A DEEP XMM–NEWTON SERENDIPITOUS SURVEY OF A MIDDLE–LATITUDE AREA

N. La Palombara[1], G. Novara[1], N. Carangelo[1], A. De Luca[1], P. Caraveo[1], R.P. Mignani[2], and G.F. Bignami[3]

[1]INAF/IASF-Milano, via Bassini 15, I–20133 Milano (I)
[2]European Southern Observatory, Karl Schwarzschild Strasse 2, D–85740 Garching (D)
[3]Centre d'Etude Spatiale des Rayonnements (CESR), CNRS–UPS, 9 Avenue du colonel Roche, F–31028 Toulouse (F)

ABSTRACT

The radio–quiet neutron star 1E1207.4-5209 has been the target of a 260 ks *XMM–Newton* observation. It is the longest observation ever performed at intermediate galactic latitude ($b \simeq 10°$), which is a rather unexplored region of the X–ray sky. Here we report on the performed source detection, which yielded an harvest of about 200 serendipitous sources above a limiting flux of 2×10^{-15} erg cm^{-2} sec^{-1}, in the 0.3-8 keV energy range. Their log$N$–log$S$ distribution is different from those measured either in the Galactic Plane or at high galactic latitudes. An identification is proposed for the brightest sources in our sample and the discovery of a previously unknown Seyfert–2 galaxy is discussed. A complete description of this work is reported in Novara et al. (2005).

Key words: Galaxies: Seyfert – X–rays: general.

1. X–RAY ANALYSIS

During the *XMM–Newton* observation of 1E1207.4-5209 all the three *EPIC* focal plane cameras (Turner et al. 2001; Strüder et al. 2001) were active: the two *MOS* cameras were operated in *Full Frame* mode, in order to cover the whole *field–of–view* of 30 arcmin; the *pn* camera was operated in *Small Window* mode, where only the on–target CCD is read–out. Therefore we used only the *MOS* data to perform the source detection.

In order to maximize the *signal–to–noise* ratio (*S/N*) of our serendipitous sources and to reach lower flux limits, we 'merged' the data of the two cameras. We performed the source detection in both the two coarse energy ranges 0.5–2 and 2–10 keV and eight fine ranges between 0.3 and 8 keV (since above 8 keV the instrument effective area decreases rapidly). The source detection was based on the *maximum detection likelihood* criterium. Selecting all the sources with likelihood $L > 8.5$ in at least one of our energy ranges and matching those detected in several energy intervals we found a total of 196 sources (with a position accuracy of $\sim$ 5"). We detected 135 sources between 0.5 and 2 keV and 89 sources between 2 and 10 keV, at a flux limit of 1.3×10^{-15} and 3.4×10^{-15} erg cm^{-2} s^{-1}, respectively; 68 of them were detected in both energy bands. In order to evaluate their flux, we assumed a template AGN spectrum, i.e. a power–law with photon–index Γ=1.75 and an hydrogen column density N_H of 1.28×10^{21} cm^{-2}, corresponding to the total galactic column density.

In Fig. 1 we show the cumulative log$N$–log$S$ distributions for the sources detected in the two energy ranges. For comparison, we have superimposed to our data the lower and upper limits of the log$N$–log$S$ distributions measured by Baldi et al. (2002) for a survey at high galactic latitude ($|b| > 27°$). Moreover, in the same figure we have also reported the log$N$–log$S$ distributions, as well

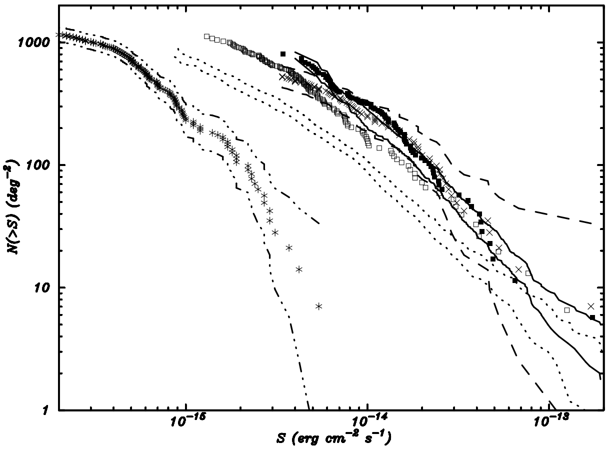

*Figure 1. Log$N$–log$S$ distribution of the detected sources in the energy ranges 0.5–2 keV (*open squares*) and 2–10 keV (*filled squares*). The dotted and the solid lines, respectively, trace the upper and lower limits obtained by Baldi et al. (2002) in the same energy ranges but at higher galactic latitudes. The asterisks and the crosses are the distributions measured by* CHANDRA *in the galactic plane (in the 0.5–2 and 2–10 keV ranges, respectively), while the dot–dashed and the dashed lines represent the corresponding limits (Ebisawa et al. 2005))*

as the 90 % confidence limits, measured by *CHANDRA* in the galactic plane (Ebisawa et al. 2005). In the soft energy band, the log$N$–log$S$ distribution of our sources is well above the high–latitude upper limit, expecially at low X–ray fluxes. Since Ebisawa et al. (2005) find that most of their soft sources detected in the galactic plane (show with the asterisks) are nearby X–ray active stars, it is possible that our excess is due to additional, more distant galactic sources, which are missed looking at $b \sim 0°$ but can be detected just outside the galactic plane. On the other hand, in the hard energy band the distribution of our sources is in good agreement with both the high latitude and the galactic plane ones. Here we expect that the effect of the galactic absorption is negligible, therefore the extragalactic sources dominate the log$N$–log$S$ distribution at all galactic latitudes, with just a small contribution of the *softer* galactic sources.

2. SOURCE IDENTIFICATION

The detected X–ray sources were cross–correlated with the *GSC* ($B_{lim} \simeq 22.5$) and the *USNO* ($V_{lim} \simeq 21$) optical catalogues, assuming a 5" radius error–circle. In such a way, we found at least one optical candidate counterpart for 95 of the 196 sources. The remaining sources lack any optical counterpart since, in view of the length of our X–ray exposure, the expected limiting magnitude of the possible counterparts is $V \simeq 25$. In order to reach this limit and to find all the missing counterparts, a complete optical coverage of the *EPIC* field at the 2.2 m ESO telescope has already been performed and the data analysis is now in progress.

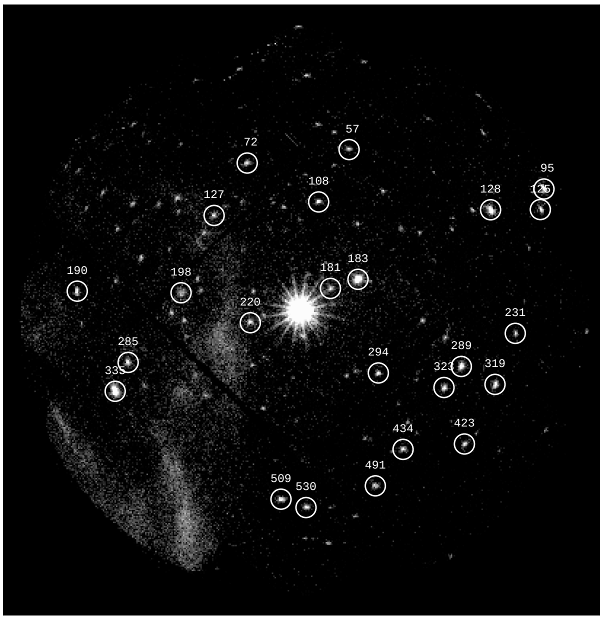

Figure 2. Image of the sky distribution of the 24 brightest sources, in the energy range 0.3–8 keV.

We also performed a spectral analysis of the 24 brightest sources, which have more than 500 counts (Fig. 2). Based on both the best–fit single–component emission model and the X–ray/optical flux ratio, it was possible to propose an AGN identification for 13 sources and a star identification for 7 sources; for the remaining 4 sources it was not possible to suggest any identification. Therefore we find that roughly one third of the brightest sources could belong to the Galaxy. Such a percentage is in agreement with the results obtained by previous surveys, which showed that the stellar content decreases from $\sim$85% to $\sim$30% moving from the galactic plane to high galactic latitudes (Motch et al. 1997; Zickgraf et al. 2003).

Finally, we focused on the analysis of one of the four identified sources (i.e. source #127 in Fig. 2), which shows a very hard and highly absorbed spectrum, with a prominent feature at $\sim$6 keV, ascribable to Fe emission line (Fig. 3). We found that its optical counterpart is the spiral galaxy ESO 217-G29, with magnitudes Bj=16.74 and F=14.93 and optical redshift z=0.032 (Visvanathan & van den Bergh 1992). Assuming a simple power–law spectrum, the estimated X–ray/optical flux ratio is $>$0.02. All these parameters suggested an AGN identification for this source. According to the AGN unification model, we tried to fit its spectrum with a complex emission model composed by primary power–law, a warm and a cold reflection component and a Gaussian component to model the Fe line. We checked that the source spectrum is well described by this model only with a redshift z=0.057, i.e. very different from the optical one. On the other hand, in order to obtain a good spectral fit with z=0.032 it is necessary to replace the Gaussian line with a relativistic one (i.e. a *laor* or a *diskline* component). The unabsorbed flux of the primary nuclear component implies that f_X/f_{opt}=0.41, a value well within the AGN range (Krautter et al. 1999). The X–ray luminosity of the source in the 2–10 keV energy band, corrected by the absorption and with the redshift at 0.032, is $2.59^{+1.84}_{-1.07}\times10^{42}$ erg s^{-1}, corresponding to a low luminosity Seyfert galaxy. Since the hydrogen column density associated to the torus of dust around the AGN nucleus is $\simeq 8\times10^{22}$ cm^{-2}, we propose that this source could be a new, low–luminosity Seyfert–2 galaxy discovered serendipitously in our field.

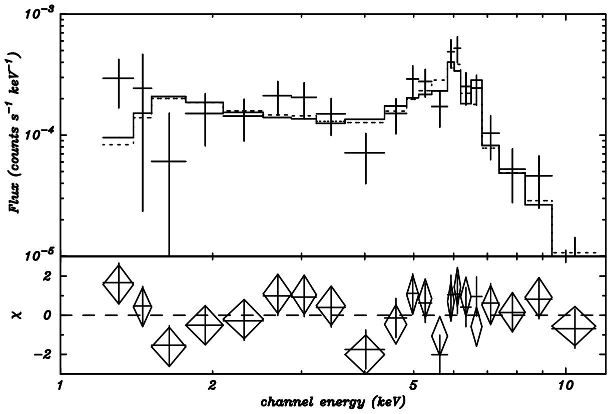

Figure 3. Top*: comparison of the spectrum of source #127 with the best–fit model and z=0.032, in the case of both a* laor *(solid line) and a* diskline *(dashed line) model for the Fe line.* Bottom*: data - model residuals (in σ) for the diskline (crosses) and the laor (diamonds) model.*

ACKNOWLEDGMENTS

We are grateful to K. Ebisawa for providing us the log$N$-log$S$ data of the *Chandra* observation of the galactic plane. The Guide Star Catalog used in this work was produced at the Space Telescope Science Institute under U.S. Government grant. This research has made use of the USNOFS Image and Catalogue Archive operated by the United States Naval Observatory at the Flagstaff Station (http://www.nofs.navy.mil/data/fchpix/).

REFERENCES

Baldi, A., Molendi, S., Comastri, A., et al. 2002, ApJ, 564, 190

Ebisawa, K., Tsujimoto, M., Paizis, A., et al. 2005, ApJ accepted astro-ph/0507185

Krautter, J., Zickgraf, F.-J., Appenzeller, I., et al. 1999, A&A, 350, 743

Motch, C., Guillout, P., Haberl, F., et al. 1997, A&A, 318, 111

Novara, G., La Palombara, N., Carangelo, N., et al. 2005, A&A accepted astro-ph/0510674

Strüder, L., Briel, U., Dennerl, K., et al. 2001, A&A, 365, L18

Turner, M. J. L., Abbey, A., Arnaud, M., et al. 2001, A&A, 365, L27

Visvanathan, N. & van den Bergh, S. 1992, AJ, 103, 1057

Zickgraf, F.-J., Engels, D., Hagen, H.-J., Reimers, D., & Voges, W. 2003, A&A, 406, 535