Poster contributions of the "Advanced Lectures on the Starburst-AGN Connection", Eds. R. Mújica, I. Aretxaga & D. Kunth, 2001, INAOE Electronic Edition (http://www.inaoep.mx/∼agn00/posters.html), pp. 55-56

Giant X-ray flares from nearby, optically *non-active* galaxies

Stefanie Komossa

Max-Planck-Institut für extraterrestrische Physik, Giessenbachstr., D-85748 Garching; skomossa@xray.mpe.mpg.de

Abstract. An efficient method to probe the direct vicinity of SMBHs in nearby galaxies is to make use of the observations of flares from tidally disrupted stars (e.g., Lidskii & Ozernoi 1979, Rees 1988). The first few excellent candidates for the occurrence of this process in non-active galaxies have emerged recently. Here, we review our observations of the two optically non-active galaxies NGC 5905 (Komossa & Bade 1999) and RXJ1242-1119 (Komossa & Greiner 1999), which both exhibited giant-amplitude X-ray outbursts interpreted in terms of tidal disruption events.

1. Introduction

There is strong evidence for massive dark objects at the centers of many galaxies. Observations of the dynamics of stars have been used to derive constraints on the mass of the nucleus. An alternative approach to probe the conditions in the nuclear region, and to detect supermassive black holes (SMBHs) if they exist there, was suggested by Lidskii & Ozernoi (1979) and Rees (1988, 1990). They proposed to look for these SMBHs based on the flare of electromagnetic radiation, emitted by a star when it is tidally disrupted and accreted by the SMBH. The first good candidates of these kind of events have been reported in the last few years (see Komossa 1999 for a review, and references therein). Below, we give a brief summary of the first two reported flaring events observed in X-rays in *optically non-active* galaxies.

2. Observations

Giant X-ray flares from the two galaxies NGC 5905 and RXJ 1242-1119 were detected by a comparison of *ROSAT* all-sky survey data and data obtained during the later phase of pointed observations (Bade et al. 1996, Komossa & Bade 1999; Komossa & Greiner 1999). The optical and X-ray properties of these galaxies during outburst and in quiescence can be summarized as follows:

- giant amplitude of variability: a factor $\gtrsim$ 200 (NGC 5905) and > 20 (RXJ 1242-11) in countrate, in the soft X-ray band (0.1–2.4 keV)
- ultra-soft X-ray spectrum during outburst with $kT_{\rm bb} \simeq$ 0.06 keV when fit by a black body emission model
- huge peak luminosity: $L_{\rm x} \gtrsim 10^{42-43}$ erg/s (NGC 5905) and $L_{\rm x} \gtrsim 10^{44}$ erg/s (RXJ 1242-11)
- no simultaneous change in optical brightness (NGC 5905) within the sensitivity limits of the photographic plates
- the optical high-resolution spectrum is that of an HII-type galaxy (NGC 5905), or does not show any emission lines at all (RXJ 1242-11); there are *no* signs of *permanent* Seyfert activity

3. Outburst scenarios

Both, the dramatic X-ray variability and the huge outburst luminosity are very rare among *non-active* galaxies. The only case reported prior to NGC 5905 and RXJ1242-11 is the, less luminous, UV outburst of the elliptical galaxy NGC 4552 (Renzini et al. 1995).

The giant peak luminosities ($L_{\rm x}$ > 10^{44} erg/s in the case of RXJ1242-11) and the absence of optical signs of AGN activity in these galaxies strongly suggests that we have seen the flare of a star that was tidally disrupted by a SMBH at the centers of these galaxies (for details see Komossa & Bade 1999 and Komossa & Greiner 1999). Alternative scenarios are unlikely due to the following reasons (an extended discussion is given by Komossa & Bade 1999):

Flaring Galactic foreground star. This is unlikely, since further optical sources within the X-ray error circle of RXJ1242-11 are extremely weak. Given the high $L_{\rm X}/L_{\rm opt}$ value, an ISM accreting neutron star might come to mind, but the strong X-ray variability would require an extreme ISM density gradient, and we thus reject this possibility. In the case of NGC 5905 the error circle just covers the nucleus of this nearby, giant spiral galaxy (Fig. 1).

Supernova in dense medium. The outburst X-ray luminosity of NGC 5905 and RXJ1242-11 by far exceeds that of individual supernovae. Those observed in X-rays range between $L_x \approx 10^{35}$ and a few 10^{40} erg/s; the X-ray brightest reached $\approx 10^{41}$ erg/s (Fabian & Terlevich 1996).

The possibility of 'buried' supernovae (SN) in *dense* molecular gas was studied by Shull (1980) and Wheeler et al. (1980), and later by Terlevich et al. (1992) in the context of the starburst model for AGN. In this scenario, X-ray emission originates from the shock, produced by the expansion of the SN ejecta into the ambient interstellar gas of high density. High luminosities can be reached this way, and the evolutionary time is considerably speeded up.

However, using the analytical estimates of Shull and Wheeler et al., and the numerical simulations of Terlevich et al., we find that the model predictions are either inconsistent with the observed softness of the X-ray outburst spectrum of NGC 5905, or they lead to an implausibly high density of the surrounding medium. The outburst luminosity of the second galaxy, RXJ1242-11, is too high to be plausibly accounted for by the scenario of a SN in dense medium.

X-ray afterglow of a Gamma-Ray Burst. Could the observed X-ray outbursts be interpreted in terms of the X-ray afterglow of a GRB ? Firstly, no GRB has been detected by Granat/WATCH in the time around the X-ray outburst of NGC 5905. Secondly, all observed X-ray afterglows of GRBs quickly faded in time, following a t^{-1} law.

Accretion disk instability. An accretion disk around a central SMBH may exhibit burst-like oscillations due to, e.g., thermal instabilities. However, in case of repeated such outbursts, one would expect to see permanent AGN-typical NLR emission lines (like [OI] or [OIII]) in the optical spectra of NGC 5905 and RXJ1242-11 which are not detected.

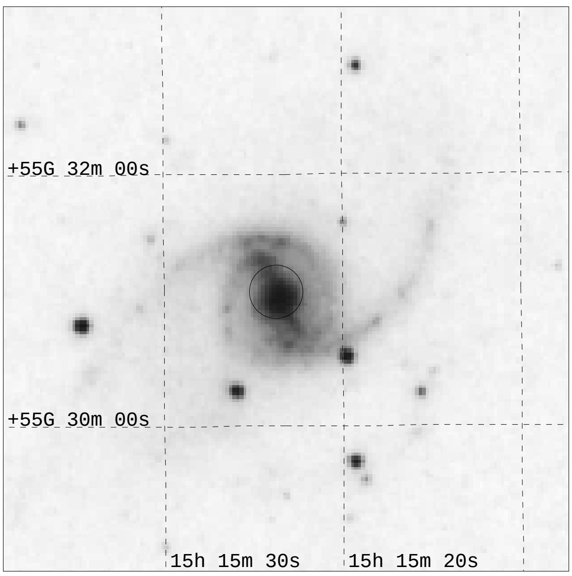

Fig. 1. Optical image of NGC 5905 and X-ray error circle (taken from Bade et al. 1996).

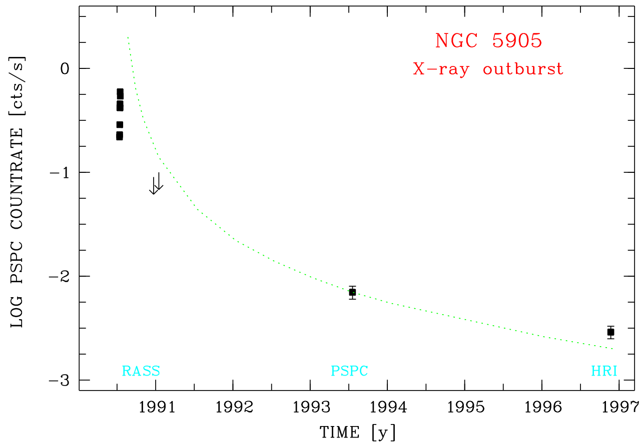

Fig. 2. Long-term X-ray lightcurve of NGC 5905.

4. Conclusions

In conclusion, the most likely model to explain the X-ray observations is the tidal disruption of a star by a central SMBH. Lidskii & Ozernoi (1979) and Rees (1988, 1990) originally proposed to use the flare of electromagnetic radiation emitted during the stellar disruption and accretion process as a means to detect SMBHs in nearby, *non-active* galaxies.

The observed X-ray flares from the (optically in-active) galaxies NGC 5905 and RXJ1242-1119 then lend further support to the scenario that *all* galaxies passed through an active phase, with unfed SMBHs now at their centers.

Future X-ray and UV surveys will be valuable in finding further of these outstanding flaring sources.

Acknowledgements. The *ROSAT* project was supported by the German Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie (BMBF/DLR) and the Max-Planck-Society.

References

Bade N., Komossa S., Dahlem M., 1996, A&A 309, L35
Fabian A.C., Terlevich R., 1996, MNRAS 280, L5
Komossa S., 1999, in Proc: ASCA/ROSAT workshop on AGN and the X-ray background, T. Takahashi, H. Inoue (eds), ISAS Report, p. 180
Komossa S., Bade N., 1999, A&A 343, 775
Komossa S., Greiner J., 1999, A&A 349, L45
Lidskii V., Ozernoi L., 1979, Sov. Astron. Lett. 5(1), 16
Renzini A., et al., 1995, Nature 378, 39
Rees M.J., 1988, Nature 333, 523
Rees M.J., 1990, Science 247, 817
Shull J.M., 1980, ApJ 237, 769
Terlevich R., Tenorio-Tagle G., Franco J., Melnick J., 1992, MNRAS 255, 713
Wheeler J.C., Mazurek T.J., Sivaramakrishnan A., 1980, ApJ 237, 781