). Note the apparent changes in amplitude and morphology of the light curves as the outburst decays. We divide the light curve into six different stages (see also Fig. 1), preoutburst quiescence (I), rise (II), peak (III), decay (IV), near-quiescence (V), and postoutburst quiescence (VI).

I. On 2004 December 19 (UT) J1118 was still in quiescence and displayed the characteristic double-humped ellipsoidal modulation, with $\sim$0.16 mag semiamplitude, driven by the tidally distorted secondary star.

II. On 2005 January 4, the outburst had already started and the $R$-band light curve shows the combination of the ellipsoidal modulation and a linear rise of 0.36 mag day$^{-1}$.

III. The outburst peaks on January 14 and then the brightness in all bands started to decay at a moderately slow rate of 0.05 mag day$^{-1}$. Near the outburst peak, on January 20 and 22,
the $R$-band light curve shows a low-amplitude modulation superimposed on short-timescale ($\lesssim 5$ s) variability, likely due to flickering. This modulation was not observed after January 23 (alas, the $R$-band data obtained in January 21 was badly affected by weather conditions). The same modulation was also reported by Chou et al. (2005) in their $V$-band light curves obtained during January 18–20. This indicates that the low-amplitude modulation was short-lived and/or its amplitude is diluted by the flickering or undetected due to the photometric accuracy. We searched for periodicities in the detrended light curves of January 20 and 22 by computing a Scargle periodogram. The result is shown in Figure 4. The observing window produces an alias pattern at $\sim 6.5$ cycles day$^{-1}$, with the strongest peak at $0.156 \pm 0.002$ days. The 1 day alias centered at $0.169 \pm 0.003$ days lies close to both the orbital and superhump periods (see Uemura et al. 2000; Zurita et al. 2002a). Although the observed modulation is probably related to the orbital motion, the poor data sampling impedes an accurate period determination. In Figure 3 we show the January 20 light curve folded on the orbital period and averaged into 50 phase bins, although the cleanest modulation is seen when folding the data on 0.156 days (see Fig. 4, top left panel).
IV. From the beginning of February the light curve began a moderately abrupt fall. We estimated a rate of \( \sim 0.15 \) mag day\(^{-1} \) in the \( R \) band and a smoother slope of 0.10 mag day\(^{-1} \) in the infrared bands. On February 2, no modulation is detected, only considerable flickering (\( \sigma_m \sim 0.02 \) mag), higher than that found at the peak of the outburst.

V. At the end of February, about 60 days after the outburst onset, J1118 settled into a near-quiescence level at \( R = 18.35 \pm 0.02 \) (Fig. 3). On February 25 the light curve is consistent with a (distorted) double-humped ellipsoidal modulation with a semi-amplitude of \( \sim 0.10 \) mag. We also note that the amplitude of the ellipsoidal modulation is lower at near-quiescence than at true quiescence before and after outburst. This is what we would expect if the contribution of the accretion disk to the total light is higher in February 25 (V) than in December 19 (I) and April 26 (VI). Assuming that the decrease in flux is solely due to the accretion disk light fading and that the disk contributed \( \sim 55\% \) to the total quiescent \( R \)-band light (Torres et al. 2004), we estimate a relative contribution of the accretion disk of \( \sim 77\% \) during epoch V.

VI. Two months later, J1118 faded another 0.6 mag and reached \( R \sim 19 \) on March 17. The system remained at this level from there on, suggesting it reached true quiescence. At the same epoch we measured the following colors in the infrared: \( K_s = 16.66 \pm 0.07, H - K_s = 0.8 \pm 0.2 \), and \( J - K_s = 1.1 \pm 0.1 \). The \( J \) and \( K_s \) magnitudes are consistent with those observed by Mikolajewska et al. (2005) during the preoutburst quiescence (our epoch I). The colors \( H - K_s \) and \( J - K_s \) are much redder than expected for a later \( K \) or early \( M \) secondary star, suggesting an additional contribution.

The Scargle periodogram of the epoch VI \( R \)-band light curves (March 17, 19, 20, and 23 and April 22 and 26) shows a strong peak centered on 0.0845 \( \pm 0.0005 \) days (see Fig. 4, bottom left panel), consistent with half the orbital period \( P_{orb} = 0.1699 \) days. These light curves are also distorted, likely due to the presence of a superhump wave, as already noticed in the near-quiescence state at the end of the 2000 outburst (Zurita et al. 2002a). In contrast, on December 19 and January 4 (epochs I and II) there is no evidence of superhumps. This suggests that during outburst, the disk expands to the \( 3:1 \) (or \( 2:1 \)) resonance radius and is then forced to precess by tidal perturbations caused by the secondary star. Afterward, it starts to shrink, although at early quiescence it is still large enough to produce superhump waves. Finally, some time later the disk radius becomes shorter than the resonance radius, and superhumps disappear.

5. AN OPTICAL PRECURSOR TO THE X-RAY OUTBURST?

There has been some evidence of optical/infrared outbursts starting before the X-ray outbursts in some XRTs, GS 1121–68 (Della Valle et al. 1991), GRO J1655–40 (Orosz et al. 1997), GRO J0422+32 (Castro-Tirado et al. 1997), V404 Cyg (Chen et al. 1997, and references therein), AqJ X-1 (Shahbaz et al. 1998), J1118 during the main 2000 (March) outburst (Wren et al. 2001), and 4U 1543–47 (Buxton & Bailyn 2004). In dwarf novae the UV rise has also been observed to start several hours after the optical outburst (e.g., Warner 1995, and references therein). In the framework of the “disk instability model” (see, e.g., Canizzo et al. 1995), the X-ray (or UV) delay suggests an “outside-in” disturbance of the accretion disk. Once the instability is triggered in the outer regions, a heating front propagates inward, turning the disk from the cold (quiescent) state to a hot state. Hence, the outburst is first noticed in the optical and then in X-rays (or UV). The timescale of the lags can be explained assuming the accretion disk is truncated at some inner radius. The heating front stops when it arrives at the truncation radius, but the inner edge of the disk moves toward the compact object on the viscous timescale, longer than the front propagation time. The ADAF model can offer a natural explanation for the disk truncation in XRTs. Hence, it has been proposed that the disk inner truncation radius can be estimated by measuring the X-ray-to-optical delay (Hameury et al. 1997; Wren et al. 2001).

To take advantage of the fact that our optical observations covered part of the rise phase (see Fig. 1), we inspected whether the optical and X-ray outbursts were simultaneous or if one lags the other. The time-resolved optical light curve taken on 2005 January 4 (see Fig. 3) shows a linear rise. We therefore estimate the starting time for the optical rise to be \( t_{opt} \approx 2,453,375.1 \pm 0.1 \) (HJD) from a linear fit to this curve. A more problematic issue is to determine the starting time of the X-ray outburst. The X-ray light curve from ASM does not provide any useful information below the \( 10 \) mcrab sensitivity level, and hence extrapolation is required. We estimate that the X-ray outburst starting time is consistent with \( t_X = 2,453,379.4 \pm 0.7 \) (HJD), where the associated uncertainty quotes the differences between the several extrapolations we performed. This implies a \( \sim 4 \) day lag between the onset of the X-ray and optical outbursts. Unfortunately, the ASM sensitivity level is well above the quiescent flux level, making it very likely that any extrapolation overestimates the delay. Besides, most of the sources detected by the ASM need to brighten significantly above quiescence to be detected (see, e.g., Homan et al. 2005 for more details on this concern). Therefore, the true start of the X-ray outburst could be earlier than \( t_X \). This fact forces us to conclude that the 4 day lag is just an upper limit, as it is the 10 day lag estimated by Wren et al. (2001). In short, although we can draw a qualitative picture of the evolution of the accretion disk in J1118 after the outburst, it is not possible to estimate a reliable preoutburst truncation radius from the X-ray delay using ASM data alone.

6. THE SPECTRAL ENERGY DISTRIBUTION

We constructed the spectral energy distributions (SEDs) for different outburst epochs through the outburst. The magnitudes were first corrected for interstellar extinction using \( E(B - V) = 0.013 \) (Hynes et al. 2000) and the reddening tables in Rieke & Lebofsky (1985), although this makes only a small difference in the dereddened magnitudes because the extinction is so low. Our outburst SEDs are shown in Figure 5. Here we have excluded some nights for clarity to avoid duplication. All SEDs are quasi-power laws with \( F_\nu \) increasing toward the blue. We have performed power-law fits to the optical SEDs only (from \( \log \nu = 14.54 \) to 14.83), to the infrared magnitudes alone (from \( \log \nu = 14.13 \) to 14.38), and then to the whole wavelength range (from \( \log \nu = 14.13 \) to 14.83). The spectral indices we found have been plotted as a function of time and are shown in Figure 5 (bottom panel), where \( F_\nu \propto \nu^{\alpha} \).

When considering the optical data alone (Fig. 5, open squares), the source appears steeper (bluer) than the canonical \( \alpha = 1/3 \) of a steady state viscously heated disk, being \( \alpha = 0.49 \pm 0.04 \) at the peak of the outburst (from HJD = 2,453,300 = 85 to 90). During the decay phase (IV), it becomes optically softer, with \( \alpha = 0.25 \). This trend is consistent with the cooling of the optically bright regions. However, when fitting the infrared alone, the trend is reversed, showing that the infrared evolves very differently (open triangles) than the optical. The joint fit (filled circles) is the interplay between these components and shows an exponential trend becoming bluer throughout the outburst. At the
Fig. 5.—Top panel: Evolution of the optical-infrared SEDs for J1118 through the outburst. Different symbols are used to distinguish alternate epochs and solid lines are power-law fits. Numbers label HJD=HJD−2,453,300 (note that the optical outburst started at HJD0 = 75). Bottom panel: Evolution of the power-law index, α (where Fν ∝ ν^α). Open squares are the indices obtained from the optical SEDs (from log ν = 14.54 to 14.83), open triangles correspond to the infrared SED fits (from log ν = 14.13 to log ν = 14.38), whereas filled circles are the indices obtained from the optical-infrared SED fits (from log ν = 14.13 to 14.83). The dotted line corresponds to the canonical ν^{-1/3} value for a steady state viscously heated disk. The dashed line shows the exponential fitting to the indices obtained from the whole wavelength range SEDs.

during the early decline and a distorted double-humped ellipsoidal modulation during the near-quiescence level and true quiescence. This suggests that the disk expanded after outburst to the 3:1 resonance disk radius, where it remained during the early phases of quiescence.

Recently, the LH state of X-ray binaries has been associated with jet activity. In some cases a jetlike structure has been resolved (e.g., Mirabel et al. 1992). When jets cannot be directly imaged, a flat or even inverted radio spectrum is often considered to be a typical signature of jet emission (Fender et al. 2001). However, it is also apparent that the jet contributes outside the radio band. The synchrotron spectrum, which is thought to be the jet signature, is frequently seen at radio but also up to higher frequencies in the infrared and possibly in the optical. In the case of J1118, the SED from radio to X-rays during the 2005 outburst has been explained as a combination of synchrotron radiation from a jet and a truncated optically thick disk (Hynes et al. 2000; Markoff et al. 2001; Yuan et al. 2005), whereas models assuming ADAF alone (McClintock et al. 2001b; Esin et al. 2001) under-estimated the optical and the infrared fluxes. The spectrum from infrared to UV is flat (Fν ∝ const; Hynes et al. 2000), although the optical spectrum alone has blue continuum slopes of α = 1/3, as expected for an optically thick accretion disk (Dubus et al. 2001; Torres et al. 2002).

The SEDs during the 2005 outburst exhibit quasi–power-law spectra with α softening from ~0.49 during the peak of the X-ray outburst to ~0.25 during the decay phase. However, when fitting the infrared alone, we find a flat spectrum with α = 0.1 ± 0.1 at the outburst peak. This difference between the optical and the infrared SEDs, more important at the outburst peak, suggests that the infrared is dominated by a different component (a jet?), whereas in the optical, we are presumably seeing the disk evolution. The very flat infrared SED (Fν ∝ const) could naturally be interpreted as a mixture of an optically thick disk spectrum and flat-spectrum emission, possibly synchrotron. Linear fits to optical SEDs have also been performed for other short-period black hole XRTs in outburst (see the compilation by Hynes 2005). The optical SEDs for the Hynes (2005) relatively uniform set, exhibit quasi–power-law spectra with α ranging between 0.5 and 1.5, all steeper than the canonical Fν ∝ ν^{-1/3}. Two of the sources among the Hynes (2005) sample (GRO J0422+32 and XTE J1859+226) were identified by Brocksopp et al. (2004) as hard sources. (XTE J1859+226 is hard, at least early in the outburst.) The spectra of both sources exhibit a quasi-exponential softening throughout the outburst, whereas the other systems exhibit no clear trends. However, very little data are available for these two systems.

Our data clearly demonstrate the added value of extending the wavelength range into the near-infrared. We were able to witness additional spectral components that show a different trend during the course of the outburst. Extending the wavelength coverage even further would have allowed for a more quantitative comparison with proposed descriptions of the accretion flow near compact objects. Looking ahead, simultaneous multiwavelength observations from X-rays through to radio will enable us to validate the interplay between disks and jets. J1118 remains an excellent target for multiwavelength studies that needs to be exploited with future and present facilities as we look forward to its next outburst.

M. A. P. T. thanks the observers at the 1.5 m telescope at FLWO (in particular Perry Berlind and Mike Calkins) for helping during the remote observations with the 1.2 m. This work was supported
REFERENCES

Blake, C. E., et al. 2005, Nature, 435, 181
Brocksopp, C., Bandyopadhyay, R. M., & Fender, R. P. 2004, NewA, 9, 249
Buxton, M. M., & Bailyn, C. D. 2004, ApJ, 615, 880
Callanan, P. J., et al. 1995, ApJ, 441, 786
Cannizzo, J. K., Chen, W., & Livio, M. 1995, ApJ, 454, 880
Castro-Tirado, A. J., Ortiz, J. L., & Gallego, J. 1997, A&A, 322, 507
Charles, P. A., & Coe, M. J. 2006, in Compact Stellar X-Ray Sources, ed. W. H. G. Lewin & M. van der Klis (Cambridge: Cambridge Univ. Press), in press (astro-ph/0306213)
Chaty, S., Haswell, C. A., Malzac, J., Hynes, R. I., Shrader, C. R., & Cui, W. 2003, MNRAS, 346, 689
Chen, W., Shrader, C. R., & Livio, M. 1997, ApJ, 491, 312
Chevalier, C., & Ilovaisky, S. A. 1995, A&A, 297, 103
Chou, Y., Chen, A., Chiang, P. S., Hu, C. P., & Hu, R. H. 2005, Astron. Tel., 412, 1
Della Valle, M., Jarvis, B. J., & West, R. M. 1991, A&A, 247, L33
Dubus, G., Kim, R. S. J., Menou, K., Szkody, P., & Bowen, D. V. 2001, ApJ, 553, 307
Esin, A. A., McClintock, J. E., Drake, J. J., Garcia, M. R., Haswell, C. A., Hynes, R. I., & Muno, M. P. 2001, ApJ, 555, 483
Fender, R. P., Hjellming, R. M., Tilanus, R. P. J., Pooley, G. G., Deane, J. R., Ogley, R. N., & Spencer, R. E. 2001, MNRAS, 322, L23
Garcia, M., Brown, W., Palhe, M., McClintock, J., Callanan, P., & Garnavich, P. 2000, IAU Circ., 7392, 2
Hameury, J. M., Lasota, J. P., McClintock, J. E., & Narayan, R. 1997, ApJ, 489, 234
Homan, J., Buxton, M., Markoff, S., Bailyn, C. D., Nespoli, E., & Belloni, T. 2005, ApJ, 624, 295
Hynes, R. I. 2005, ApJ, 623, 1026
Hynes, R. I., Mauche, C. W., Haswell, C. A., Shrader, C. R., Cui, W., & Chaty, S. 2000, ApJ, 539, L37
Landolt, A. U. 1992, AJ, 104, 340
Levine, A. M., Bradt, H., Cui, W., Jernejan, J. G., Morgan, E. H., Remillard, R., Shirey, R. E., & Smith, D. A. 1996, ApJ, 469, 33L
Malzac, J., Merloni, A., & Fabian, A. C. 2004, MNRAS, 351, 253
Markoff, S., Falcke, H., & Fender, R. 2001, A&A, 372, L25
McClintock, J. E., Garcia, M. R., Caldwell, N., Falco, E. E., Garnavich, P. M., & Zhao, P. 2001a, ApJ, 551, L147
McClintock, J. E., Narayan, R, Garcia, M. R., Orosz, J. A., Remillard, R., & Murray, S. S. 2003, ApJ, 593, 435
McClintock, J. E., & Remillard R. A. 2006, Compact Stellar X-ray Sources, ed. W. H. G. Lewin, & M. van der Klis (Cambridge: Cambridge Univ. Press), in press (astro-ph/0306213)
McClintock, J. E., et al. 2001b, ApJ, 555, 477
Merloni, A., Di Matteo, T., & Fabian, A. C. 2001, Ap&SS Suppl., 276, 213
Merloni, A., & Fabian, A. C. 2001, MNRAS, 321, 549
———. 2002, MNRAS, 332, 165
Mikołajewska, J., Rutkowski, A., Gończałves, D. R., & Szostek, A. 2005, MNRAS, 362, L13
Miralbel, I. F., Dhawan, V., Mignani, R. P., Rodrigues, I., & Guglielmetti, F. 2001, Nature, 413, 139
Miralbel, I. F., Rodriguez, L. F., Cordier, B., Paul, J., & Lebrun, F. 1992, Nature, 358, 215
Narayan, R., McClintock, & J. E., & Yi, I. 1996, ApJ, 457, 821
Orosz, J. A., Remillard, R. A., Bailyn, C. D., & McClintock, J. E. 1997, ApJ, 478, L83
Patterson, J., et al. 2000, IAU Circ., 7412, 2
Pooley, G. G., & Waldram, E. M. 2000, IAU Circ., 7390, 2
Remillard, R., Morgan, E., Smith, D., & Smith, E. 2000, IAU Circ., 7389, 2
Rieke, G. H., & Lebofsky, M. J. 1985, ApJ, 288, 618
Shahbaz, T., Bandyopadhyay, R. M., Charles, P. A., Wagner, R. M., Mulhi, P., Hakala, P., Casares, J., & Greenhill, J. 1998, MNRAS, 300, 1035
Torres, M. A. P., Callanan, P. J., Garcia, M. R., Zhao, P., Laycock, S., & Kong, A. K. H. 2004, ApJ, 612, 1026
Torres, M. A. P., et al. 2002, ApJ, 569, 423
Uemura, M., et al. 2000, PASJ, 52, L15
Wagner, R. M., Foltz, C. B., Shahbaz, T., Casares, J., Charles, P. A., Starrfield, S. G., & Hewett, P. 2001, ApJ, 556, 42
Warner, B. 1995, Cataclysmic Variable Stars (Cambridge: Cambridge Univ. Press)
Whitehurst, R., & King, A. 1991, MNRAS, 249, 25
Wood, K. S., Titarchuk, L., Ray, R. P., Wolff, M. T., Lovellette, M. N., & Bandyopadhyay, R. M. 2001, ApJ, 563, 246
Wren, J., et al. 2001, ApJ, 557, L97
Yuan, F., Cui, W., & Narayan, R. 2005, ApJ, 620, 905
Zurita, C., et al. 2002a, MNRAS, 333, 791
———. 2002b, MNRAS, 334, 999
———. 2005, Astron. Tel., 383, 1

by NASA LTSA grant NAG-5-10889. D. S. acknowledges a Smithsonian Astrophysical Observatory Clay Fellowship. The Peters Automated Infrared Imaging Telescope (PAIRTEL) is operated by the Smithsonian Astrophysical Observatory (SAO) and was made possible by a grant from the Harvard University Milton Fund, the camera loan from the University of Virginia, and the continued support of the SAO and the University of California, Berkeley.