Tidal disruption events from the XMM-Newton Slew Survey

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Dynamical studies assert that massive dark objects reside in the nuclei of many galaxy bulges. Dormant supermassive black holes hosted by normal galaxies can be unveiled by the detection of outburst radiation produced when a star is tidally disrupted and subsequently accreted by the nuclear black hole. A number of these exceptional events have been hitherto detected, being the two most recent ones discovered by XMM-Newton during slew observations.

The XMM-Newton Slew Survey

Characteristics

- EPIC-pn in FF, eFF and LW mode
- 10 seconds eff. on-axis exposure time
- Low background
- Positional accuracy: 8" (1σ)
- Flux limit:
  - Total band (0.2-12 keV): 1.2x10-12 ergs/s/cm²
  - Hard band (2-12 keV): 4x10-12 ergs/s/cm²
  - Soft band (0.2-2 keV): 6x10-13 ergs/s/cm²

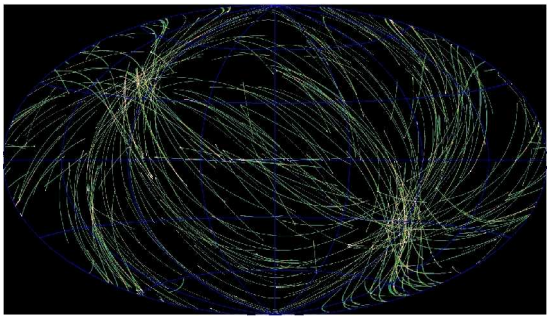

Fig.1. Sky coverage of the slew survey (XMMSL1 + Delta-1) in galactic coordinates.

Catalogues

- XMMSL1:
  - Slew sources from rev 314-978
  - Sky coverage 15%
  - Released on May 2006
- Delta-1
  - To be released

Tidal disruption events

Slew observations

Two optically non-active galaxies were detected in the XMM-Newton Slew Survey (Saxton et al. in prep.) showing soft X-ray spectra and high variability with respect to ROSAT All-Sky Survey (RASS) 2σ-upper limits (Esquej et al. 2007, A&A, 462,49):

- NGC 3599 is an elliptical galaxy at redshift 0.0028. This source is the nearest non-active galaxy hosting a supermassive black hole ever detected. Its unabsorbed X-ray luminosity at the time of the slew observation was $1.38 \cdot 10^{41}$ erg s^{-1}, the flux comparison with its RASS upper limit showed a variability factor of 88. Upper limits derived from ROSAT PSPC pointed observations show variability factors of 297 and 100.
- SDSS J132341.97+482701.3 is a normal galaxy at redshift 0.088, variability factor of 83 and X-ray luminosity from the slew of $1.39 \cdot 10^{43}$ erg s^{-1}.

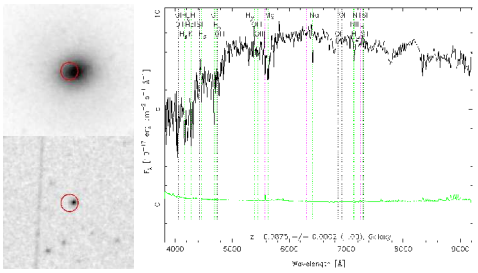

Fig.2. Left: Positions of the slew sources (red circles) overplotted on DSS images of 2 arcmin. The radius of the circles has been fixed to 8 arcsec, which is the astrometric uncertainty of the slew sources. Right: Optical spectrum of SDSS J132341.97+482701.3 performed seven months before the corresponding slew exposure.

Follow-up observations

XMM-Newton:

Follow-up pointed XMM-Newton observations performed on NGC 3599 and SDSS J132341.97+482701.3 roughly two years after the slew observation show that both sources have faded by factors of 50 and 70 respectively leaving a residual steep soft spectrum. The best-fit model to the EPIC spectra for NGC 3599 is a power-law model (Γ_x=2.95) with absorption fixed to the Galactic value (Fig.3).

Swift:

Both sources were too weak at the time of the follow-up Swift observations to apply spectral fits but they were used to provide a further point in the light curve of the sources.

Temporal evolution of the sources

Subsequent observations of NGC 3599 have shown that its flux experimented a further decrease following a $t^{-5/3}$ decline law (as can be inferred from the light curve in Fig. 4), consistent with efficient accretion to the supermassive black hole from a thick disk (Ulmer 1999, ApJ, 514, 180). SDSS J132341.97 +482701.3 was very faint at the time of the Swift observation and only a few counts were detected, the flux did not decrease as expected. Nevertheless, its light curve can be also fitted by a $t^{-5/3}$ decline law.

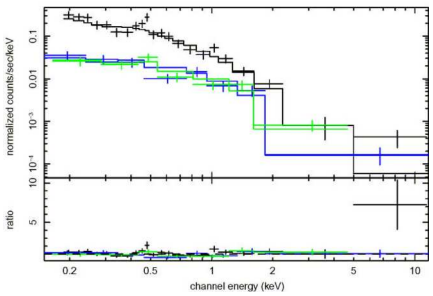

Fig.3. Spectrum of NGC 3599 (black: EPIC-pn, blue: EPIC-MOS1, green: EPIC-MOS2) from the XMM-Newton pointed observation. A power-law model plus Galactic absorption has been fitted to the data.

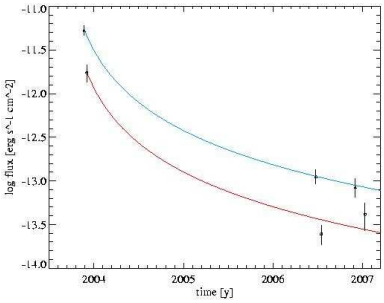

Fig.4. X-ray light curves of the two tidal disruption events. Triangles: NGC 3599. Circles: SDSS J132341.97+482701.3. The points come from the XMM slew, XMM pointed and Swift observations respectively. A $t^{-5/3}$ law has been fitted for both sources.