Part 7

Normal Galaxies and Clusters

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Giant-Amplitude X-ray Flares as Probes of the Black Hole Region of Nearby Galaxies

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Abstract. In the last few years, several giant-amplitude, non-recurrent X-ray flares have been observed from optically non-active galaxies. The observations were interpreted in terms of the long-predicted tidal disruption flares of stars captured by supermassive black holes. In this contribution, we review the observations and interpretation of the X-ray flares and add some new thoughts. Future X-ray observations of the flare events are expected to open up a new window to detect and investigate SMBHs and their immediate environment in galaxies. Here, we concentrate on the possibility to detect new X-ray flares in deep fields with the planned European X-ray mission *XEUS*.

1. Introduction

It has long been suggested that supermassive black holes in non-active galaxies might be tracked down by occasional tidal disruptions and subsequrnt accretion of stars. A tidal disruption event would reveal itself by a luminous flare of electromagnetic radiation. Theorists argued that the convincing detection of such a tidal disruption event would be the observation of an event which fulfills the following three criteria: (1) the event should be of finite duration (a 'flare'), (2) it should be very luminous (up to $L_{\max} \approx 10^{45}$ erg/s in maximum), and (3) it should reside in a galaxy that is otherwise perfectly *non*-active (to be sure to exclude an upward fluctuation in gaseous accretion rate of an *active* galaxy). During the last few years, several X-ray flare events were detected which match these criteria. (The third one always reflects current instrument sensitivity limits, of course). We therefore consider these events to be excellent candidates for the occurrences of the theoretically predicted tidal disruption flares. In this contribution, we review the previous observations of giant X-ray flares from normal galaxies and discuss results for some of these.

2. Summary of the flare observations and a new development

With the X-ray satellite *ROSAT*, some rather unusual observations have been made in the last few years: the detections of giant-amplitude, non-recurrent X-ray outbursts from a handful of galaxies which lack AGN-indications in optical groundbased spectra. Based on the huge observed outburst luminosity, and other properties, the observations were interpreted in terms of tidal disruption events (e.g., Komossa & Bade 1999, Li et al. 2002). Four X-ray flaring galaxies (NGC 5905, RXJ1242−1119, RXJ1624+7554, RXJ1420+5335) were identified and there is a possible fifth candidate, all of which show similar properties (see Komossa 2002 for a review)

- huge X-ray peak luminosity (up to $\sim 10^{44}$ erg/s),
- giant amplitude of variability (up to a factor ~ 200),
- ultra-soft X-ray spectrum ($kT_{\rm bb} \simeq 0.04$-0.1 keV),
- absence of optical signs of Seyfert activity in ground-based spectra (and in HST spectra when available, with one exception: interestingly, an HST spectrum of NGC 5905 reveals weak high-excitation emission lines, further discussed below).

These observations nearly inevitably call for the presence of supermassive black holes as ultimate energy reservoirs to power the flares (see the extended discussion by Komossa & Bade 1999, and Komossa 2002). The events are therefore of the general kind suggested by Lidskii & Ozernoi (1979) and Rees (1988) to be used as tracers of SMBHs in otherwise non-active galaxies (i.e., galaxies which appear non-active to the observer, as judged from typical, ground-based observations).

In particular, the observations match the above mentioned criteria to qualify as tidal disruption events (or, event candidates; an ultimate certainty will likely only be possible once relativistic effects are discovered in the spectra. This might take a while, though, given the fact that we even barely know any AGN which reveal their SMBHs by relativistic effects. Nevertheless, it is generally accepted that AGN are powered by SMBHs).

NGC 5905 was recently observed by HST in an ongoing effort to put ever better constraints on the presence of extremely weak AGN activity in this galaxy. These observations led to the detection of weak high-excitation emission lines in the very nucleus of NGC 5905 (Gezari et al. 2002). It is presently being investigated, whether these lines were excited by the X-ray flare, or indicate the presence of a permanent very-low-level Seyfert nucleus not detectable in ground-based spectra. *If* originating from permanent very-low-level Seyfert activity, the amplitude of variability of NGC 5905 – of order at least several times 10^3 (!), if low-state Hβ luminosity is converted to low-state X-ray luminosity – would be humongous, never before recorded among AGN. Tidal disruption would still remain the most likely explanation of this unusual event.

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3. Search for new X-ray flares with future X-ray missions

An important aspect is the search for more flare events with the new generation of X-ray missions (Yuan et al. 2002). If caught in high-state, the flares can be studied in detail, and multi-wavelength follow-up observations will add further valuable insight into the phenomenon (Komossa 2002).

New X-ray flares can either be detected with new X-ray all-sky surveys, or in pointed-mode observations. Surveys offer the advantage of large sky coverage but suffer from lower sensitivity, while deep pointings have small sky coverage but extend to much lower flux densities. The number of events is expected to increase at lower flux densities (Yuan et al. 2002).

The best strategy to search for flares with the planned European X-ray mission *XEUS* (Arnaud et al. 1999) would be repeated observations of deep fields, taking account of the facts, that (i) the field of view of *XEUS* is rather narrow, but (ii) the sensitivity is much higher than present-day missions. Once a new flare is detected, and observed with high spectral and temporal resolution in X-rays, the flare spectra may allow to probe the realm of strong gravity, since the temporal evolution of the stellar debris and of potential spectral features, will depend on relativistic precession effects around the Kerr metric.

Reprints of this and related papers are available at http://www.xray.mpe.mpg.de/~skomossa/

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