A Catalogue of Galactic Supernova Remnants (Version VI, 1996 August)

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1. The Catalogue Format

This catalogue of Galactic supernova remnants (SNRs) is an updated version of those presented in detail in Green (1984, 1988), in summary form in Green (1991, 1996) — hereafter Versions I, II, III and IV respectively — and on the World-Wide-Web (Version V, 1995 July). (Note that Version IV, although published in 1996, was produced in 1993.)

This, the 1996 August version of the catalogue contains 215 SNRs (which is 21 more than in Version V), with about thousand references in the detailed listings, plus notes on several dozen possible or probable remnants. For each remnant in the catalogue the following parameters are given.

- **Galactic Coordinates** of the source centroid quoted to the nearest tenth of a degree as is conventional.
- **Other Names** that are commonly used for the object. These are given in parentheses if the remnant is only a part of the source. For some object, notably the Crab Nebula, not all common names are given.
- **Right Ascension** and **Declination** of the source centroid. The accuracy of the quoted values depends on the size of the remnant; for small remnants they are to the nearest few seconds of time and the nearest minute of arc respectively, whereas for larger remnants they are rounded to coarser values, but are in every case sufficient to specify a point within the boundary of the remnant. These coordinates are almost always deduced from radio maps rather than from X-ray or optical observations, and are for B1950.0.
- **Angular Size** of the remnant, in arcminutes, usually taken from the highest resolution radio map available, although for some barely resolved sources that are thought to be SNRs the only available size is that from Gaussian models after deconvolution with the observed beam size. The boundary of most remnants approximates reasonably well to a circle or an ellipse; a single value is quoted for the angular size of the more nearly circular remnants, which is the diameter of a circle with an area equal to that of the remnant, but for elongated remnants the product of two values is quoted, and these are the major and minor axes of the remnant boundary modelled as an ellipse. In a few cases an ellipse is not a satisfactory description of the boundary of the object (refer to the description of the individual object given in its catalogue entry), although an angular size is still quoted for information. For 'filled-centre' remnants the size quoted is for the largest extent of the observed radio emission, not, as at times has been used, the half-width of the centrally brightened peak.
- **Flux Density** of the remnant at 1 GHz in jansky. This is *not* a measured value, but that deduced from the observed radio frequency spectrum of the source. The frequency of 1 GHz is chosen because flux density measurements at frequencies both above and below this value are usually available.

- **Spectral Index** of the integrated radio emission from the remnant, α (here defined in the sense, $S \propto \nu^{-\alpha}$, where S is the flux density at a frequency ν), either a value that is quoted in the literature, or one deduced from the available integrated flux densities of the remnant. For several SNRs a simple spectral model is not adequate to describe their radio emission because there is evidence that the spectral index varies across the face of the remnant or that the integrated spectrum is curved, and in these cases the spectral index is given as 'varies' (refer to the description of the remnant and recent references in the catalogue entry for more information). In some cases, for example where the remnant is highly confused with thermal emission, the spectral index is given as '?' since no value can be deduced with any confidence.
- **Type** of the SNR, either 'S', 'F' or 'C' if the remnant shows a 'shell', 'filled-centre' or 'composite' (or 'combination') radio structure (or 'S?', 'F?' or 'C?', respectively, if there is some uncertainty), or '?' in several cases where an object is conventionally regarded as an SNR even though its nature is poorly known or not well understood.

In the detailed listings, for each remnant, notes on a variety of topics are given. First, it is noted if other Galactic coordinates have at times been used to label it (usually before good observations have revealed the full extent of the object), if the SNR is thought to be the remnant of a historical SN, or if the nature of the source as an SNR has been questioned (in which case an appropriate reference is usually given later in the entry). Brief descriptions of the remnant from the available radio, optical and X-ray observations as applicable are then given, together with notes on available distance determinations, and any point sources or pulsars in the field of the object (although they may not necessarily be related to the remnant). Finally, appropriate references to observations are given for each remnant, complete with journal, volume, page, and a short description of what information each paper contains (for radio observations these include the telescopes used, the observing frequencies and resolutions, together with any flux density determinations). These references are *not* complete, but cover representative and recent observations of the remnant, and they should themselves include references to earlier work. The references do not generally include large observational surveys — of particular interest in this respect are: the Effelsberg 100-m survey at 2.7 GHz of the Galactic plane $358° < l < 240°$, $|b| < 5°$ by Reich *et al.* (1990) and Fürst *et al.* (1990); reviews of the radio spectra of some SNRs by Kassim (1989) and by Kovalenko, Pynzar' & Udal'tsov (1994); the Parkes 64-m survey at 2.4 GHz of the Galactic plane $238° < l < 365°$, $|b| < 5°$ by Duncan *et al.* (1995); reviews of *Einstein* X-ray imaging and *FPCS* observations of Galactic SNRs by Seward (1990) and Lum *et al.* (1992) respectively; surveys of *IRAS* observations of SNRs and their immediate surroundings by Arendt (1989) and by Saken, Fesen & Shull (1992); and the survey of HI emission towards SNRs by Koo & Heiles (1991).

A summary of the data available for all 215 remnants in the catalogue is given in Table I. The other names for SNRs are listed in Table II, and the abbreviations for journals, proceedings and telescopes (both radio and X-ray) used here are listed in Table III. The detailed listings for each SNR are given in Table IV.

2. Revisions and Notes

2.1 Objects no longer thought to be SNRs

The following objects, which were listed in Version I of the catalogue were removed because they were no longer thought to be remnants, or are poorly observed (see Version II for references and further details): G2.4+1.4 (see also Gray 1994a; Goss & Lozinskaya 1995; Polcaro *et al.* 1995), G41.9−4.1 (=CTB 73, PKS 1920+06), G47.6+6.1 (=CTB 63), G53.9+0.3 (part of HC40), G93.4+1.8 (=NRAO 655), G123.2+2.9, G194.7+0.4 (the Origem Loop), G287.8−0.5 (see below), G322.3−1.2 (=Kes 24) and G343.0−6.0 (see below).

G350.1−0.3, which was listed in Version II of the catalogue, was removed as it is no longer thought to be a SNR (see Version III for details).

G358.4−1.9, which was listed in Version IV of the catalogue, was removed, as following the discussion of Gray (1994a), as it is not clear that this is a SNR.

In this version of the catalogue the following have been removed:

- G240.9−0.9, as Duncan *et al.* (1996) show that it is not a distinct SNR;
- G299.0+0.2 and G328.0+0.3, following improved radio observations, and comparisons with IRAS data by Whiteoak & Green (1996) which showed that these are not SNRs.

The following objects, which have been reported as SNRs, but have not been included in any of SNR catalogues, have subsequently been shown not to be SNRs.

- G70.7+1.2, which was reported as a SNR by Reich *et al.* (1985), but this has not been confirmed by later observations (see Green 1986; de Muizon *et al.* 1988; Becker & Fesen 1988; Caswell 1988; Bally *et al.* 1989; Phillips, Onello & Kulkarni 1993; Onello *et al.* 1995).
- G81.6+1.0 a possible SNR in W75 reported by Ward-Thompson & Robson (1991). From the published data (see the observations in Wendker, Higgs & Landecker 1991) it was noted in Version IV of the catalogue that this is thermal source not a SNR, because of its thermal radio spectrum, and high infrared-to-radio emission (see the subsequent discussion by Wendker *et al.* 1993).
- Green & Gull (1984) suggested that G227.1+1.0 as a very young SNR, but subsequent observations (Channan *et al.* 1986; Green & Gull 1986) have shown that this is most likely an extragalactic source, not an SNR.
- A candidate SNR, G274.7−2.8, identified by Helfand & Channan (1989), has been shown not to be a SNR by Caswell & Stewart (1991).
- G25.5+0.2, which was reported as a very young SNR by Cowan *et al.* (1989), although this identification was not certain (see White & Becker 1990; Green 1990; Zijlstra 1991). Sramek *et al.* (1992) report the detection of recombination lines from this source (also see Subrahmanyan *et al.* 1993). Becklin *et al.* (1994) identify G25.5+0.2 as a ring nebula around a luminous blue star.
- Most of the possible SNRs listed by Gorham (1990) — following up SNR candidates suggested by Kassim (1988) — have been shown not to be SNRs by Gorham, Kulkarni & Prince (1993).

Some entries in the catalogue have been renamed, due to improved observations revealing a larger true extent for the object (G5.3−1.0 is now G5.4−1.2; G193.3−1.5 is now G192.8−1.1; G308.7+0.0 is now incorporated into G308.8−0.1).

2.2 New SNRs

The following remnants were added to Version II of the catalogue: G0.9+0.1, G1.9+0.3, G5.9+3.1, G6.4+4.0, G8.7−0.1, G16.8−1.1, G18.9−1.1, G20.0−0.2, G27.8+0.6, G30.7+1.0, G31.5−0.6, G36.6−0.7, G42.8+0.6, G45.7−0.4, G54.1+0.3, G73.9+0.9, G179.0+2.6, G312.4−0.4, G357.7+0.3 and G359.1−0.9.

The following remnants were added to Version III of the catalogue: G4.2−3.5, G5.2−2.6, G6.1+1.2, G8.7−5.0, G13.5+0.2, G15.1−1.6, G16.7+0.1, G17.4−2.3, G17.8−2.6, G30.7−2.0, G36.6+2.6, G43.9+1.6, G59.8+1.2, G65.1+0.6, G68.6−1.2, G69.7+1.0, G279.0+1.1, G284.3−1.8 (=MSH 10−5*3*), G358.4−1.9 and G359.0−0.9.

The following remnants were added to Version IV of the catalogue: G59.5+0.1, G67.7+1.8, G84.9+0.5, G156.2+5.7, G318.9+0.4, G322.5−0.1, G343.1−2.3, and G348.5−0.0.

The following remnants were added to Version V of the catalogue: G1.0−0.1, G1.4−0.1, G3.7−0.2, G3.8+0.3, G28.8+1.5, G76.9+1.0, G272.2−3.2, G341.2+0.9, G354.1+0.1, G355.6−0.0, G356.3−0.3, G356.3−1.5 and G359.1+0.9.

The following remnants have been added to this version of the catalogue:

- G13.3−1.3 and G299.2−2.9, both identified from ROSAT observations by Seward *et al.* (1995) and Busser, Egger & Aschenbach (1996) respectively;
- G286.5−1.2, G289.7−0.3, G294.1−0.0, G299.6−0.5, G301.4−1.0, G308.1−0.7, G310.6−0.3, G310.8−0.4, G315.9−0.0, G317.3−0.2, G318.2+0.1, G320.6−1.6, G321.9−1.1, G327.4+1.0, G329.7+0.4, G342.1+0.9, G343.1−0.7, G345.7−0.2, G349.2−0.1, G351.7+0.8, G351.9−0.9 and G354.8−0.8, identified or confirmed as SNRs from the MOST radio survey of Whiteoak & Green (1996).

2.3 Possible and probable SNRs not listed in the catalogue

The following are possible or probable SNRs for which further observations are required to confirm their nature or parameters, or for which observations are not yet in the published literature.

2.3.1 Radio

- A possible SNR near the Galactic centre reported by Ho *et al.* (1985) from radio observations.
- Gosachinskiĭ (1985) reported evidence for non-thermal radio emission, presumably from SNRs, associated with several bright, thermal Galactic sources (also see Odegard 1986, who questions the reliability of some of Gosachinskiĭ's results).
- G300.1+9.4, a possible SNR nearly 2° in diameter reported by Dubner, Colomb & Giacani (1986) from radio observations.
- Routledge & Vaneldik (1988) report a possible faint shell SNR nearly 2° in diameter at radio wavelengths, near the young pulsar PSR 1930+22 (see also Gómez-González & del Romero 1983, who report a smaller (about 40 arcmin) possible SNR (G57.1+1.7) associated with this pulsar, and see Caswell, Landecker & Feldman 1985 and Kovalenko 1989).
- G28.6−0.2, a possible SNR reported by Helfand *et al.* (1989) from radio observations.
- Seven possible remnants (G45.9−0.1, G55.2+0.5, G63.7+1.1, G71.6−0.5, G72.2−0.3, G83.0−0.2 and G85.2−1.2) of the eleven reported by Taylor, Wallace & Goss (1992) from a radio survey of part of the Galactic plane. (One of the other possible SNRs reported by Taylor *et al.*, G76.9+0.9, has now been included in the catalogue, but is called G76.9+1.0, see above.)
- A faint, poorly defined possible remnant G41.1+1.2 reported by Gorham *et al.* (1993) from radio observations.
- G9.7−0.1, a possible SNR report by Frail, Kassim & Weiler (1994) from radio observations.
- Ten (G355.4+0.7, G356.6+0.1, G357.1−0.2, G358.1+1.0, G358.5−0.9, G358.7+0.7, G359.2−1.1, G0.3+0.0, G3.1−0.6 and G4.2+0.0) of the seventeen possible SNRs listed by Gray (1994b) from radio observations near the Galactic centre (see also Dagkesamanskii, Kovalenko & Udal'tsov 1994, who from radio observations also suggest a SNR, G0.4+0.1, in the Galactic centre region which presumably related to G0.3+0.0 suggested by Gray).
- G104.7+2.8, a possible SNR reported by Green & Joncas (1994) from radio observations. However, recent observations at 10.7 GHz (W. Reich, private communication) cast doubt on this identification, as they do not support a non-thermal radio spectrum for the source.
- G310.6−0.2 and G310.8−0.4, two possible radio SNRs listed by Whiteoak, Cram & Large (1994).
- G11.2−1.1, a possible SNR listed by Kovalenko, Pynzar' & Udal'tsov (1994), based on unpublished radio studies (Trushkin 1988, preprint).
- Duncan *et al.* (1995) list 10 large-scale (1.5 to 10 degree), and 22 smaller, low radio surface-brightness candidate SNRs.
- Whiteoak & Green (1996) list sixteen possible SNRs (G308.4−1.4, G317.5+0.9, G319.9−0.7, G320.6−0.9, G322.7+0.1, G322.9−0.0, G323.2−1.0, G324.1+0.1, G325.0−0.3, G331.8−0.0, G337.2+0.1, G339.6−0.6, G345.1+0.2, G345.1−0.2, G348.8+1.1 and G350.1−0.3) from their radio survey of much of the southern Galactic plane.

2.3.2 Optical/Infra-red

- G343.0−6.0 was listed in Version I as a SNR, identified optically by Meaburn & Rovithis (1977). However, it was removed from the catalogue in Version II as its extent is uncertain, and it has not been identified at other wavelengths (also see Bedford *et al.* 1984; Meaburn *et al.* 1991).
- A possible SNR overlapping G296.1−0.5, identified from optical (and X-ray) observations by Hutchings, Crampton & Cowley (1981).
- A SNR (G260.4−3.3) about 4 arcmin in diameter within the Puppis A remnant identified optically by Winkler *et al.* (1989). This has not been detected at radio wavelengths (Dubner *et al.* 1991).
- A possible SNR (G32.1+0.1) reported from optical spectroscopy by Thompson, Djorgovski & de Carvalho (1991), following up radio and infrared observations of Jones, Garwood & Dickey (1988).
- G203.2−12.3, a optical ring about 3 arcmin in diameter, which was identified as a SNR by Winkler & Reipurth (1992).

- G75.5+2.4, a possible large (about 2°) old SNR in Cygnus suggested by Nichols-Bohlin & Fesen (1993) from infra-red and optical observations (see also Dewdney & Lozinskaya 1994).
- A possible optical SNR (G247.8+4.9) noted by Weinberger (1995), which may be Balmer dominated.

2.3.3 X-ray

- H1538−32 a large X-ray source in Lupus, near $l = 307°$, $b = 20°$ (Reigler, Agrawal & Gull 1980, see also Colomb, Dubner & Giacani 1984) which is a possible old SNR;
- The Monogem ring, near $l = 203°$, $b = +12°$, is a possible old SNR (see Nousek *et al.* 1981; Plucinsky *et al.* 1996, and references therein).
- X-ray emission in the Gum Nebula near $l = 250°$, $b = 0°$ (Leahy, Nousek & Garmire 1992, see also Reynolds 1976, Dubner *et al.* 1992 and Duncan *et al.* 1996) which, together with optical spectra indicate a possible old remnant;
- an X-ray enhancement due to an old SNR in Eridanus near $l = 200°$, $b = -40°$ (Naranan *et al.* 1976, see also Burrows *et al.* 1993 and Snowden *et al.* 1995).
- G189.6+3.3, a faint, possible SNR overlapping G189.1+3.0 (=IC443) identified by Asaoka & Aschenbach (1994) from ROSAT X-ray observations.
- G117.7+0.6, a faint shell of soft X-ray emission near CTB1 (=G116.9+0.2), which contains a pulsar (Hailey & Craig 1995).

2.3.4 Other

- G284.2−1.8 (=MSH 10−5*3*), which was listed in early SNR catalogues, but subsequently rejected because of its apparent thermal spectrum (see Version II for details). Ruiz & May (1986) report optical and CO radio observations that indicate the presence of shock-excited material in this region, supporting the SNR identification, although the parameters of any SNR are not well defined.
- G287.8−0.5, which is associated with η Carinae, was listed in Version I as a SNR, but was removed from the catalogue in Version II as its parameters are uncertain (see Jones 1973, Retallack 1984, Tateyama, Strauss & Kaufmann 1991, and the discussion in Version II).
- G359.2−0.8 (the 'mouse'), near the Galactic centre, which has been suggested as being analogous to the central region of CTB 80 (=G69.0+2.7) by Predehl & Kulkarni (1995).

Finally, it should be noted that some radio loops in the Galactic plane (see Berkhuijsen 1973) may be parts of very large, old SNRs, but they have not been included in the catalogue (see also Combi *et al.* 1995).

2.4 Questionable SNRs listed in the catalogue

As noted in Versions II and IV of the catalogue, the following sources are listed as SNRs, although, as discussed in each case, the identifications are not certain: G5.4−1.2, G39.7−2.0 (=W50), G65.7+1.2 (=DA 495), G69.0+2.7 (=CTB 80), G318.9+0.4 and G357.7−0.1. The nature of G76.9+1.0 (an unusual radio source similar to G65.7+1.2 (=DA 495)), and of G354.1+0.1 (which appears may be similar to G357.7−0.1 (=MHS 17−3*9*)) are also uncertain (see Landecker, Higgs & Wendker 1993 and Frail, Goss & Whiteoak 1994 respectively).

There are also some objects that have been identified as SNRs and are listed in the catalogue, although they have been barely resolved in the available observations, or are faint, and have not been well separated from confusing background or nearby thermal emission, and their identification as SNRs, or at least their parameters remain uncertain.

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