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A New Catalogue of Galactic SNRs Corrected for Distance from the Galactic Plane

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Abstract

A new catalogue of 125 galactic SNRs is presented. A surface brightness – diameter relationship, corrected for variation in height $|z|$ above the galactic plane, is derived and applied to the catalogue to yield $|z|$-corrected distances and diameters. A birth rate of about one every 30 or 40 years is indicated from the number–diameter diagram.

1. Catalogue at 1 GHz

In this paper I present a new catalogue of galactic SNR data at 1 GHz (Table 1). This catalogue follows directly from my earlier work (Milne 1970, 1971) and borrows heavily from that of Downes (1971) and Clark and Caswell (1976), and the reader is referred to these papers for many of the source references. Where additional references have been used, they are cited by a number in column 8 and listed at the end of the table. I continue to present the data at a frequency of 1 GHz because this provides values, interpolated from many observations, at a frequency that is central to the various observations but not within any of the allocated radio astronomy bands, so that the data cannot be mistaken for direct observations.

(*a*) *Description of Catalogue*

Columns 1 and 2 of Table 1 give the galactic number of the SNR and names listed in other catalogues. Columns 3, 4 and 5 give the 1 GHz values for the angular size θ, the flux density S and the spectral index α, while column 6 gives the corresponding surface brightness Σ calculated from the relation

$$\Sigma = 1\cdot 505\times 10^{-19}\, S/\theta^2 \quad \mathrm{W\,m^{-2}\,Hz^{-1}\,sr^{-1}}\,.$$

Column 7 gives the distance d to the SNR (where known), and column 8 lists references to the data, as described above.

A $\Sigma - D$ diagram for all SNRs in Table 1 with known distances (column 7) is given in Fig. 1*a*. The linear least squares fitted relationship is represented by

$$\Sigma = 3\cdot 4\times 10^{-15} D^{-3\cdot 8} \quad \mathrm{W\,m^{-2}\,Hz^{-1}\,sr^{-1}}\,, \tag{1}$$

or

$$D = 1\cdot 7\times 10^{-4}\,\Sigma^{-0\cdot 26} \quad \mathrm{pc}\,. \tag{2}$$

Table 1. Radio data for 125 galactic SNRs

(1) Galactic number designation	(2) Other catalogue name	(3) θ (′)	(4) S (Jy)	(5) 1 GHz 'observed' data α	(6) 1 GHz 'observed' data Σ ($W\,m^{-2}\,Hz^{-1}\,sr^{-1}$)	(7) d (kpc)	(8) Data ref. No.†	(9) Derived from $\Sigma-D$ D' (pc)	(10) Derived from $\Sigma-D$ d' (kpc)	(11) Derived from $\Sigma-D$ z' (pc)	(12) Corrected for $\lvert z\rvert$ D_c (pc)	(13) Corrected for $\lvert z\rvert$ d_c (kpc)	(14) Corrected for $\lvert z\rvert$ z_c (pc)
G2·4+1·4		6·0	8·0	−0·90	$0{\cdot}33\times10^{-19}$		13	20·3	11·7	285	12·5	7·2	176
G4·5+6·8	Kepler's SNR	3·8	20·0	−0·58	$0{\cdot}21\times10^{-18}$	12·0	10, 18	12·6	11·4	1351	3·3	3·0	357
G5·3−1·0	Milne 56, A4	15·0	35·0	−0·20	$0{\cdot}23\times10^{-19}$		1	22·3	5·1	−88	21·6	5·0	−85
G6·4−0·1	W28	49·0	315·0	−0·38	$0{\cdot}20\times10^{-19}$	>4·5		23·3	1·6	−2	34·1	2·4	−3
G7·7−3·7		19·5	10·0	−0·25	$0{\cdot}40\times10^{-20}$			35·5	6·3	−403	18·1	3·2	−205
G10·0−0·3		6·0	1·4	−0·34	$0{\cdot}59\times10^{-20}$			32·1	18·4	−95	30·0	17·2	−89
G11·2−0·3		4·2	22·0	−0·56	$0{\cdot}19\times10^{-18}$	>5·0		13·0	10·6	−55	14·5	11·9	−61
G11·4−0·1		7·0	6·1	−0·48	$0{\cdot}19\times10^{-19}$		1	23·7	11·6	−19	30·9	15·2	−25
G12·0−0·1		5·4	3·5	−0·71	$0{\cdot}18\times10^{-19}$			23·9	15·2	−26	30·0	19·1	−32
G15·9+0·2		5·0	4·7	−0·56	$0{\cdot}28\times10^{-19}$		1	21·3	14·6	51	23·9	16·5	57
G18·8+0·3	Kes 67, MSH 18−18	15·0	30·0	−0·36	$0{\cdot}20\times10^{-19}$	9·5		23·2	5·3	28	29·0	6·6	35
G21·5−0·9		1·0	6·5	−0·01	$0{\cdot}98\times10^{-18}$		3, 14	8·4	29·0	−454	4·4	15·0	−235
G21·8−0·6	Kes 69, MSH 18−113	22·8	68·0	−0·54	$0{\cdot}20\times10^{-19}$	6·3		23·4	3·5	−36	28·0	4·2	−43
G22·7−0·2		24·6	32·0	−0·57	$0{\cdot}80\times10^{-20}$			29·6	4·1	−13	39·5	5·5	−18
G23·3−0·3	W41, Kes 70	21·0	60·0	−0·50	$0{\cdot}20\times10^{-19}$			23·1	3·8	−19	30·3	5·0	−25
G23·6+0·3		7·2	7·6	−0·30	$0{\cdot}22\times10^{-19}$			22·7	10·8	57	24·9	11·9	62
G24·7+0·6		14·0	15·0	−0·50	$0{\cdot}12\times10^{-19}$		1	26·9	6·6	69	27·9	6·8	72
G24·7−0·6		14·6	7·8	−0·50	$0{\cdot}55\times10^{-20}$			32·6	7·7	−79	32·2	7·6	−78
G27·4+0·0	Kes 73 (Part)	4·4	2·9	−0·45	$0{\cdot}23\times10^{-19}$		1	22·6	17·6	3	32·9	25·7	4
G29·7−0·2	Kes 75, 4C−03·70	2·4	10·0	−0·71	$0{\cdot}26\times10^{-18}$	>6·6	3	11·9	17·0	−58	13·2	18·9	−65
G31·9+0·0	3C 391	4·2	22·0	−0·57	$0{\cdot}19\times10^{-18}$	11·0	3	13·0	10·6	2	19·5	16·0	3
G32·0−4·9*	3C 396·1	20·0	19·0	−0·60	$0{\cdot}71\times10^{-20}$		5	30·4	5·2	−446	14·7	2·5	−215
G32·8−0·1	Kes 78	17·2	11·0	−0·20	$0{\cdot}56\times10^{-20}$		5	32·5	6·5	−10	44·1	8·8	−14
G33·6+0·1	4C 00·70	9·2	16·0	−0·60	$0{\cdot}28\times10^{-19}$		1, 5	21·2	7·9	14	28·8	10·8	19
G34·6−0·5	W44	27·2	230·0	−0·30	$0{\cdot}47\times10^{-19}$	3·0		18·6	2·4	−20	24·5	3·1	−26
G35·6−0·4		10·0	20·0	−0·75	$0{\cdot}30\times10^{-19}$		1, 5	20·9	7·2	−49	23·7	8·1	−56
G39·2−0·3	3C 396, NRAO 593	6·6	20·0	−0·49	$0{\cdot}69\times10^{-19}$	>11·3	5	16·8	8·8	−45	19·6	10·2	−52
G39·7−2·0	W50	50·0	100·0	−0·48	$0{\cdot}60\times10^{-20}$		5	31·8	2·2	−75	31·9	2·2	−76
G41·1−0·3	3C 397	3·6	20·0	−0·49	$0{\cdot}23\times10^{-18}$	>7·5	5	12·3	11·7	−60	13·4	12·8	−66
G41·9−4·1	CTB 72	164·0	150·0	−0·50	$0{\cdot}84\times10^{-21}$		5	53·3	1·1	−79	51·9	1·1	−77
G43·3−0·2	W498	4·2	36·0	−0·47	$0{\cdot}31\times10^{-18}$	12·0	9	11·4	9·3	−32	14·2	11·6	−40
G46·8−0·3	HC 30	15·6	19·0	−0·53	$0{\cdot}12\times10^{-19}$		1, 5	26·7	5·9	−30	32·6	7·2	−37
G47·6+6·1	CTA 63	83·4	12·0	−0·50	$0{\cdot}26\times10^{-21}$		5	72·4	3·0	317	41·2	1·7	180
G49·2−0·5	W51 (Part)	26·6	160·0	−0·25	$0{\cdot}34\times10^{-19}$	4·1		20·3	2·6	−22	26·2	3·4	−29
G53·7−2·2	3C 400·2, NRAO 611	26·6	8·9	−0·60	$0{\cdot}19\times10^{-20}$		5, 8	43·1	5·6	−213	29·7	3·8	−146

Table 1 (*Continued*)

(1) Galactic number designation	(2) Other catalogue name	(3) θ (′)	(4) S (Jy)	(5) 1 GHz 'observed' data α	(6) Σ (W m^{-2} Hz^{-1} sr^{-1})	(7) d (kpc)	(8) Data ref. No.†	(9) Derived from $\Sigma-D$ D' (pc)	(10) d' (kpc)	(11) z' (pc)	(12) Corrected for $\|z\|$ D_c (pc)	(13) d_c (kpc)	(14) z_c (pc)
G54·4−0·3	HC40	43·0	27·0	−0·49	$0\cdot22\times10^{-20}$			41·4	3·3	−16	53·8	4·3	−22
G55·7+3·4	PSR 1919+21(?)	20·4	1·2	−0·60	$0\cdot43\times10^{-21}$		7	63·3	10·7	632	26·6	4·5	265
G65·7+1·2	DA 495	18·6	6·0	−0·54	$0\cdot26\times10^{-20}$		5	39·6	7·3	153	31·3	5·8	121
G74·0−8·6	Cygnus Loop	180·0	200·0	−0·45	$0\cdot93\times10^{-21}$	0·77		51·9	1·0	−147	41·3	0·8	−117
G74·9+1·2	CTB 87	6·5	10·0	−0·47	$0\cdot36\times10^{-19}$	> 12·0	20	20·0	10·6	222	13·8	7·3	153
G78·1+1·8*	DR 4, γ Cygni	62·0	340·0	−0·65	$0\cdot13\times10^{-19}$		12	25·9	1·4	45	29·7	1·6	52
G82·2+5·4	W63	77·0	150·0	−0·70	$0\cdot38\times10^{-20}$		1	35·9	1·6	151	28·6	1·3	120
G84·2−0·8		18·0	10·0	−0·50	$0\cdot46\times10^{-20}$		15	34·1	6·5	−90	32·4	6·2	−85
G89·0+4·7	HB 21	105·0	230·0	−0·40	$0\cdot31\times10^{-20}$		11	37·7	1·2	101	34·6	1·1	93
G93·2+6·7	DA 530	24·0	8·0	−0·51	$0\cdot21\times10^{-20}$		17	42·0	6·0	701	16·9	2·4	282
G93·6−0·2*	CTB 104A	61·0	40·0	−0·35	$0\cdot16\times10^{-20}$			44·9	2·5	−8	61·2	3·4	−11
G94·0+1·0	3C 434·1	26·6	12·0	−0·53	$0\cdot26\times10^{-20}$			39·8	5·1	90	37·8	4·9	85
G111·7−2·1	Cas A	4·2	3400·0	−0·76	$0\cdot29\times10^{-16}$	3·3		3·5	2·8	−103	3·4	2·8	−100
G117·3+0·1	CTB 1	30·0	8·0	−0·58	$0\cdot13\times10^{-20}$		1	47·2	5·4	9	63·9	7·3	13
G119·5+10·0	CTA 1	130·0	39·0	−0·20	$0\cdot35\times10^{-21}$			67·1	1·8	308	38·8	1·0	178
G120·1+1·4	Tycho's SNR, 3C 10	7·9	58·0	−0·55	$0\cdot14\times10^{-18}$	> 6·0	6	14·0	6·1	149	11·5	5·0	122
G127·1+0·5	R5	48·0	30·0	−0·00	$0\cdot20\times10^{-20}$		4	42·7	3·1	27	52·5	3·8	33
G130·7+3·1	3C 58	4·5	35·0	−0·09	$0\cdot26\times10^{-18}$	> 8·0	14	11·9	9·1	492	5·9	4·5	243
G132·4+2·2	HB 3	72·0	62·0	−0·52	$0\cdot18\times10^{-20}$	2·0		43·6	2·1	80	42·8	2·0	78
G160·5+2·8	HB 9	139·0	150·0	−0·44	$0\cdot12\times10^{-20}$			48·9	1·2	59	51·7	1·3	63
G166·0+4·3	VRO 42·05·0	44·0	6·6	−0·40	$0\cdot51\times10^{-21}$			60·6	4·7	355	32·7	2·6	192
G166·2+2·5	OA 184	76·0	10·0	−0·51	$0\cdot26\times10^{-21}$		5	72·3	3·3	143	57·8	2·6	114
G180·0−1·7	S147	171·0	66·0	−0·50	$0\cdot34\times10^{-21}$			67·5	1·4	−39	76·7	1·5	−45
G184·6−5·8	Tau A, Crab Nebula	3·5	1000·0	−0·26	$0\cdot12\times10^{-16}$	2·0	14	4·3	4·3	−431	2·2	2·2	−220
G189·1+2·9	IC 443	40·0	160·0	−0·40	$0\cdot15\times10^{-19}$	2·0		25·1	2·2	109	22·7	1·9	99
G193·3−1·5*	PKS 0607+17	80·0	27·0	−0·70	$0\cdot63\times10^{-21}$		2, 5	57·3	2·5	−63	59·1	2·5	−65
G194·7+0·4	Origem Loop	360·0	180·0	−0·30	$0\cdot21\times10^{-21}$		2	76·6	0·7	5	104·8	1·0	7
G205·5+0·2	Monoceros Loop	253·0	150·0	−0·44	$0\cdot35\times10^{-21}$	1·0	5	66·8	0·9	3	93·1	1·3	4
G206·9+2·3	PKS 0646+06	80·0	5·0	−0·50	$0\cdot12\times10^{-21}$		19	89·0	3·8	154	68·8	3·0	119
G260·4−3·4	Pup A	47·0	135·0	−0·48	$0\cdot92\times10^{-20}$			28·5	2·1	−123	24·6	1·8	−106
G261·9+5·5	PKS 0902−38	40·0	10·0	−0·38	$0\cdot94\times10^{-21}$			51·7	4·4	426	25·5	2·2	210
G263·9−3·0	Vela X, Y, Z	256·0	1750·0	−0·40	$0\cdot40\times10^{-20}$	0·5	16	35·4	0·5	−24	44·2	0·6	−30
G290·1−0·8	MSH 11−61A	12·6	66·0	−0·55	$0\cdot63\times10^{-19}$	> 3·4		17·3	4·7	−65	18·4	5·0	−69
G291·0−0·1	MSH 11−62	10·0	20·0	−0·44	$0\cdot30\times10^{-19}$			20·9	7·2	−12	28·7	9·9	−16
G292·0+1·8	MSH 11−54	2·3	15·0	−0·40	$0\cdot43\times10^{-18}$	> 3·7	14	10·5	15·6	491	5·2	7·8	244

Table 1 (*Continued*)

(1) Galactic number designation	(2) Other catalogue name	(3) θ (′)	(4) S (Jy)	(5) 1 GHz 'observed' data α	(6) Σ (W m^{-2} Hz^{-1} sr^{-1})	(7) d (kpc)	(8) Data ref. No.†	(9) Derived from $\Sigma-D$ D' (pc)	(10) d' (kpc)	(11) z' (pc)	(12) Corrected for $\lvert z \rvert$ D_c (pc)	(13) d_c (kpc)	(14) z_c (pc)
G293·8+0·6		9·0	5·3	−0·58	$0 \cdot 98\times10^{-20}$			28·0	10·7	112	25·0	9·6	100
G296·1−0·7		16·0	3·7	−0·70	$0 \cdot 22\times10^{-20}$			41·5	8·9	−108	37·1	8·0	−96
G296·5+10·0	PKS 1209−51/52	81·0	55·0	−0·45	$0 \cdot 13\times10^{-20}$			47·9	2·0	353	26·1	1·1	192
G296·8−0·3		14·9	8·6	−0·62	$0 \cdot 58\times10^{-20}$			32·1	7·4	−38	37·7	8·7	−45
G298·5−0·3		3·7	5·4	−0·36	$0 \cdot 59\times10^{-19}$			17·5	16·3	−84	17·3	16·1	−83
G298·6+0·0		8·3	4·2	−0·30	$0 \cdot 92\times10^{-20}$			28·5	11·8	2	41·5	17·2	3
G299·0+0·2		10·5	8·9	−0·39	$0 \cdot 12\times10^{-19}$			26·5	8·7	30	32·5	10·6	37
G302·3+0·7		16·5	5·4	−0·37	$0 \cdot 30\times10^{-20}$			38·2	8·0	97	35·5	7·4	90
G304·6+0·1	Kes 17	6·9	15·0	−0·47	$0 \cdot 47\times10^{-19}$	9·4		18·6	9·3	16	25·1	12·5	22
G308·7+0·0		7·3	12·0	−0·35	$0 \cdot 34\times10^{-19}$		14	20·3	9·5	2	30·0	14·1	2
G309·2−0·6		12·6	7·1	−0·38	$0 \cdot 67\times10^{-20}$			30·9	8·4	−87	29·8	8·1	−84
G309·8+0·0		19·2	17·0	−0·51	$0 \cdot 69\times10^{-20}$			30·7	5·5	1	44·8	8·0	1
G311·5−0·3		3·9	3·7	−0·48	$0 \cdot 37\times10^{-19}$	> 6·6		19·9	17·5	−91	19·1	16·9	−87
G315·4−0·3		16·0	10·0	−0·47	$0 \cdot 59\times10^{-20}$			32·0	6·9	−35	38·2	8·2	−42
G315·4−2·3	MSH 14−63, RCW 86	39·0	48·0	−0·62	$0 \cdot 47\times10^{-20}$	2·5		33·9	3·0	−119	29·4	2·6	−103
G316·3−0·0	MSH 14−57	17·1	26·0	−0·32	$0 \cdot 13\times10^{-19}$	> 7·2		25·8	5·2	0	38·1	7·7	0
G320·4−1·2	MSH 15−52, RCW 89	25·8	63·0	−0·34	$0 \cdot 14\times10^{-19}$	4·2		25·4	3·4	−70	26·2	3·5	−72
G321·9−0·3		24·2	13·0	−0·34	$0 \cdot 33\times10^{-20}$			37·1	5·3	−27	45·6	6·5	−33
G322·3−1·2*	Kes 24	5·8	5·0	−0·90	$0 \cdot 22\times10^{-19}$	> 20·0		22·6	13·4	−280	14·0	8·3	−173
G323·5+0·1		10·8	2·9	−0·41	$0 \cdot 37\times10^{-20}$			36·1	11·5	20	46·3	14·8	26
G326·3−1·8	MSH 15−56	36·0	145·0	−0·24	$0 \cdot 17\times10^{-19}$	> 1·5		24·3	2·3	−72	24·9	2·4	−74
G327·1−1·1		14·2	7·7	−0·36	$0 \cdot 57\times10^{-20}$			32·2	7·8	−149	25·9	6·3	−119
G327·4+0·4	Kes 27	21·0	30·0	−0·61	$0 \cdot 10\times10^{-19}$			27·7	4·5	32	33·6	5·5	38
G327·6+14·0	SN 1006AD	34·0	21·0	−0·57	$0 \cdot 27\times10^{-20}$	1·3		39·1	4·0	991	13·3	1·3	336
G328·0+0·3		6·4	2·5	−0·55	$0 \cdot 92\times10^{-20}$			28·5	15·3	80	28·3	15·2	80
G328·4+0·2	MSH 15−57	4·0	17·0	−0·24	$0 \cdot 16\times10^{-18}$			13·5	11·6	41	16·2	14·0	49
G330·0+15·0	Lupus Loop	368·0	340·0	−0·30	$0 \cdot 38\times10^{-21}$			65·6	0·6	159	50·5	0·5	122
G330·2+1·0		8·3	6·5	−0·30	$0 \cdot 14\times10^{-19}$			25·4	10·5	184	18·9	7·8	137
G332·0+0·2		12·0	9·3	−0·44	$0 \cdot 97\times10^{-20}$	> 6·6		28·1	8·1	28	34·8	10·0	35
G332·4+0·1	MSH 16−51	13·2	26·0	−0·51	$0 \cdot 22\times10^{-19}$	> 6·6		22·6	5·9	10	31·3	8·2	14

Table 1 (*Continued*)

(1) Galactic number designation	(2) Other catalogue name	(3) θ (′)	(4) S (Jy)	(5) 1 GHz 'observed' data α	(6) Σ ($\mathrm{W\,m^{-2}\,Hz^{-1}\,sr^{-1}}$)	(7) d (kpc)	(8) Data ref. No.†	(9) Derived from $\Sigma-D$ D' (pc)	(10) d' (kpc)	(11) z' (pc)	(12) Corrected for $\lvert z \rvert$ D_c (pc)	(13) d_c (kpc)	(14) z_c (pc)
G332·4−0·4	RCW 103	9·4	25·0	−0·55	$0\cdot43\times10^{-19}$	3·3		19·1	7·0	−48	21·8	8·0	−55
G335·2+0·1		18·6	18·0	−0·46	$0\cdot78\times10^{-20}$			29·7	5·5	10	41·0	7·6	13
G336·7+0·5		9·9	5·6	−0·45	$0\cdot86\times10^{-20}$			29·0	10·1	88	28·0	9·7	85
G337·0−0·1	CTB 33 (Part)	7·6	19·0	−0·40	$0\cdot50\times10^{-19}$			18·4	8·3	−13	25·1	11·3	−19
G337·2−0·7		3·9	2·1	−0·67	$0\cdot21\times10^{-19}$			23·0	20·3	−247	15·1	13·3	−162
G337·3+1·0	Kes 40	11·8	15·0	−0·49	$0\cdot16\times10^{-19}$			24·6	7·2	125	21·2	6·2	108
G337·8−0·1	Kes 41	10·6	17·0	−0·51	$0\cdot23\times10^{-19}$	>9·3		22·5	7·3	−12	30·7	10·0	−16
G338·2+0·4		11·7	2·0	−0·42	$0\cdot22\times10^{-20}$			41·4	12·2	85	40·0	11·7	82
G338·3−0·1		8·2	7·0	−0·66	$0\cdot16\times10^{-19}$			24·8	10·4	−17	32·7	13·7	−23
G338·5+0·1		12·4	27·0	−0·33	$0\cdot26\times10^{-19}$			21·6	6·0	10	30·0	8·3	15
G339·2−0·4*		9·9	6·2	−0·20	$0\cdot95\times10^{-20}$			28·2	9·8	−67	29·3	10·2	−70
G340·4+0·4		6·4	5·7	−0·41	$0\cdot21\times10^{-19}$			23·0	12·4	86	22·5	12·1	84
G340·6+0·3		4·9	5·1	−0·37	$0\cdot32\times10^{-19}$			20·6	14·4	76	21·0	14·7	77
G341·9−0·3	MSH 16−48	6·1	4·4	−0·59	$0\cdot18\times10^{-19}$			24·0	13·5	−70	24·8	14·0	−72
G344·7−0·1		7·8	3·0	−0·51	$0\cdot74\times10^{-20}$			30·1	13·3	−22	38·3	16·9	−28
G346·6−0·2		8·0	9·6	−0·49	$0\cdot23\times10^{-19}$			22·5	9·7	−33	27·2	11·7	−40
G348·5+0·1	CTB 37A	8·0	77·0	−0·33	$0\cdot18\times10^{-18}$	10·2		13·1	5·6	10	18·6	8·0	14
G348·7+0·3	CTB 37B	5·1	38·0	−0·30	$0\cdot22\times10^{-18}$	10·2		12·4	8·4	44	14·7	9·9	52
G349·7+0·2		1·7	21·0	−0·49	$0\cdot11\times10^{-17}$	18·3		8·2	16·5	58	9·2	18·7	65
G350·0−1·8		28·9	31·0	−0·51	$0\cdot56\times10^{-20}$			32·5	3·9	−120	28·1	3·3	−104
G350·1−0·1		4·1	5·6	−0·73	$0\cdot50\times10^{-19}$			18·3	15·3	−79	18·4	15·4	−80
G351·2+0·1		6·2	5·8	−0·38	$0\cdot23\times10^{-19}$			22·5	12·5	22	29·1	16·2	28
G352·7−0·1		6·4	5·8	−0·57	$0\cdot21\times10^{-19}$			22·9	12·3	−20	29·7	15·9	−27
G355·9−2·5		11·2	7·8	−0·51	$0\cdot94\times10^{-20}$			28·4	8·7	−379	15·0	4·6	−200
G357·7−0·1	MSH 17−39	4·3	38·0	−0·35	$0\cdot31\times10^{-18}$	>6·0	14	11·4	9·1	−15	15·7	12·5	−21

* For descriptive note, see Section 1*b* of text.

† References given in column 8:

1, Angerhofer *et al.* (1977).
2, Berkhuijsen (1974).
3, Becker and Kundu (1976).
4, Caswell (1977*b*).
5, Dickel and DeNoyer (1975).
6, Duin and Strom (1975).
7, Goss *et al.* (1977).
8, Goss *et al.* (1975).
9, Green *et al.* (1975).
10, Gull (1975).
11, Haslam *et al.* (1975).
12, Higgs *et al.* (1977).
13, Johnson (1975).
14, Lockhart *et al.* (1977).
15, Mathews *et al.* (1977).
16, D. K. Milne (unpublished data).
17, Roger and Costain (1976).
18, van den Bergh *et al.* (1973).
19, S. van den Bergh (personal communication).
20, Kazès and Caswell (1977).

The diameter D' of the SNR, obtained from Σ via equation (2) is given in column 9 of Table 1. The corresponding distances d' and z' of the SNR from the Sun and from the galactic plane are given in columns 10 and 11.

The $\Sigma - D$ relationship derived here (equation 1) has a steeper gradient than that obtained by Clark and Caswell (1976) using essentially the same data. This difference arises because equation (1) is derived from data for all SNRs with measured distances, whilst Clark and Caswell omitted those SNRs with low surface brightness ($\Sigma < 10^{-26}$ $\mathrm{W\,m^{-2}\,Hz^{-1}\,sr^{-1}}$ in Fig. 1). These latter objects, they claimed, define a very steep ($\Sigma \propto D^{-10}$) relation.

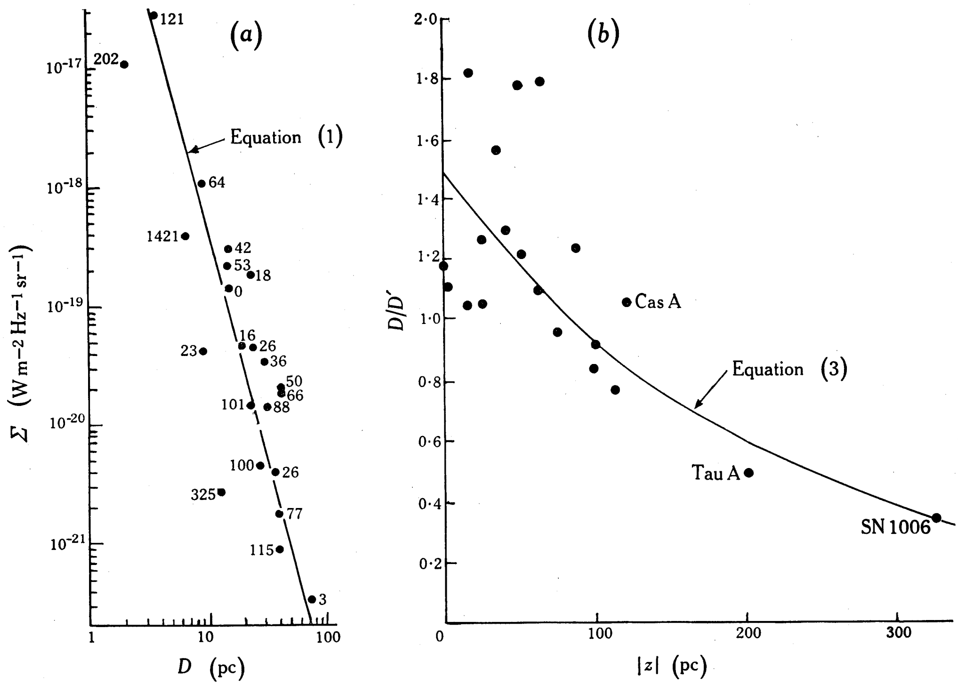

Fig. 1. Plots for SNRs in Table 1 with known distances (column 7) of:

(*a*) The variation of surface brightness Σ at 1 GHz as a function of the source diameter D, showing the best linear fit to these data (equation 1). True $|z|$ distances are given alongside the data points.

(*b*) The variation of the ratio D/D' of the true diameter to that calculated by inverting the derived $\Sigma - D$ relation (equation 2) as a function of the distance $|z|$ from the galactic plane, showing the best fitting exponential curve (equation 3).

Henning and Wendker (1975) and Caswell (1977*a*) suggested that an allowance should be made in the $\Sigma - D$ relationship for variations in density and magnetic field strength at varying distances from the galactic plane. Caswell and Lerche (1979, present issue pp. 79–82) have shown how this effect can be deduced quantitatively from the z variation of surface brightness across individual remnants. A $|z|$ effect is in fact somewhat evident in the $\Sigma - D$ diagram in Fig. 1*a*. The remnants at higher $|z|$ (where $|z|$ is calculated from the 'true' distance given in column 7) are systematically to the left-hand side of those at lower $|z|$. In the present paper we investigate the $\Sigma - D$ diagram to evaluate the $|z|$ effect independently of the method applied by Caswell and Lerche.

The $|z|$ effect in the $\Sigma-D$ diagram is better expressed in Fig. 1*b*, where the ratio D/D' of the true diameter to that estimated from the $\Sigma-D$ relationship (column 9) is plotted against $|z|$. (RCW 103 and Kepler's SNR, which are widely separated from the other data points, have been omitted; see discussion in Section 2.) If we assume an exponential relationship then the best fit to these points is given by

$$D/D' \equiv 1\cdot5\exp(-|z|/219), \tag{3}$$

where D, D' and $|z|$ are in parsecs. Our problem is to optimize the $\Sigma-D$ relation in terms of this correction.

Generalizing equations (2) and (3) we have

$$D/D' = A\exp(-|z|/z_0) \qquad \text{and} \qquad D' = B\Sigma^{\beta}, \tag{4}$$

where the primed quantities are uncorrected for the $|z|$ effect. Then the true diameter (or more correctly—the corrected diameter) D_c can be expressed in terms of the observed quantities Σ, θ and b (the galactic latitude) thus:

$$D_c\exp\big(D_c\sin(|b|/\theta z_0)\big) = k\Sigma^{\beta}, \tag{5}$$

where θ is in radians and $k = AB$. Using values of D and Σ for sources with known distances (and once again omitting RCW 103 and Kepler's SNR) best fitting values for k and z_0 are obtained when $\beta = -0\cdot25$. For this value we have

$$k = 4\cdot12\times10^{-4} \quad \text{pc}\,(\text{W m}^{-2}\,\text{Hz}^{-1}\,\text{sr}^{-1})^{-\beta} \qquad \text{and} \qquad z_0 = 214 \quad \text{pc}.$$

Then setting $|z| \equiv D_c\sin(|b|/\theta)$ in equation (5) we have

$$D_c = 4\cdot12\times10^{-4}\,\Sigma^{-0\cdot25}\exp(-|z|/214), \tag{6}$$

or

$$\Sigma = 2\cdot88\times10^{-14}\,D_c^{-4}\exp(-|z|/54). \tag{7}$$

It should be pointed out that the $|z|$ correction evaluated here depends heavily on the data for Tau A and AD 1006. If these are omitted then (for $1/\beta = -4\cdot0$) the scale height of $|z|$ in equation (6) increases to 307 pc, and the scale height of the $|z|$ effect in surface brightness (equation 7) increases from 54 to 78 pc. This indicates that the mean scale height is $\sim$66 pc with 50% uncertainty.

Diameters determined by iterative solution of equation (5) and corresponding distances from the Sun and the galactic plane are given in columns 12, 13 and 14 of Table 1. In the brief discussion given in Section 2 below these corrected values are used.

(*b*) *Notes on Some Catalogue Sources*

The following short notes refer to individual sources accompanied by an asterisk in column 1 of the table:

G32·0−4·9. 3C 396·1 is a doubtful source; see the cautionary note by Clark and Caswell (1976).

G78·1+1·8. A detailed discussion of the optical and radio features of the γ Cygni region is given by Baars *et al.* (1978).

G93·6–0·2. CTB 104A is most likely not an SNR. Its spectral index is heavily dependent on one doubtful observation (J. R. Dickel, personal communication).

G193·3 − 1·5. PKS 0607+17 is possibly part of the Origem Loop (Berkhuijsen 1974).

G322·3 − 1·2. Kes 24 is possibly an extragalactic source (Caswell *et al.* 1975).

G339·2 − 0·4. S. van den Bergh (personal communication) has found a faint 5′ arc nonfilamentary shell, possibly a planetary nebula, in this position.

2. Discussion

Clark and Caswell (1976) noted that the SNRs located closer to the galactic centre lie within a narrower range of z than those located at the edges of the Galaxy. This effect is apparent (though to a lesser extent) in Fig. 2, where z distances are plotted against galactocentric distances Δ: there is a slight thickening and upturn beyond 8 kpc apparent in this figure. The mean half-density thickness is 139 ± 137 pc centred about a mean z distance of $\langle z \rangle = -11$ pc within 8 kpc of the galactic centre; beyond 8 kpc we have 192 ± 131 pc about $\langle z \rangle = +32$ pc—an insignificant variation.

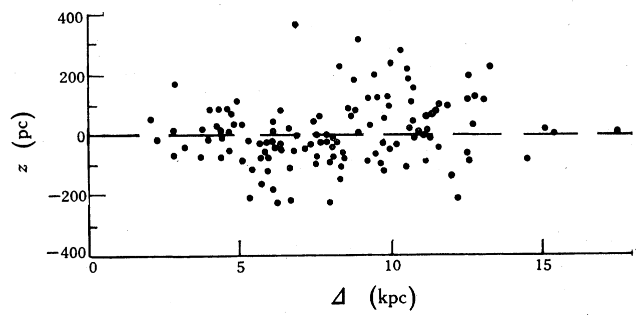

Fig. 2. Distribution for SNRs in Table 1 of the distance z from the galactic plane against the galactocentric distance Δ, calculated from the $|z|$-corrected $\Sigma - D$ relationship (via equation 6).

The cumulative $N(<D)-D$ diagram for the entire catalogue (Fig. 3) is most likely incomplete, representing perhaps only half of the SNRs in the Galaxy. However, over part of the distribution, the gradient is close to the 5/2 value predicted from Sedov's formula (Taylor 1950; Sedov 1959). Using this section of the distribution and applying the method given in Milne (1970), together with the assumption of Clark and Caswell (1976) that $E_0/n_H = 5 \times 10^{51}$ erg cm^3, we obtain a birth rate of one remnant-forming supernova every 60 years.

If we take only those remnants within 10 kpc of the Sun (Fig. 3) the birth rate is one every 140 years for about one-third of the Galaxy, or about one every 47 years for the whole Galaxy. Finally, if we restrict the distance to 5 kpc (about 1/10 of the Galaxy) then the birth rate is (with some uncertainty in defining the adiabatic section of the $N-D$ relation) 1/260 yr^{-1}, or one each 26 years for the entire Galaxy. It is suggested that these values are approaching the correct value, as the sample approaches completeness, and so we arrive at a birth rate of about one every 30 or 40 years rather than the lower rate of one every 150 years derived from the same E_0/n_H value by Clark and Caswell (1976).

The catalogue given here has advantages over that given by Clark and Caswell (1976). It is at the more convenient frequency of 1 GHz, all of the data are in the one table and corrections have been made for $|z|$ distance. Perhaps it is not as homogeneous as their table over a restricted portion of the Galaxy, but it is based on a consideration of all available SNR data rather than being biased toward the 408 MHz results. Only RCW 103 and Kepler's SNR have been rejected from the analysis. If the present model is correct then either the distances to these two sources are incorrect or else these sources are expanding in regions where the density and/or magnetic field do not follow the average model used here. Alternatively there may be energy losses, so that these remnants are not in the adiabatic regime implied by the $\Sigma - D$ relation. Kepler's SNR is at high $|z|$ distance in the galactic centre bulge, and most likely it is expanding in a region of higher density than prevails at much lower $|z|$ distances in regions further from the galactic centre. For RCW 103, I question the distance.

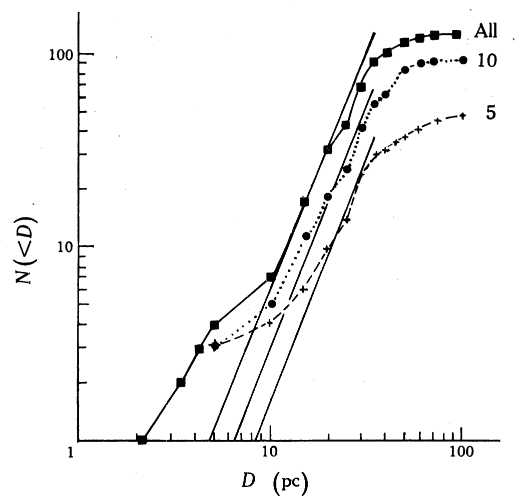

Fig. 3. Cumulative plots for SNRs in Table 1 of the number $N(<D)$ having diameters less than D as a function of D. The data are for SNRs that are less than 5 kpc from the Sun, less than 10 kpc from the Sun, and for all SNRs (as indicated). The straight lines denote the $D^{5/2}$ gradients expected for adiabatic expansion.

Clearly proper application of this method requires data for additional SNRs at high $|z|$ distances. It should also be remembered that the correction is only statistical, and local fluctuations in the magnetic field and the density will modify the distances obtained for individual remnants.

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