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Searching for Submillisecond 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 cataloged 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 64-m telescope, we conducted searches with sample intervals of 50 μs and 80 μs, 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 & Tian (1999) identified 97 known pulsars from the NVSS source catalog 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 no period bias, including submillisecond pulsars for which normal untargeted surveys are difficult. Submillisecond pulsars could be strange-quark stars (e.g. Madsen 1998), but are so far undetected (e.g. Edwards, van Straten & Bailes 2001).

2. The Search

We have selected 253 unresolved sources with high linear polarization (linear polarization percentage $L/S > 25\%$; 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.

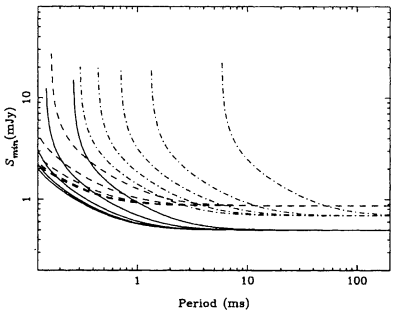

Figure 1. The minimum detectable flux density at 8σ, assuming the pulse has a width of 10% of period. Solid lines are for the 512×0.5 MHz system, and dashed lines are for the 256×0.25 MHz system, each with 5 DM values (bottom to top): 0, 20, 40, 80, and 160 pc cm^{-3}. Dash-dotted lines are for the converted sensitivity of the Parkes 70 cm pulsar survey. Our searches are sensitive to submillisecond pulsars.

We searched for short-period pulsed emission from these selected sources by using the Parkes telescope on 1999 Oct 8–19 and Dec 9–11. 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 signals were amplified and fed to a filterbank system, which was used in one of two configurations: 512 channels of 0.5 MHz bandwidth centered at 1390 MHz, or 256 channels of 0.25 MHz bandwidth centered on 1362 MHz. After detection of each channel, the two polarization signals were added together and 1-bit digitized. Data were sampled every 80 μs for 340 seconds for the 512×0.5 MHz system, and a 50 μs sample time was used for 450 seconds for the other system.

Data processing consisted of sub-band dedispersion, fine dedispersion and periodicity search. As shown in Figure 1, our search is very sensitive to submillisecond pulsars up to a dispersion measure of DM = 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 pulsars were discovered though observations of known pulsars gave results as expected. This result implies that either radio pulsars do not have pulse periods of less than 1 ms, or submillisecond pulsars are not highly polarized.

References

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