Searching for sub-millisecond pulsars from highly polarized radio sources

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Abstract. Pulsars are among the most highly polarized sources in the universe. The NVSS has catalogued 2 million radio sources with linear polarization measurements, from which we have selected 253 sources, with polarization percentage greater than 25\%, as targets for pulsar searches. We believe that such a sample is not biased by selection effects against ultra-short spin or orbit periods. Using the Parkes 64m telescope, we conducted searches with sample intervals of 0.05 ms and 0.08 ms, sensitive to submillisecond pulsars. Unfortunately we did not find any new pulsars.

1. Introduction

The NRAO VLA Sky Survey (NVSS; Condon et al. 1998) contains 1.8 million radio sources with flux density at 1400 MHz greater than 2.5 mJy with linear polarization information. Many pulsars are known to have high linear polarization on average. Han & Tain (1999) identified 97 known pulsars from the NVSS source catalogue and they found that, on average, the linear polarization percentage of pulsars is much higher than that of other classes of objects such as quasars and BL-Lac objects. Therefore, high linear polarization can be used as a criterion for selecting pulsars with all kinds of possible periods, including submillisecond pulsars for which normal untargeted surveys are presently impossible. Submillisecond pulsars could be strange-quark stars, which have been explored theoretically (e.g. Madsen 1998), but with no detection observationally yet (e.g. Edwards et al. 2001).

We have selected 253 unresolved sources with high linear polarization (linear polarization percentage $L/S > 25\%$; the uncertainty of $L/S < 10\%$) from the NVSS catalog and searched for pulsed emission. These sources have a flux density which is generally larger than $\sim 4$ mJy. To have been missed by previous pulsar surveys, they must have some combination of the following properties: short (millisecond) pulse period, short orbital period, and/or high dispersion. Most of these sources are at relatively high Galactic latitudes and so the first two properties are likely to be the most important if they are pulsars.

We searched for short-period pulsed emission from these selected sources by using Parkes 64m telescope in October 8-19 1999 and December 9-11 1999. The central beam of the 20-cm multibeam system was used, having a system temperature of 21 K and a gain of 0.735 K Jy$^{-1}$. The two orthogonally polarized
Figure 1. The minimum detectable flux density at 8\(\sigma\), assuming the pulse has a width of 10\% of period. Solid lines are for the 512x0.5MHz system, and dashed lines for the 256x0.25MHz system, each with 5 DM values (bottom to top): 0, 20, 40, 80, and 160 pc cm\(^{-3}\). Dash-dotted lines are for the converted sensitivity of Parkes 70 cm pulsar survey. Our searches are sensitive to sub-millisecond pulsars.

Signals were amplified and fed to a filter-bank system, which was used in one of two configurations: 512 channels of 0.5 MHz bandwidth centered at 1261.75 MHz, or 256 channels of 0.25 MHz bandwidth centered on 1293 MHz. After detection of each channel, the two polarization signals were added together and 1-bit digitized. Data were sampled every 0.08 ms for a total observation time of 340 seconds for the 512x0.5 MHz system, and 0.05 ms sample time for 450 seconds for the 256x0.25 MHz system.

Data-processing consisted of sub-band dedispersion, fine-dedispersion and periodicity search. As shown in Fig.1, our search is very sensitive to submillisecond pulsars up to a dispersion measure of 80 pc cm\(^{-3}\), much better than the Parkes 70 cm pulsar survey (Manchester et al. 1996) which had a sensitivity of 3 mJy at 400 MHz for long period pulsars, corresponding to about 0.5 mJy at 1400 MHz for a typical pulsar spectral index of \(-1.5\). That survey was insensitive to pulsars with period less than 2 ms for typical DMs.

No new pulsars were detected though test observations of known pulsars gave results as expected. This null result implies that either radio pulsars do not have pulse periods of less than 1 ms, or submillisecond pulsars are not highly polarized radio sources.

References