A SEARCH FOR PULSARS ASSOCIATED WITH SUPERNOVA REMNANTS IN THE GALAXY AND THE MAGELLANIC CLOUDS

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It is widely accepted and almost certainly true that both pulsars and supernova remnants (SNRs) are products of the collapse of a star at the end of its evolution. Given this, it is a considerable puzzle why, of the more than 120 known SNRs in the Galaxy, only two have unambiguously associated pulsars. Beaming of the pulsar emission probably accounts for the absence of detectable pulsars in up to 80% of the SNRs; however, this still leaves 20-30 SNRs in which one should be able to detect a pulsar. Vivekanand and Narayan (1981) show that there is a deficit of pulsars with periods $\lesssim$0.5 s and suggest that a majority of pulsars do not become active for a time $\sim 10^4$ years after their birth. This would account for the lack of pulsar-SNR associations. It is however possible that the observed lack of short-period pulsars is simply due to observational selection. In the past, most pulsar searches have been made at relatively low radio frequencies, typically close to 400 MHz. At these frequencies SNRs are bright and the effects of interstellar scattering are significant, especially for distant, short-period pulsars. Further, most of these searches have used a relatively long sampling interval, typically about 20 ms, which further reduces the sensitivity for short-period pulsars.

We have undertaken a survey specifically designed to avoid these selection effects. The Parkes 64-m telescope was used in two sessions, November 1981 and March 1982, with a dual-channel cooled FET receiver operating at a frequency of 1.4 GHz. Each channel was divided into four adjacent 5 MHz bands and the detected output of each band sampled at 2-ms intervals. In off-line analysis the data were de-dispersed and searched for periodicities. For typical observation times of 20 min, the limiting sensitivity was $\sim$1 mJy for pulsars with periods in the range 20 ms to 4 s and dispersion measures $\lesssim$1800 cm^{-3} pc. A total of 55 galactic SNRs, 30 Magellanic Cloud SNRs, three COS-B error circles (Swanenburg et al., 1981) and about 20 miscellaneous objects were searched.

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TABLE 1 - Parameters of pulsars detected at 1.4 GHz.

PSR	R.A. (1950)	Dec. (1950)	P (s)	DM (cm^{-3} pc)	Association
Definite					
1338-62	$13^h38^m30^s\pm20^s$	-62°08'±2'	0.1932024	885±45	G308.7+0.0
1509-58	$15^h09^m59^s.5$*	-58°56'57"*	0.15021718	235±25	G320.4-1.4 X-ray pulsar
1758-23	$17^h58^m15^s\pm30^s$	-23°05'±3'	0.4157644	1050±100	W28, CG006-00
Probable					
1758-24	$17^h58^m29^s\pm45^s$	-24°50'±10'	0.1248315	260±60	G5.3-1.0
1802-23	$18^h02^m45^s\pm45^s$	-23°22'±10'	0.1125343	400±100	CG006-00

*X-ray position (Seward and Harnden, 1982).

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The results of the search are summarized in Table 1. Three pulsars were detected and confirmed; for two other objects, periodic signals were detected but not confirmed. All five detections are associated with galactic objects. The most interesting detection is that of PSR 1509-58, which is also observed as an X-ray pulsar (Seward and Harnden, 1982). This pulsar, the radio detection of which has been previously reported by the present authors (Manchester et al., 1982), is close to the centre of the SNR G320.4-1.4 (MSH 15-52); it is most probably associated with this SNR and hence joins the Crab and Vela examples as a third relatively unambiguous pulsar-SNR association.

The two other confirmed pulsars are interesting in that their dispersion measures are very high - in the case of 1758-23, more than twice the previously highest value (Manchester and Taylor, 1981). PSR 1338-62 is close to but outside the radio contours of the SNR G308.7+0.0 (Caswell et al., 1981) and is probably not associated with this SNR. Similarly PSR 1758-23 is outside the radio contours of W28 (Shaver and Goss, 1970) but within the error circle for the COS-B γ-ray source CG006-00 and is probably not associated with either object. The two unconfirmed detections are both short-period pulsars, and it is important to confirm their reality and (if confirmed) to improve their positions in order to establish any association. A further result from this search is an upper limit on the pulsed flux from the central object in RCW 103 (Tuohy et al., 1982), which strengthens the case for interpreting the X-ray emission from this object as thermal emission from the surface of a neutron star.

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