Mem. S.A.It. Vol. 75, 486

Memorie della

X-Ray properties of NGC 300 point sources detected with XMM-Newton, and their optical counterparts

S. Carpano[1], J. Wilms[1]⋆, M. Schirmer[2] and E. Kendziorra[1]

[1] Institut für Astronomie und Astrophysik, Abt. Astronomie, Universität Tübingen, Sand 1, 72076 Tübingen, Germany
[2] Institut für Astrophysik und Extraterrestrische Forschung, Auf dem Hügel 71, 53121 Bonn, Germany

Abstract. We present X-Ray properties of NGC 300 point sources, extracted from 66 ksec of *XMM-Newton* data taken in Dec. 2000/Jan. 2001. A total of 73 sources were detected above a maximum likelihood threshold of 100. We report global properties of these detected sources and search for their optical counterparts in B, V, R, and Hα images from the 2.2 m MPG/ESO telescope.

Key words. Galaxies: individual: NGC 300 – X-rays: galaxies

1. Introduction

NGC 300 is a dwarf galaxy of type SA(s)d in the nearby (~2.1 Mpc, Freedman et al. 1992) Sculptor galaxy group with a $22'' \times 15''$ (13.3 kpc × 9.4 kpc) D_{25} optical disk (de Vaucouleurs et al., 1991). Its closeness, its almost face-on orientation, and its low Galactic column density ($N_{\mathrm{H}} = 3.6 \times 10^{20}\,\mathrm{cm}^{-2}$), minimizing any absorption of soft X-rays, provide an ideal target for the study of its X-ray population.

The galaxy has been observed for 5 times between 1991 and 1997 with *ROSAT*, for a total exposure of 46 ksec for the PSPC, and 40 ksec for the HRI. See Read & Pietsch (2001) for a detailed analysis of these data.

In this contribution we report on some properties of the NGC 300 X-ray point sources obtained with *XMM-Newton*, and search for possible optical counterparts. Our results will be presented in further detail by Carpano et al. (2004).

2. Observations and data reduction

XMM-Newton observed NGC 300 on 2000 December 26 and 2001 January 1 during its revolutions 192 and 195. For both observations, all three EPIC cameras were in the full frame mode with the medium filter. The total observation time was 37 ksec for orbit 192 and 47 ksec for orbit 195.

After background screening, we reduced the raw Observation Data Files using the

Send offprint requests to: S. Carpano, email: carpano@astro.uni-tuebingen.de
⋆ *present address: Dept. of Physics, University of Warwick, Coventry, CV4 7AL, U.K.*

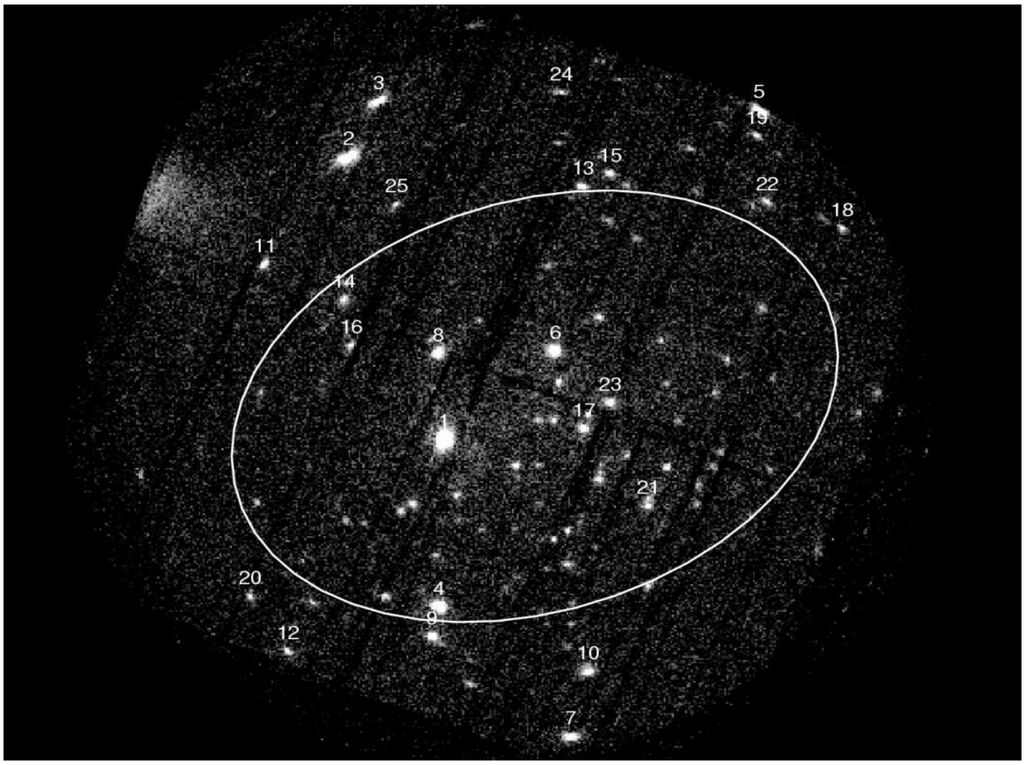

Fig. 1. X-ray image of NGC 300 in the 0.3–6.0 keV energy band. Overlayed are the D_{25} optical disk and the positions of the 25 brightest X-ray detected sources.

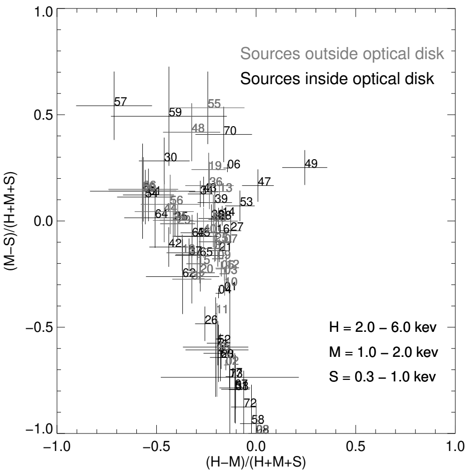

Fig. 2. Color-color diagram of the 73 X-ray sources in the field of NGC 300.

epchain and *emchain* tasks of the *XMM-Newton* SAS package, version 5.4.1. Spectra, images and lightcurves were extracted with *evselect*; only single and doubles events are considered. The Response Matrix and Ancillary Response Files are created with *rmfgen* and *arfgen*. We also analyze optical images of NGC 300 taken as part of the Garching-Bonn Deep Survey with the 2.2 m MPG/ESO telescope on La Silla, Chile, between 1999 July and 2000 January (Schirmer et al., 2003). The field of view of the WFI images was $34' \times 34'$, and the total exposure times were ~10 h in B and V, and ~5 h in R and Hα.

3. Properties of the X-ray detected sources

Source detection and the determination of source fluxes are performed on the merged

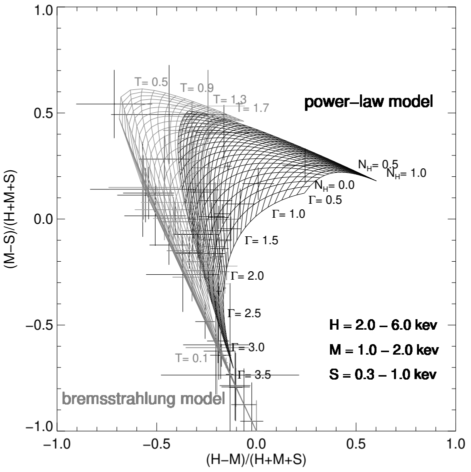

Fig. 3. Color-color diagram of the X-ray sources in the field of NGC 300 and predicted color-color contours for sources with absorbed bremsstrahlung or power law spectra ($N_{\rm H}$ is given in units of 10^{22} cm^2).

event file of all three EPIC cameras of both orbits 192 and 195. The SAS *edetect_chain* task detected 73 point sources with a likelihood threshold >100 in the 0.3–10 keV energy band (44 of them are within the D_{25} optical disk). This threshold is chosen high enough to exclude fictious point sources from the final list. A mask is created using a gradient threshold parameter of 0.28 to avoid the inclusion of the galaxy cluster CL 0053−37, visible near the northeastern edge of NGC 300. The intermediate background map was created with *esplinemap* using a spline fit with 20×20 nodes. Fig. 1 shows the resulting X-ray image for the 0.3–6.0 keV energy band.

To study the source properties, we compute X-ray colors from the background subtracted EPIC data, combining the pn and MOS spectra from both orbits. The colors are defined by

$$\mathrm{HR_{hard}} = \frac{H - M}{T}, \quad \mathrm{HR_{soft}} = \frac{M - S}{T} \qquad (1)$$

where S, M, and H are the total count rate in the 0.3–1.0 keV, 1.0–2.0 keV, and 2.0–6.0 keV band, and where $T = H + M + S$. Error bars are determined from Poisson statistics. Fig. 2 shows the resulting color-color diagram for the 73 sources. In Fig. 3 we compare their colors to those expected from sources with absorbed power law and bremsstrahlung spectra. This figure shows that the spectral shapes of the sources are in good agreement with these models, with a possible population of strongly absorbed sources.

4. Optical counterparts

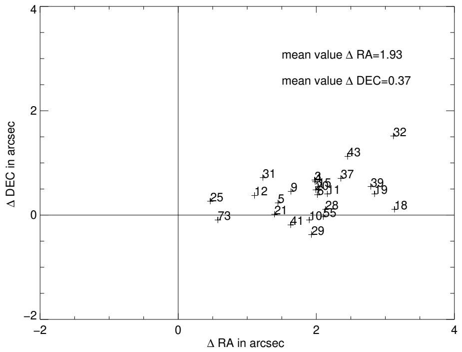

Fig. 4. Shift in right ascension (RA) and declination (DEC), between coordinates of the X-ray sources and possible optical counterparts, expressed in arc seconds.

The second step consists on searching for optical counterparts of the detected X-ray sources. Results shown come from the ESO optical data in the visible band. The comparison of the coordinates of the X-ray sources and possible optical counterparts reveals a systematic shift of 1.93″ in right ascension and of 0.37″ in declination (shown in Fig. 4). After correcting the X-ray position for this offset, the optical and X-ray positions match well (see Fig. 5 for the optical counterparts of the 16 brightest X-ray sources).

5. Conclusions

We have shown some global properties of the detected X-ray sources in NGC 300, for which the data have been taken with *XMM-Newton*.

ht!

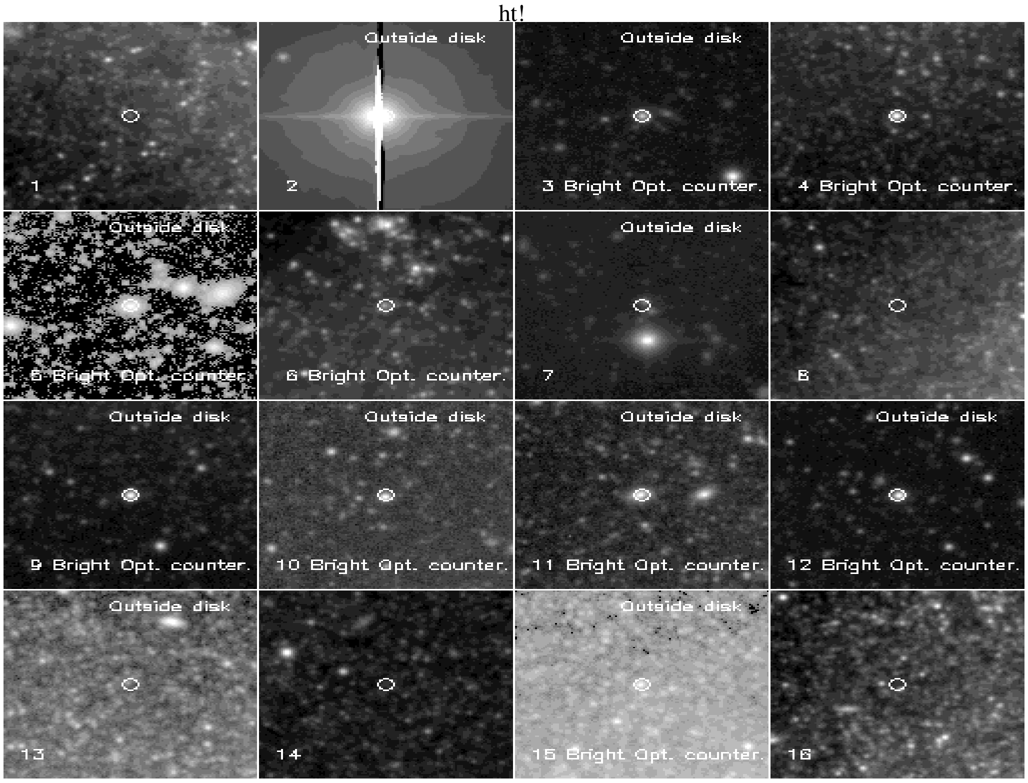

Fig. 5. Optical images of the region centered on the position of the 16 brightest X-ray sources. The $2''$ radius of the overlayed circle is an estimate of the absolute error of X-ray coordinates, counterparts designated "Bright Opt. counter." denote the brightest optical counterparts which were chosen for correcting the X-ray positions.

73 sources were found above a maximum likelihood of 100, from which 44 are in the optical D_{25} disk. The color-color diagram allowed us to determine fluxes of the sources. Comparing the X-ray and optical positions revealed a small positional offset.

In a future work we will attempt to identify as many X-ray sources as possible. This will be done by cross-correlating the available information on the possible optical counterparts using B, V, R and Hα data (kind of object, color, magnitude).

Acknowledgements. We acknowledge partial support from DLR grant 50OX0002. This contribution is based on observations with *XMM-Newton*, an ESA science mission with instruments and contributions directly financed by ESA Member State and the USA (NASA).

References

Carpano, S., Wilms, J., Schirmer, M., et al. 2004, A&A, in prep.

de Vaucouleurs, G., de Vaucouleurs, A., Corwin, H.G., Jr., et al. 1991, Third Catalogue of Bright Galaxies, Springer-Verlag, New-York

Freedman, W.L., Madore, B.F., Hawley, S.L., et al. 1992, ApJ, 396, 80

Read, A.M. & Pietsch, W. 2001, A&A, 373, 473

Schirmer, M., Erben, T., Schneider, P., et al. 2003, A&A, 407, 869