ASTRONOMY & ASTROPHYSICS
SUPPLEMENT SERIES

Astron. Astrophys. Suppl. Ser. **136**, 81–94 (1999)

A ROSAT PSPC X-ray survey of the Small Magellanic Cloud*

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Received May 25; accepted December 7, 1998

Abstract. We present the results of a systematic search for point-like and moderately extended soft ($0.1 - 2.4$ keV) X-ray sources in a raster of nine pointings covering a field of 8.95 deg^2 and performed with the *ROSAT PSPC* between October 1991 and October 1993 in the direction of the Small Magellanic Cloud (SMC). We detect 248 objects which we include in the first version of our SMC catalogue of soft X-ray sources. We set up seven source classes defined by selections in the count rate, hardness ratio and source extent. We find five high luminosity super-soft sources (1E $0035.4 - 7230$, 1E $0056.8 - 7146$, RX J$0048.4 - 7332$, RX J$0058.6 - 7146$ and RX J$0103 - 7254$), one low-luminosity super-soft source RX J$0059.6 - 7138$ correlating with the planetary nebula L357, 51 candidate hard X-ray binaries including eight bright hard X-ray binary candidates, 19 supernova remnants (SNRs), 19 candidate foreground stars and 53 candidate background active galactic nuclei (and quasars). We give a likely classification for ∼60% of the catalogued sources. The total count rate of the detected point-like and moderately extended sources in our catalogue is 6.9 ± 0.3 s^{-1}, comparable to the background subtracted total rate from the integrated field of $\sim 6.1 \pm 0.1$ s^{-1}.

Key words: catalogues — Magellanic Clouds — X-rays: stars — X-rays: galaxies — ISM: supernova remnants (SNRs)

1. Introduction

The SMC was the subject of several recent high resolution surveys in different wavelength bands. A CO survey of the SMC was produced by Rubio et al. (1993a,b). Recent Hα surveys were performed by Coarer et al. (1993) and Caplan et al. (1996) (see also Davies et al. 1976). At radio frequencies a neutral Hydrogen survey at 1.4 GHz (Staveley-Smith et al. 1997) and continuum surveys at 1.4 and 2.3 GHz (Filipović et al. in preparation) were made with the Compact Array of the Australia Telescope National Facility. Also, Parkes radio surveys of the SMC were undertaken by Filipović et al. (1997).

Early X-ray surveys were performed with the *Einstein* satellite (Seward & Mitchell 1981; Inoue et al. 1983; Bruhweiler et al. 1987; Wang & Wu 1992). Wang & Wu (1992) found 20 sources from a sample of 70 sources to be intrinsic to the SMC. Filipović et al. (1998) compared the Parkes radio catalogue with the *ROSAT PSPC* catalogue presented in this paper and found 27 sources common to these two surveys.

Our aim in this paper is to present the first-pass catalogue of *ROSAT* X-ray sources in the SMC region with their basic properties and classification. This catalogue is given in Table 1. We classify about 60% of the sources by making use of X-ray spectral parameters and correlations with optical, radio and other X-ray catalogues. Each source class is discussed separately in terms of statistical properties.

2. Observations and data analysis

The observations used in this analysis were carried out with the *PSPC* detector on-board the *ROSAT* observatory during nine pointed observations between 8 October 1991 and 14 October 1993. The satellite, its X-ray telescope (XRT) and the focal plane detector (*PSPC*) used were discussed in detail by Trümper (1983) and Pfeffermann et al.

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* Table 1 is also available in electronic from at the CDS via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5) or via http://cdsweb.u-strasbg.fr/Abstract.html

(1986). The pointings were performed in a raster covering the *Optical Bar* and the *Eastern Wing* of the SMC quite homogeneously (cf. Fig. 1, Fig. 2 and Table 1 in Kahabka & Pietsch 1996, herafter Paper I). A search for unresolved and moderately extended sources has been conducted on the data obtained from these fields (Table 2).

Table 2. Fields used for source search in the SMC Survey

Point. (Pap. I)	Sequence Number	RA (J2000.0)	Dec (J2000.0)	Expos. (ksec)
A1	600195p-0	$0^h58^m12.0^s$	$-72^d16^m48^s$	16.6
A2	600195p-1	$0^h58^m12.0^s$	$-72^d16^m48^s$	9.4
B1	600196p-0	$0^h50^m12.0^s$	$-73^d13^m48^s$	1.3
B2	600196p-1	$0^h50^m12.0^s$	$-73^d13^m48^s$	22.2
C	600197p	$1^h13^m24.0^s$	$-72^d49^m12^s$	21.5
D	600452p	$1^h05^m55.2^s$	$-72^d33^m36^s$	14.2
E	600453p	$0^h54^m28.7^s$	$-72^d45^m36^s$	17.6
F1	600454p-0	$0^h42^m55.2^s$	$-73^d38^m24^s$	9.7
F2	600454p-1	$0^h42^m55.2^s$	$-73^d38^m24^s$	8.3
G1	600455p-0	$1^h01^m16.7^s$	$-71^d49^m12^s$	3.6
G2	600455p-1	$1^h01^m16.7^s$	$-71^d49^m12^s$	1.7
G3	600455p-2	$1^h01^m16.7^s$	$-71^d49^m12^s$	4.6
G4	600455p-3	$1^h01^m16.7^s$	$-71^d49^m12^s$	4.1
X0	400299p-0	$0^h37^m19.2^s$	$-72^d14^m24^s$	5.1
X1	400299p-1	$0^h37^m19.2^s$	$-72^d14^m24^s$	1.7
X2	400299p-2	$0^h37^m19.2^s$	$-72^d14^m24^s$	2.3
Y1	400300p-0	$0^h58^m33.5^s$	$-71^d36^m00^s$	5.2
Y2	400300p-1	$0^h58^m33.5^s$	$-71^d36^m00^s$	7.2
Y3	400300p-2	$0^h58^m33.5^s$	$-71^d36^m00^s$	7.1

A sophisticated detection procedure was applied to the SMC survey. Each pointed observation has been analyzed with three detection methods (local, map and maximum likelihood, cf. Zimmermann et al. 1994). These detection procedures were applied to the data of single pointings given in Table 2. Data with the same pointing direction have been merged to one data set. The analysis was performed in the five energy channel ranges Soft = (channel 11 − 41, 0.1 − 0.4 keV), Hard = (channel 52 − 201, 0.5 − 2.1 keV), Hard1 = (channel 52 − 90, 0.5 − 0.9 keV), Hard2 = (channel 91 − 201, 0.9 − 2.0 keV) and Broad (0.1 − 2.4 keV). The five source lists were merged to one final source list taking only detections at an off-axis angle $\leq 45'$ into account. This list comprises the source catalogue published in this paper. The maximum likelihood algorithm was used to determine the final source position, the counts in five energy bands and the source extent. A one-dimensional energy and position dependent Gaussian distribution (cf. Zimmermann et al. 1994) was applied in order to obtain the source extent. The source extent (Ext) is given as the Gaussian σ_{Gauss}

$$Ext = \sigma_{\mathsf{Gauss}} = FWHM_{\mathsf{Gauss}}/2.35. \quad (1)$$

Hardness ratios $HR1$ and $HR2$ were calculated from the counts in the bands as $HR1 = (H - S)/(H + S)$ and $HR2 = (H2 - H1)/(H1 + H2)$. The existence likelihood ratio and the extent likelihood ratio was calculated according to Cash (1979) and Cruddace et al. (1988).

3. The catalogue

We selected for our final source catalogue only detections with an existence likelihood ratio $LH_{\mathsf{exist}} > 10$, which is equal to a probability of existence $P \sim (1 - \exp(-LH_{\mathsf{exist}})) \sim (1 - 4.5\ 10^{-5})$. We give the value for the extent only in case the extent likelihood ratio is $LH_{\mathsf{extent}} \geq 10$.

A 90% source error radius was calculated, adding quadratically a 5″ systematic error.

$$P_{\mathsf{e}} = 2.1 \times \sqrt{x_{\mathsf{err}}^2 + y_{\mathsf{err}}^2 + (5'')^2}. \quad (2)$$

The positional error derived for large off-axis angles $\Delta \gtrsim 30'$ may be somewhat underestimated due to the asymmetry of the point-spread-function. But the positional error should not be larger than $\sim 1'$.

We catalogued all point-like and moderately extended sources found in this survey in Table 1. A small fraction (∼9%) of catalogued sources may be false (artifacts due to the PSPC detector structure). The source positions were not corrected with respect to the positions of known standard sources (e.g. foreground stars or background active galactic nuclei (AGNs)) because it may easily introduce improper shifts in position. Column 1 gives the source catalogue number and Col. 2 the *ROSAT* source name. In Cols. 3 and 4 we list source positions, the right ascension (RA) and declination (Dec) for the epoch J2000 with the 90% confidence positional uncertainty (Col. 5). Column 6 gives the total count rate (with the 1σ errors). We list the soft ($HR1$) and the hard ($HR2$) hardness ratio (with 1σ errors) in Cols. 7 and 8, while in Col. 9 we present the source extent in cases where the likelihood ratio for extent is greater than 10. In Col. 10 is listed the likelihood ratio of existence (LH_{exist}) and in Col. 11 the off-axis angle (Δ) for the detection with the highest LH_{exist} from different bands. Columns 12 and 13 give the *Einstein* index (from the Wang & Wu 1992, catalogue) and the distance to the *Einstein* source. Columns 14, 15 and 16 list the stellar type, the magnitude of the *Simbad* identified star and the distance to the *Simbad* star. In Col. 17 we list the source class according to our classification scheme (Sect. 5, Table 3). In addition four sources are classified as SNRs although they have a smaller extent likelihood ratio as required from the classification. However, they coincide with SNRs detected with *Einstein*. In Col. 18 we give a refined classification for candidate AGN and hard X-ray binary. In Col. 19 we give some notes on either radio or optical identifications.

For the hard X-ray binary and the AGN class we have refined the classification scheme. We have taken the local Hydrogen column into account and from simulations of power-law slope -2.0 and -2.6 AGN spectra we have predicted hardness ratios which we compared with the measured hardness ratios. In case the classification was not unique we introduced the class AB in Table 1, Col. 18.

In Fig. 1 we show the spatial distribution of all 248 detections in the direction of the SMC overlaid on a merged exposure image. Only the central $45'$ of the field of view are considered for source detection.

4. The survey

The X-ray survey of the SMC covers a field of 8.95 deg^2 considering the used $45'$ field of view of each pointed observation. From the merged (0.1 − 2.4) keV image corrected for exposure we derive a total count rate of 53.2 s^{-1}. The mean exposure of this image is 7 500 s and the maximum 22 000 s. We created a merged background image of the same field and subtracted the background rate image from the count rate image. We find an excess rate of $6.1 \pm 0.1\ \mathrm{s}^{-1}$. In comparison the total source count rate we derive from our catalog of 248 point-like and moderately extended sources is $6.9 \pm 0.3\ \mathrm{s}^{-1}$. Both rates are within the 2σ errors identical and are in agreement with the finding from the *ROSAT* All-Sky Survey (RASS) data that the residual count rate of an extended emission component (a hot gas) is small. Kahabka & Pietsch (1993) find an excess count rate of $\sim 0.7\ \mathrm{s}^{-1}$ for the $8 \times 8\ \mathrm{deg}^2$ RASS field after subtracting a smooth background component and the source contribution. This result may be compared with the finding of Irwin & Sarazin (1998). They found that the integrated X-ray emission and colors of X-ray faint galaxies (group 1 galaxies) to which also M 31 and the SMC are belonging can be explained as the integrated emission from (low-mass) X-ray binaries.

5. Source classes

The X-ray spectral characteristics of the catalogued sources are given as two hardness ratios (the soft hardness ratio - $HR1$ and the hard hardness ratio - $HR2$), the source extent (assuming a Gaussian model) and the count rates in a spectrally soft and hard band. This information is used to characterize a source and to allow a source classification. We previously applied some selections to this catalogue in order to derive the sample of super-soft X-ray sources of the SMC (Kahabka et al. 1994). In Kahabka & Pietsch (1996) we applied another set of selections in order to derive the sample of spectrally hard X-ray binary candidates with luminosities in excess of $3\ 10^{35}$ erg s^{-1}. These subsets comprise only a small number of sources (four supersoft and $7-13$ hard). The majority of sources (209) have not been classified previously.

In a recent paper Filipović et al. (1998) presented results of a comparison between the *ROSAT PSPC* catalogue presented here and the Parkes catalogue of sources towards the SMC at radio frequencies (1.42, 2.45, 4.75, 4.85 and 8.55 GHz). They found 27 sources in common to both surveys (cf. Table 3 in their paper). These include 14 SNRs (with two SNR candidates), eight background sources and three H II regions.

We now define other classes, set up the selection criteria, identify the members, derive the relevant distributions of the source properties and discuss the implications in terms of population studies. The positional distribution of the classified sources using criteria established here (Table 3) is shown in Fig. 2.

5.1. The high luminosity super-soft sources

This class was extensively discussed in Kahabka et al. (1994) and in Paper I. Applying the strict selection criteria outlined in these papers ($HR1 + \delta HR1 < -0.8$ and count rate $> 0.015\ \mathrm{s}^{-1}$) we obtain candidates classified as class = Sl in Table 1. Sources Nos. 20, 62, 133, 135 and 181 were discussed in Paper I. Sources Nos. 6, 112 and 173 coincide with struts of the *PSPC* detector system and are classified as possible detector artifacts.

5.2. The low luminosity super-soft sources

Low luminosity super-soft sources are not yet established as a new class of objects, but they are expected to exist e.g. as hot central stars of planetary nebulae (PNe) which, if they are on the cooling track, can attain luminosities in the range $10^{34} - 10^{36}$ erg s^{-1}. This would translate into *PSPC* count rates for sources in the SMC of $\sim 7\ 10^{-5} - 7\ 10^{-3}\ \mathrm{s}^{-1}$ i.e. below our threshold of 0.015 s^{-1} for high luminosity super-soft sources.

There are three objects which are fulfilling these criteria and they are classified as class = Sw in Table 1. The source No. 38 is found at a large off-axis angle of $43'$ and is extended (Gaussian $\sigma = 214''$). This may indicate either diffuse structure or an artifact. The source No. 141 coincides with a *Simbad* star of 17.5 mag and with the planetary nebula L357 in the catalogue of Meyssonnier & Azzopardi (1993). It is therefore a real candidate. Source No. 243 is found at an off-axis angle of $20'$ and coincides with the inner *PSPC* support structure and may be an artifact. This leaves us with one firm low-luminosity super-soft source No. 141 (RX J0059.6 − 7138).

5.3. The "stronger" hard X-ray binary candidates

The sample of X-ray binary candidates with luminosities in excess of $3\ 10^{35}$ erg s^{-1} has been given in Paper I.

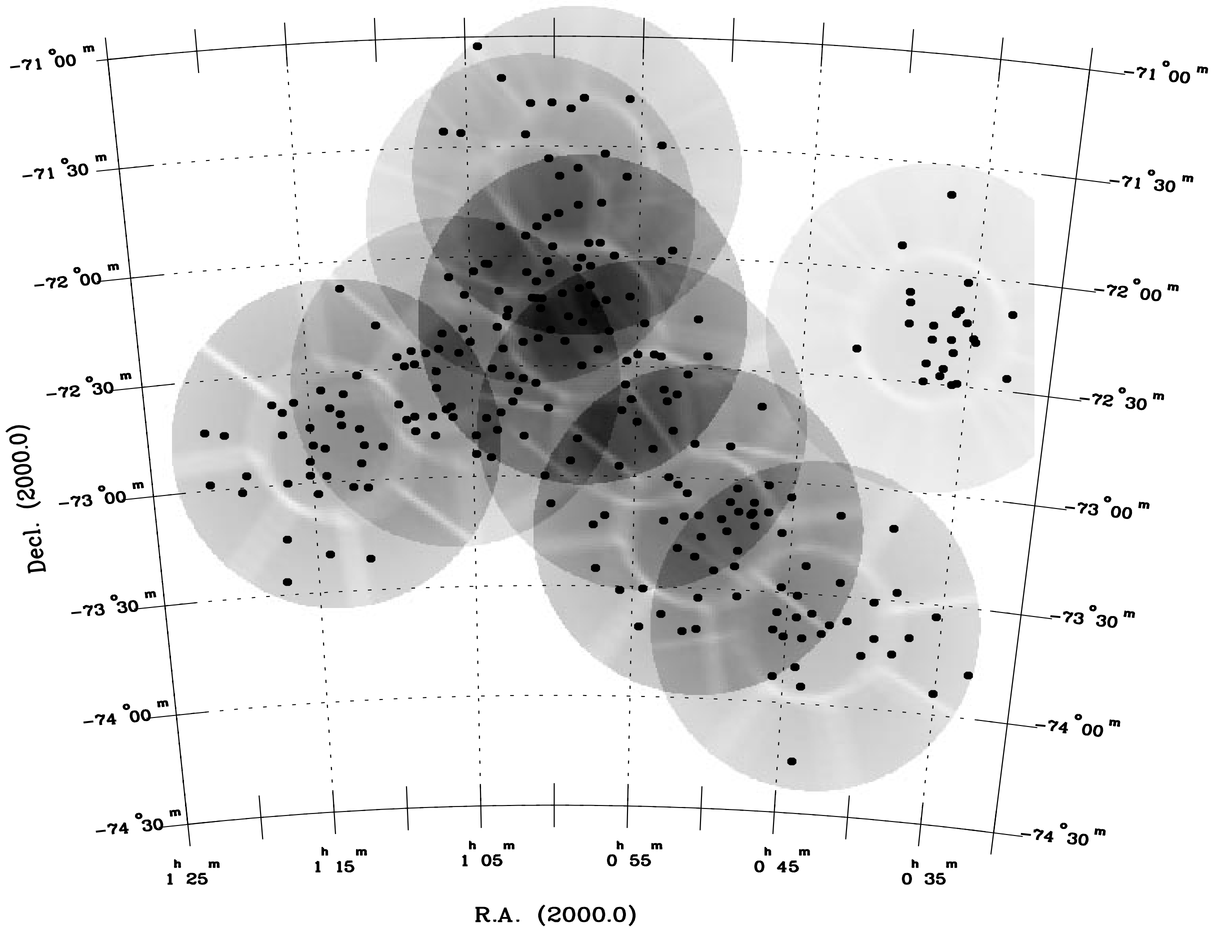

Fig. 1. Distribution of all X-ray detections in the field of the SMC drawn over integrated exposure map

Table 3. Definition of the source classes and the selection criteria

	Source Class	Selection Criteria			
		Count Rate (s^{-1})	$HR1$	$HR2$	Extent Likelihood
Sl	High luminosity super-soft sources	>0.015	$HR1 + \delta HR1 < -0.8$		
Sw	Low luminosity super-soft sources	<0.015	$HR1 + \delta HR1 < -0.8$		
Bl	Stronger hard X-ray binaries	>0.015	$HR1 - \delta HR1 > +0.5$	$HR2 - \delta HR2 > +0.3$	<50
Bw	Weaker hard X-ray binaries	<0.015	$HR1 - \delta HR1 > +0.5$	$HR2 - \delta HR2 > +0.3$	<50
R	SNRs and extended structure		$HR1 - \delta HR1 > -0.8$		>50
F	Foreground stars		$HR1 + \delta HR1 < +0.5$	$HR2 - \delta HR2 > -0.8$	<50
A	Background objects (AGNs)		$HR1 - \delta HR1 > +0.5$	$HR2 + \delta HR2 < +0.3$	<50
D	Possible artifacts				

Remark: additional classes from refined classification: AB = AGN or hard X-ray binary source and H = H II region.

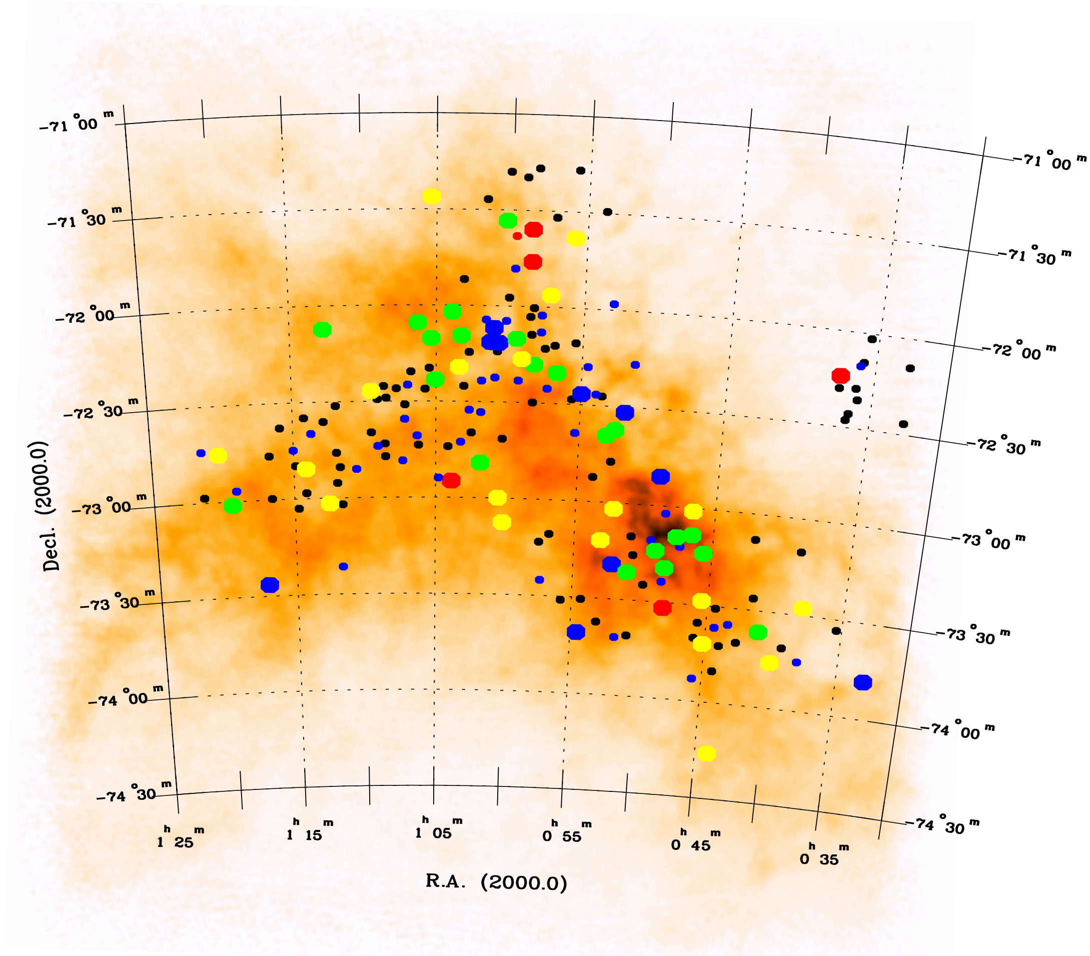

Fig. 2. Distribution of classified X-ray detections (this work) in the field of the SMC plotted over high resolution H I image of the SMC (from Stanimirovic et al. 1999). Selected classes are: super-soft sources (red), hard X-ray binaries (blue), AGNs (black), SNRs (green) and foreground stars (yellow). Big/small circles are drawn for the high/low luminosity subclass respectively. For the AGNs and hard X-ray binaries the refined classification is used (cf. Table 1)

The selection criteria were $HR1 - \delta HR1 > 0.5$, $HR2 - \delta HR2 > 0.3$ with extent likelihood $LH_{\rm extent} < 50$ and count rate > 0.015 s^{-1}. We classify these sources as class = Bl in Table 1.

The sources Nos. 3, 69, 83, 84, 100, 157, 158, 160 and 242 were selected as candidate X-ray binaries. In Paper I sources with Nos. 26, 105 and 153 were rejected mainly due to the absence of time variability. For these sources radio emission was found in the radio survey of Filipović et al. (1998) and they are candidates for AGNs.

The source No. 103 (RX J0054.9 − 7226) is identified with the XTE J0055 − 724 = 1SAX J0054.9 − 7226 source (Marshall et al. 1998; Israel 1998). The detection of pulsations with a period of 59 s with *BeppoSAX* confirm the X-ray binary nature of this source.

Stevens et al. (1998) identified early type emission-line stars through colour indices and Hα emission for the sources with catalogue indices 3, 69, 103, and 158.

The source No. 153 (RX J0100.7−7211) was considered to be consistent with a background AGN shining through the SMC bulge (Paper I). Sources Nos. 157 and 160 were found to coincide with detector struts and were rejected accordingly (Paper I).

5.4. The "weaker" hard X-ray binary candidates

Weak hard X-ray binaries are an interesting class of X-ray objects as they have been predicted to exist and their number is expected to be large especially in galaxies of low metallicity like the SMC. In previous work (Bruhweiler et al. 1987; Wang & Wu 1992) candidates for such sources have been found and either classified as low luminosity Be systems or as background objects.

Here, we are searching for candidates of this class by applying the same selection criteria as for the strong (or higher luminosity) hard X-ray binaries as outlined in Paper I: $HR1 - \delta HR1 > 0.5$, $HR2 - \delta HR2 > 0.3$ and

Table 4. New X-ray pulsars discovered in recent *ASCA*, *BeppoSAX* and *Rossi-XTE* observations of the SMC

Cat. No.	Source name	Pulsation Period [s]	Period [d]	Ref.
98	XTE J0053−724 = 1WGA J0053.8 − 7226	46.64(4)	139?	1-3
79	AX J0051−722	91.12(5)	∼120	1, 4, 5
	XTE J0054−720	169.3 − 168.4	–	1
103	XTE J0055−724 = 1SAX J0054.9−7226	59.072(1)	–	5-7
69	AX J0049−729 = RX J0049.1−7250	74.8(4)	–	8, 9
72	AX J0051-73.3 = RX J0050.7−7316	323.2(4)	*) 0.708	10-13
	AX J0058-72.0	280.4(3)	–	14
	1SAX J0103.2-7209 = AX J0103−722	345.2(1)	– / –	5 / 15
	AX J0105−722	3.34300(3)	–	21
	AX J0049−732	9.1321(4)	–	22
	XTE J0111.2−7317	31.0294(7)	–	23-25
	Previously known SMC X-ray pulsars			
242	SMC X−1	0.7077	3.892	16
	RX J0059.2−7138	2.76	–	17
	RX J0117.6−7330	–	–	18
83	RX J0051.8−7231 = 2E 0050.1−7247	8.9	–	19

Refs. Corbet et al. 1998 (1), Lochner 1998b (2), Buckley et al. 1998a (3), Lochner 1998a (4), Israel et al. 1998 (5), Marshall et al. 1998 (6), Israel 1998 (7), Yokogawa & Koyoma 1998a (8), Kahabka & Pietsch 1998 (9), Yokogawa & Koyoma 1998b (10), Kahabka 1998 (11), Cook 1998 (12), Schmidtke & Cowley 1998 (13), Yokogawa & Koyama 1998b (14), Yokogawa & Koyoma 1998c (15), Wojdowski et al. 1998 (16), Hughes 1994 (17), Clark et al. 1997 (18), Israel et al. 1997 (19), Buckley et al. 1998b (20), Yokogawa & Koyama 1998d (21), Imanishi et al. 1998 (22), Chakrabarty et al. (1998a) (23), Wilson & Finger (1998) (24), Chakrabarty et al. (1998b) (25).
*) MACHO has seen a 0.708 day period. This is consistent with a rotation period of a Be star.

extent likelihood $LH_{\mathsf{extent}} < 50$. The only difference is to select objects with count rates of < 0.015 s^{-1}, i.e. with luminosities below $\sim 3\ 10^{35}$ erg s^{-1} assuming a standard spectral model for the source flux (Paper I). There are 60 such objects and we tentatively classify these sources as class = Bw. This class is a substantial fraction (25%) of the total catalogue entries and turns out to be the class with most members.

We find 15 of these objects which coincide with *Einstein* detections. This may reflect that we are considerably deeper in sensitivity than the *Einstein* survey. Some 17 objects were found to coincide with a *Simbad* source. However, such a correlation could be misleading as most of the distances to the *Simbad* sources are too large ($> 60''$) to be considered reliable. Only three sources have a distance to a *Simbad* source of $< 50''$ and may be considered to be identified. This is a very small fraction of all catalogued sources here.

Four sources are found close to the inner ring of the *PSPC* window support system and may be artifacts. A more thorough investigation of these sources appears to be required as these sources can still be real. Another 46 sources have been found inside the inner support ring of the *PSPC* detector and are considered as firm candidates. This comprises 22% of all reliable entries in the catalogue. Sources found outside the detector ring suffer due to less accurate positions.

"Screening" of the catalog using hardness ratios derived from simulated power-law slope -0.8 spectra for hard X-ray binaries, and power-law slope -2.0, and slope -2.6 spectra for "radio loud" and "radio quiet" AGNs respectively gives 43 firm weak hard X-ray binary candidates. Six previous hard X-ray binary candidates are consistent with AGNs and 11 candidates are consistent with either class (cf. Table 1).

Recent observations towards the SMC with *ASCA*, *BeppoSAX* and *Rossi-XTE* established 10 new X-ray pulsars in this galaxy (Table 4). Most (if not all) of them appear to be connected with a Be-type donor star. Pulsation periods in the range $3 - 345$ s have been determined. This range in pulsation periods is covered by the range of pulsation periods found in the galactic Be-star X-ray binaries of $\sim 4 - 1500$ s (cf. van den Heuvel & Rappaport 1987). An orbital period has been estimated only for the two systems AX J0051 − 722 and XTE J0053 − 724 with 110 − 120 and 139 days. The orbital period deduced for AX J0051 − 722 is in agreement with the relation between pulsation period and orbital period found by Corbet (1986), while the orbital period estimated for XTE J0053 − 724 is twice the predicted period. Five of these new X-ray pulsars may have a counterpart in our SMC X-ray catalogue. Source 98 (RX J0053.9 − 7226) has been discovered with *Rossi-XTE* = *RXTE* (cf. Levine et al. 1996) in an outburst and 46.6 s pulsations have been found (Corbet et al. 1998). This confirms the correct classification of this source. In addition, source 79 (RX J0051.3 − 7216) may be identical with AX J0051 − 722 (Corbet et al. 1998) also confirming the correct classification. Source 89 coincides with the transient source RX J0052.9 − 7158 of Cowley et al. (1997) and AX J0051 − 73.3 (Yokogawa et al. 1998b) coincides with RX J0050.7 − 7316 (cf. Cook 1998; Cowley et al. 1997; Kahabka 1998). This source with catalog index 72 apparently both fits to the AGN and the hard X-ray binary class but it is a strong candidate for a hard X-ray binary.

The derived number of 51 hard X-ray binary candidates may be compared with the number of X-ray binaries predicted from the population synthesis calculations of Dalton & Sarazin (1995) for the SMC. These calculations predict 46 X-ray binaries with luminosities in excess of 10^{34} erg s^{-1}, the lower sensitivity limit of our SMC X-ray survey.

Table 5. Upper panel: Previously detected SNRs identified in the *ROSAT* sample, classified as SNR candidates and extended structure. The *Einstein* No. refers to Wang & Wu (1992). Source radio name is given following Filipović et al. (1998)

Cat. No.	*Einstein* No.	Name of SNR	Radio Source Name
34	-	–	SMC B0039 – 7353
55	15	SNR 0044 – 7325	–
61	16	SNR 0045 – 734	SMC B0045 – 7324
68	22	SNR 0047 – 735	SMC B0047 – 7332
77	24	SNR 0049 – 736	SMC B0049 – 7338
140	44	SNR 0057 – 724	SMC B0057 – 7226
189	52	SNR 0103 – 726	SMC B0103 – 7239
191	53	DEM S128	SMC B0104 – 7226
195	54	SNR 0104 – 723	–
SNRs missed by our selection			
63	21	SNR 0046 – 735	SMC B0046 – 7333
86	30	SNR 0050 – 728	–
90	–		SMC B0051 – 7254
128	42	SNR 0056 – 725	–
148	–	SNR 0058 – 718	SMC B0058 – 7149
177	50	SNR 0101 – 724	SMC B0101 – 7226
182/183	51	SNR 0102 – 723	SMC B0102 – 7218

5.5. Supernova remnants and other extended structures

SNRs have been identified in the SMC by work done in the radio, optical and X-ray regime (Mills et al. 1982, 1984). In the work of Ye & Turtle (1993), some 15 SNRs and SNR candidates are detected in a 843 MHz survey.

We applied the selection criteria likelihood of extent $LH_{\mathsf{extent}} > 50$ and $HR1 - \delta HR1 > -0.8$ in order to derive a candidate sample of SNRs and other extended structures. We find 19 objects fulfilling these criteria (including four SNRs detected by *Einstein*, although they have a LH_{ext} below our classification threshold: sources 86, 128, 177 and 182). These sources are classified as class = R in Table 1. The sources with catalogue number 95, 132, and 136 may be detector artifacts. They have the class = R/D. For 13 sources an *Einstein* identification has been found. We give the *Einstein* number and the identification for these sources in Table 5. 12 of these sources actually are known SNRs. The bright young oxygen-rich SNR 0102 – 723 (Amy & Ball 1993) has two entries (182 and 183) in our catalog due to the merging of two pointed observations at different off-axis-angles. Entry 183 is the more accurate one. An additional classified source (34) correlates with a SNR proposed by Filipović et al. (1998). We find new candidate SNRs in our X-ray survey: RX J0101.8 – 7249 (source 165) and RX J0112.7 – 7207 (223) were not reported before, while RX J019.4 – 7301 (245) was already detected with *Einstein* (BKGS 30, Bruhweiler et al. 1987), however not classified as SNR.

Table 6. Optically identified X-ray selected candidates identified with *Simbad* stars

Cat. No.	Spectral Type	mag	Distance (″)
33	F3V	8.9	3
44	F6IV	8.0	20
109	FV/FVI	11.5	12
138	O7III	14.1	52
246	A9/F0	7.8	26
Star identified in class A			
179	–	16.6	47

We miss a few well known SNRs in the SMC with this selection. They have an extent likelihood ratio >10 and fulfill the criteria of being extended, suggesting we have chosen too strict an extent criterion in order to be on the secure side. It also suggests that there are still unrecognized SNRs in our sample (see discussion in Filipović et al. 1998). We list these SNRs in the lower part of Table 5.

5.6. Foreground stars

It is not trivial to select this sample just from the X-ray characteristics. Stars are coronal emitters with temperatures in the range of a few 10^6 to 10^7 K. The $HR1$ would then fall into the regime $HR1 + \delta HR1 < 0.5$, $HR2 - \delta HR2 > -0.8$ and the likelihood of extent $LH_{\mathsf{extent}} < 50$. Actually, all galactic foreground stars detected in a $8^\circ \times 8^\circ$ field centered on the SMC and observed during the RASS have values of $HR1 < 0.1$ (Kahabka & Pietsch 1993). This means that we may be too conservative in selecting stars in our sample with the criteria mentioned above.

We find 19 candidates and we classify these sources as class = F in Table 1. For seven objects, a *Simbad* match exists. Six of these identifications appear to be reliable as the distance to the *Simbad* source is $< 60''$. Five of them correlate with stars of spectral type O, A or F and they are given in Table 6. Source 138 coincides with an O star. Assuming a conversion factor of 0.76 10^{37} erg cts^{-1} we derive for the O-star in the SMC an X-ray luminosity of 10^{34} erg s^{-1} from the measured count rate. The nature of the other 14 sources remains unclear.

5.7. Background objects and AGNs

Background objects are selected as $HR1 - \delta HR1 > 0.5$, $HR2 + \delta HR2 < 0.3$ and extent likelihood $LH_{\mathsf{extent}} < 50$. The same criterion has already been applied in Paper I in order to identify a possible sample of AGNs in the high luminosity X-ray binary candidate sample. We find 20 sources to fulfil these criteria. Source 148 correlates with a SNR and has to

Table 7. "Tinney" quasars found in pointings X1 and C of the SMC X-ray survey

Cat. No.	*ROSAT* name	Object
9	RX J0035.5 − 7201	QJ0035 − 7201
16	RX J0036.5 − 7225	QJ0036 − 7225
17	RX J0036.6 − 7227	QJ0036 − 7227
20	RX J0037.3 − 7214	QJ0037 − 7218
218	RX J0111.7 − 7250	QJ0111 − 7246
224	RX J0112.8 − 7236	QJ0112 − 7236
238	RX J0116.5 − 7259	QJ0116 − 7259

be removed from this class. Three sources correlate within a radius of $< 60''$ with a *Simbad* star (either foreground or SMC). We refine and extend the classification of candidate AGNs by comparing the measured hardness ratios with the predictions from simulated power-law spectra of slope −2.0 and −2.6. We find 53 candidates for class = A and 62 candidates if we also consider class = AB in Table 1. Class = AB means a hard X-ray binary nature is also possible due to the hardness ratio criteria.

Tinney et al. (1997) present 10 quasars behind the SMC. Seven of them are covered by the fields X1 and C (cf. Table 2) and are listed in Table 7. None of these quasars was detected in the radio survey of Filipović et al. (1998). QJ0102 − 7546, one of the three quasars not covered by our survey was detected in the RASS field (Kahabka & Pietsch 1993).

We independently calculate the number of background sources in the analyzed field by taking the distribution of the neutral hydrogen into account. By making use of the standard $\log(N) - \log(S)$ of the soft extragalactic X-ray background (Hasinger et al. 1993) and by taking into account the absorption due to the SMC (from the H I image of Stanimirovic et al. 1999) the expected number of background sources with absorbed fluxes in excess of 10^{-13} erg cm^{-2} s^{-1} has been determined. We derive a number of 10 background sources for our covered field. As we expect to be complete for this flux limit we consider 10 background sources as the lower limit. The lower end of the flux distribution extends to 10^{-14} erg cm^{-2} s^{-1}. In case of completeness we expect to detect 519 background sources. The fact that we classify 53-62 sources as background sources is consistent with these numbers.

6. Conclusions

We performed an X-ray survey of a 8.95 deg^2 field in the direction of the Small Magellanic Cloud. We detect 248 point-like and moderately extended sources. Using criteria established here, six sources were classified as supersoft sources, 51 as hard X-ray binary candidates, 19 as supernova remnants, 19 as candidate foreground stars and 53 as candidate background AGNs. These are 60% of all catalog entries. The number of hard X-ray binaries agrees with the numbers predicted from population synthesis calculations for luminosities in excess of 10^{34} erg s^{-1}. Assuming the standard $\log(N) - \log(S)$ of the soft extragalactic X-ray background we estimate that in our field are 10 background AGNs with fluxes in excess of 10^{-13} erg cm^{-2} s^{-1} and 519 background AGNs with fluxes in excess of 10^{-14} erg cm^{-2} s^{-1}. We propose three new SNR candidates.

Acknowledgements. This research was supported in part by the Netherlands Organization for Scientific Research (NWO) through Spinoza Grant 08-0 to E.P.J. van den Heuvel. P.K. thanks E.P.J. van den Heuvel for stimulating discussions and X. Li for reading the manuscript. S. Stanimirovic is thanked for providing the H I image of the SMC. Part of the work has been performed during the stay of P.K. at the Max-Planck-Institut für extraterrestrische Physik in Garching. The *ROSAT* project is supported by the Max-Planck-Gesellschaft and the Bundesministerium für Forschung und Technologie (BMFT). This research made use of the Simbad data base operated at CDS, Strasbourg, France. We thank the referee for useful comments and suggestions to improve this work.

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Table 1. *ROSAT PSPC* Point Source Catalogue of the SMC

(1) No.	(2) Source Name RX J	(3) RA (J2000) h m s	(4) Dec (J2000) ° ′ ″	(5) P_e (″)	(6) Count Rate Total (10^{-3} s^{-1})	(7) Hardness Ratio $HR1$	(8) $HR2$	(9) Ext (″)	(10) LH	(11) Δ (′)	(12) Einstein ID	(13) Einstein Dist (″)	(14) Simbad Type	(15) Mag	(16) Dist (″)	(17) Class	(18) Class (refined)	(19) Note
1	0032 6−7226	00 32 37 6	−72 26 32	34	3 86 ± 1 12	0 86 ± 0 51	0 14 ± 0 32		12	25							A	
2	0032 7−7208	00 32 42 3	−72 08 59	17	15 6 ± 2 1	0 79 ± 0 14	0 11 ± 0 14		107	22						A		
3	0032 9−7348	00 32 55 1	−73 48 11	16	118 ± 5	1 0	0 55 ± 0 04	45	909	43				14 1	68	Bl		
4	0034 7−7217	00 34 43 3	−72 17 42	15	2 76 ± 0 72	1 0	0 18 ± 0 26		31	12								
5	0034 8−7216	00 34 51 9	−72 16 44	17	2 17 ± 0 92	0 67 ± 0 51	0 56 ± 0 31		15	11								
6	0035 0−7354	00 35 04 8	−73 54 14	35	21 0 ± 4 80	−1 0	0 00 ± 0 00	170	104	36						Sl/D		
7	0035 3−7212	00 35 20 8	−72 12 34	13	4 87 ± 0 90	0 83 ± 0 20	0 29 ± 0 19		68	9								
8	0035 3−7333	00 35 23 3	−73 33 19	51	3 43 ± 1 03	1 0	−0 08 ± 0 34		10	32						A		
9	0035 5−7201	00 35 31 2	−72 01 34	17	6 32 ± 1 42	0 86 ± 0 25	0 21 ± 0 21		47	15							A	quasar
10	0035 6−7229	00 35 36 4	−72 29 20	32	8 25 ± 1 86	0 98 ± 0 29	0 46 ± 0 18		29	17								
11	0035 8−7209	00 35 51 0	−72 09 13	16	3 42 ± 1 13	0 22 ± 0 36	0 47 ± 0 30		19	8							A	
12	0035 8−7229	00 35 53 7	−72 29 47	25	4 38 ± 1 11	1 0	−0 26 ± 0 25		22	17						A		
13	0036 0−7221	00 36 00 1	−72 21 05	12	6 89 ± 1 22	0 55 ± 0 18	0 23 ± 0 18		83	9							A	
14	0036 0−7210	00 36 02 6	−72 10 24	18	0 95 ± 0 44	1 0	1 0		11	7						Bw		
15	0036 1−7217	00 36 10 8	−72 17 34	14	3 14 ± 1 13	0 31 ± 0 31	0 28 ± 0 28		25	6							A	
16	0036 5−7225	00 36 30 5	−72 25 40	17	2 50 ± 0 87	0 86 ± 0 41	−0 29 ± 0 29		20	12							A	quasar
17	0036 6−7227	00 36 39 8	−72 27 41	17	4 23 ± 1 01	1 0	0 42 ± 0 22		33	14							A	quasar
18	0036 9−7339	00 36 59 9	−73 39 43	46	5 12 ± 1 63	0 28 ± 0 36	−0 31 ± 0 31		12	25								
19	0036 9−7138	00 36 59 9	−71 38 07	31	24 6 ± 2 8	1 0	0 38 ± 0 11		83	36								rad
20	0037 3−7214	00 37 19 5	−72 14 08	10	503 ± 10	−0 97 ± 0 01	−0 95 ± 0 06	3	10410	0						Sl		rad?
21	0037 3−7217	00 37 19 5	−72 17 58	12	6 92 ± 1 35	0 65 ± 0 20	0 04 ± 0 19		81	4							A	quasar
22	0037 5−7224	00 37 33 9	−72 24 36	19	3 19 ± 1 06	0 51 ± 0 37	−0 48 ± 0 29		18	10								
23	0037 6−7229	00 37 38 5	−72 29 34	15	5 32 ± 1 14	1 0	0 13 ± 0 21		45	15								
24	0038 0−7344	00 38 01 6	−73 44 38	26	1 62 ± 0 59	1 0	1 0		14	22						Bw		
25	0038 0−7327	00 38 02 4	−73 27 43	32	4 73 ± 1 41	0 09 ± 0 31	0 27 ± 0 34		23	23						F		
26	0038 6−7310	00 38 36 3	−73 10 22	26	31 7 ± 2 5	1 0	0 39 ± 0 07	6	167	34						Bl	A	rad
27	0038 7−7214	00 38 47 2	−72 14 08	16	2 53 ± 0 96	0 64 ± 0 46	0 57 ± 0 29		20	7						D		
28	0038 8−7208	00 38 48 8	−72 08 21	16	1 81 ± 0 58	1 0	0 21 ± 0 32		18	9								
29	0038 8−7205	00 38 52 8	−72 05 31	13	6 71 ± 1 26	0 78 ± 0 19	0 29 ± 0 17		80	11								
30	0039 2−7340	00 39 15 8	−73 40 50	17	2 42 ± 0 63	1 0	0 57 ± 0 24		25	16						Bw	AB	
31	0039 4−7330	00 39 27 0	−73 30 56	21	1 17 ± 0 51	1 0	−0 37 ± 0 30		17	16						A		
32	0039 5−7153	00 39 35 5	−71 53 03	27	5 14 ± 1 52	0 77 ± 0 37	0 16 ± 0 25		23	24								
33	0040 0−7345	00 40 01 0	−73 45 45	13	15 4 ± 1 54	−0 04 ± 0 10	−0 07 ± 0 13		146	14			F3V	8 9	3	F		star
34	0041 0−7336	00 41 05 7	−73 36 38	16	9 65 ± 1 33	0 89 ± 0 15	−0 14 ± 0 12	30	67	8						R		rad
35	0041 7−7326	00 41 42 3	−73 26 19	17	2 46 ± 0 84	0 97 ± 0 46	0 67 ± 0 23		30	13						Bw	AB	
36	0041 7−7222	00 41 47 5	−72 22 08	35	6 30 ± 1 72	0 91 ± 0 35	0 27 ± 0 22		23	22						Sw/D		
37	0041 9−7308	00 41 58 5	−73 08 01	60	5 85 ± 1 28	1 0	0 59 ± 0 26		15	31						Bw	AB	rad
38	0042 2−7338	00 42 12 1	−73 38 04	111	5 79 ± 14 8	−1 0		214	24	44						Sw/D		
39	0042 6−7340	00 42 41 3	−73 40 37	14	2 59 ± 0 80	0 96 ± 0 41	0 60 ± 0 23		37	2						Bw	AB	
40	0043 3−7335	00 43 23 2	−73 35 17	15	0 93 ± 0 33	1 0	0 88 ± 0 22		18	4						Bw		
41	0043 7−7355	00 43 47 6	−73 55 21	22	2 67 ± 0 84	0 42 ± 0 37	0 30 ± 0 27		19	17								
42	0043 9−7342	00 43 55 9	−73 42 09	14	1 46 ± 0 45	1 0	0 19 ± 0 31		22	6							A	
43	0043 9−7322	00 43 57 7	−73 22 24	18	4 53 ± 1 01	0 67 ± 0 26	0 84 ± 0 14		46	17								
44	0044 0−7415	00 44 02 5	−74 15 53	39	17 3 ± 3 05	0 09 ± 0 18	0 01 ± 0 19		32	38			F6IV	8 0	20	F		star
45	0044 2−7350	00 44 14 9	−73 50 09	21	1 03 ± 0 39	1 00 ± 0 00	0 05 ± 0 38		10	13			F0V	9 2	3		A	
46	0044 3−7336	00 44 21 9	−73 36 34	18	1 20 ± 0 39	1 0	0 81 ± 0 23		16	6						Bw		
47	0044 3−7330	00 44 23 2	−73 30 37	16	2 51 ± 0 73	0 85 ± 0 36	0 43 ± 0 24		34	10			F0V	11 3	47		A	
48	0045 1−7303	00 45 08 5	−73 03 56	24	2 92 ± 0 54	1 0	−0 19 ± 0 19		30	26						A	H	
49	0045 1−7341	00 45 08 6	−73 41 57	18	2 31 ± 0 79	−0 04 ± 0 34	0 78 ± 0 40		11	10						F		rad
50	0045 4−7328	00 45 27 1	−73 28 36	58	33 6 ± 7 3	−0 43 ± 0 19	−0 46 ± 0 75		23	27						F		

Table 1. continued

(1) No.	(2) Source Name RX J	(3) RA (J2000) h m s	(4) Dec (J2000) ° ′ ″	(5) P_e (″)	(6) Count Rate Total (10^{-3} s^{-1})	(7) Hardness Ratio $HR1$	(8) $HR2$	(9) Ext (″)	(10) LH	(11) Δ (′)	(12) Einstein ID	(13) Einstein Dist (″)	(14) Simbad Type	(15) Mag	(16) Dist (″)	(17) Class	(18) Class (refined)	(19) Note
51	0045 6−7313	00 45 37 1	−73 13 49	50	4 19 ± 1 73	0 79 ± 0 58	0 13 ± 0 37		10	27			B2	12 9	11			rad snr?
52	0045 6−7335	00 45 38 2	−73 35 27	17	1 89 ± 0 51	1 0	0 46 ± 0 25		25	12							AB	
53	0045 6−7352	00 45 41 9	−73 52 57	20	3 08 ± 0 74	1 0	0 69 ± 0 22		30	19						Bw		
54	0045 8−7340	00 45 50 6	−73 40 15	15	3 67 ± 0 69	1 0	0 31 ± 0 18		52	12			B5I	12 6	18		A	
55	0046 5−7308	00 46 31 8	−73 08 23	14	10 7 ± 1 00	0 78 ± 0 10	−0 28 ± 0 08	31	196	19	15	35				R		
56	0046 5−7300	00 46 35 3	−73 00 59	25	4 79 ± 1 02	−0 49 ± 0 18	0 39 ± 0 42	47	52	22						F		
57	0047 2−7239	00 47 17 2	−72 39 39	51	2 11 ± 0 71	1 0	1 0		11	33	19	60				Bw		rad
58	0047 3−7312	00 47 21 3	−73 12 18	11	11 6 ± 0 84	1 0	0 49 ± 0 06		481	15	18	46			82	Bw		
59	0047 4−7305	00 47 27 1	−73 05 59	23	2 28 ± 0 45	1 0	−0 18 ± 0 18		19	16	0		M	12 9	70	A		
60	0047 5−7308	00 47 30 8	−73 08 46	18	35 1 ± 2 0	1 0	0 21 ± 0 06		361	38	16	34	B0	12 5	88	A		
61	0047 6−7309	00 47 38 1	−73 09 21	11	22 92 ± 1 21	0 92 ± 0 04	0 21 ± 0 05	20	837	14	16	74	B5I	12 2	83	R		rad
62	0048 2−7331	00 48 16 3	−73 31 44	10	187 ± 3	−0 97 ± 0 01	−0 92 ± 0 12	15	8852	21					73	SI		
63	0048 3−7319	00 48 21 6	−73 19 19	15	3 87 ± 0 52	1 0	0 40 ± 0 13	21	57	12	21	33			14			rad snr
64	0048 4−7308	00 48 24 8	−73 08 39	20	0 78 ± 0 38	0 89 ± 0 73	−0 24 ± 0 32		12	11								
65	0048 5−7323	00 48 30 8	−73 23 35	15	1 54 ± 0 34	1 0	0 84 ± 0 17		38	14						Bw		
66	0048 5−7302	00 48 32 4	−73 02 18	13	5 30 ± 0 59	1 0	0 47 ± 0 10		137	15			A0I	12 8	79	Bw		
67	0048 9−7306	00 48 57 6	−73 06 07	18	1 61 ± 0 35	1 0	−0 21 ± 0 22		22	11					37	A	H	rad
68	0049 0−7314	00 49 05 9	−73 14 06	11	12 5 ± 0 84	1 0	0 11 ± 0 06	15	450	7	22	2		16 3	83	R		rad
69	0049 0−7250	00 49 05 9	−72 50 55	22	45 2 ± 7 0	1 0	0 86 ± 0 10		64	24					75	BI		
70	0049 4−7310	00 49 27 6	−73 10 53	12	2 32 ± 0 48	0 86 ± 0 25	0 86 ± 0 11		85	6			B1	13 7	85	Bw		
71	0049 8−7324	00 49 50 0	−73 24 57	18	1 40 ± 0 45	0 81 ± 0 43	0 68 ± 0 23		22	12					55		AB	
72	0050 6−7315	00 50 41 9	−73 15 56	11	3 35 ± 0 44	1 0	0 57 ± 0 11		132	2						Bw	A	
73	0050 7−7226	00 50 43 1	−72 26 37	53				93	31	35						D		
74	0050 7−7332	00 50 45 9	−73 32 35	28	1 25 ± 0 37	1 0	−0 32 ± 0 29		14	19						A		
75	0050 8−7341	00 50 48 9	−73 41 07	42	4 77 ± 1 45	1 0	0 40 ± 0 31	70	43	33							AB	rad
76	0050 9−7310	00 50 54 3	−73 10 07	11	2 67 ± 0 46	0 99 ± 0 20	0 49 ± 0 13		106	4						Bw	A	
77	0051 0−7321	00 51 03 9	−73 21 24	10	118 ± 2 2	0 79 ± 0 02	−0 26 ± 0 02	28	3973	8	24	17			13	R		rad
78	0051 3−7250	00 51 18 7	−72 50 36	18	1 52 ± 0 51	0 28 ± 0 38	0 94 ± 0 30		17	15			B1	13 6	61			
79	0051 3−7216	00 51 22 3	−72 16 37	30	5 66 ± 0 79	1 0	0 65 ± 0 14		52	31			B2I	13 5	86	Bw		
80	0051 6−7304	00 51 40 6	−73 04 09	18	0 77 ± 0 38	0 91 ± 0 75	1 0		18	10								
81	0051 7−7341	00 51 42 7	−73 41 51	67	1 64 ± 0 68	1 0	1 0		10	28						Bw		
82	0051 8−7310	00 51 49 2	−73 10 30	10	12 3 ± 0 86	0 98 ± 0 04	0 33 ± 0 06		744	6	25	34		15 2	68			
83	0051 8−7231	00 51 53 0	−72 31 44	10	102 ± 2	0 95 ± 0 01	0 47 ± 0 02	10	4489	18	27	14	B2	14 0	81	BI		
84	0052 1−7319	00 52 11 2	−73 19 13	10	18 5 ± 1 0	0 95 ± 0 04	0 61 ± 0 04		1162	8	29	27	O9	12 5	56	BI		
85	0052 2−7301	00 52 16 9	−73 01 54	23	1 67 ± 0 54	0 09 ± 0 34	0 81 ± 0 37		12	14						F		
86	0052 5−7237	00 52 30 0	−72 37 18	16	6 41 ± 0 90	0 90 ± 0 16	−0 49 ± 0 11	26	76	12	30	50	BN	13 6	82	R		rad snr
87	0052 6−7247	00 52 40 8	−72 47 14	16	0 95 ± 0 28	1 0	0 28 ± 0 30		18	8	31	85	B0	14 2	73		A	
88	0052 8−7259	00 52 51 7	−72 59 56	21	2 18 ± 0 67	0 98 ± 0 45	0 02 ± 0 22		22	16						A		
89	0053 0−7158	00 53 02 1	−71 58 05	27	4 54 ± 0 69	1 0	0 80 ± 0 16		55	30	32	44				Bw		
90	0053 0−7239	00 53 05 6	−72 39 14	22	0 96 ± 0 46	0 87 ± 0 71	−0 50 ± 0 31		10	9			B6I	10 8	74			rad snr
91	0053 1−7311	00 53 06 2	−73 11 52	17	0 78 ± 0 37	0 46 ± 0 63	0 76 ± 0 35		11	10			B2	14 0	88		F	
92	0053 1−7337	00 53 06 9	−73 37 21	48	2 50 ± 0 62	1 0 ± 0 0	0 20 ± 0 26		11	26						-	A	
93	0053 3−7236	00 53 18 2	−72 36 05	27	4 44 ± 0 95	0 80 ± 0 27	−0 33 ± 0 17		20	11						A		
94	0053 5−7227	00 53 32 2	−72 27 04	23	2 62 ± 0 67	1 0	0 35 ± 0 26	49	76	19							A	
95	0053 6−7201	00 53 41 9	−72 01 02	49				133	43	34						R/D		
96	0053 8−7129	00 53 48 7	−71 29 26	33	2 68 ± 0 81	1 0	0 22 ± 0 29		14	23							AB	
97	0053 8−7252	00 53 53 2	−72 52 19	17	0 54 ± 0 21	1 0	0 91 ± 0 39		11	7					64	Bw	AB	
98	0053 9−7226	00 53 57 3	−72 26 35	12	11 4 ± 0 78	1 0	0 58 ± 0 06	19	380	22	34	15		14 4	37	Bw/D		
99	0054 3−7330	00 54 19 0	−73 30 31	30	0 91 ± 0 34	1 0	0 29 ± 0 40		11	23							AB	
100	0054 5−7340	00 54 31 7	−73 40 56	14	372 ± 20	0 97 ± 0 02	0 63 ± 0 04	34	907	32					18	BI		

Table 1. continued

(1) No.	(2) Source Name RX J	(3) RA (J2000) h m s	(4) Dec (J2000) ° ′ ″	(5) P_e (″)	(6) Count Rate Total (10^{-3} s^{-1})	(7) Hardness Ratio $HR1$	(8) $HR2$	(9) Ext (″)	(10) LH	(11) Δ (′)	(12) Einstein ID	(13) Dist (″)	(14) Simbad Type	(15) Mag	(16) Dist (″)	(17) Class	(18) Class (refined)	(19) Note
101	0054 5−7218	00 54 35 1	−72 18 07	17	3 41 ± 0 60	0 91 ± 0 22	0 62 ± 0 13		64	17			B0	14 2	82	Bw		
102	0054 9−7245	00 54 54 7	−72 45 02	11	3 12 ± 0 58	0 64 ± 0 22	0 60 ± 0 14		85	2			B1II	14 0	76			
103	0054 9−7226	00 54 57 3	−72 26 39	11	27 3 ± 1 15	1 0	0 55 ± 0 03	16	1304	18	35	13			41	Bl		
104	0055 2−7238	00 55 17 7	−72 38 53	12	3 32 ± 0 58	0 79 ± 0 20	0 77 ± 0 12		97	8						Bw		
105	0055 4−7210	00 55 29 2	−72 10 53	10	24 7 ± 1 04	1 0	0 36 ± 0 04	8	1632	14	36	12				Bl	A	rad
106	0055 6−7228	00 55 36 8	−72 28 26	14	4 36 ± 0 51	1 0	0 33 ± 0 11		88	17							A	
107	0055 6−7234	00 55 39 9	−72 34 55	28	1 12 ± 0 31	1 0	0 49 ± 0 25		12	21						D		
108	0055 6−7116	00 55 41 6	−71 16 58	40	5 24 ± 1 41	1 0	0 18 ± 0 30		14	23							A	
109	0055 7−7138	00 55 47 0	−71 38 11	19	4 22 ± 1 07	−0 42 ± 0 21	−0 20 ± 0 40		20	13			F5/F6	11 5	12	F		star
110	0055 7−7331	00 55 47 7	−73 31 04	17	12 7 ± 1 0	1 0	0 34 ± 0 08		176	28							A	
111	0055 8−7241	00 55 51 7	−72 41 58	13	2 45 ± 0 50	0 63 ± 0 23	−0 01 ± 0 19		53	7								
112	0055 9−7257	00 55 58 1	−72 57 10	70	22 0 ± 6 7	−1 0		91	17	28						Sl/D		
113	0056 4−7159	00 56 26 9	−71 59 47	24					33	19						D		
114	0056 6−7220	00 56 41 7	−72 20 24	12	1 95 ± 0 39	0 86 ± 0 25	0 55 ± 0 15		64	8						Bw		rad snr?
115	0056 8−7310	00 56 49 3	−73 10 41	41	3 19 ± 0 66	1 0	0 37 ± 0 23		15	26							A	
116	0056 9−7211	00 56 54 1	−72 11 57	14	0 73 ± 0 20	1 0	0 59 ± 0 26		19	8						Bw	AB	
117	0057 0−7131	00 57 03 6	−71 31 58	19	1 85 ± 0 67	1 0	0 46 ± 0 37		11	8							AB	
118	0057 2−7145	00 57 14 6	−71 45 23	20	1 48 ± 0 59	1 0	−0 26 ± 0 39		11	11						A		
119	0057 2−7156	00 57 17 8	−71 56 20	52	7 51 ± 1 00	−0 52 ± 0 12	−0 46 ± 0 31		13	21						F		
120	0057 3−7225	00 57 20 5	−72 25 26	11	7 48 ± 0 62	0 83 ± 0 07	0 64 ± 0 06		403	9	39	20				Bw		
121	0057 3−7325	00 57 21 9	−73 25 08	25	7 96 ± 0 95	1 0	0 69 ± 0 11		85	31					86	Bw		
122	0057 5−7313	00 57 32 4	−73 13 15	33	3 54 ± 0 68	1 0	0 53 ± 0 22		26	29						Bw	AB	
123	0057 5−7212	00 57 33 7	−72 12 59	11	4 64 ± 0 45	1 0	0 44 ± 0 09		255	5	40	18	BE	13 4	37	Bw	A	
124	0057 8−7202	00 57 51 0	−72 02 40	13	2 06 ± 0 34	1 0	0 82 ± 0 12		71	14	41	49				Bw		
125	0057 8−7207	00 57 51 7	−72 07 56	11	2 92 ± 0 36	1 0	0 58 ± 0 11		129	9						Bw		
126	0057 9−7156	00 57 58 2	−71 56 26	26	1 98 ± 0 57	0 88 ± 0 40	0 63 ± 0 21		25	20						D		
127	0058 2−7116	00 58 17 4	−71 16 47	27	3 28 ± 0 83	1 0	0 21 ± 0 26		19	19							A	
128	0058 3−7218	00 58 18 0	−72 18 03	12	7 86 ± 0 68	0 90 ± 0 08	0 44 ± 0 08	17	246	1	42	26	F2IA	12 3	70	R		rad snr
129	0058 3−7229	00 58 19 4	−72 29 52	19	0 57 ± 0 20	1 0	0 64 ± 0 32		10	13						Bw	AB	
130	0058 3−7200	00 58 23 6	−72 00 26	30	2 14 ± 0 45	1 0	0 50 ± 0 21		18	16							AB	
131	0058 5−7208	00 58 30 1	−72 08 46	15	0 65 ± 0 19	1 0	0 33 ± 0 30		13	8					28		A	
132	0058 5−7249	00 58 34 0	−72 49 47	70				175	36	42						R/D		
133	0058 5−7146	00 58 35 8	−71 46 01	13	25 5 ± 2 5	−0 99 ± 0 024	−1 0		166	10			B0	13 2	83	Sl		
134	0058 6−7203	00 58 37 0	−72 03 11	20	0 80 ± 0 24	1 0	0 20 ± 0 30		11	14							A	
135	0058 6−7135	00 58 37 1	−71 35 56	10	355 ± 7	−0 99 ± 0 01	−1 0	12	9230	0	43	3		16 6	7	Sl		
136	0058 9−7255	00 58 59 3	−72 55 50	29				120	184	38						R/D		
137	0059 0−7119	00 59 02 4	−71 19 41	24	1 54 ± 0 56	1 0	0 09 ± 0 37		10	16							A	
138	0059 1−7216	00 59 08 7	−72 16 27	18	1 34 ± 0 36	−0 16 ± 0 26	−0 39 ± 0 34		14	4			O7III	14 1	52	F		star
139	0059 3−7223	00 59 21 1	−72 23 12	10	8 07 ± 0 42	0 86 ± 0 07	0 52 ± 0 06		470	8						Bw		
140	0059 5−7210	00 59 31 0	−72 10 09	10	33 4 ± 1 20	0 88 ± 0 03	−0 08 ± 0 04	22	1232	9	44	24	O9		74	R		rad
141	0059 6−7138	00 59 40 8	−71 38 05	23	4 05 ± 1 17	−1 0			12	6				17 4	8	Sw		
142	0059 7−7148	00 59 44 0	−71 48 17	20	1 06 ± 0 45	1 0	1 0		12	13						Bw		
143	0100 0−7157	01 00 05 3	−71 57 21	22	2 41 ± 0 86	1 0	0 58 ± 0 36		11	10			B5I	13 2	54		AB	
144	0100 1−7118	01 00 07 6	−71 18 03	21	2 67 ± 0 72	1 0	0 30 ± 0 26		23	19							A	
145	0100 2−7307	01 00 12 6	−73 07 32	28	12 3 ± 1 59	0 02 ± 0 13	−0 01 ± 0 15		50	33						F		
146	0100 2−7220	01 00 12 8	−72 20 08	14	1 10 ± 0 34	0 94 ± 0 45	0 73 ± 0 20		31	10								
147	0100 2−7204	01 00 15 1	−72 04 40	19	1 40 ± 0 33	1 0	0 77 ± 0 21		24	15						Bw		
148	0100 3−7133	01 00 18 9	−71 33 21	24	7 91 ± 1 20	1 0	−0 33 ± 0 15	29	37	9			O9		25	A		rad snr
149	0100 3−7241	01 00 21 3	−72 41 27	44	2 01 ± 0 58	1 0	0 43 ± 0 32		10	26			O9III	13 5	31		AB	
150	0100 4−7201	01 00 24 3	−72 01 23	30	4 18 ± 0 63	1 0	−0 32 ± 0 14	47	14	18			A0I	12 8	88	A		

Table 1. continued

(1) No.	(2) Source Name RX J	(3) RA (J2000) h m s	(4) Dec (J2000) ° ′ ″	(5) P_e (″)	(6) Count Rate Total (10^{-3} s^{-1})	(7) Hardness Ratio $HR1$	(8) $HR2$	(9) Ext (″)	(10) LH	(11) Δ (′)	(12) Einstein ID	(13) Einstein Dist (″)	(14) Simbad Type	(15) Mag	(16) Dist (″)	(17) Class	(18) Class (refined)	(19) Note
151	0100 4−7149	01 00 26 6	−71 49 28	15	2 64 ± 1 06	0 95 ± 0 51	0 91 ± 0 16		25	4								
152	0100 5−7259	01 00 34 3	−72 59 55	29	13 8 ± 1 79	0 07 ± 0 13	−0 30 ± 0 14		54	30						F		
153	0100 7−7211	01 00 43 4	−72 11 34	10	23 9 ± 1 05	0 97 ± 0 03	0 33 ± 0 04	8	1481	13	45	37	K5		48	A	A	rad
154	0100 8−7214	01 00 48 9	−72 14 15	17	1 00 ± 0 26	1 0	0 56 ± 0 27		16	12			B1I	13 1	16		AB	
155	0100 9−7222	01 00 57 4	−72 22 25	14	1 80 ± 0 33	1 0	0 86 ± 0 14		52	14				13 0	44	Bw		
156	0101 0−7151	01 01 00 6	−71 51 53	47	2 61 ± 1 77	−0 62 ± 0 57	0 88 ± 3 80		11	20								
157	0101 0−7211	01 01 03 2	−72 11 29	24	36 1 ± 3 6	1 0	0 53 ± 0 09	55	107	22	45	67		14 9	25	BI/D		
158	0101 0−7206	01 01 03 5	−72 06 56	10	27 7 ± 1 18	0 91 ± 0 03	0 45 ± 0 04	11	1368	16			O8V	14 6	38	BI		
159	0101 1−7234	01 01 06 6	−72 34 39	24	1 46 ± 0 51	1 0	−0 08 ± 0 44	45	45	22			G5	11 7	69			
160	0101 3−7211	01 01 18 4	−72 11 22	15	29 3 ± 1 7	1 0	0 44 ± 0 06	36	316	31				14 9	78	BI/D		
161	0101 3−7118	01 01 20 4	−71 18 14	59	5 10 ± 2 38	−0 83 ± 0 39	−1 0		12	22				16 9	54	D		
162	0101 6−7204	01 01 37 3	−72 04 23	16	4 75 ± 0 71	0 78 ± 0 17	0 59 ± 0 12		79	20	46	40	B	13 9	83	Bw/D		
163	0101 6−7126	01 01 38 3	−71 26 46	26	1 59 ± 0 84	0 69 ± 0 71	0 36 ± 0 35		10	17							AB	
164	0101 6−7154	01 01 40 4	−71 54 26	15	6 78 ± 1 51	0 64 ± 0 23	0 03 ± 0 22		42	6	79	41	B0	14 3	85			
165	0101 8−7249	01 01 51 3	−72 49 03	29	16 7 ± 1 8	−0 57 ± 0 09	0 12 ± 0 27	88	49	24						R		
166	0101 8−7223	01 01 52 2	−72 23 26	13	7 79 ± 0 77	0 94 ± 0 10	0 73 ± 0 07	17	221	18	47	65			48	Bw		
167	0101 8−7233	01 01 52 9	−72 33 18	41	1 99 ± 0 53	1 0	884 ± 339		14	23			O9	13 8	51	Bw		
168	0102 1−7236	01 02 11 3	−72 36 49	106					12	36						D		
169	0102 5−7239	01 02 31 5	−72 39 40	20	1 70 ± 0 40	1 0	0 20 ± 0 24		23	16			B0 5V	14 7	52		A	
170	0102 6−7232	01 02 41 5	−72 32 36	12	8 66 ± 0 98	0 72 ± 0 11	0 62 ± 0 09		178	15			K0		86	Bw		
171	0102 7−7214	01 02 44 8	−72 14 34	29	0 79 ± 0 59	1 0	0 96 ± 1 23		37	24							AB	
172	0102 8−7216	01 02 50 0	−72 16 24	36	1 88 ± 0 55	1 0	0 56 ± 0 39		20	21			B2I	12 3	76	D		
173	0102 9−7111	01 02 58 6	−71 11 17	73	17 3 ± 4 9	−1 0		127	20	32						SI/D		
174	0103 0−7225	01 03 05 0	−72 25 11	21	1 58 ± 0 43	1 0	0 62 ± 0 27		17	15			B	13 7	53	Bw	AB	
175	0103 1−7151	01 03 08 5	−71 51 50	16	2 67 ± 1 36	0 82 ± 0 54	0 22 ± 0 33		18	9							A	
176	0103 2−7242	01 03 15 7	−72 42 37	16	4 48 ± 0 82	0 74 ± 0 22	0 45 ± 0 15		59	15						Bw		
177	0103 2−7209	01 03 16 8	−72 09 26	18	9 05 ± 0 88	1 0	0 35 ± 0 10	30	107	24	50	32				R		rad snr
178	0103 4−7219	01 03 24 8	−72 19 16	39	1 41 ± 0 80	−0 20 ± 0 53	−1 0		10	18				16 1	88	F		
179	0103 4−7247	01 03 29 2	−72 47 23	12	9 59 ± 1 07	0 97 ± 0 11	0 02 ± 0 10		204	18				16 6	47	A		
180	0103 7−7230	01 03 44 7	−72 30 34	15	1 50 ± 0 50	0 48 ± 0 42	0 66 ± 0 24		21	10			B0	14 8	87			
181	0103 8−7254	01 03 53 3	−72 54 49	15	21 8 ± 1 5	−1 0			227	23	72	13				SI		
182	0103 9−7202	01 03 54 7	−72 02 01	11	1352 ± 16	0 93 ± 0 01	−0 11 ± 0 01	25	11073	36	51	23	B1I	12 5	58	R		rad snr
183	0104 0−7201	01 04 04 2	−72 01 56	10	1885 ± 13	0 93 ± 0 01	−0 10 ± 0 01	9	19778	18	51	21	B1I	12 5	79			
184	0104 1−7244	01 04 08 8	−72 44 04	23	2 69 ± 0 52	1 0	0 57 ± 0 18		25	13						Bw	AB	
185	0104 2−7102	01 04 17 9	−71 02 33	95				194	32	43								
186	0104 7−7203	01 04 46 6	−72 03 57	32	5 32 ± 1 69	1 0	−0 42 ± 0 53		31	22			F5I	11 0	89	A		
187	0104 7−7248	01 04 47 7	−72 48 45	18	1 33 ± 0 57	0 78 ± 0 59	1 0		21	16			B0	14 0	79			
188	0104 7−7253	01 04 47 8	−72 53 53	30	1 36 ± 0 41	1 0	0 71 ± 0 25		13	21						Bw/D		
189	0105 0−7223	01 05 03 4	−72 23 14	11	240 ± 4	0 66 ± 0 01	−0 32 ± 0 01	44	6430	32	52	52	B1	13 4	83	R		rad
190	0105 3−7126	01 05 20 1	−71 26 08	88	54 5 ± 5 4	−0 53 ± 0 08	0 10 ± 0 20		14	30						F		
191	0105 3−7210	01 05 20 4	−72 10 21	21	18 8 ± 1 6	1 0	0 07 ± 0 09	57	99	23	53	58				R		rad
192	0105 4−7219	01 05 28 4	−72 19 36	20	0 89 ± 0 30	0 99 ± 0 82	0 07 ± 0 34		11	14							A	
193	0105 7−7226	01 05 45 1	−72 26 09	24	1 22 ± 0 35	1 0	0 12 ± 0 29		12	7							A	
194	0106 2−7243	01 06 12 3	−72 43 38	17	0 83 ± 0 26	1 0	0 34 ± 0 32		14	10			BW	14 6	56		A	
195	0106 2−7205	01 06 15 1	−72 05 25	15	24 6 ± 1 5	1 0	0 24 ± 0 06	42	348	28	54	49			20	R		
196	0106 3−7240	01 06 18 0	−72 40 46	18	0 47 ± 0 21	1 0	1 0		12	7						Bw		
197	0106 3−7125	01 06 19 8	−71 25 40	59					27	34						D		
198	0106 6−7241	01 06 36 0	−72 41 30	18	0 76 ± 0 25	1 0	−0 35 ± 0 31		13	9						A		
199	0106 7−7220	01 06 43 9	−72 20 45	18	0 78 ± 0 27	1 0	0 68 ± 0 38		12	13						Bw	A	
200	0106 9−7224	01 06 57 7	−72 24 55	11	9 72 ± 0 87	0 87 ± 0 08	0 45 ± 0 08		426	10	55	51				Bw		

Table 1. continued

(1) No.	(2) Source Name RX J	(3) RA (J2000) h m s	(4) Dec (J2000) ° ′ ″	(5) P_e (″)	(6) Count Rate Total (10^{-3} s^{-1})	(7) Hardness Ratio $HR1$	(8) $HR2$	(9) Ext (″)	(10) LH	(11) Δ (′)	(12) Einstein ID	(13) Dist (″)	(14) Simbad Type	(15) Mag	(16) Dist (″)	(17) Class	(18) Class (refined)	(19) Note
201	0107 1−7231	01 07 09 1	−72 31 03	12	2 98 ± 0 49	1 0	0 27 ± 0 17		82	6				16 0	62		A	
202	0107 1−7235	01 07 09 9	−72 35 35	15	0 73 ± 0 26	1 0	1 0		18	6	56	16				Bw		
203	0107 3−7248	01 07 18 5	−72 48 32	23	0 80 ± 0 31	1 0	1 0		12	16						Bw		
204	0107 4−7243	01 07 27 4	−72 43 21	11	6 22 ± 0 82	0 85 ± 0 14	0 39 ± 0 11		187	12	82	31						
205	0107 7−7226	01 07 44 7	−72 26 01	15	1 17 ± 0 31	1 0	0 32 ± 0 26		22	11			B0	13 8	41		A	
206	0108 4−7228	01 08 27 2	−72 28 56	17	1 36 ± 0 52	0 95 ± 0 59	0 13 ± 0 26		22	12	59	61					A	
207	0108 5−7247	01 08 31 1	−72 47 12	35	0 27 ± 0 32	1 0	0 11 ± 1 22		12	18							AB	
208	0108 5−7243	01 08 33 0	−72 43 13	21	1 21 ± 0 37	1 0	0 39 ± 0 30		14	15							A	
209	0108 6−7225	01 08 37 7	−72 25 17	15	5 41 ± 0 84	0 84 ± 0 19	0 47 ± 0 12		89	15	58	14				Bw	A	
210	0109 0−7243	01 09 02 9	−72 43 59	30	0 50 ± 0 38	1 0	1 0	36	13	17						Bw		
211	0109 0−7229	01 09 04 1	−72 29 22	17	2 94 ± 0 69	0 80 ± 0 31	0 33 ± 0 17		42	15							A	
212	0109 4−7239	01 09 29 9	−72 39 42	22	1 18 ± 0 34	1 0	0 24 ± 0 28		15	17							A	
213	0109 5−7226	01 09 30 1	−72 26 47	27	1 87 ± 0 59	−0 30 ± 0 27	−0 06 ± 0 44		10	18						F		
214	0110 5−7251	01 10 33 9	−72 51 03	20	0 53 ± 0 20	1 0	0 93 ± 0 38		12	13						Bw		
215	0110 6−7217	01 10 41 8	−72 17 53	40	2 10 ± 0 87	0 80 ± 0 60	−0 16 ± 0 28		12	27								
216	0111 5−7302	01 11 35 5	−73 02 01	15	3 03 ± 0 64	0 69 ± 0 28	0 32 ± 0 16		53	15							A	rad
217	0111 6−7321	01 11 39 5	−73 21 27	47	1 79 ± 0 62	1 0	1 0		14	33						Bw		
218	0111 7−7250	01 11 43 1	−72 50 25	11	5 59 ± 0 63	0 87 ± 0 12	0 53 ± 0 08		278	8						Bw	A	quasar
219	0111 9−7255	01 11 56 1	−72 55 20	17	0 75 ± 0 43	0 57 ± 0 82	0 51 ± 0 39		13	9							AB	
220	0111 9−7245	01 11 58 0	−72 45 55	15	1 08 ± 0 43	0 47 ± 0 51	0 54 ± 0 27		21	7							A	
221	0111 9−7231	01 11 58 3	−72 31 19	23	1 52 ± 0 36	1 0	0 51 ± 0 25		20	19	83	17					AB	
222	0112 5−7301	01 12 30 3	−73 01 40	15	3 10 ± 0 33	0 11 ± 0 20	−0 34 ± 0 18		43	13						F		
223	0112 7−7207	01 12 43 6	−72 07 25	29	2 11 ± 1 96	1 0	1 0	205	265	41						R		
224	0112 8−7236	01 12 51 2	−72 36 12	14	2 58 ± 0 39	0 92 ± 0 31	0 25 ± 0 16		61	13							A	quasar
225	0113 0−7244	01 13 03 4	−72 44 41	15	1 38 ± 0 42	0 40 ± 0 55	0 15 ± 0 30		17	5								
226	0113 1−7241	01 13 06 2	−72 41 36	13	1 40 ± 0 28	1 0	−0 03 ± 0 20		44	8						A		
227	0113 7−7239	01 13 43 6	−72 39 50	15	0 74 ± 0 21	1 0	0 90 ± 0 20		25	9						Bw		
228	0114 1−7250	01 14 08 2	−72 50 47	14	1 43 ± 0 45	0 09 ± 0 33	0 48 ± 0 26		23	4						F		
229	0114 1−7258	01 14 08 4	−72 58 15	16	0 63 ± 0 20	1 0	0 25 ± 0 33		14	10							A	
230	0114 2−7234	01 14 12 5	−72 34 51	23	1 00 ± 0 28	1 0	0 34 ± 0 29		13	15							AB	
231	0114 2−7319	01 14 12 5	−73 19 43	34	2 96 ± 0 64	1 0	0 71 ± 0 23		27	31	85	29				Bw	H	rad
232	0114 7−7303	01 14 43 3	−73 03 02	22	1 49 ± 0 35	1 0	0 61 ± 0 24		24	15						Bw	AB	
233	0114 8−7249	01 14 51 9	−72 49 44	18	0 0 ± 0 41	0 83 ± 1 12	0 67 ± 0 31		14	7							AB	
234	0115 0−7244	01 15 00 1	−72 44 52	13	0 14 ± 0 28	1 0	0 71 ± 0 17		55	8						Bw		
235	0115 1−7254	01 15 06 6	−72 54 08	15	0 73 ± 0 21	1 0	−0 25 ± 0 28		17	9						A		
236	0115 1−7257	01 15 09 6	−72 57 55	14	1 98 ± 0 50	0 38 ± 0 31	0 57 ± 0 20		39	12								
237	0115 9−7237	01 15 54 3	−72 37 46	20	0 83 ± 0 26	1 0	0 32 ± 0 31		11	16							AB	
238	0116 5−7259	01 16 35 9	−72 59 41	17	4 98 ± 0 59	1 0	0 43 ± 0 11	24	86	18	62	27				Bw	A	quasar
239	0116 6−7240	01 16 38 0	−72 40 18	15	0 39 ± 0 53	0 80 ± 0 36	0 64 ± 0 17		48	17				14 5	18			
240	0116 7−7246	01 16 42 6	−72 46 24	15	1 66 ± 0 51	0 57 ± 0 40	0 61 ± 0 23		31	15							A	
241	0116 8−7314	01 16 52 0	−73 14 55	48	2 27 ± 0 58	1 0	0 16 ± 0 28		12	30						D		
242	0117 0−7326	01 17 03 3	−73 26 28	11	271 ± 3	1 0	0 31 ± 0 01	32	8494	41	63	20				Bl		
243	0117 2−7238	01 17 14 7	−72 38 02	30	0 51 ± 0 47	−1 0			12	20						Sw/D		
244	0119 1−7256	01 19 06 7	−72 56 49	24	3 96 ± 0 62	1 0	0 74 ± 0 17		51	26						Bw		
245	0119 4−7301	01 19 26 7	−73 01 19	19	25 4 ± 1 4	1 0	0 62 ± 0 06	62	324	29	66	11				R		
246	0120 2−7245	01 20 17 0	−72 45 20	37	5 81 ± 1 16	−0 15 ± 0 19	0 06 ± 0 26		14	31			A9/F0	7 8	26	F		star
247	0121 4−7258	01 21 24 8	−72 58 28	31	7 49 ± 0 96	1 0	0 28 ± 0 14		54	37			B0	14 4	89		A	
248	0121 4−7244	01 21 28 2	−72 44 13	37	5 14 ± 0 88	1 0	0 71 ± 0 20		33	36						Bw		