2000

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Repository Citation

"A Search for Submillisecond Pulsations from Unidentified FIRST and NVSS Radio Sources" F. Crawford, V. M. Kaspi, & J. F. Bell, Astronomical Journal, 119, 2376 (2000).

The Astronomical Journal, 119:2376–2381, 2000 May

A SEARCH FOR SUBMILLISECOND PULSATIONS IN UNIDENTIFIED FIRST AND NVSS RADIO SOURCES

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Received 1999 June 22; accepted 2000 January 25

ABSTRACT

We have searched 92 unidentified sources from the Faint Images of the Radio Sky at Twenty Centimeters (FIRST) and NRAO VLA Sky Survey (NVSS) 1400 MHz radio survey catalogs for radio pulsations at 610 MHz. The selected radio sources are bright, have no identification with extragalactic objects, are pointlike, and are more than 5% linearly polarized. Our search was sensitive to submillisecond pulsations from pulsars with dispersion measures less than ~ 500 pc cm^{-3} in the absence of scattering. We have detected no pulsations from these sources and consider possible effects that might prevent detection. We conclude that, as a population, these sources are unlikely to be pulsars.

Key words: pulsars: general — radio continuum — surveys

1. INTRODUCTION

The Faint Images of the Radio Sky at Twenty Centimeters survey (FIRST) and the NRAO VLA Sky Survey (NVSS) are recent 1400 MHz Very Large Array (VLA) radio surveys of the northern sky. The FIRST survey is an ongoing survey of the north and south Galactic caps using the VLA in B configuration with a synthesized beam size of 5″.4 (Becker, White, & Helfand 1995). In the published FIRST catalog of radio sources from the first two observing sessions in 1993 and 1994 (White et al. 1997), 1550 deg^2 of the north Galactic cap, spanning $7^{\rm h} < \alpha < 18^{\rm h}$ and $+28^\circ < \delta < +42^\circ$ (J2000.0), were covered. The positions and flux densities of $\sim 1.4 \times 10^5$ discrete radio sources are complete down to a flux density of ~ 1 mJy.[4] The NVSS (Condon et al. 1998) covers $\delta > -40^\circ$ (82% of the celestial sphere) and catalogs more than 1.8×10^6 sources, complete down to a flux density of ~ 2.5 mJy. The NVSS was conducted with the VLA in D and DnC configurations, with a synthesized beam size of 45″. The NVSS also preserves polarization information.

Several large-scale pulsar surveys have previously been conducted at high Galactic latitudes (see Camilo 1997 and references therein). However, the rates at which the received analog power was sampled and digitized in these surveys, typically 3–4 kHz, and the low observing radio frequencies (~ 400 MHz), combined with relatively large radio frequency channel bandwidths between 125 kHz and 1 MHz, restricted their sensitivity to submillisecond pulsars to very small dispersion measures (DMs) (DM $\lesssim 10$ pc cm^{-3}). Large-scale surveys that maintain sensitivity to submillisecond periodicities over a wide range of DMs are difficult: the fast sampling rate and small radio frequency channel bandwidth required currently make large total bandwidths and long integration times impractical. However, a targeted search for submillisecond pulsations is possible using narrow frequency channels and a fast sampling rate. Such a survey is of course also sensitive to long-period pulsars that may have been missed in previous surveys because of radio-frequency interference or scintillation.

Consideration of the properties of known recycled pulsars and representative models of magnetic field decay and equations of state suggests that a significant population of submillisecond pulsars could be present in the Galaxy (see, e.g., Possenti et al. 1998). It is possible, therefore, that some of the sources that remain unidentified in radio survey catalogs could be bright submillisecond radio pulsars that have previously escaped detection in high-latitude pulsar surveys. To date, no pulsar has been found with a period shorter than that of the first millisecond pulsar discovered, PSR B1937+21, which has a 1.56 ms period (Backer et al. 1982). The discovery of a submillisecond pulsar would place important constraints on the equation of state of neutron matter at high densities (see, e.g., Kulkarni 1992).

2. TARGET CHOICE AND OBSERVATIONS

The FIRST and NVSS surveys contain a number of bright sources that are unresolved and have no identification in other wave bands. Although over 99% of bright sources ($S_{1400} > 60$ mJy) found in previous large-scale surveys are believed to be active galactic nuclei (Condon et al. 1998), many sources in the FIRST and NVSS catalogs remain unidentified. One possibility is that they are previously unrecognized radio pulsars. Since pulsars often have a high degree of linear polarization (Lyne & Manchester 1988), polarized sources are good targets for pulsar searches. Han & Tian (1999) have identified 97 objects in the NVSS catalog that are coincident with known pulsars. Of the 89 redetected pulsars in Table 1 of their paper for which the degree of linear polarization could be determined from the NVSS observations, only eight had an observed

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[4] The on-line catalog is updated regularly as observing proceeds and currently contains more than 5.4×10^5 sources derived from data taken from 1993 to 1998 (1999 July 21 catalog version; see http://sundog.stsci.edu/first/catalogs.html).

TABLE 1

Observed Sources

Source	FIRST Source?	α (J2000.0)	δ (J2000.0)	S_{1400}[a] (mJy)	Percent Polarization[b]
0002−1952......	N	00 02 40.965	−19 52 52.43	58	9
0004−1148......	N	00 04 04.905	−11 48 58.52	450	6
0011−2254......	N	00 11 09.912	−22 54 58.64	37	9
0014−2800......	N	00 14 44.065	−28 00 47.39	52	14
0023−2155......	N	00 23 30.215	−21 55 37.73	135	8
0024+0308......	N	00 24 49.369	+03 08 34.65	68	9
0026−1112......	N	00 26 51.454	−11 12 52.57	166	7
0027−3030......	N	00 27 02.074	−30 30 32.16	24	13
0032−2649......	N	00 32 33.032	−26 49 17.70	131	6
0037−2323......	N	00 37 08.808	−23 23 40.65	66	5
0040+1329......	N	00 40 21.805	+13 29 37.72	34	9
0051+0229......	N	00 51 51.304	+02 29 44.11	15	20
0054−1754......	N	00 54 10.786	−17 54 13.32	29	11
0057+1341......	N	00 57 36.448	+13 41 45.24	64	8
0107−1211......	N	01 07 11.786	−12 11 23.96	56	6
0114−3219......	N	01 14 48.887	−32 19 51.76	122	16
0138−2954......	N	01 38 40.505	−29 54 46.04	45	10
0146+0222......	N	01 46 14.619	+02 22 08.16	136	8
0147+0715......	N	01 47 27.777	+07 15 02.82	237	6
0154−2422......	N	01 54 56.898	−24 22 33.61	45	10
0214+1027......	N	02 14 59.232	+10 27 48.65	27	12
0217−2354......	N	02 17 50.767	−23 54 56.42	82	11
0223+0732......	N	02 23 33.975	+07 32 18.99	128	12
0223+1159......	N	02 23 40.829	+11 59 10.11	34	9
0224+1357......	N	02 24 41.842	+13 57 33.00	93	9
0238−3032......	N	02 38 55.197	−30 32 02.67	155	5
0249+1237......	N	02 49 44.482	+12 37 06.27	255	6
0251−1742......	N	02 51 06.234	−17 42 39.77	65	12
0258−3146......	N	02 58 05.951	−31 46 27.90	242	8
0259+0747......	N	02 59 27.067	+07 47 39.06	807	5
0259+4708......	N	02 59 04.207	+47 08 40.31	107	9
0317+0606......	N	03 17 26.849	+06 06 14.53	196	8
0322−3458......	N	03 22 13.098	−34 58 33.34	49	7
0326−3243......	N	03 26 15.123	−32 43 24.41	93	5
0349+0354......	N	03 49 14.315	+03 54 45.34	147	8
0403+6445......	N	04 03 42.805	+64 45 56.01	72	5
0421+3511......	N	04 21 19.710	+35 11 15.79	68	9
0458+4953......	N	04 58 28.750	+49 53 55.67	19	12
0505+2606......	N	05 05 54.171	+26 06 25.03	23	9
0518+6439......	N	05 18 43.662	+64 39 57.72	28	12
0606+4401......	N	06 06 50.206	+44 01 40.73	145	8
0607+2915......	N	06 07 18.949	+29 15 27.64	25	14
0620+7334......	N	06 20 52.108	+73 34 41.12	84	9
0701+2631......	N	07 01 20.742	+26 31 56.95	32	11
0719+2935......	Y	07 19 22.188	+29 35 43.30	15	14
0733+3331......	N	07 33 13.289	+33 31 51.81	19	13
0755+3013......	Y	07 55 01.887	+30 13 46.68	51	11
0755+3341......	Y	07 55 36.599	+33 41 56.27	81	7
0757+2721......	Y	07 57 52.648	+27 21 07.62	44	7
0758+3929......	N	07 58 08.846	+39 29 28.61	530	8
0802+3122......	N	08 02 12.783	+31 22 40.56	84	10
0805+2737......	N	08 05 19.023	+27 37 35.99	41	9
0806+3310......	N	08 06 01.704	+33 10 10.16	44	6
0810+3034......	Y	08 10 40.249	+30 34 32.99	152	6
0840+2923......	Y	08 40 30.750	+29 23 32.57	17	13
0843+3738......	Y	08 43 08.663	+37 38 16.42	108	11
0844+3629......	Y	08 44 56.087	+36 29 27.64	49	6
0846+3746......	N	08 46 47.432	+37 46 14.97	21	15
0903+3523......	Y	09 03 05.211	+35 23 18.91	57	6
0911+3349......	Y	09 11 47.745	+33 49 16.60	370	7
0923+3011......	Y	09 23 30.450	+30 11 10.92	34	6
0928+4142......	N	09 28 22.186	+41 42 21.77	96	12
0944+3803......	N	09 44 59.202	+38 03 17.34	42	11
1000+3718......	Y	10 00 21.815	+37 18 44.99	35	9

TABLE 1—*Continued*

Source	FIRST Source?	α (J2000.0)	δ (J2000.0)	S_{1400}[a] (mJy)	Percent Polarization[b]
1003+3244......	Y	10 03 57.560	+32 44 02.87	419	7
1013+3445......	Y	10 13 49.574	+34 45 50.74	350	6
1033+2851......	Y	10 33 19.483	+28 51 22.16	29	9
1126+3418......	Y	11 26 12.536	+34 18 20.67	39	7
1129+3622......	Y	11 29 51.387	+36 22 15.70	119	6
1145+3145......	Y	11 45 23.236	+31 45 17.24	77	10
1146+2601......	Y	11 46 08.554	+26 01 05.58	114	7
1150+3020......	Y	11 50 43.890	+30 20 17.66	31	13
1201+2550......	Y	12 01 25.648	+25 50 04.55	20	24
1201+3129......	Y	12 01 44.264	+31 29 03.22	87	6
1220+3111......	Y	12 20 04.656	+31 11 45.04	28	8
1234+2917......	Y	12 34 54.323	+29 17 43.93	434	9
1236+3706......	Y	12 36 50.831	+37 06 02.01	62	9
1242+2721......	Y	12 42 19.687	+27 21 57.32	69	10
1251+3643......	Y	12 51 24.132	+36 43 57.27	29	8
1334+3434......	Y	13 34 26.833	+34 34 25.11	48	7
1343+2903......	Y	13 43 24.006	+29 03 57.55	22	17
1414+4022......	Y	14 14 40.585	+40 22 25.75	43	6
1426+4035......	Y	14 26 58.101	+40 35 38.36	28	9
1434+3805......	Y	14 34 46.988	+38 05 14.87	149	9
1458+3720......	Y	14 58 44.704	+37 20 22.15	210	6
1508+2818......	Y	15 08 08.312	+28 18 13.51	76	7
1547+3954......	Y	15 47 40.147	+39 54 38.48	128	15
1606+2709......	Y	16 06 16.249	+27 09 28.69	29	7
1609+2628......	Y	16 09 50.978	+26 28 38.72	17	15
1618+2931......	Y	16 18 27.685	+29 31 17.99	29	8
1635+3751......	Y	16 35 53.071	+37 51 54.59	47	6
2321−1758......	N	23 21 02.411	−17 58 22.09	17	13

NOTE.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.

[a] NVSS catalog total intensity 1400 MHz peak flux density.

[b] NVSS catalog percent linear polarization from 1400 MHz peak flux densities.

nominal fractional linear polarization less than 5%. The intrinsic degree of polarization of these pulsars may be even higher if bandwidth depolarization effects are significant, in which case an even higher fraction of the pulsar sample is more than 5% linearly polarized. Figure 2 of Han & Tian (1999) shows that only ∼10% of identified quasars and ∼10% of BL Lac objects are more than 5% linearly polarized. Thus, although there is not a clear polarization cutoff separating the pulsar and extragalactic populations, a polarization threshold of 5% excludes most (∼90%) of the identified nonpulsar population while retaining the majority (∼90%) of the identified pulsar population.

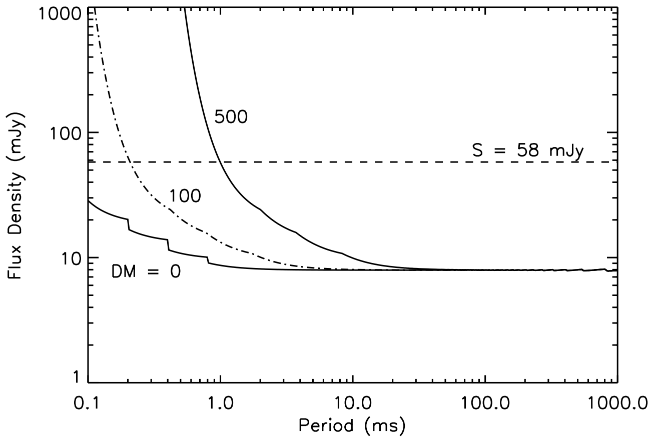

FIG. 1.—Pulsar sensitivity curves for DMs of 0, 100, and 500 pc cm^{-3}, assuming a 5% intrinsic pulsed duty cycle. The dashed line at 58 mJy is the flux density of our weakest source at 600 MHz, assuming a typical pulsar spectral index of $\alpha = 1.6$. All our sources are expected to have DM < 100 pc cm^{-3} (*dash-dotted line*).

We have searched for radio pulsations in bright ($S_{1400} \geq 15$ mJy) pointlike unidentified sources from the FIRST and NVSS survey catalogs that are more than 5% linearly polarized at 1400 MHz. Sources were selected directly from the catalogs if they met certain criteria.

The flux densities of unidentified FIRST sources were checked against their corresponding NVSS flux densities. If a source were extended, the better resolution of the FIRST survey would be expected to yield a lower flux density for the source than the NVSS survey. Therefore, to eliminate extended objects, sources were included only if their FIRST and NVSS flux densities agreed within a few percent (indicating an unresolved nonvariable source) or if the FIRST flux density exceeded the NVSS flux density (indicating an unresolved scintillating source). The large number of extended sources in the catalogs makes this filter necessary, though it does unfortunately eliminate scintillating sources that happen to be fainter in the FIRST survey.

For unresolved NVSS sources outside the FIRST survey region, pointed VLA observations were undertaken in 1995 October in B configuration to obtain the same angular resolution (5″.4) as the FIRST survey (R. Becker & D. Helfand 1995, unpublished). Sources from these observations were then subjected to the selection criteria described above. A total of 92 objects from the catalogs (39 appearing in both FIRST and NVSS and 53 appearing only in NVSS) fitted our selection criteria and were sufficiently far north to be observed in our search. The positions, NVSS total intensity peak flux densities, and fractional linear polarization from the NVSS peak flux values are listed for the selected sources in Table 1.

Each of the 92 unidentified sources was observed at a center frequency of 610 MHz in two orthogonal linear polarizations for 420 s with the 76 m Lovell Telescope at Jodrell Bank, UK. A total bandwidth of 1 MHz was split into 32 frequency channels with detected signals from each channel added in polarization pairs and recorded on Exabyte tape as a continuous 1-bit digitized time series sampled at 50 μs.

The minimum detectable flux density of periodicities in a pulsar search depends upon the raw sensitivity of the system and a number of propagation and instrumental effects (see, e.g., Dewey et al. 1985). Interstellar dispersion contributes to the broadening of the intrinsic pulse according to

$$\tau_{\rm DM} = (202/\nu)^3 {\rm DM}\, \Delta\nu \ . \quad (1)$$

Here $\tau_{\rm DM}$ is in milliseconds, ν is the observing frequency in megahertz, DM is the dispersion measure in parsecs per cubic centimeter, and $\Delta\nu$ is the channel bandwidth in megahertz. For our observing system, $\tau_{\rm DM}$ is 1.135 μs for one parsec per cubic centimeter of DM. The fast sampling rate ($t_s = 50$ μs) and small channel bandwidth ($\Delta\nu = 31.25$ kHz) in our survey made it sensitive to submillisecond pulsars for a large range of DMs (DM $\lesssim 500$ pc cm^{-3}) in the absence of pulse-scattering effects. Our estimated sensitivity to pulsations for a range of periods and DMs is shown in Figure 1. A detailed explanation of the calculation used to produce Figure 1 can be found in Crawford (2000).

3. DATA REDUCTION

In each observation, the frequency channels were dedispersed at 91 trial DMs, which ranged from 0 to 1400 pc cm^{-3} and were summed. We searched this large DM range in the unlikely event that a source could be a previously missed long-period pulsar with a high DM. For DM $\gtrsim 500$ pc cm^{-3}, the channel dispersion smearing is too great to maintain sensitivity to submillisecond pulsations from all our sources. However, the Taylor & Cordes (1993) model of the Galactic free-electron distribution indicates that for all our sources, except two that are within 5° of the Galactic plane, the DMs are expected to be less than 100 pc cm^{-3}, regardless of distance. Each resulting dedispersed time series of 2^{23} samples was then coherently Fourier-transformed to produce an amplitude modulation spectrum corresponding to a trial DM.

Radio-frequency interference (RFI) produced many false peaks in certain narrow regions of the modulation spectra at low DMs. We therefore masked several frequency ranges and their harmonics in which RFI appeared regularly so that any true pulsar signals were not swamped by interference. Typically 1%–2% of the modulation spectrum in each observation was lost in this way.

We then looked for the strongest peaks in the spectra. First, each modulation spectrum was harmonically summed. In this process, integer harmonics in the modulation spectrum are summed, enhancing sensitivity to harmonic signals (see, e.g., Nice, Fruchter, & Taylor 1995). This is particularly useful for long-period pulsars, which have a large number of unaliased harmonics. After summing up to 16 harmonic signals, the highest candidate peaks in the modulation spectrum were recorded along with the period, the DM, and the signal-to-noise ratio (S/N). Redundant harmonic candidates were then eliminated. Unique candidates were recorded if they had S/N > 7 and if the candidate period appeared in at least 10 DM trials. The final candidates for each beam were inspected by dedispersing the original data at DMs near the candidate DM and folding the data at periods near the candidate period to look for a broadband, continuous pulsar-like signal.

This technique was tested by observing several known bright pulsars (PSRs B1937+21, B0329+54, and J2145−0750) throughout the survey. The results for these pulsars are listed in Table 2. All three pulsars were detected with a S/N consistent with our survey sensitivity, though scintillation affects the detection strengths.

4. DISCUSSION

We did not detect any significant pulsations from the target sources. Here we consider possible effects that could prevent detection if the target sources were pulsars.

The selected sources were bright, with the weakest source having a 1400 MHz flux density of 15 mJy. Assuming a typical pulsar spectral index of $\alpha = 1.6$ (Lorimer et al. 1995), where α is defined according to $S \sim \nu^{-\alpha}$, this source would have flux density 58 mJy at 600 MHz (Fig. 1, *dashed line*). For expected DMs, this is about 7 times greater than our sensitivity limit for periods greater than 1 ms (about 4 times greater than our sensitivity limit for periods equal to about 1 ms), as indicated in Figure 1. All our sources, therefore, were bright enough (in the absence of scintillation) to be easily detectable with our observing system if they were pulsars.

Dispersion smearing is not a factor preventing detection, since all but two of these sources have high Galactic latitudes ($|b| > 5°$) and should have DM < 100 pc cm^{-3} regardless of distance. This is well within our sensitivity limits to submillisecond pulsations (see Fig. 1). Interstellar

TABLE 2

OBSERVED TEST PULSARS

Name	P (ms)	DM (pc cm^{-3})	S_{1400}[a] (mJy)	S_{600}[b] (mJy)	S/N
PSR B0329+54........	714.52	26.8	203	785	725
PSR B1937+21........	1.56	71.0	16	100	46
PSR J2145−0750......	16.05	9.0	10	30	36

[a] Catalog 1400 MHz flux density (Taylor, Manchester, & Lyne 1993).

[b] Catalog 600 MHz flux density (Taylor Manchester, & Lyne 1993).

scattering, which can be estimated from the Taylor & Cordes (1993) model of the Galactic electron distribution, is expected to be negligible at 610 MHz. Two of the target sources (0458+4953 and 0607+2915) are within 5° of the Galactic plane; for an assumed DM of 100 pc cm^{-3}, their predicted pulse scatter–broadening times are ~ 140 μs at 610 MHz. This is small enough to maintain sensitivity to submillisecond pulsations and is of the same order as the dispersion smearing (113 μs) at this DM.

An extremely wide beam would prevent modulation of the pulsed signal and could render a pulsar undetectable. However, this would likely occur only in an aligned rotator geometry in which both the spin and magnetic axes are pointing toward us. This is unlikely for our targets, since, if they were pulsars, the position angle of linear polarization would be expected to follow the projected direction of the magnetic axis as the star rotates (Lyne & Manchester 1988). This geometry would significantly reduce the measured degree of linear polarization as the pulsar rotates, inconsistent with our choice of significantly polarized sources.

Scintillation is the modulation of a radio signal passing through a medium of variable index of refraction, such as an inhomogeneous interstellar plasma. In diffraction scintillation, the wave scattering causes interference, which can enhance or suppress the amplitude of the radio signal on a timescale of minutes (see, e.g., Manchester & Taylor 1977). These intensity fluctuations vary as a function of radio frequency at any given time and have a characteristic bandwidth $\Delta\nu$, where

$$\Delta\nu \simeq 11\nu^{22/5}d^{-11/5} . \tag{2}$$

Here $\Delta\nu$ is in megahertz, ν is the observing frequency in gigahertz, and d is the distance to the source in kiloparsecs (Cordes, Weisberg, & Boriakoff 1985). For pulsars with $d < 1$ kpc, this characteristic bandwidth exceeds our 610 MHz observing bandwidth of 1 MHz. Indeed, of 28 nearby pulsars observed at 660 MHz by Johnston, Nicastro, & Koribalski (1998), 13 had scintillation bandwidths greater than our bandwidth of 1 MHz and had a characteristic fluctuation timescale greater than our integration time of 420 s. More than half these 13 pulsars had distances less than 1 kpc, and only one had $d > 2$ kpc. If the sources we surveyed were placed at a distance of 2 kpc and a spectral power-law index of $\alpha = 1.6$ is assumed, their 400 MHz luminosities would all be at the upper end of the observed pulsar luminosity distribution ($L_{400} > 450$ mJy kpc^2). This suggests that if these sources were pulsars, they are likely to be closer than 2 kpc and therefore in the distance range where the scintillation bandwidth exceeds our observing bandwidth. In this case, because of scintillation, the probability distribution of the observed intensity is an exponential function with a maximum in the distribution at zero intensity (McLaughlin et al. 1999). The number of sources we expect to see in our sample is the sum of the probabilities that we will see each individual source (i.e., that the scintillated flux is above the minimum detectable flux). For the range $P > 1$ ms, we expect to see 88 of the 92 sources (5% missed). For the range $P \sim 1$ ms, we expect to see 85 of the 92 sources (8% missed). Thus, only a few of our sources are likely to have been missed because of scintillation. Therefore scintillation cannot account for the nondetection of the bulk of the sources in the survey.

A pulsar in a binary orbit experiences an acceleration that changes the observed modulation frequency during the course of the observation. Sensitivity to pulsations is degraded if the frequency drift exceeds a single Fourier bin $\Delta f = 1/T_{\mathrm{int}}$, where T_{int} is the integration time. Assuming that the acceleration of the pulsar is constant during the observation, a critical acceleration, above which the change in frequency is greater than Δf and the sensitivity is reduced, can be defined:

$$a_{\mathrm{crit}} = \frac{c}{fT_{\mathrm{int}}^2} . \tag{3}$$

Since the Fourier drift scales linearly with acceleration, the reduction in sensitivity also scales linearly with acceleration. For our integration time of 420 s, the critical acceleration is $a_{\mathrm{crit}}/P \sim 1.7$ (where a_{crit} is in meters per second squared and P is the pulsar period in milliseconds). Our weakest source is several times brighter than our detection limit (Fig. 1), so a reduction in sensitivity by a factor of several should still maintain detectability to pulsations. Thus, a more appropriate critical acceleration for the weakest source in our list is $a_{\mathrm{crit}}/P \sim 12$ for $P > 1$ ms and $a_{\mathrm{crit}}/P \sim 7$ for $P \sim 1$ ms.

Orbits containing millisecond or submillisecond pulsars that have been spun up from mass transfer from a low-mass donor would be expected to be circular. Of the 40 known pulsars in circular ($e < 0.01$) binary orbits, the largest projected mean acceleration to our line of sight (assuming $i = 60°$) is $a_{\mathrm{mean}}/P \sim 3.6$ for PSR J1808−3658, an X-ray millisecond pulsar with a 2.5 ms period in a 2 hr binary orbit around a 0.05 $M_{\odot}$ companion (Chakrabarty & Morgan 1998). This acceleration is well below the critical acceleration a_{crit}/P, even for our weakest source.

The mean flux density of the sources on our list, however, is much higher ($S_{610} \sim 400$ mJy, assuming $\alpha = 1.6$) than our weakest source, which raises the critical acceleration for our typical source. Only very large accelerations ($a_{\mathrm{mean}}/P \gtrsim 85$ for $P > 1$ ms and $a_{\mathrm{mean}}/P \gtrsim 40$ for $P \lesssim 1$ ms) would prevent detection of pulsations for our typical source. A system such as PSR J1808−3658 with $S_{610} \sim 400$ mJy would still be detectable if it had $P \sim 0.3$ ms or if it had an orbital period $P_b \sim 15$ minutes (but not both). Thus it is unlikely that binary motion in a submillisecond or millisecond pulsar system would be a significant source of nondetections for most of our sources.

We have also estimated the likelihood of serendipitously detecting a pulsar not associated with these sources by using the observed surface density of both normal and millisecond pulsars in the Galactic plane (Lyne et al. 1998). With standard assumptions for a spectral power-law index and luminosity distribution (Lorimer et al. 1993), we find that it is unlikely (<2% probability) that we would detect any pulsars from the chance placement of our 92 beams.

5. CONCLUSIONS

No pulsations were detected at 610 MHz from the 92 polarized, pointlike sources that we searched from the FIRST and NVSS radio surveys. Sensitivity to submillisecond pulsations was maintained for DMs less than about 500 pc cm^{-3} (without scattering effects), which encompasses the expected DM range for all these sources. We find that several effects that could prevent detection (brightness, dispersion smearing, scattering, and beaming) are not significant factors here. Scintillation is expected to account for only a few of our nondetections and therefore cannot be the cause of the majority of our nondetections. For a source with a typical flux density in our list, Doppler motion in a tight binary system would only prevent detection if the mean projected line-of-sight acceleration of the pulsar were at least an order of magnitude higher than those observed in the known population of circular binary pulsar systems. We conclude that as a population these sources are unlikely to be pulsars. Given that ∼10% of extragalactic sources in the NVSS were identified by Han & Tian (1999) as being at least 5% linearly polarized, it is possible that most of our target sources are unidentified extragalactic objects. However, the nature of these sources is still not certain.

We thank R. Becker and D. Helfand for providing us with the list of target sources from the FIRST and NVSS surveys, A. Lyne for assistance with observing, and N. D'Amico and L. Nicastro for providing the FVSLAI software package. We thank an anonymous referee for insightful and helpful comments. V. M. K. is grateful for hospitality while visiting Jodrell Bank.

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