A Tidal Disruption Event Candidate from the 2XMM Catalog

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1. Introduction

Stars approaching supermassive black holes (SMBHs) can be tidally disrupted and subsequently accreted. Such events provide a unique way to find and study dormant SMBHs believed to reside in many galaxies. About a dozen of such event candidates are found, with peak spectra typically soft (~0.04-0.1 keV) and luminosities up to 10^{44} erg/s. We report our discovery of a new candidate, with two ultrasoft X-ray spectra of unprecedented quality near the peak, and the Chandra follow-up on it (Lin et al. 2011, 2014).

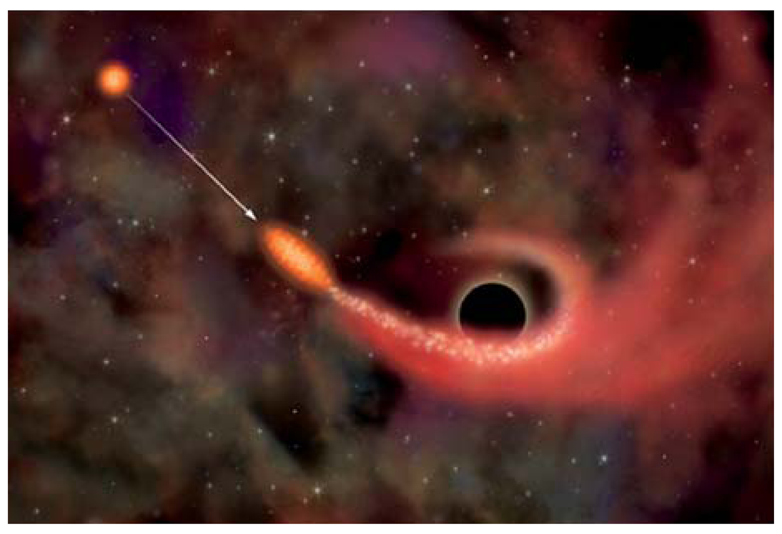

Fig 1. Artist's sketch of the tidal disruption of a star around a SMBH

2. A New Candidate: 2XMMi J184725.1-631724

(1) Lying toward the center of a galaxy (z=0.0353, Figure 2), which is inactive: no clear optical emission lines but typical stellar absorption features (Figure 3)

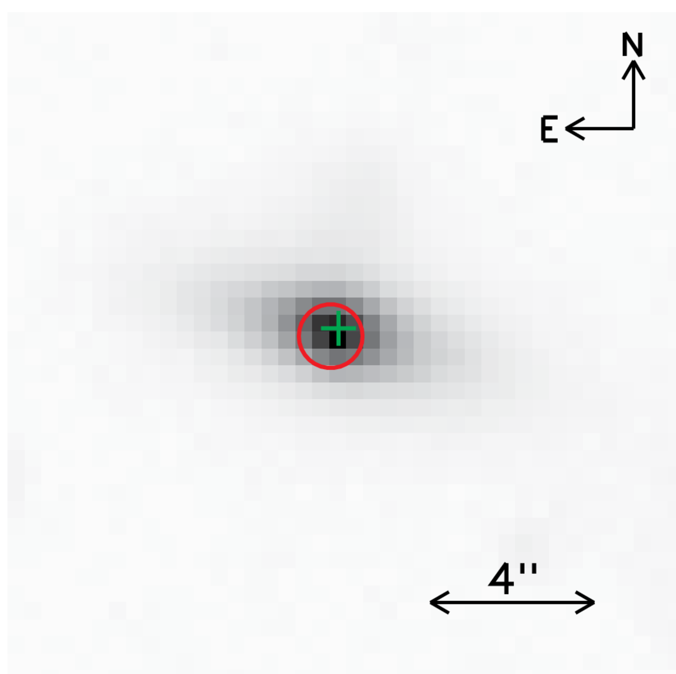

Fig 2. The V-band image of the galaxy. The green plus is the galaxy center from the profile fit. The red circle is the 3-σ error of the X-ray position.

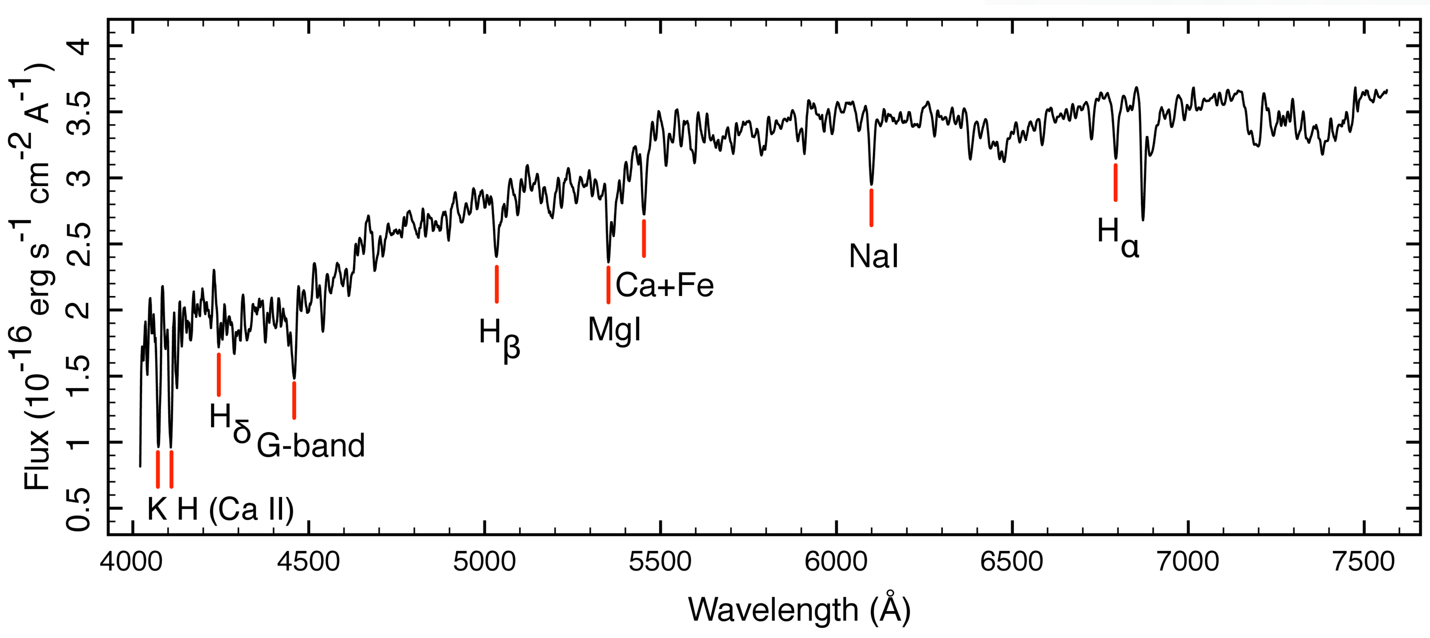

Fig 3. The optical spectrum of the galaxy from the Gemini South Telescope four years after the flare.

(2) An X-ray transient source. It was detected serendipitously in two XMM-Newton observations (XMM1 and XMM2 in Figure 4), but not in a ROSAT observation in 1992 or a Swift observation in 2011. In our 2013 Chandra 15 ks observation, we detected 5 net counts from the source, indicating a decay factor of about 400 (absorbed flux) from XMM2.

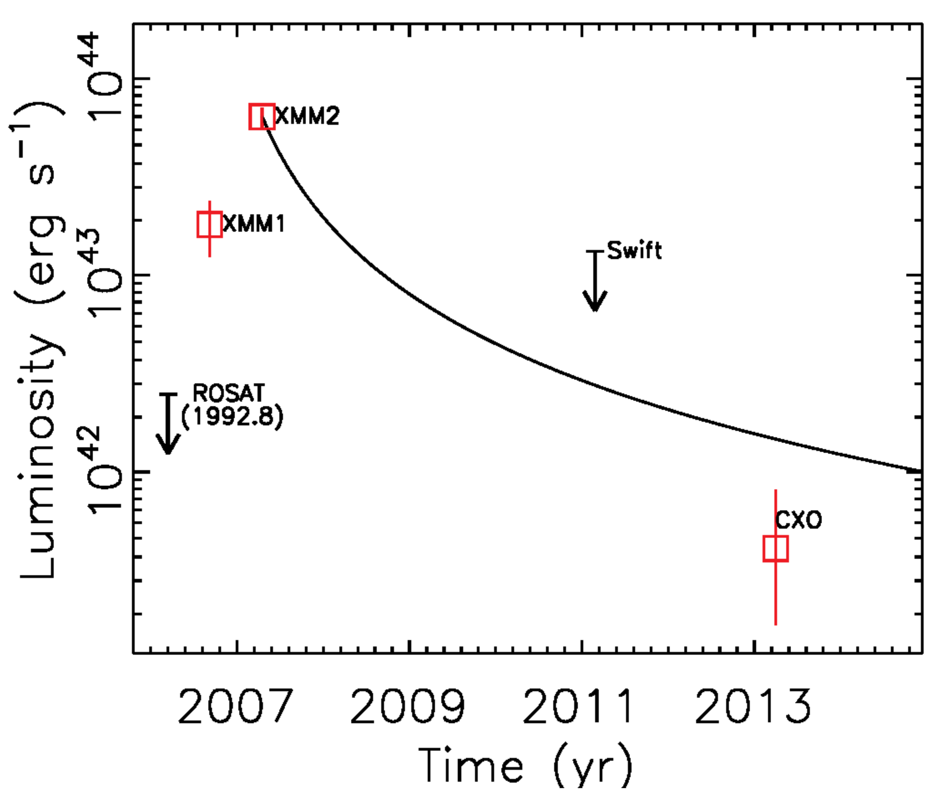

Fig 4. The long-term luminosity curve. Errors are at the 90% C.L. Arrows are 3-σ upper limits. The solid line is a theoretic decay curve, assuming disruption time at one month before XMM1. The Chandra luminosity in 2013 was estimated assuming the spectral shape in XMM1 and is lower than expected, probably indicating cooler disk than in XMM1.

(3) Ultrasoft X-ray spectra. Both XMM-Newton spectra can be described by a strong thermal disk plus a weak power law (Figure 5). The disk temperatures (~0.07-0.1 keV) and luminosities are consistent with $L \propto T^4$, similar to BH X-ray binaries in the thermal state but for a SMBH of ~10^6 $M_\odot$.

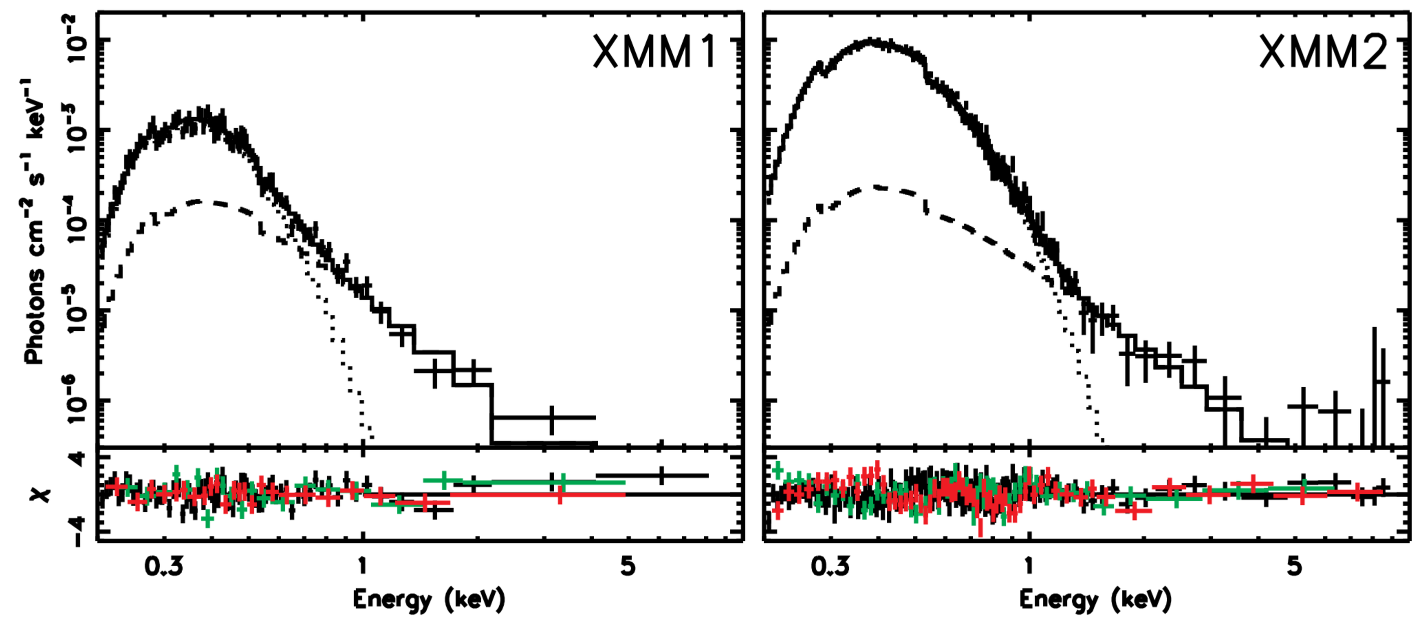

Fig 5. The unfolded pn spectrum and the fit residuals (black/red/green for pn/MOS1/MOS2, respectively), using a multicolor disk model (dotted line) plus a power law (dashed line).

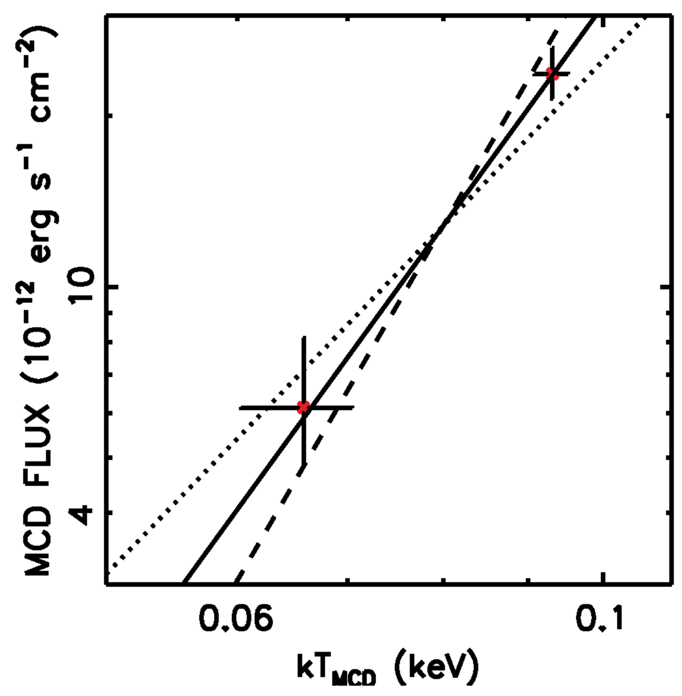

Fig 6. The disk flux versus the temperature. The solid ($L \propto T^4$), dotted ($L \propto T^3$), and dashed ($L \propto T^5$) lines are for guidance.

(4) Fast X-ray variability. Both XMM-Newton observations show large variability, with rms values about 21% on timescales of hours (Figure 7). The disk temperature is found to increase with the flux, implying a possible explanation for the fast variability: it is due to the fast variation of the accretion rate caused by shocks during tidal disruption of the star.

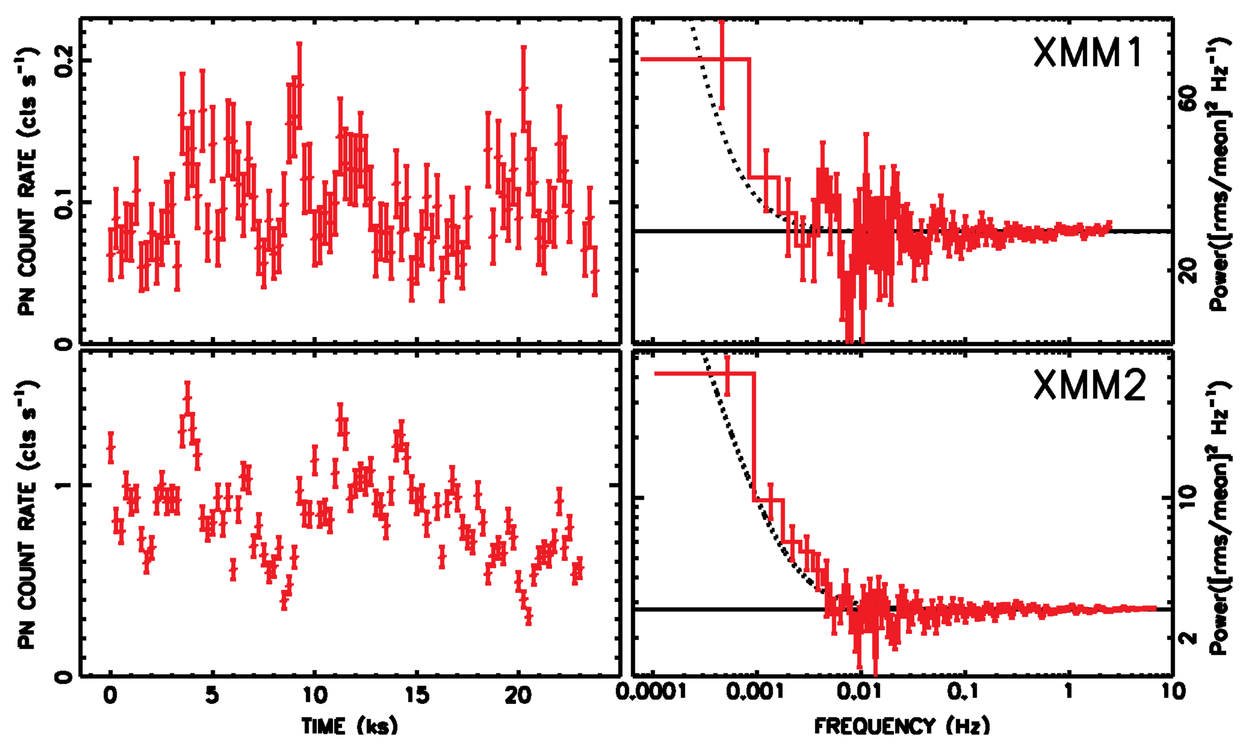

Fig 7. Left panels: the pn 0.2-2.0 keV light curves. Right panels: the power density spectra. The dotted line is the fit with a power law plus a constant Poisson level (the solid line).

3. Conclusion

2XMMi J184725.1-631724 is an ultrasoft X-ray transient, as confirmed with our 2013 Chandra observation, with peak luminosity near 10^{44} erg/s and lying toward the center of an inactive galaxy, thus probably a tidal disruption event. From its two ultrasoft X-ray observations near the peak of unprecedented quality, we gain more insights into such events:

- Near the flare peak, the disk luminosity appears to follow $L \propto T^4$, similar to BH X-ray binaries in the thermal state but for a SMBH;
- Large variability on timescales of hours are seen, probably due to fast variations in the mass accretion rate caused by shocks during tidal disruption of the star.

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References: Lin, D., et al. 2011, ApJ, 738, 52; Lin, D., et al. 2014, paper in preparation