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X-RAY SURVEY OF THE SMALL MAGELLANIC CLOUD

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ABSTRACT

A region of over 40 square degrees centered on the Small Magellanic Cloud (SMC) has been surveyed with the imaging instruments of the *Einstein* Observatory. The survey is approximately complete to $L_x = 10^{36}$ ergs s^{-1}, and the faintest source detected, if in the SMC, has $L_x \approx 3 \times 10^{35}$ ergs s^{-1}. Twenty-six sources were clearly seen. Five are identified with objects not associated with the SMC. The only previously known source detected was SMC X-1 which, when in a high state, is the brightest source in the SMC. The second brightest source observed, a previously unknown supernova remnant (SNR), is located in the central part of the SMC. Four other weaker sources are probably also SNRs in the SMC. The remaining 15 sources are not yet identified and, since some are far from the center of the cloud, are probably not all members of the SMC.

Subject headings: galaxies: Magellanic Clouds — X-rays: sources

I. INTRODUCTION

X-ray sources in the Magellanic Clouds are of great astrophysical interest. The Small and Large Clouds are the nearest extragalactic star systems, and individual X-ray sources with rather low luminosities can be detected and compared with a large sample of Milky Way X-ray sources. Because the distance is known, the absolute X-ray luminosity is easily determined, whereas the distance is highly uncertain to most sources in our own Galaxy. Attempts have been made (Seward *et al.* 1972; Margon and Ostriker 1973) to classify X-ray sources on the basis of their luminosities, and indeed, SMC X-1 and the strong sources in the LMC were shown to have approximately the same X-ray luminosities as the galactic bulge sources. If a sufficient number of objects are detected in the Magellanic Clouds, such a classification can be attempted for the weaker sources.

Since stellar populations, metal abundances, and relative mass of stars and gas vary in the Large Magellanic Cloud (LMC), Small Magellanic Cloud (SMC), and our own Galaxy, study of X-ray sources will reveal important differences in the three populations, as well as information about the nature of galactic sources in general. Clark *et al.* (1978) have already shown that the strongest X-ray sources in the Magellanic Clouds are likely to be more luminous than those in the Milky Way.

X-rays from the Small Magellanic Cloud were first observed with a rocket-borne detector in 1970 September (Price *et al.* 1971). Results from the *Uhuru* satellite soon showed that these X-rays were from one luminous source, SMC X-1 (Leong *et al.* 1971). Two additional transient sources, SMC X-2 and SMC X-3, were discovered by Clark *et al.* (1978), and subsequent observations showed that the outbursts from these two sources lasted only on the order of months (Clark, Li, and van Paradijs 1979). These three sources all have maximum X-ray luminosities of $\gtrsim 10^{38}$ ergs s^{-1}, placing them in the same luminosity class as the bright bulge sources in our own Galaxy. The 4U catalog lists another weaker source, 4U 0026−73 (Forman *et al.* 1978), and X-ray emission from the globular cluster NGC 104 has recently been reported (Grindlay 1980). NGC 104 is, of course, in the SMC field but not in the SMC.

The imaging instruments of the *Einstein* Observatory make possible a search for much fainter sources using short observing times. This paper gives results of a survey consisting of 40 fields, each with exposure ~ 1000–2000 s, and capable of detecting X-ray sources in the SMC with luminosities greater than ~ 10^{36} ergs s^{-1}.

There is an *important* difference between the *Einstein* survey and previous observations. The *Einstein* telescope is a soft X-ray detector. Maximum sensitivity is at 2 keV and below. The efficiency of the telescope falls rapidly above 3 keV and is effectively zero above 5 keV. Previous observations of the strong SMC sources utilized detectors sensitive to X-rays from 2–10 keV.

Soft X-ray emission from the SMC and vicinity has been of great interest in the study of the diffuse, soft X-ray background. Several attempts have been made to search for soft X-ray absorption in the neutral hydrogen of the SMC with the purpose of measuring the extragalactic contribution to this background (McCammon *et al.* 1971; Bunner, Sanders, and Nousek 1979). The detectors used did not have sufficient spatial resolution to see faint point sources, and no decrease in soft X-ray flux was observed. Any possible absorption by the SMC of soft X-rays from extragalactic sources is apparently balanced by soft X-ray emission from the cloud itself (McCammon *et al.* 1976). Our survey, which was sensitive to point sources, did not measure the diffuse background. It is possible, however, to sum the flux from the faint point sources discovered and to compare this sum with that required to explain the Wisconsin results.

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II. THE SMALL MAGELLANIC CLOUD

The distance to the SMC given in the literature varies from ~ 60 to ~ 70 kpc. We will use 70 kpc as given by Sandage and Tammann (1974). The SMC morphology has been determined by several techniques: the distribution of 10^4 stars brighter than $M_{pg} = 16$ was measured by de Vaucouleurs (1955) and the distribution of supergiants by Azzopardi and Vigneau (1977). The spatial extent and motion of neutral hydrogen has been mapped by Hindman (1967), and the general outline follows the distribution of stars, although maximum concentrations of N_H do not coincide with regions of maximum star density. The main body of the cloud is at $\sim 01^h00^m$, $-72°30'$. A wing extends southwest to $\sim 00^h30^m$, $-74°00'$, and a wing southeast to $\sim 01^h20^m$, $-73°30'$.

The neutral hydrogen velocity measurements show that the SMC is rotating in a plane oriented approximately edge-on to the observer. The rotation curve yields a total mass of $1.5 \times 10^9\ M_\odot$, and the mass of neutral hydrogen is $4.8 \times 10^8\ M_\odot$ (based on a distance of 60 kpc). Since 32% of the mass is neutral hydrogen, the SMC has a relatively high gas content. For comparison, our own Galaxy has a mass of $2 \times 10^{11}\ M_\odot$ interior to a radius of 15 kpc (Faber and Gallagher 1979) and 5–10% of the mass is thought to be neutral hydrogen. Active regions of the SMC are shown in the 6 cm map of McGee, Newton, and Butler (1976), and H II regions are catalogued by Henize (1956).

III. OBSERVATIONS

The observatory and instruments have been described by Giacconi *et al.* (1979). The detector used for the survey was the IPC (Imaging Proportional Counter). It is sensitive to X-rays with energies from 0.15–4 keV and has a spatial resolution of ~ 1′. Results from two HRI (High Resolution Imager) fields are also included; one centered on SMC X-1 and the other centered on NGC 104. The HRI has a field of view of 25′, spatial resolution of a few arc seconds, and an efficiency ranging from approximately equal to that of the IPC at 0.15 keV to a factor of ~ 25 less than that of the IPC at 2–3 keV.

Most data were taken in 1979 April and in 1979 November, with a few observations completed in 1980 April. An exposure time of 2000 s was planned for each field, but data were lost because of high charged-particle–induced background in the South Atlantic Anomaly and because the sunlit Earth sometimes entered the field of view of the star trackers causing loss of data used to determine aspect. Fields with very short exposure times were reobserved 6 months after the first attempt. Exposure times of data used ranged between 800 s and 3300 s.

Table 1 lists 40 IPC and 2 HRI pointings comprising the survey and the time and duration of each observation. Figure 1 gives a map showing the coverage of the 40 fields and the sources detected. The area shown for each field is a 60′ × 60′ square, smaller than the 75′ × 75′ full field of the detector. Because the charged particle background is higher at the edges of the field, the outer $7'.5$ is routinely excluded from analysis. We have searched this outer region in selected fields in order to fill in the gaps between fields apparent in Figure 1.

TABLE 1

THE OBSERVATIONS

Field (seq. no.)	Exposure Time (s)	Start of Observation, UT	
		(m-d-y	h-m)
590	1064	05-01-79	09:25
591	2089	11-20-79	05:56
592	3325	04-30-79 04-14-80	20:47 20:37
593	1311	05-02-79	06:05
594	1165	11-12-79	20:03
595	1974	11-13-79	01:49
596	1605	04-29-79	06:23
597	1141	11-13-79	10:00
598	1573	04-30-79	06:39
599	1717	04-29-79	19:06
600	1678	05-01-79	19:41
601	1694	04-30-79	13:57
602	1933	04-30-79	05:04
603	2179	04-29-79	21:07
604	1662	11-12-79	10:46
605	1679	05-02-79	05:20
606	1399	04-30-79	19:18
607	1091	04-30-79	16:07
608	2341	04-30-79	03:30
609	1140	11-12-79	23:36
610	2224	11-13-79	00:15
611	1677	05-02-79	17:51
612	1005	05-02-79	06:37
613	881	04-30-79	17:44
614	2214	04-30-79	09:41
615	2124	04-28-79	06:46
616	761	04-28-79	21:21
617	1676	05-02-79	19:18
618	3178	05-02-79 11-13-79 04-14-80	18:44 06:30 19:16
619	1678	05-02-79	07:40
620	2198	04-14-80	06:52
621	1919	04-28-79	19:54
622	1682	11-11-79	23:37
623	1726	11-12-79	22:55
624	2222	05-02-79 04-14-80	20:19 13:42
625	1665	05-02-79	09:12
626	1580	04-28-79	18:00
627	2164	11-11-79	22:58
628	1392	11-12-79	07:21
629	1225	11-12-79	11:18
658 (HRI)	1612	04-21-79	00:53
958 (HRI)	2960	04-22-79	20:26

There is vignetting in the telescope such that the effective area of the instrument in the outer part of the field is half the effective area in the center. Thus, the sensitivity of the survey varies not only with varying exposure time, but with the position of sources in the field. An additional complication arises because of the window support ribs. There are four ribs of width ≈ 3′ forming a tic-tac-toe pattern with the central square 38′ on a side. The pointing is stable enough so that these ribs shadow part of the detector. A weak source under a rib will not be seen in our survey, but since there is some motion in the spacecraft pointing, a strong source cannot be completely

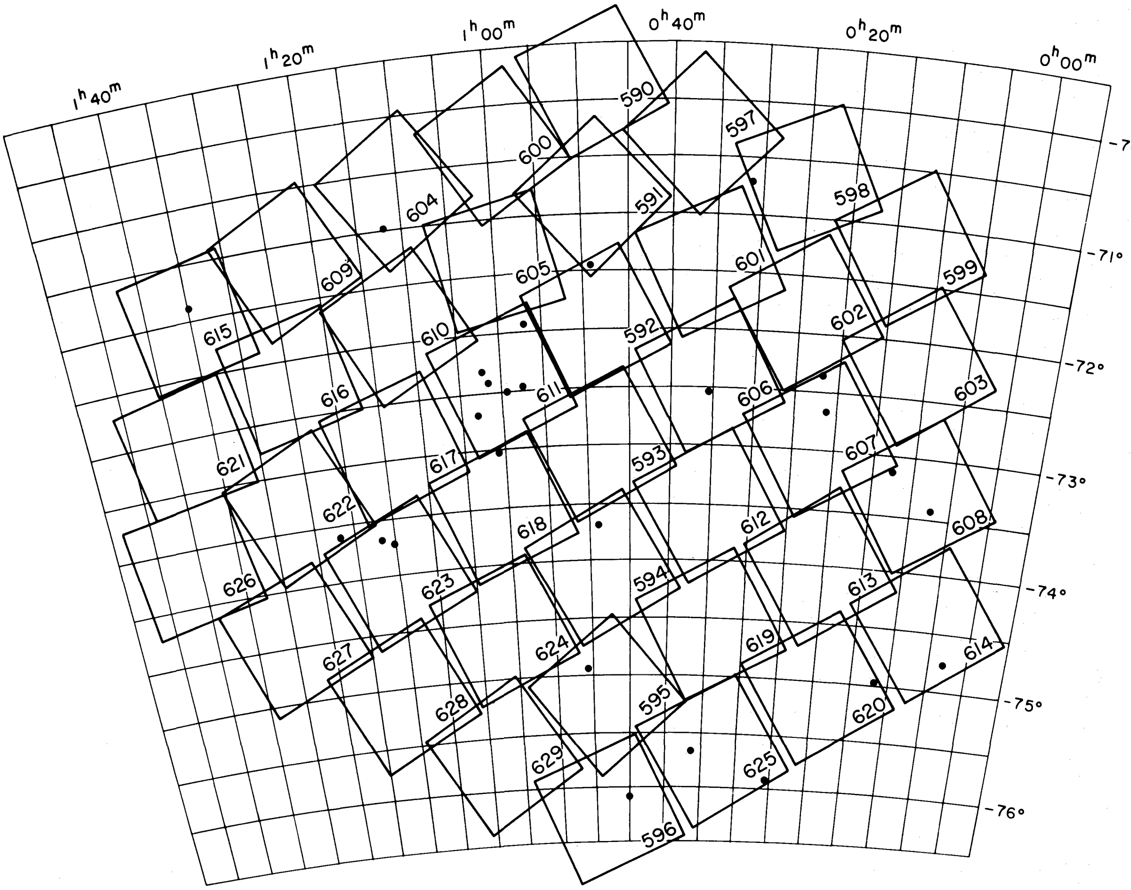

FIG. 1.—Sky coverage of the 40 IPC fields of this survey. Coordinates are epoch 1950. Each field is a square 60′ on a side and is labeled with its *Einstein* sequence number. The positions of 26 detected sources are indicated.

blocked by a rib nor can a moderately strong extended supernova remnant. Because of reduced sensitivity at the edges of the field and shadowing, the survey is not 100% complete. We estimate we have covered 93% of the area within the outer boundary of the fields shown in Figure 1 to a sensitivity of $L_x = 1 \times 10^{36}$ ergs s^{-1}. The weakest SMC source detectable in the center of a field with 2000 second exposure has $L_x = 3 \times 10^{35}$ ergs s^{-1}.

Because the bright Earth disables the star sensors when near the field of view, we were unable to obtain an aspect solution for several fields. These data were taken with the spacecraft oriented by gyros referenced to star sensor locations determined from the previous field. We were able to position such fields to an accuracy of 1′.5. The accuracy of IPC locations within a field with a good aspect solution varies between 1′ in the center of the field to 1′.5 at the edges of the field. Combining the two uncertainties, the accuracy of source locations in no-aspect fields is 2′ in the center and 2′.5 at the edge.

Table 2 lists sources detected and their characteristics. Figure 2 shows the sources placed on the neutral hydrogen map of the SMC. To determine the nature of these sources, we have looked at spectra and time variability during the observation. Neither of these, of course, can be well measured for sources at the threshold of detectability. We can, however, examine all the data in two colors. Faint sources sometimes appeared in only the soft or hard bands and thus could be classified as soft (S) or hard (H), although no quantitative hardness ratio was derived. For the stronger sources, we have calculated a hardness ratio which can be compared with that of stronger known sources of various types. Numbers in parentheses show information extracted from only part of the data, e.g., location derived from a short interval for which good aspect information was available. The last column on Table 2, Δr, gives the separation between X-ray source position and candidate object.

If a source is in the SMC, 1 IPC count s^{-1} corresponds to $L_x = 2 \times 10^{37}$ ergs s^{-1} with an uncertainty factor of 1.5 since the X-ray spectrum is not well determined. A SNR with diameter 20 pc subtends 1′.

IV. SMC X-1, X-2, X-3

SMC X-1 was detected in the IPC survey with a luminosity $L_x \approx 6 \times 10^{36}$ ergs s^{-1}. It had the hardest spectrum of any source detected and varied significantly during the 1700 s observing interval. The source was apparently in a low state at this time. When observed with

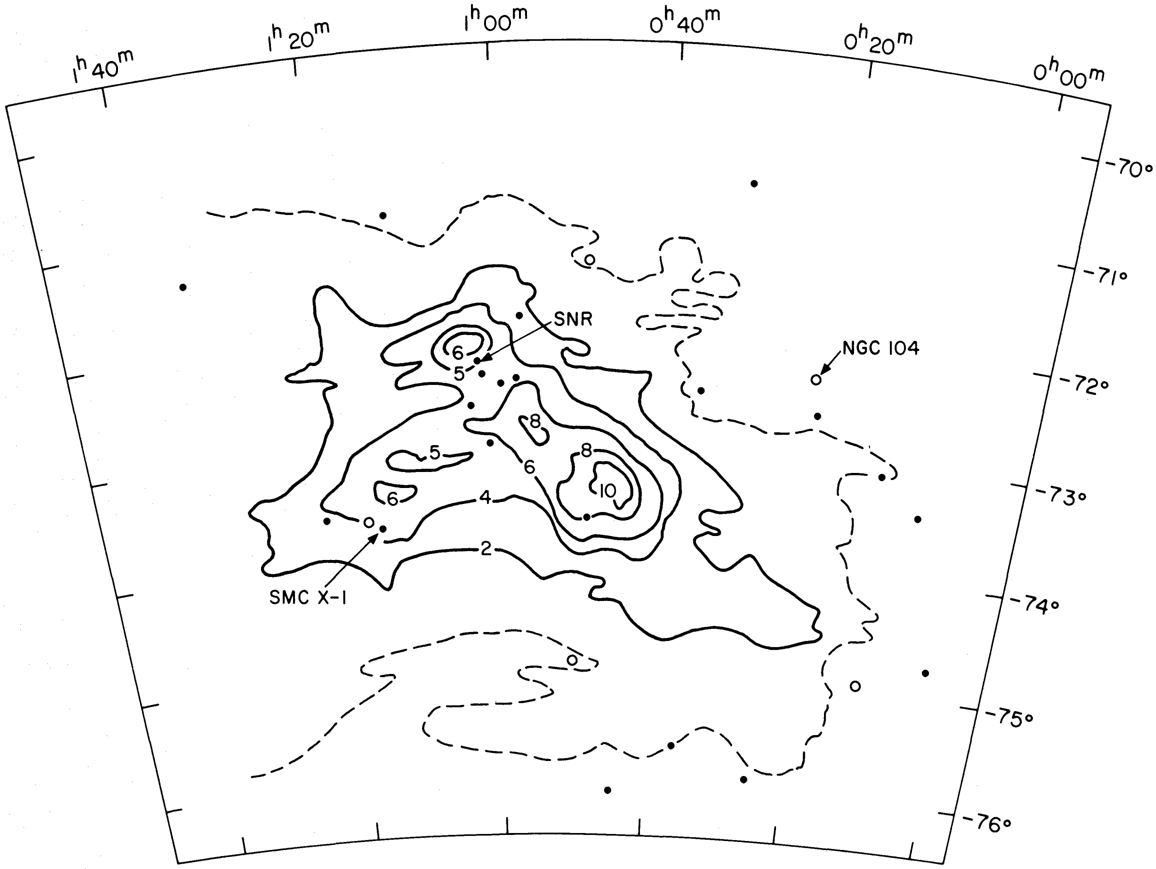

FIG. 2.—The detected sources overlaid on contours of 21 cm integrated brightness taken from Hindman (1967). One contour unit $\approx 10^{21}$ atoms of neutral hydrogen per cm^2. The region of maximum brightness corresponds to a column density $\approx 10^{22}$ hydrogen atoms per cm^2. Sources identified with objects which are not members of the SMC are indicated as open circles; closed circles show all other sources. The very bright supernova remnant is indicated.

the HRI 7 months earlier, it was clearly the brightest SMC source, having $L_x \approx 2 \times 10^{38}$ ergs s^{-1}, which is the more usual state. Neither SMC X-2 nor SMC X-3 were detected; but their previously determined positions placed them close to a rib; and these objects may have been shadowed. In any event, they were certainly not in a high state.

SMC X-1, highly variable but not transient, is one component of a binary system with an orbital period of 3.9 days (Schreier *et al.* 1972). Lucke *et al.* (1976) discovered 0.71 s pulsations and the optical counterpart, Sanduleak 160, was identified by Webster *et al.* (1972) and Liller (1973). Thus SMC X-1 was determined to be a neutron star orbiting around a B0 I supergiant, and the orbital elements and masses have been calculated by Primini, Rappaport, and Joss (1977). Similar optical candidates have been proposed for the other two transients (Clark *et al.* 1978), but have not been confirmed. SMC X-1 was not in eclipse during either of our observations.

V. STARS: CORONAL EMISSION

Four (perhaps five) of the sources can be identified with Milky Way stars. They are foreground objects, not associated with the SMC. Initial results from an *Einstein* stellar survey (Vaiana *et al.* 1981) can be used to determine whether these identifications are reasonable: In the stellar survey, 18 main sequence stars of spectral types F and G were found to have ratios of X-ray to V-band flux (f_x/f_v) ranging from 10^{-6} to 10^{-3}. Characteristics of the five candidate stars are listed in Table 3. On the basis of X-ray to optical luminosity, all qualify as valid identifications.

In addition, all five sources are far from the center of the SMC, and there are not many candidate objects in the error boxes. Positional uncertainties are $\sim 1'$ for three of these, and they can be identified with confidence as SAO 255713, SAO 255716, and HD 987. The HRI position is uncertain to $\sim 0'.1$. Since HD 8191 is the only bright object within the error box, the identification of 1E011710−7341.2 with this star is also definite.

The positional uncertainty for the remaining source is $\sim 2'$ and the identification with HD 2496 is possible but not definite. The brightest stars in the region surveyed, λ Hyi and θ Tuc, were not detected. Upper limits of f_x/f_v are listed in Table 3. These are consistent with stellar survey results for giant stars.

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TABLE 2

X-RAY SOURCES DETECTED

Field	Source	IPC Position	Radius of Error Circle (arcmin)	Counts s^{-1}	$\left(\frac{1.2\text{–}3.0\text{ keV}}{0.5\text{–}1.2\text{ keV}}\right)$ Hardness Ratio	Identification	Δr (arcmin)
614	1E0003.0–7443	$00^h03^m01^s$,–74°43′46″	1.0	0.082	0.9 ± .4		
608	1E0007.4–7325	00 07 28 ,–73 25 31	1.0	0.021	0.6 ± .35	MC0007–734?	0.51
620	1E0011.7–7458	00 11 47 ,–74 58 20	1.5	0.06	S	star/HD 987	1.2
608	1E0012.7–7308	00 12 43 ,–73 08 48	1.5	0.032	0.5 ± .3	SNR?	
607	1E0021.3–7241	00 21 23 ,–72 41 08	1.0	0.041	0.9 ± .6 H		
602	1E0022.1–7221	00 22 08 ,–72 21 06	1.5	0.11	0.45 ± .25	Glob.Cl.NGC 104	1.2
658	1E002151–7221.5	00 21 51.4 ,–72 21 33	0.1	0.04	–HRI–	NGC 104	
625	1E0025.7–7555	00 25 42 ,–75 55 57	2.5	0.027	0.8 ± .2	star/HD 2496?	2.6
598	1E0031.7–7042	00 31 44 ,–70 42 24	1.5	0.024	---	MC0021–707?	1.3
606	1E0035.4–7230	00 35 26 ,–72 30 46	1.0	0.070	0.05 ± .08	SNR? Extended?	
625	1E0036.6–7539	00 36 37 ,–75 39 56	2.0	0.013	H		
596	1E0045.2–7606	00 45 16 ,–76 06 20	2.0	0.022	H	galaxy?	1.0
592	1E0049.0–7125	00 49 03 ,–71 25 57	1.5	0.036	---	star/SAO 255713	0.5
594	1E0049.4–7339	00 49 26 ,–73 39 27	1.0	0.015	0.4 ± .25	SNR?	
595	1E0051.3–7454	00 51 21 ,–74 54 59	(1.0)	(0.3)	H	star/SAO 255716	0.6
611	1E0056.8–7154	00 56 48 ,–71 54 53	2.5	0.02	---	nebula/N67?	3.1
611	1E0057.6–7228	00 57 39 ,–72 28 02	2.0	0.034	0.60 ± .3	nebula/N66?	1.1
611	1E0059.0–7228	00 59 04 ,–72 28 56	2.0	0.015	---		
618	1E0101.3–7301	01 01 20 ,–73 01 23	1.5	0.02	---		
611	1E0101.5–7226	01 01 33 ,–72 26 34	2.0	0.022	---		
611	1E0102.2–7219	01 02 17 ,–72 19 24	2.0	0.86	0.54 ± .10	SNR near N76	2.0
611	1E0103.3–7240	01 03 18 ,–72 40 05	2.0	0.076	0.35 ± .12	SNR?	
604	1E0112.0–7059	01 12 02 ,–70 59 46	1.5	0.013	H		
623	1E0115.5–7342	01 15 35 ,–73 42 47	(1.0)	0.27	1.9 ± .4	H SMC X–1	
958	1E011545–7342.4	01 15 45.7,–73 42 25	0.1	1.2	–HRI–	SMC X–1	
958	1E011719–7341.2	01 17 19.2,–73 41 12	0.1	.008	–HRI–	Star/HD 8191	
622	1E0121.9–7335	01 21 55 ,–73 35 45	1.5	0.02	H		
615	1E0135.1–7122	01 35 07 ,–71 22 14	2.0	0.017	H		

NOTE.—MC = Molonglo Catalog; N = Henize Emission Nebula Catalog.

It is possible that other sources may eventually be identified with late-type stars. For example, f_x/f_v for dMe stars ranges from 10^{-3} to 10^{-1}. The corresponding magnitude associated with an IPC counting rate of 0.02 counts s^{-1} would range from $V = 10$ to 15—faint enough so that identifications cannot be made without carefully studying all objects within the error box.

VI. SUPERNOVA REMNANTS

The second most luminous source seen, 0102.2 – 7219, is almost certainly a supernova remnant. The X-ray luminosity between 0.2 and 2 keV is $L_x = 2.1 \times 10^{37}$ ergs s^{-1}. The identification is based on the measured very soft spectrum and on the LMC results. A survey of the LMC (Long and Helfand 1979), approximately half completed, has resulted in the detection of three luminous SNRs having very soft spectra and IPC counting rates in excess of 1 count s^{-1}. HRI observations have shown these objects to be extended and shell-like, and the identification as SNRs is definite.

The positional uncertainty associated with the bright SMC source is large. The most conspicuous nearby object is the H II region N76. The supernova remnant is either coincident with this region or nearby. The spectrum is soft and the source appears pointlike in the IPC. Thus, the

TABLE 3

STELLAR X-RAY SOURCES AND BRIGHT STARS

Star	V_{mag}	Spectrum	IPC cts s^{-1}	f_x/f_v
HD 8191	10.4	F8/G2 IV/V	0.008 (HRI)	1×10^{-3}
HD 987	9.0	G6 V	0.090	2×10^{-3}
HD 2496	8.3	G6 III	0.027	3×10^{-4}
HD 5028 (SAO 255713)..	7.1	F5 V	0.03	1×10^{-4}
HD 5303 (SAO 255716)..	7.8	G2 V + F0	0.24	1.5×10^{-3}
HD 3112 (θ Tuc)	6.1	A7 IV	<0.025	$<3 \times 10^{-5}$
HD 4815 (λ Hyi)	5.0	K4 III	<0.020	$<1 \times 10^{-5}$

extent of the SNR is $\lesssim 2'$ (diameter $\lesssim$ 40 pc). The source has been observed with the HRI, and the position and extent will soon be measured precisely (Tanaka 1980).

There are four other unidentified sources with soft spectra (hardness ratio less than 0.50). Since there are no bright stars within the error circles, it is highly likely that these sources are also SNRs having $L_x = 0.5\text{–}2 \times 10^{36}$ ergs s^{-1}. One of them is in field 611, the same region as 0102.2−7219. We note that there have been only two SNRs previously identified in the SMC, N19 (Mathewson and Clarke 1972) and 0046−73.5 (Mathewson and Clarke 1973), neither of which was detected in our survey.

The presumed SMC supernova remnants can be compared with nearby SNRs in our own Galaxy which are found to be soft X-ray sources (Seward *et al.* 1976; Pye *et al.* 1981). Characteristics of these are listed in Table 4. A few young SNRs, such as Cas A, are known to be in the free expansion stage and are strong sources ($L_x = 10^{36}\text{–}10^{37}$ ergs s^{-1}) of X-rays with energies above 1 keV. As the remnant expands and picks up interstellar matter, the expansion velocity slows, and the X-ray spectrum softens. Older remnants, such as the Cygnus Loop and Vela X, emit almost all their X-rays at energies below 1 keV. When the remnant expands to a diameter greater than ~ 50 pc, the shell is expected to cool rapidly and will no longer emit X-rays.

Since evolution through the initial free expansion stage is rapid, we expect to see only the older X-ray emitting remnants in the SMC. The very bright SNR, 0102.2−7219, is perhaps similar to Pup A, and the other SNR candidates similar to the Cygnus Loop. A remnant with the luminosity of SNR 1006 in the SMC would be too faint to see in our survey.

Absorption of gas in the galactic plane limits detection of old Milky Way SNRs to nearby objects. By way of contrast, the hydrogen column density to the SMC is only 3×10^{20} H atoms cm^{-2}, and soft X-rays can be observed from all SNRs except those imbedded in the denser regions of the SMC where the column density could be a few $\times 10^{21}$. It is interesting that the group of five sources in the center of field 611, including two SNR candidates, is situated in a local minimum of $N_{\rm H}$ column density. Perhaps deeper observations will detect more strongly absorbed SNRs in the gas clouds to the NE and SW.

Field 611 covers the region of maximum star density measured by de Vaucouleurs (1955). There are seven X-ray sources in or close to this field, an unusual group. Soft spectra suggest at least two of these are SNRs. Perhaps all are SNRs and the neutral hydrogen in this region has been depleted by ionizing radiation from supernovae or their remnants. Cash *et al.* (1980) have discovered a large ionized region in the Milky Way, a superbubble probably produced by past supernovae associated with an ancient OB association in Cygnus. Although in the SMC there is no strong diffuse X-ray emission from the interior, the X-ray sources are all inside one of the expanding shells of neutral hydrogen postulated by Hindman (1967), and this region of the SMC might be similar to the Cygnus superbubble.

TABLE 4

X-RAY LUMINOSITIES OF FOUR GALACTIC SNR

Remnant	Distance (kpc)	Diameter (pc)	L_x (ergs s^{-1})
SN 1006	1.0	9	0.2×10^{36}
Puppis A	1.8	28	6×10^{36}
Cygnus Loop	0.8	42	1.6×10^{36}
Vela X	0.5	44	0.5×10^{36}

On the basis of radio data, Ilovaisky and Lequeux (1972) have estimated that the Milky Way contains ~ 10^3 SNRs with diameters < 50 pc. Only ~ 10% of these are young SNRs with diameters < 20 pc. Clark and Caswell (1976) estimate this number to be ~ 10^2 SNRs, a factor of 10 less. The mass of the SMC is ~ 1% of the mass of the Milky Way disk, so we might expect to see soft X-rays from 1–10 SNRs with diameters 20–50 pc. Our observations are compatible with this expectation, but on the high side. Considering that we detect only the brightest objects, we see more possible SNRs than expected. The high luminosity of 0102.2−7219 was unexpected and might indicate that soft X-ray emission from SNRs has been underestimated. Deeper observations and high resolution observations are being conducted by Tanaka (1980) and by Gull (1980). These deep observations should discover fainter SNRs and will determine the SNR luminosity function in the SMC. We will eventually be able to compare in detail SMC results with those from the LMC and the Milky Way.

The source 0057.6−7228 is within or close to the emission nebula N66 (NGC 346), the largest H II region in the SMC. This nebula contains several O type stars (Walborn 1978) and is rather like the η Carinae Nebula. This latter region has been observed by *Einstein* (Seward *et al.* 1979) and found to be a diffuse X-ray source $L_x \approx 10^{35}$ ergs s^{-1} containing many point sources (O stars), each with $L_x \approx 10^{33}$ ergs s^{-1}. The precision of our location is not good enough to place 0057.6−7228 inside or outside of N66. If the source can be identified with the nebula, its luminosity, $L_x = 8 \times 10^{35}$ ergs s^{-1}, is greater than that of the η Carinae Nebula. If, on the other hand, the source is a SNR near N66, the luminosity is reasonable and the proximity to a group of early stars is expected.

VII. DIFFUSE X-RAY BACKGROUND

To explain the Wisconsin observations (i.e., that the SMC does not cast an X-ray shadow), the background flux expected to be absorbed by the SMC must be approximately balanced by emission from sources in the SMC. In the energy range 0.15–0.28 keV, a flux of $\sim 1 \times 10^{-10}$ ergs cm^{-1} s^{-1} is needed (McCammon *et al.* 1971) and in the range 0.8–1.5 keV, a flux of $\approx 5 \times 10^{-12}$ ergs cm^{-1} s^{-1} is needed (Bunner, Sanders, and Nousek 1979).

Most of the SMC soft X-rays come from the five sources listed in Table 2 as possible SNRs. The total flux from these sources is 1.1 counts s^{-1} $\approx 2 \times 10^{-11}$ ergs cm^{-2} s^{-1}. Even assuming this is all in the 0.15–0.28 keV band, it is not enough to explain the observed lack of absorption. Therefore, the origin of the soft component of the diffuse X-ray background must be within the Milky Way, a conclusion already reached by McCammon *et al.* (1976).

The harder sources in Table 2, however, contribute 0.6 counts $s^{-1} \approx 1 \times 10^{-11}$ ergs cm^{-2} s^{-1}, enough to explain the Wisconsin result in the 0.8–1.5 keV band. Remember that the diffuse background is assumed to have two components: X-rays of extragalactic origin characterized by a power law spectrum of index -1.4, and a softer thermal component probably of galactic origin. At 1 keV, the extragalactic component dominates and X-rays from sources in the SMC (or in the field) compensate for absorption of background X-rays in the neutral gas of the SMC. At 0.2 keV, the dominant contribution is galactic in origin and has prevented observation of the SMC shadow.

VIII. NGC 104 AND OTHER SOURCES

The globular cluster NGC 104 (47 Tuc) was detected in the extended portion of one IPC field. The X-ray luminosity was calculated to be $L_x \approx 1 \times 10^{34}$ ergs s^{-1} (distance = 5 kpc). This is a factor of 3 less than the L_x calculated from the earlier HRI observation (Grindlay 1980), and probably indicates that this source, like other globular cluster X-ray sources, is variable.

Of the remaining sources that have not been identified as stars or as probable supernova remnants, four have interesting objects inside their error boxes. One source is near the H II region N67, another is possibly a faint Galaxy listed in the atlas of Hodges and Wright (1977), and two sources are close to 408 MHz sources from the Molonglo MC4 catalog (Clark, Little, and Mills 1976) for which we have no optical identifications.

The *Uhuru* source 4U 0026−73 was not detected nor were the two nearby globular clusters proposed by Grindlay (1978) as candidates. No detected sources are close enough to the error box to be reasonable candidates, so we conclude that this source was transient or the result of source confusion caused by SMC X-1, X-2, and X-3.

Many quasars have been found by *Einstein* to be X-ray sources (Zamorani *et al.* 1981). All but a few have hardness ratios in the range 0.8–1.4. In the 40 sq. deg. of our survey, we expect to detect ~ 5 quasars, which are no doubt lurking among the unidentified sources of Table 2.

IX. CONCLUSIONS

At the time of this survey, the SMC contained only one highly luminous source ($L_x > 10^{38}$ ergs s^{-1}), the well-known SMC X-1. If there were others, transient in nature, we found no sign of them. There were no detections which might be identified as sources powered by accretion onto compact objects with $10^{38} > L_x > 10^{37}$ ergs s^{-1}. Not until $L_x \approx 10^{36}$ ergs s^{-1} do sources appear which might eventually be identified with such objects.

There is one (and only one) bright SNR with $L_x \approx 2 \times 10^{37}$ ergs s^{-1} and several other soft sources which are likely to be SNRs with $L_x \approx 10^{36}$ ergs s^{-1}. Several sources, possibly all SNRs, are clustered in one location.

A few sources are identified with foreground stars, and probably several of the remaining unidentified sources are not associated with the SMC. This first survey will be followed by deeper observations and high resolution observations, which will detect fainter objects and which should lead to identifications for most of the sources found in this survey.

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