The X-ray source associated with M32

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ABSTRACT

We present new analyses of the X-ray emission from the Andromeda Galaxy companion M32 observed with the ROSAT satellite. Benefitting from reprocessed data, the analysis of the best available frame with M32 in the central area of the detector improves on previously published results and indicates only one source associated with this galaxy. The re-analysis of the dedicated HRI exposure for M32 also yields conclusions that differ from a recent publication. At HRI resolution M32 appears as an extended source, probably a bit offset from the optical nucleus. Possible interpretations are discussed, which are relevant to the question whether a low-level active nucleus could be present or not, and the potential for XMM to clarify the situation is evaluated.

1. Introduction

M32 (NGC 221) is one of the nearest elliptical galaxies. The optical imaging and spectroscopy indicate that M32 contains a central dark object, probably a black hole, of mass $M \cong 3 \times 10^6\ M_\odot$ (Van der Marel et al. 1997). The Einstein satellite detected 1 source with a total 0.2–4 keV luminosity of $L_X \sim 5.4 \times 10^{37}$ erg s^{-1} (Fabbiano 1989) and HRI position (J2000) RA = $00^h42^m42.4^s$, Dec = $40°51'55''$ (Crampton et al. 1984).

Since M32 is a satellite galaxy of M31, many M31 ROSAT PSPC observations were carried out that contain also M32; most of them are part of two PSPC surveys of M31. The first survey was carried out during July 1991 (Supper et al. 1997), featuring 6 pointed observations with exposure times 27–50 ksec of which 4 include M32. The second survey was in 1992 with many short (few ksec) pointed observations. There is also one HRI observation with M32 in the centre.

The best PSPC exposure (ID. 600068) combines an exposure time of several tens of ksec with a position of M32 in the inner detector area. An analysis of these data by Eskridge et al. (1996) suggests a weaker source just NE of the main contributing source, demonstrates several spectral shapes to fit the data and summarizes the evidence for a low-level nuclear source or perhaps several sources of stellar origin.

The HRI observation was recently published (Loewenstein et al. 1998). M32 is associated with one fairly strong source some $7''$ away from the optical centre of the galaxy. There is a suggestion that after subtracting this source some residual emission remains closer to the centre of M32.

2. Analysis of reprocessed PSPC observation

Our X-ray image of the best available PSPC observation with ID. 600068 benefits from a re-processing of the satellite data and shows no evidence for any additional source located just North-East of M32. The previous result of that kind (Eskridge et al. 1996) may be due to some bad satellite attitude solution. The HRI observation does not detect any source at that location either. Figure 1 presents the contours of the PSPC and HRI observations of M32.

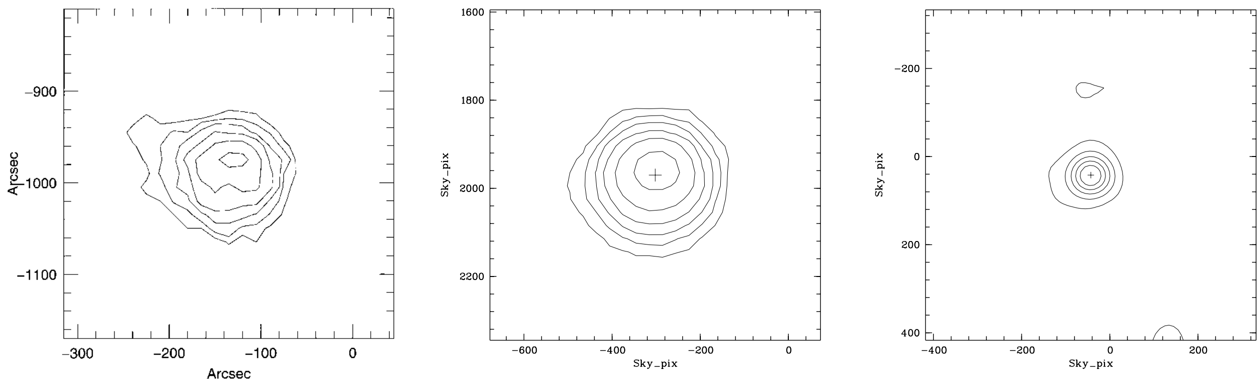
We have determined the X-ray spectrum for these reprocessed PSPC data. The contribution from the background was determined in an annulus around the source. There is no great change in our results compared to Eskridge et al. (who combined photons from three long observations), except for the fact that they used too many spectral bins for their fits (more than 100) while we with 21 stay closer to an optimum spectral binning for PSPC data (*c.f.* Davelaar 1969).

3. HRI exposure re-analysed

Our analysis of the M32 HRI field results in a source for which the source detection algorithm returns a position that agrees closely with the brightness peak (Figure 1c). Loewenstein et al. (1998) however found a source position that is shifted by ca. $5''$ towards the North-West. Since after a source subtraction exercise some residual emission is left closer to the centre of M32 where also their source detection algorithm finds a weak second source, they hint at the possibility that a weak X-ray source in the nucleus of M32 pulls the detection position towards it. In Section 4 we show that this is an unlikely interpretation, supporting the correctness of our plotted detection result.

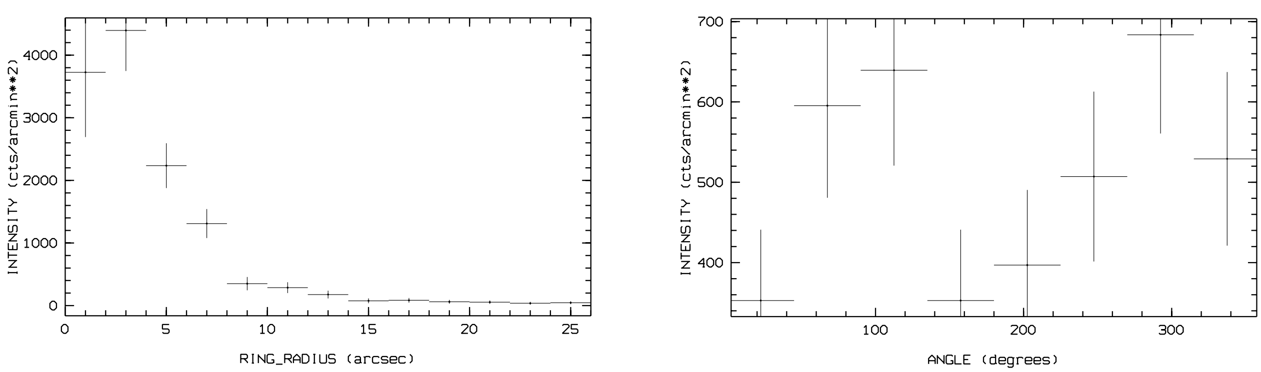
The source detection routine attributes a small extension to the source associated with M32. To investigate this further we determined the radial brightness profile and the azimuthal brightness variation for this source (Figure 2). The azimuthal variation shows a fairly symmetric double wave with peaks of comparable amplitude, as may be expected for an elongated source. The position angle of the direction of elongation does point roughly towards the M32 optical centre.

Six sources in the HRI field have counterparts within the unobstructed central area of the ID. 600068 PSPC exposure which are located North-East of their HRI position with offsets between $3''$ and $9''$ (except for M32 itself). A few of the (non-M32) HRI sources have optical counterparts that suggest positional corrections of $-2''$ in RA and $+3''$ in DEC. When these adjustments are applied, the offset of the X-ray source to the optical nucleus of M32 is still ca. $6''$ roughly in Easterly direction. Other measurements with (errors $\pm 4''$) yield offsets of ca. $3'' - 6''$. M32 may require a dedicated optical position measurement before the X-ray/optical offset can be reliably established.



(a) (b) (c)

Fig. 1.— Contour plots of the X-ray source associated with M32, in a 6.25×6.25 arcmins field: (a) PSPC analysis of Eskridge et al. (1996); (b) our PSPC result for the same field, and (c) our HRI contours. Notice that 1 arcsec equals 2 sky-pixels. The cross in (b) and (c) refers to the position found for the X-ray source.



(a) (b)

Fig. 2.— M32 ROSAT HRI brightness profiles within $26''$: (a) radial profile, (b) azimuthal variation.

4. Discussion

The idea that a source at a few arcsec distance could cause a shift in detection position (see Section 3) as reported by Loewenstein et al. (1998) can be tested with a simple simulation. Two HRI sources are generated (within EXSAS) and added together at $10''$ separation with count ratios varying between 12:12 and 12:1 (the latter roughly the ratio quoted in Loewenstein et al.). Figure 3 shows the effect of the second source on the position returned by the detection algorithm. As expected a halfway position is found for two equal sources, but for the ratio relevant for the case of M32 any shift is less than $1''$. Figure 3 displays the effect for the local- and map detection steps, since the simulations do not produce a photon event file as is required for the normally reported ML detections. We have checked however that for sources near the centre of the image and with strengths like the M32 source the ML detections are not more than $0.5''$ – $1''$ different from the positions found with local- and map detections. Since also our own detection result coincides with the peak of the brightness distribution, we conclude that the position offset in Loewenstein et al. is probably not correct. This casts doubt on their source subtraction attempt and we prefer source extension above a putative additional source, which is supported by the clear azimuthal variation in Figure 2.

Loewenstein et al. (1998) have summarized the X-ray brightness history of the M32 source. The PSPC data points are often above the HRI flux, but some are comparable. This implies real increases in brightness rather than the PSPC resolution allowing a completer flux measurement of an extended source. Over the longest timespan available, from Einstein till ASCA, there seems to be a base level for the M32 flux and only the ROSAT PSPC appears to have witnessed a flaring interval. Perhaps the base level indicates the X-ray flux from an extended component, in which the source of the X-ray variation is situated.

The present study shows the X-ray source associated with M32 as one source, but probably with intrinsic structure. The possible source extension and the uncertain offset from the optical nucleus bear on the interpretation of this source.

The source extension would be an important clue. Depending on the possible positional consistency with the centre of M32, the source could be a low-level active nucleus, a SNR or perhaps a star-formation complex. The last possibility is not likely since no on-going starformation is known for M32, unless the source is a chance superposition and belongs to M31; in both cases such a complex would be only a few tens of parsecs in size. Another possibility — which may increase the likelihood that a source appears extended — is a chance superposition of a Galactic source. If the source were the nuclear source in M32, then an interesting interpretation for the flaring observed with PSPC is that it could have been a stellar disruption flare as described by Rees (1988). Perhaps such a flare is superposed on a small specimen of hot gas halo as often observed around E and S0 galaxies.

The current status of positional information in the optical would favour a SNR interpretation. A size of around $10''$ corresponds to just over 30 pc at the distance of M32, which is rather normal for SNRs in our galaxy and in the LMC. The observed brightness increases during the PSPC exposures could originate from an associated pulsar. Notice that Eskridge et al. (1996) found a weak indication for a period of 1.27 days. This is slow for a pulsar but it could be part of a binary that survived the supernova explosion. Its age could be consistent with the intermediate population that several authors have noticed from optical spectroscopy. Given the expected lifetimes involved, the supernova itself would have been of type Ia, which is indeed typical of spheroidal objects including bulges. The observed X-ray luminosity is consistent with such a LMXB (possibly together with a SNR contribution).

The features exhibited by the M32 X-ray source render it an interesting target for XMM. The combination of high spectral resolution with good spatial resolution should allow to attain a better understanding of the nature of the extended and small, varying components suggested above. If these components can be followed over a flaring period as witnessed by the ROSAT PSPC, one can expect valuable information to be extracted. In any case, the spectrum which so far has not been uniquely described by any particular model can be investigated with much greater levels of significance. The considerable sensitivity of the XMM telescope is likely to reveal more sources in the field around M32 that will assist in improving the astrometric calibration of the X-ray observations. With these prospects one can hope to answer the very interesting question whether M32 has a small-scale nuclear source or not.

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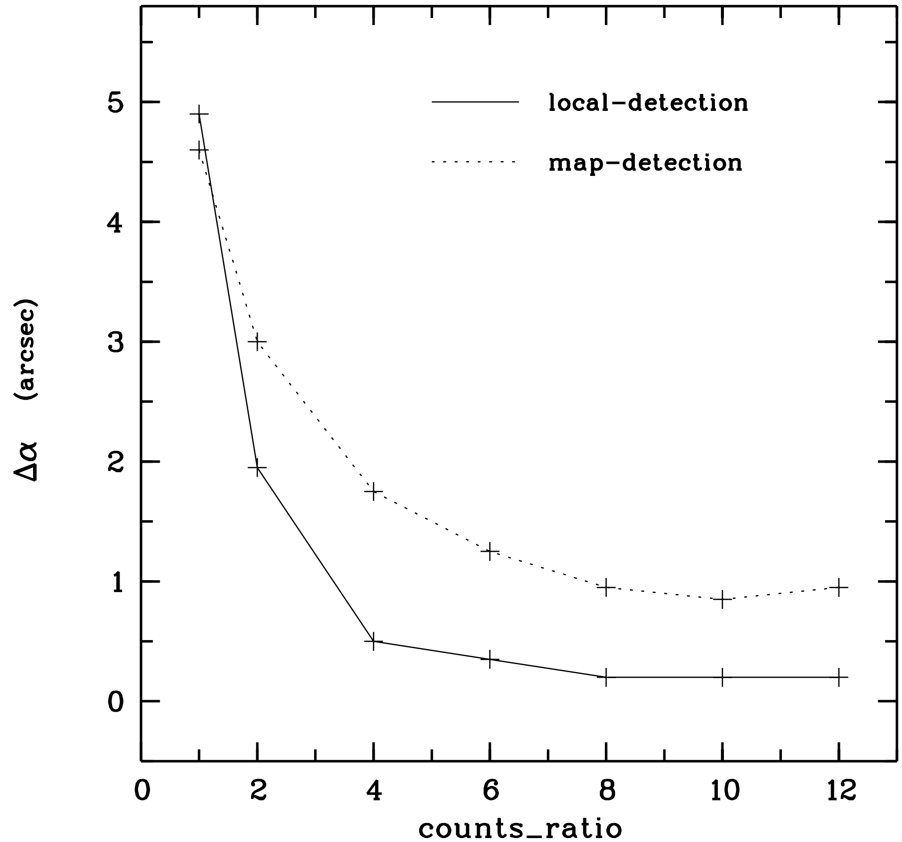

Fig. 3.— Source position affected by an additional source for various count ratios from 12:12 to 12:1. Two sources are simulated for the HRI detector with 10″ separation.