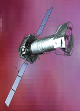
Tidal Disruption Events



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The tidal disruption (TD) of stellar objects by the central black hole of galactic nuclei remains very much a peripheral area of AGN physics. Calculations and experience show that events are rare ~1/galaxy/105 years and they are difficult to unambiguously identify against a background of AGN outbursts and supernovae. Until very recently, TD candidates have been detected by flares in X-ray or UV observations, usually well after the peak of the event (e.g. RX J1242-119 [Komossa & Greiner 1999]; RX J1420.4+5334 [Greiner et al. 2000]; NGC 3599, SDSS 132341+482701 [Esquej et al. 2007]). The best observed object was NGC 5905, whose light curve was well enough sampled [Komossa & Bade 1999] to enable Li, Narayan & Menou (2002) to constrain the progenitor to be either a brown dwarf or gas stripped from the outer layers of a main sequence star. All ROSAT spectra were exceptionally soft, matching well predictions [Rees 1988] of a thermal spectrum of kT=30-70 eV, even though the actual spectral *shape* could not be measured with ROSAT. Later epoch observations with ROSAT, Chandra and XMM-Newton then showed a significant spectral hardening [e.g. Komossa et al. 2004, Vaughan, Edelson & Warwick 2004; Esquej et al.2008] more similar to AGN spectra.

In an attempt to gain more timely information we instituted a program of systematic monitoring of XMM-Newton slew sources, designed to detect candidates while at the peak of their emission, and follow them with XMM-Newton triggered TOOs, regular SWIFT XRT/UVOT monitoring and optical spectra. Here we report on the first fruit of that program.

DISCOVERY and OBSERVATIONS

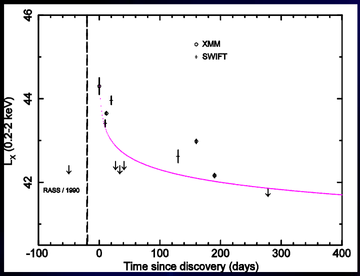

Figure 1: The 0.2-2 keV light curve fitted with a $t^{-5/3}$ curve (purple)

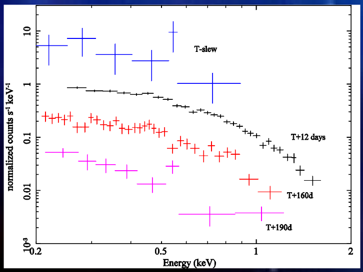

Figure 2: The XMM-Newton spectra: slew, 1st,2nd and 3rd TOO from top to bottom

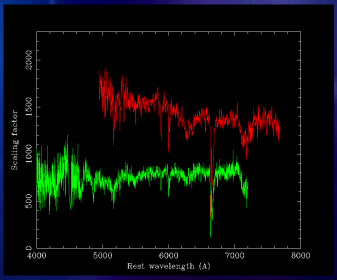

Fig. 3: Calar-Alto 3.6m/Twin (red) and WHT/ISIS (green) spectra taken 15 and 320 days respectively after discovery.

The new X-ray source was discovered in June 2010 in an XMM-Newton slew. Monitoring started with SWIFT 10 days later and three pointed XMM-Newton observations were made 12, 160 and 190 days after the event. In detail the light curve deviates wildly from the theoretical $t^{-5/3}$ evolution predicted for returning tidal debris (Rees, 1988). However, the overall decay is represented reasonably well by this model. If correct, then the source will be emitting at $L_x > 5 \times 10^{41}$ ergs/s for the next 1-2 years and will continue to be easily visible to XMM-Newton or Chandra. A shallower initial light curve is predicted by detailed modelling of the stellar internal density [Lodato, King & Pringle 2008] and there may be evidence for this.

The X-ray spectrum (Fig. 2) is quite constant in shape from discovery down to the faintest spectrum, 190 days later. This strongly implies that variations are due to a decrease in intrinsic emission rather than changes in cold or ionized absorption. In fact there is very little evidence for absorption, intrinsic to the source, in any of the XMM-Newton spectra. There is, however, a dramatic drop, of factor ~50, between the SWIFT-XRT observations made 20 and 27 days after the discovery. This is not well understood. Models where material builds up and accretes at super-Eddington luminosities until being blown away by a radiation-driven wind, may be involved.

The TOO spectra can not be fit with a power-law model or a power-law plus black-body.
They can be well fit with a bremsstrahlung of temperatures 370 eV, 310 eV and 200 eV respectively (and Galactic absorption), or with a broken power-law. No intrinsic absorption is needed except in the 1st obs. which requires a small edge at ~600 eV.

Discussion

From the WHT spectrum $L_{[OIII]5007} < 4 \times 10^{39}$ ergs/s implying that any persistent AGN emission will have $L_{bol} < 3 \times 10^{41}$ ergs/s [Lamastra et al. 2009]. At the flare peak, $L_{0.2-10} = 3 \pm 1 \times 10^{44}$ ergs/s. The bolometric luminosity may be a factor 2 higher than this. From the relationship of black hole mass to bulge luminosity [Marconi & Hunt 2004] we find $M_{BH} < 1.7 \times 10^{7} M_{\odot}$. The lack of short-term variability in the X-ray light curves argues against a much lower mass. Assuming that the emission is unbeamed, the luminosity at peak is then >0.1 L_{edd}. We tentatively suggest that the large flux variations seen in the opening 30 days of the event are due to an irregular supply of returning debris possibly due to disruption by outflowing, radiation-driven winds [Strubbe & Quataert 2009].

Another possibility is that we are seeing jet emission (no post-flare radio observation has been made). The variability and X-ray spectrum is similar to that seen in the recently discovered TD candidate, SWIFT J164449.3+573451 where the huge luminosity has to be non-isotropic [Burrows et al. 2011].

No emission features are seen in the optical spectra. The redshift, from the NAII and MgII absorption lines is 0.146+/-0.002. The lack of features suggests that the source was inactive at the time of the flare. Nevertheless, X-ray bright AGN without optical features are known. Trump et al. (2009) discussed a sample from the COSMOS survey which appeared to be accreting at very low rates, possibly in a RIAF disk where the optical/UV bump is suppressed and the ionizing continuum is too weak to excite the broad or narrow lines. Certainly, the lack of intrinsic X-ray absorption argues against the optical lines being removed by obscuration.
While this may account for the current X-ray activity, it doesn't provide a natural explanation for the factor 100 increase in X-ray activity, unless the disk temporarily changed into an efficient accretion mode. At the peak of the X-ray flare the optical and UV flux did not increase, however, which makes this unlikely.

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The X-ray Universe 2011, Berlin, June 27-30, 2011