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Multiwavelength Observations of the Black Hole Candidate Swift J1753.5-0127

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Abstract. We present preliminary results from the analysis of simultaneous multiwavelength observations of the black hole candidate Swift J1753.5-0127. The source is still continuing its outburst started in May 2005, never leaving the Low/Hard State. In the X-ray energy spectra we confirm evidence for a thermal component at a very low luminosity possibly extending close to but not at the innermost stable orbit. This is unusual for black hole candidates in the Low/Hard State. Furthermore, we confirm that its radio emission is significantly fainter than expected from the relation observed in other Black Hole Candidates between the observed radio/X-ray fluxes.

1. Introduction

Swift J1753.5-0127 was discovered with Swift/BAT on 2005 May 30 (Palmer et al. 2005). Spectral and timing analysis performed with Swift/XRT and RXTE/PCA (Morris et al. 2005, Morgan et al. 2005) revealed a hard power-law spectrum and a 0.6 Hz QPO that might indicate the presence of a black hole in the system. The source was also detected in the radio band with MERLIN at a flux density of 2.1 mJy at 1.7 GHz (Fender et al. 2005), probably indicating jet activity.

After reaching a flux peak of 120 mCrab on 2005 July 1 (Morgan et al. 2005), the source flux began to decay, but has stalled for months in its decline at a level of ~20 mCrab (2-20

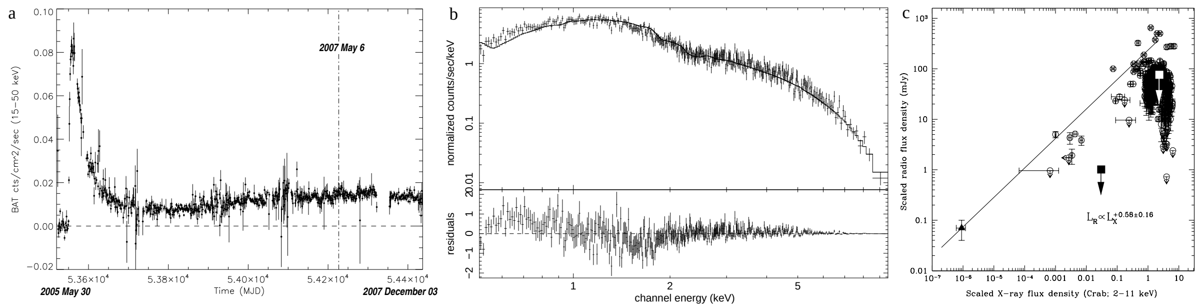

Figure 1. *Panel a:* Swift/BAT light curve of Swift J1753.5-0127. The vertical dashed-dotted line indicates the beginning of our multiwavelength observational campaign. *Panel b:* Swift/XRT energy spectrum for 2007 July 03, 1.7 ks exposure. The spectrum is fitted with an absorbed power law. From the plot of the residuals one can see that a thermal component is needed to get an acceptable fit. *Panel c:* figure 4 from Gallo et al. 2006 where we added the Swift J1753.5-0127 data point (black square with black thick arrow for a distance of 1 kpc, white square with white thick arrow for a distance of 8.5 kpc) taken from a simultaneous Swift/XRT - WSRT observation on 2007 July 08.

keV). This is an unusual behaviour for a black hole transient, but even more unusual is the slow rebrightening, which occurred between 2006 June and 2007 July-August, as can be seen in the Swift/BAT light curve in Figure 1 (panel a). At present, the X-ray light curve of Swift J1753.5-0127 suggests a slow decay. The source never left the Low/Hard State (LS) during the whole outburst (Cadolle Bel et al. 2007, Zhang et al. 2007).

Miller et al. 2006a, analysing XMM-Newton observations collected during 2006 March, estimated a disk component extending to the innermost stable orbit at $L_{\rm X}/L_{\rm Edd} \simeq 0.003\,(d/8.5\,{\rm kpc})^2\,(M/10M_{\odot})$. This is one of only three black hole candidates (BHCs) that show a thermal component in LS at a very low X-ray luminosity, since they are usually found not to have such a component (Esin et al. 1997, Fender, Belloni & Gallo 2004; but see exceptions: Miller et al. 2006b for GX 339-4; Rykoff et al. 2007 for XTE J1817-330).

Cadolle-Bel et al. 2007 analysing radio VLA observations, reported an average flux of 0.7 ± 0.1 mJy at 8.5 GHz, when the unabsorbed X-ray flux was 1.5×10^{-9}erg/cm^2/sec (2-11 keV). With these values the source is extremely radio fainter than expected from the empirical correlation found by Gallo et al. 2006 between the radio and the X-ray luminosity (scaled to a distance of 1 kpc) of a number of BHCs in LS and in quiescence: $L_{\rm R} \propto L_{\rm X}^{0.58\pm0.16}$.

2. Observations

We are currently observing the source with several instruments in different bands of the electromagnetic spectrum.

X-ray - RXTE+Swift: we started monitoring the source weekly on 2007 May 6th with the *Rossi X-ray Timing Explorer* satellite (~3-100 keV, PCA+HEXTE) and we are currently observing it. The vertical dashed-dotted line in Figure 1 (panel a) indicates the beginning of the RXTE observing campaign. Swift/XRT (~0.5-10 keV) pointed at the source 9 times between 2007 May 28th and 2007 July 15th, with a typical exposure of ~2 ksec.

Radio - WSRT: we observed the source in radio 4 times with the Westerbork Synthesis Radio Telescope on 2007 July 1st, 2007 July 8th, 2007 July 15th and 2007 July 22nd, at 5 and 8 GHz. RXTE and Swift observed the source simultaneously during the first three radio pointings, only RXTE observed the last one.

Optical/IR - SMARTS: the SMARTS telescope observed the source 47 times between 2007 July 9th and 2007 September 30th, in the I, V and H band. The usual exposures were 15 min, enough to get a typical signal to noise ratio higher than 50.

3. Preliminary results and conclusions

Here we present preliminary results from our multiwavelength analysis, focusing on the two issues pointed out at the end of section §1.

Figure 1 (panel b) shows a Swift/XRT energy spectrum taken on 2007 July 03. Fitting the spectrum with an absorbed power law we obtain a fit with a reduced chi squared $\chi^2_\nu = 1.55$ (fixing the galactic absorption N_H to the value found by Miller et al. 2006a, $N_H = 2.3 \times 10^{21}$ cm^{-2}). The residuals can be significantly reduced by the addition of a thermal component with $kT_{bb} = 0.20 \pm 0.02$ keV (significance 4.2 σ): the new fit gives a chi squared $\chi^2_\nu = 1.23$. This three-component model gives an absorbed flux of 7.4×10^{-10}erg/cm^2/sec (0.5-10 keV): this corresponds to $L/L_X = 0.005(d/8.5\text{kpc})^2(M/10M_\odot)$. The normalization gives an inner radius $R_{in} = 72^{+17}_{-9}(d/8.5\text{kpc})/cos\, i$ km. In all our spectral fits (but one that gave not consistent results) we found a temperature for the thermal component consistent with $kT_{bb} = 0.20$ keV and an inner disc radius R_{in} in the range $(46^{+21}_{-8} < R < 72^{+17}_{-9})$ km. Spectra have been fitted fixing the Galactic absorption N_H to the value found by Miller et al. 2006a.

Figure 1 (panel c) shows simultaneous X-ray/radio flux densities for a number of BHCs (scaled to a distance of 1 kpc) used by Gallo et al. 2006 to find the empirical correlation between the radio and the X-ray luminosity mentioned in §1. We measured Swift J1753.5-0127 X-ray and radio flux on 2007 July 08: in radio, with WSRT, we did not detect the source but we could give a 3 σ upper limit on its flux of 1.1 mJy/beam. With Swift/XRT we measured a X-ray flux (2-11 keV) of 6.2×10^{-10}erg/cm^2/sec (26 mCrab). We added two points to the plot, a black and a white square, for a source distance of 1 kpc and 8.5 kpc respectively.

Our preliminary results from simultaneous multiwavelength observations of the BHC Swift J1753.5-0127 confirm previous results:

(i) in all our spectral fits (but one) we found results partially consistent with Miller et al. 2006a : a thermal component with a temperature consistent with the one found by Miller et al. 2006a ($kT_{bb} = 0.22 \pm 0.01$ keV) is needed. The inner radius of the disc blackbody associated with the thermal component is higher than the radius found by Miller et al. 2006a ($R_{in} = 30 \pm 5$ km) and not consistent with it (only in one case it is consistent within the errors). A broad band spectral analysis is clearly needed to model Swift J1753.5-0127 emission, putting light on the origin of the thermal emission.

(ii) Figure 1 clearly shows that the source is still less luminous in radio than expected from the $L_\text{X} - L_\text{R}$ correlation, as previously reported by Cadolle Bel et al. 2007. This might weaken the identification of Swift J1753.5-0127 as a BHC, not supported by any dynamical measurement of the mass of the compact object: NSs are usually much radio fainter than BHCs at the same X-ray luminosity (Fender & Hendry 2000). However note that other LS sources are also "partially radio quenched" (e.g. XTE J1720-318, IGR J17497-2821, XTE J1650-500, 1E 1740.7-2942, GRS 1758-258; Gallo 2007). This issue will need further studies and observations.

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