A&A manuscript no.
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ASTRONOMY
AND
ASTROPHYSICS
26.7.2011

The observability of old neutron stars accreting the interstellar medium

III. The solar proximity

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[the date of receipt and acceptance should be inserted later]

Abstract. Old isolated accreting neutron stars may show up among unidentified soft X–ray sources detected by the ROSAT All Sky Survey. We argue that the chances of identification are greater for ONSs located in the closest overdense regions of the solar neighbourhood. In particular, we consider the neutral hydrogen wall in the second Galactic quadrant ($15^\circ < l < 150^\circ$) which shrinks the estimated contour of the Local Bubble to $\approx 16 - 30$ pc. Due to their vicinity, we expect ~ 10 ONSs to be detectable at a relatively high flux limit (~ 0.1 counts/s) in the 0.2–2.4 keV band. This implies that about 5 % of unidentified sources above this threshold could be ONSs. No optical counterpart is present, but EUV emission from these objects could be detected using EUVE Lex filter at the highest sensitivity limits.

Key words: Stars: neutron–Ultraviolet: stars–X–rays: stars

1. Introduction

The possibility that old, isolated neutron stars (ONSs) accreting the interstellar material (ISM) may be detected as soft X–ray sources was suggested long ago by Ostriker, Rees & Silk (1970). Such observations would be of the greatest importance since they can provide a unique tool for investigating the basic properties of NSs. Although the total number of ONSs in the Galaxy could be as high as 10^9, the detection of these sources appears very difficult for two main reasons: their intrinsic weakness, bolometric luminosity $\lesssim 10^{31}$ erg s^{-1} for typical ISM densities and star velocities, and their emitted radiation, peaked around ≈ 50 eV, which falls in an energy band which is not easily accessible even to spaceborne instrumentation.

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The launch in the early 90's of two satellites especially committed to the study of the extreme ultraviolet and soft X–ray bands, EUVE and ROSAT, renewed the interest in accreting ONSs and led a number of investigators to reconsider the problem of their observability (Treves & Colpi 1991; Blaes & Madau 1993, hereafter TC and BM respectively; Colpi, Campana & Treves 1993; Madau & Blaes 1994) The main result is that, assuming that a relic B–field $\sim 10^9$ G funnels the accretion flow onto polar caps, thousands of ONSs could have been detected by ROSAT All Sky Survey (R–ASS) and one possible ONS candidate in the Cyrrus Cloud has been already identified by Stocke et al. (1995) in the *Einstein* MSS .

All these investigations relied on the assumption that the radiation spectrum is a blackbody. In the case of polar cap accretion $T_{\rm eff}$ is about four times larger than in the isotropic case, if one assumes that the only effect of the magnetic field is to reduce the emitting area. Detailed radiative transfer calculations (Zampieri et al. 1995, hereafter ZTZT) showed, however, that the emerging spectrum may be sensibly harder; in this case the majority of ONSs would emit a substantial fraction of their flux above ~ 0.3 keV and should be detectable also by ROSAT PSPC. Exploiting this result, Zane et al. (1995, paper I in the following) have recently shown that the Galactic population of ONSs can contribute up to 25 % of the unresolved X–ray excess detected by ROSAT in the 0.5–2 keV band.

Clearly the chance of detecting an ONS would be larger by far for sources located in the solar neighbourhood. If we assume an ONSs spatial density of $\sim 3 \times 10^{-4}$ pc^{-3} (BM, paper I), about 140 ONSs are present in a sphere of radius 50 pc centered on the Sun. Unfortunately, the local interstellar medium (LISM) is underdense and relatively hot so the advantage expected from the vicinity of the source is deceptive because its bolometric luminosity is a factor $n_{\rm LISM}/n_{\rm ISM} \sim 0.07$ smaller (see section 3). The LISM, however, is highly inhomogeneous and contains at least one region, the Wall, where the gas density approaches the average ISM density, $n \sim 1$ cm^{-3} (see Paresce 1984; Diamond, Jewell & Ponman 1995).

In this paper we consider the detectability of accreting ONSs in the solar proximity, focussing our attention on the closest overdense regions outside the Local Bubble which surrounds the Sun. We suggest the intriguing possibility that the nearest neutron stars may account for a non–negligible fraction of the relatively bright unidentified R–ASS sources in the Wall direction.

2. The local interstellar medium

Although a relatively high number of ONSs, $\gtrsim 100$, are expected within ~ 50 pc from the Sun, their observability as accretion powered sources is severely hindered by the shortage of fuel. In fact, in the presently accepted picture, the Sun is surrounded by a region, the Local Bubble, where the plasma has both very low density ($n \sim 0.05 - 0.07\,\mathrm{cm}^{-3}$) and high temperature ($T \gtrsim 10^5$ K). In the scenario proposed by McKee & Ostriker (1977), see also Cox & Anderson (1982), Cox (1983), the hot gas would fill $\sim 70 - 80\%$ of the interstellar space and a large number ($\sim 2 \times 10^4$) of cool ($T \sim 80$ K), roughly spherical clouds are expected to be present. Observational data support this model for the region beyond $\sim 50 - 100$ pc from the Sun (Knude 1979), but, as discussed by Paresce (1984), soft X–ray, radio and color excess surveys seem to indicate that no clouds are present at smaller distances and that the denser material is more probably organized into large, elongated, moving fronts within ~ 50 pc. The Sun itself is embedded in a medium, the Local Fluff, which is warm ($T \approx 10^3 - 10^4$ K) and slightly overdense ($n \sim 0.1$ cm^{-3}) with respect to the Local Bubble on scales $\lesssim 20$ pc (Diamond, Jewell & Ponman 1995).

Because both the underdensity and the high temperature in the Local Bubble work against the accretion process, the location of the overdense, warm fronts in the local neighbourhood is of great importance as far as the detection of ONSs is concerned. The present picture indicates that the contour of the Local Bubble in the Galactic plane is highly asymmetric, with four major discontinuities in four different Galactic sectors (Paresce 1984). In particular, a wall of neutral hydrogen is located very close to the Sun in the second quadrant, $15^\circ < l < 120^\circ$. According to Paresce (1984), the wall is roughly parallel to the $l = 330^\circ - 150^\circ$ axis and is located at $d \leq 16$ pc, with an estimated depth of about 35 pc. The N_{HI} contours presented by Frisch & York (1983) are generally farther away, with the denser material ($n \sim 1\,\mathrm{cm}^{-3}$) at ~ 90 pc from the Sun. Welsh et al. (1994) have derived a highly asymmetric contour of the Local Bubble that in the second quadrant is roughly intermediate between those presented by Paresce and Frisch & York. The minimum radius of the local cavity has been estimated to be $\sim 25 - 30$ pc, but, as stressed by the same authors, their indirect method could produce an underestimate of N_{HI} at distances smaller than 50 pc. A very recent analysis of ROSAT EUV data (Diamond, Jewell & Ponman 1995) has shown that n reaches ~ 1 cm^{-3} at $\sim 25 - 30$ pc and this result seems to be in agreement with the asymmetric contour found by Welsh et al. more than with those of Paresce, Frisch & York (see also Pounds et al. 1993). Despite this, the shrink of the local cavity to less than $25 - 30$ pc from the Sun cannot be ruled out on the basis of present observations.

Being very close, the overdense region in the second Galactic quadrant (the Wall) provides one of the most favourable environment for the detection of accreting ONSs. In the following sections we will discuss this issue, using two limiting models for the LISM in the Wall: in model I the overdense region is located between 16 and 50 pc, in model II between 30 and 50 pc; in both cases the angular range is $15^\circ < l < 120^\circ$, $|b| < 30^\circ$. If the total number of ONSs in the Galaxy and their local density are taken to be $N = 10^9$ and $n_0 = 3 \times 10^{-4}\,\mathrm{pc}^{-3}$ respectively (see paper I), we expect 22 (model I) and 18 (model II) objects to be present in the Wall. The observability of such objects depends on their velocity distribution and on the physical parameters of the medium. In order to account for the interstellar absorption, we assume in model I a typical HI density of $n = 0.1\,\mathrm{cm}^{-3}$ in the Local Fluff and $n = 1\,\mathrm{cm}^{-3}$ between 16 and 50 pc (the Wall). In model II we use $n = 0.1\,\mathrm{cm}^{-3}$ within 20 pc, $n = 0.07\,\mathrm{cm}^{-3}$ for $20 < d < 30$ pc and $n = 1\,\mathrm{cm}^{-3}$ for $30 < d < 50$ pc. However, due to the high gas temperature in the Local Bubble, interstellar absorption between 20 and 30 pc can be safely neglected.

Although X–ray surveys toward the Galactic plane detect a very large number of sources, the extreme vicinity of these objects could make them relatively bright and, as a consequence, detectable at larger flux limits.

3. Predicted number of sources

The total bolometric luminosity emitted by an accreting neutron star depends on both the star velocity and the density of the surrounding medium and, for a NS with $M = 1.4 M_\odot$ and $R = 12.4$ km, it is given by

$$L = 6.6 \times 10^{31} \left(\frac{n}{1\,\mathrm{H\,cm^{-3}}}\right) \left(\frac{v}{10\,\mathrm{km\,s^{-1}}}\right)^{-3} \ \mathrm{erg\,s^{-1}}\,. \quad (1)$$

If the star moves subsonically relative to the ambient medium, the previous formula is still valid provided that the local sound speed, c_s, is used in place of the star velocity v.

The choice of the most favourable energy bands for detecting accreting ONSs is crucially related to the spectral properties of the emitted radiation and in particular on the mean photon energy. In the simplest assumption of blackbody emission from the entire star surface, the spectrum is peaked at $\sim 3T_{\rm eff}$, where

$$T_{\rm eff} = 3 \times 10^5 \left(\frac{L}{10^{31} {\rm erg\,s^{-1}}} \right)^{1/4} {\rm K} \qquad (2)$$

is the effective temperature. However, if the star retains a relic magnetic field, the accretion flow can be channeled onto polar caps. As a result of the smaller emitting area, the spectrum is harder (TC) and the effective temperature is now

$$T_{\rm eff} = 1.2 \times 10^6 \left(\frac{L}{10^{31} {\rm erg\,s^{-1}}} \right)^{1/4} \left(\frac{B}{10^9 {\rm G}} \right)^{1/7} \times \left(\frac{v}{10\,{\rm km\,s^{-1}}} \right)^{3/14} \left(\frac{1\,{\rm Hcm^{-3}}}{n} \right)^{1/14} {\rm K}\,; \qquad (3)$$

for typical parameter values $(T_{\rm eff})_{\rm mag} \sim 4(T_{\rm eff})_{\rm unmag}$. Moreover, detailed radiative transfer calculations (ZTZT) which we have already mentioned, have recently shown that the actual spectrum sensibly deviates from a blackbody at $T_{\rm eff}$ and is harder by a factor 2–3 for $L \sim 10^{31}$ erg s^{-1}. This result is independent of the emitting area and is due to the fact that higher frequencies decouple at larger scattering depths in the NS atmosphere, where temperature is higher: the emerging spectrum is a superposition of blackbody spectra at different temperatures, which is broader than a Planckian at $T_{\rm eff}$.

For a typical value of the ISM density in the Local Bubble, $n = 0.07$ cm^{-3}, and assuming $v = 40$ Km s^{-1}, the total luminosity is $\sim 7 \times 10^{28}$ erg s^{-1} and these sources would be within the EUVE and ROSAT WFC bandpasses, regardless of the details about the emitted spectrum. However, even if they are located at a distance of 20 pc, they are too faint to be above the sensitivity threshold of both detectors. In the case of polar cap accretion, a non–negligible fraction of the total luminosity is emitted in the 0.2–0.4 keV energy interval (S bandpass of ROSAT PSPC), producing a count rate ($\sim$ 0.1–0.6 counts/s) well above the sensitivity limit. However, the expected number of these relatively bright nearby sources is so small to be subject to large statistical fluctuations and, in addition, it could be strongly affected by the physical state of the gas in the Local Bubble which is poorly known: if the temperature is as large as 10^6 K, the accretion luminosity drops below $\sim 5 \times 10^{27}$ erg s^{-1} (corresponding to $v \simeq c_{\rm s} \simeq 100$ km/s) and these sources would become too faint.

On the other hand, if we restrict our attention to the region of the Wall ($|b| < 30°$, $15° < l < 120°$), where $n \sim 1\,{\rm cm^{-3}}$, the luminosity is $\sim 10^{30}$ erg s^{-1} and the mean photon energy ranges from 40 eV in the case of accretion on the entire NS surface to 400 eV for polar cap accretion with a magnetic field of 10^9 G. In the following we will concentrate only on the Wall direction: as it will be discussed in detail later on, a number of sources accreting in this locally overdense region turns out to be detectable at least by some of these instruments.

Since the accretion luminosity depends on the star velocity, a statistical approach is required to calculate the expected number of detectable sources above a fixed sensitivity threshold. In paper I, following BM, we derived the present distribution function of ONSs in phase space, following the evolution of the orbits of $\sim 5 \times 10^4$ stars taken as representative of the F population considered by Narayan & Ostriker (1991). These stars account for ~ 55 % of the total and correspond to fast rotating, low velocity objects at birth. Here we are interested in investigating the observability of these objects in the solar proximity, $d \lesssim 50$ pc. As already discussed in paper I, the use of the analytical fit

$$G(v) = \frac{(v/v_0)^m}{1 + (v/v_0)^n} \qquad (4)$$

to the computed cumulative velocity distribution is to be preferred whenever an estimate of the number of ONSs in a limited volume of phase space is needed; in the previous expression $v_0 = 69\,{\rm km\,s^{-1}}$ and $n \simeq m = 3.3$. We assume that the star distribution is spatially homogeneous and use our derived value for the local density, $n_0 = 3 \times 10^{-4}\,{\rm pc^{-3}}$.

The count rate measured at earth, corrected for the absorption of the interstellar gas, is:

$$CR = \frac{1}{4\pi d^2} \int_{\Delta E} \frac{L_\nu}{h\nu} \exp\left(-\sigma_\nu N_H\right) A_\nu d\nu \qquad (5)$$

where A_ν is the detector effective area, L_ν is the monochromatic luminosity at the source, d is the distance, N_H is the column density and σ_ν is the absorption cross section (Morrison & McCammon 1983). The effective areas were taken from Malina et al. (1994, Lex ASS), Edelstein, Foster & Bowyer (1995, Lex DE), Pounds et al. (1993, WFC) and the ROSAT guide for observers (PSPC).

Three different spectral shapes have been considered: *a*) blackbody emission from the entire surface, *b*) blackbody emission from the polar caps and *c*) polar caps emission using in this case the spectra calculated by ZTZT. Once the shape of the emitted spectrum has been fixed, we have calculated the maximum value of v, $v_{\rm max}$, at which a star at the inner boundary of the Wall, d_1, produces a count rate above each chosen threshold. For each value of v, the star distance was varied between d_1 and 50 pc (the assumed outer boundary of the Wall for both models) in order to calculate the maximum distance, $d_2\,(v)$, at which such an object can be detected in the Wall. The star will be observable within a volume $V\,(v)$:

$$V\,(v) = 2 \int_{l_1}^{l_2} dl \int_{\pi/3}^{\pi/2} \sin\theta d\theta \int_{d_1}^{d_2} r^2 dr = \frac{\alpha}{3}\left(d_2^3 - d_1^3\right) \qquad (6)$$

where $d_1 = 16$ pc (model I) and $d_1 = 30$ pc (model II), $l_1 = 15°$, $l_2 = 120°$ and $\alpha = 1.83$ ster $\simeq 6000\,{\rm deg}^2$ is the angular size of the Wall. If $v_{\rm max}$ is larger then the sound speed, the predicted number of sources is found integrating dN/dv in the range $0 < v < v_{\max}$

$$N = n_0 V(c_s) G(c_s) + n_0 \int_{c_s}^{v_{\max}} V(v) \frac{dG}{dv} dv ; \quad (7)$$

the integral was evaluated numerically. In the accreting gas photoionized by the star, $T \simeq 10^4$ K and $c_s \simeq 10$ km/s.

Two distinct surveys, the All–Sky Survey (E–ASS) and the Deep Survey (E–DE) were conducted with the EUVE telescopes. Moreover observations with longer exposure times, the Right Angle Program (RAP, McDonald et al. 1994), allow the detection of sources with count rates down to 0.001 counts/s, so we repeated our calculations using also this limiting threshold. We have considered the two filters centered at higher frequencies, covering the wavelength range 58–364 A. However, in the following we will report only results for the Lex filter since our calculations in the AlC bandpass indicate that no sources are expected to be observable in this band. As for the observability with ROSAT, we focussed on the total band T of PSPC and WFC. The bandpasses and limiting thresholds for these instruments are summarized in table 1.

Table 1. Bandpasses and thresholds for the EUVE and ROSAT instruments

detector	filter	bandpass (keV)	threshold (ct/s)
EUVE ASS	Lex	0.071–0.214	0.01
EUVE DE	Lex	0.069–0.183	0.015
ROSAT WFC	S1	0.09–0.206	0.02
ROSAT WFC	S2	0.062–0.11	0.025
ROSAT PSPC	T	0.2–2.4	0.015

Above a sensitivity limit of 1.5×10^{-2} counts/s the R–ASS detected a very large number of sources toward the Galactic plane. If some ONSs are really present in the solar proximity, we expect that their emission persists at larger flux limits where the number of unidentified sources in the ROSAT survey is lower. For this reason we have repeated our calculations considering three different values for the threshold count rate: 1.5×10^{-2}, 0.1 and 1 counts/s. Results are summarized in table 2 and 3. The optical counterparts of ONSs are very faint (TC, BM), so the relatively high count rate and the lack of optical identification of the X–ray sources will be a distinguishing criterion.

The numbers in the tables suggest that, in the assumption of blackbody emission, accreting ONSs could produce a non–negligible count rate in the UV band. Because the hardening of the spectra computed by ZTZT is comparable to that induced by the presence of a magnetic field, we

Table 2. Expected number of detectable sources for Model I

detector	bandpass	threshold (ct/s)	N^{a}	N^{b}	N^{c}
EUVE ASS	Lex	0.01	2	7	1
EUVE DE	Lex	0.015	3	7	1
EUVE RAP	Lex	0.001	8	19	11
ROSAT WFC	S1	0.02	1	3	0
ROSAT WFC	S2	0.025	1	0	0
ROSAT PSPC	T	0.015	2	21	18
ROSAT PSPC	T	0.1	1	16	10
ROSAT PSPC	T	1.	0	5	2

[a] Blackbody emission from the entire star surface.
[b] Blackbody emission from the polar caps, $B = 10^9$ G.
[c] ZTZT spectra, $B = 10^9$ G.

Table 3. Same as in table 1 for Model II

detector	bandpass	threshold (ct/s)	N^{a}	N^{b}	N^{c}
EUVE ASS	Lex	0.01	3	7	1
EUVE DE	Lex	0.015	4	8	1
EUVE RAP	Lex	0.001	9	17	12
ROSAT WFC	S1	0.02	2	2	0
ROSAT WFC	S2	0.025	2	0	0
ROSAT PSPC	T	0.015	2	17	16
ROSAT PSPC	T	0.1	1	13	8
ROSAT PSPC	T	1.	1	4	1

expect that, accounting for more realistic spectral properties, UV radiation could be detected even in the assumption of emission from the entire NS surface. In this case the number of detectable sources should be similar to the values of N^b in tables 2–3. The highest number of detectable objects corresponds to the intermediate model in which only one source of hardening acts, either the reduced emitting area or the differential free–free absorption effect. Since in this case the spectrum is peaked in the EUV–soft X–ray bands and the LISM does not produce significant absorption at these energies, the count rates turn out to be larger than those produced by the ZTZT spectra emitted from the polar caps, which are too hard to give a comparable contribution in the S band (0.2–0.4 keV) of ROSAT PSPC. However, we think that in a more plausible physical scenario both a non zero magnetic field and the effects of bremsstrahlung opacity should be accounted for. Then, it follows that ONSs are, mainly, soft X–ray emitters (see the last columns in tables 2–3), although the EUV counterpart of very bright sources could be detected by EUVE in the Lex band at the limiting sensitivity thresholds, 0.01 counts/s; at the slightly higher sensitivity limit of 2×10^{-2} counts/s, the predicted number of sources is already zero. In this respect the RAP, improving the EUV sensitivity in pointed mode, seems to be the most profitable way to search for the EUV counterparts of ONSs. A detailed analysis of ROSAT PSPC ASS appears nevertheless the best approach for detecting ONSs in the Wall. In particular, being such sources very close, about 10 objects are expected to be observable with ROSAT PSPC above a sensitivity limit of 0.1 counts/s.

4. Comparison with present observations

In order to compare our predicted number of sources with the actual number of non optically identified sources (NOIDs) observed so far in the direction of the Wall, we have performed a systematic analysis of the ROSAT WFC ASS Bright Source Catalogue (Pounds et al. 1993), the First EUVE Source Catalog (Bowyer et al. 1994), the EUVE Bright Source List (Malina et al. 1994), the EUVE RAP source list (McDonald et al. 1994) and the on–line catalogue of the ROSAT PSPC ASS public pointings (White, Giommi & Angelini 1994, WGA). We note that R–ASS is not available for public consultations.

The WFC Bright Source Catalogue collects the observations of the ROSAT WFC telescope, which carried out the first almost complete survey of the UV sky (96%) in the 60–200 A wavelength band. In addition, the EUVE Bright Source List, the First EUVE Source Catalogue and the EUVE RAP source list contain the positive detections of sources in the E–ASS and E–DE. About 97 % of the sky has been covered in E–ASS, while the deep survey spanned only a small strip along the ecliptic plane. As discussed in the previous section, relatively soft spectra could produce a non–negligible EUV emission and it is therefore interesting to analyze the present available data in this band. Searching in the direction of the Wall, we found 5 sources without any counterpart within a circle of 3 ′above 0.02 counts/s in the EUVE Lex filter and 5 unidentified sources in both the S1 and S2 WFC filters; the EUVE RAP source list contain 4 new unidentified sources. WFC sources are not seen by EUVE. They are probably too soft to be ONSs, because their S2 count rate always exceeds the S1 one, at variance with what is expected for the majority of ONSs. We stress, however, that it cannot be ruled out that some of the faintest unidentified sources in E–ASS could be ONSs, if their emitted spectrum is soft enough. In the case of blackbody emission from the polar caps, we have calculated that 4 sources can be detected in the Lex band above 0.02 counts/s which corresponds to 80 % of EUVE NOIDs. However, the E–ASS is far from being complete at a threshold of 0.02 counts/s (~ 3.5 % of the sky in the Lex band, Bowyer et al. 1994) and the five detected sources are an absolute lower limit for the total number of unidentified objects in the Wall. As a consequence, the number of NOIDs in the Wall is consistent with the expected number of ONSs in the EUV band.

Table 4. WGA sources in the Wall direction as a function of threshold

threshold (ct/s)	sources	source density ($\deg^{-2}$)	expected sources[a]	expected NOIDs[a]
0.015	469	3.25	19500	1500
0.1	132	0.91	5500	170
1.0	48	0.33	2000	30

[a] density × total area of the Wall.

The comparison with soft X–ray ROSAT observations has been performed on the basis of the WGA catalogue, since R–ASS is not available for public use. We found that pointings in the WGA catalogue cover about 7% (414 $\deg^{-2}$) of the Wall, with a total number of ~ 7000 detected sources. The number of objects observed within an offset angle $\leq 20'$ from the image center (where the sensitivity of the detector is maximum) is given in table 4 as a function of threshold.

We note that, quite independently of the assumptions on the emitted spectrum, the total number of NOIDs is substantially larger than our estimated number of observable ONSs in the Wall. In particular, at a threshold of 0.1 counts/s, about 5% of NOIDs could be ONSs, when the emitted spectrum falls mainly within the ROSAT band. Clearly the number of NOIDs decreases with increasing flux limit, so the search for ONSs could conveniently be restricted to sources above a relatively high ROSAT threshold, ~ 0.1 counts/s. Although a slightly larger ONSs/NOIDs ratio is expected at higher flux limits (~ 1 count/s), the search for accreting NSs among such bright sources could be fruitless because the estimated number is so close to unity to be seriously biased by the uncertainties of the model. On the other hand, the choice of a lower sensitivity limit, ~ 0.01 counts/s, does not provide a larger ONSs/NOIDs ratio, suggesting that 0.1 counts/s is indeed the most favourable threshold for identifying nearby accreting ONSs.

5. Conclusions

The search for relatively bright R–ASS sources in the Wall direction could be a promising strategy for selecting ONSs candidates. At present this search is reserved to the groups which have access to the R–ASS. We have shown that old neutron stars may account for a few percent of still unidentified sources above a threshold of 0.1 ct/s. In the case of polar cap accretion with the spectrum calculated by ZTZT, which seems the more realistic assumption, the emitted radiation is hard enough to give no detectable flux in the visual band, $m_V \gtrsim 29$. The absence of an optical counterpart would be, therefore, a primary identification criterion. The R–ASS candidates could be then searched for by E–DE in individual pointings. If these objects have some radio emission, as suggested by Treves, Colpi & Lipunov (1993), another distinguishing feature would be the high proper motion, ~ 0.2 arcsec/yr assuming a velocity of 35 km/s and a distance of 30 pc.

Acknowledgements. We thank Stuart Bowyer for helpful discussions and the referee, Roger Malina, for bringing to our attention some recent EUVE data.

References

Blaes, O., Madau, P. 1993, ApJ, 403, 690 (BM)
Bowyer, S., et al. 1994, ApJS, 93, 569
Colpi, M., Campana, S., Treves, A. 1993, A&A, 278, 161
Cox, D.P., Anderson, P.R. 1982, ApJ, 253, 268
Cox, D.P. 1983, in *Supernova Remnants and Their X–ray Emission*, IAU Symp. 101, eds. Danziger, J. & Gorenstein, P., Reidel, Dordrecht
Diamond, C.J., Jewell, S.J., Ponman, T.J. 1995, MNRAS, 274, 589
Edelstein, J., Foster, R.S., & Bowyer, S. 1995, ApJ, in press
Frisch, P.C., York, D.G. 1983, ApJ, 271, L59
Knude, J.K. 1979, A&A Suppl., 38, 407
Madau, P., Blaes, O. 1994, ApJ, 423, 748
Malina, R.F., et al. 1994, AJ, 107, 751
McKee, C., Ostriker, J.P. 1977, ApJ, 218, 148
McDonald, K., et al. 1994, AJ, 108, 1843
Morrison, R., McCammon, D. 1983, ApJ, 270, 119
Narayan, R., Ostriker, J.P. 1990, ApJ, 270, 119
Ostriker, J.P., Rees, M.J., Silk, J. 1970, Astrophys. Letters, 6, 179
Paresce, F. 1984, AJ, 89, 1022
Pounds, K.A., et al. 1993, MNRAS, 260, 77
Stocke, J.T., et al. 1995, AJ, 109, 1199
Treves, A., Colpi, M. 1991, A&A, 241, 107 (TC)
Treves, A., Colpi, M., Lipunov, V.M. 1993, A&A, 269, 319
Welsh, B.Y., Craig, N., Vedder, P.W., Vallerga, J.V. 1994, ApJ, 437, 638
White, N.E., Giommi, P., Angelini, L. 1994, IAU Circ. 6100
Zampieri, L., Turolla R., Zane S., Treves, A. 1995, ApJ, 439, 849 (ZTZT)
Zane, S., Turolla, R., Zampieri, L., Colpi, M., Treves, A. 1995, ApJ, in press (paper I)

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