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Searching for Radio Pulsars in 3EG Sources at Urumqi Observatory

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Abstract Since mid-2005, a pulsar searching system has been operating at 18 cm on the 25-m radio telescope of Urumqi Observatory. Test observations on known pulsars show that the system can perform the intended task. The prospect of using this system to observe 3EG sources and other target searching tasks is discussed.

Key words: pulsars: general — radio continuum: stars — telescopes

1 INTRODUCTION

Among the more than 1700 known pulsars, seven are seen at γ-ray frequency (Lorimer & Kramer 2005). It is worth mentioning that six of the seven have detected radio emission (McLaughlin 2001). This might indicate a possible relationship between γ-ray sources and radio pulsars (McLaughlin 2001; Lorimer 2003; Gonthier et al. 2002; Cheng et al. 2004; Qiao et al. 2004). Encouraged by such finding, we started a program of searching for radio pulsars in the error boxes of 3EG sources.

The Compton Gamma Ray Observatory (CGRO) was the second of NASA's Great Observatories. It operated from 1991 April 5 to 2000 June 4. The Energetic Gamma Ray Experiment Telescope (EGRET) provides the highest energy gamma-ray window for the Compton Observatory. Its energy range is from 20 MeV to 30 GeV. EGRET is 10 to 20 times larger and more sensitive than previous detectors operated at these high energy frequencies and has made detailed observations of high-energy processes associated with diffuse gamma-ray emission, gamma-ray bursts, cosmic rays, pulsars, and active galaxies known as blazars.

In the next section we introduce our pulsar searching system at Nanshan, Urumqi Observatory, and discuss the use of small radio telescopes to search for pulsars and, possibly, transient radio sources (Cordes et al. 2004). We report our primary results and discuss the prospect of future observations in Section 3.

2 THE FACILITIES AT URUMQI OBSERVATORY

The Urumqi Observatory operates a 25-m radio telescope at Nanshan. Its location is close to the geographic center of Asia, with an altitude of 2080 m above sea level, longitude 87° and latitude $+43^\circ$.

A pulsar timing system at 18 cm was built in 1999 (Wang et al. 2001). For this band, the telescope uses the Cassegrain focus and a feed horn transmitting orthogonal linear polarisations. The receiver has dual-polarisation, cryogenic pre-amplifiers with center radio frequency (RF) of 1540 MHz and total bandwidth of 320 MHz. The receiver noise temperature is less than 10 K, and the system temperature is approximately 23 K. The polarisations are amplified and then down-converted to intermediate frequency (IF) in the range 80–400 MHz using a local oscillator (LO) at 1300 MHz. After conversion, the signals are fed to a filterbank system which has 128 2.5-MHz channels for each polarisation. An online program of Pulsar Searching Data Acquistion is written in Visual C++ and run on windows NT system. Our sampling interval is 256 μs or higher, so it is sensitive for detecting millisecond pulsars (MSPs) (Roberts et al. 2004).

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After summing the two polarisation data by software, we perform a standard Fourier analysis use the **Sigproc** [1] (Lorimer 2000) software package for slow (> 4 ms) pulsars and a fast-folding algorithm **FFA** [2] for very slow (3–20 s) pulsars, and full acceleration searches using the **Presto** [3] search software (Ransom 2001) which is sensitive to pulsars in tight binary systems.

The technique of resampling has been applied in pulsar search (Lorimer & Kramer 2005). When the ratio of oversampling equals to 64 for 1-bit quantiser, we almost can achieve the precision of 14 bits in the decimator (Oppenheim, Schafer & Buck 1999). We will use it in our search.

3 PRIMARY RESULTS AND PROSPECT

3.1 Primary Results

We have improved the data acquisition system for pulsar searching at Urumqi Observatory. Observations of known pulsars show that after summing two polarisations off line, our data can perform pulsar searching using Sigproc & Presto. Figures 1 and 2 present some de-dispersion and Fourier transform results on PSR B0329+54 using the Presto software.

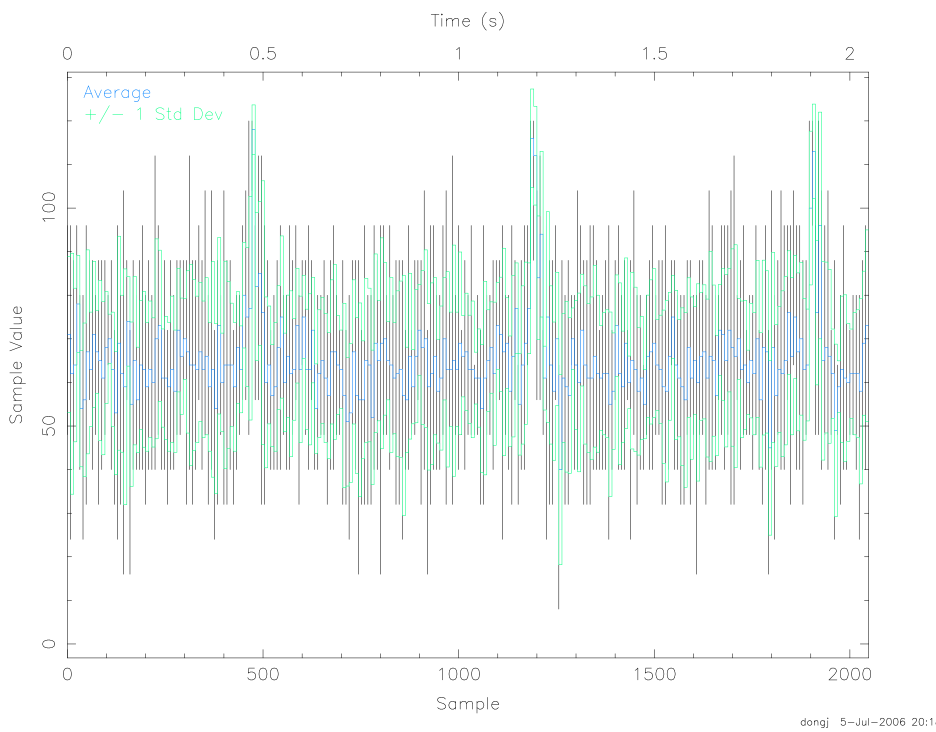

Fig. 1 De-dispersed data of PSR B0329+54 after summing two polarisations off line.

3.2 Prospect

Some 3EG sources (Hartman et al. 1999) and one Tev source were observed. Data reduction is continuing at present. Ten points are needed to cover the $\sim 1.5°$ error box of each source with the beam size of $0.5°$ at 18 cm (Lorimer & Kramer 2005). For our telescope each pointing lasted at least 5 hours to get enough sensitivity. Our recording format is similar to Parkes.

[1] See http://sigproc.sourceforge.net/
[2] See http://www.mpifr-bonn.mpg.de/staff/peter/ffades.en.html
[3] See http://www.cv.nrao.edu/ sransom/

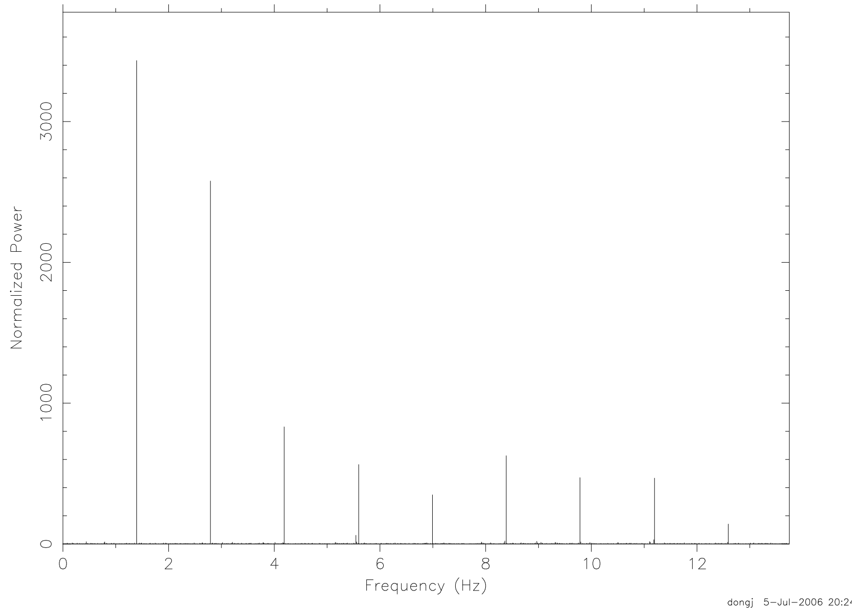

Fig. 2 FFT spectra of PSR B0329+54 after summing two polarisations off line.

The 3EG catalog was inspected for candidate sources satisfying the following criteria:

(1) They must not be listed as identified sources in the catalogs.
(2) They should be located within galactic latitude range $5° < |b| < 30°$.
(3) They should have hard spectra, with γ-ray photon indices $\Gamma < 2$, within the errors quoted in the catalog.
(4) They should be non-variable sources according to the main variability indices introduced in the literature: the I index (Torres et al. 2001a) and the τ index (Tompkins 1999). These two indices are in general well-correlated, at a $7 - \sigma$ level (Torres et al. 2001b).
(5) They are not already in the lists of the other groups (Champion et al. 2005; Kramer et al. 2003; Roberts et al. 2004; Camilo et al. 2001; D'Amico et al. 2001; Torres et al. 2001; Halpern et al. 2001; Roberts et al. 2002; Becker et al. 2004).

Now that large radio telescopes including ALFA, GBT, the updated Lovell Telescope in the northern Hemisphere are active in pulsar surveys, our advantage would be with adequate provision of telescope time. It is also possible to find transient radio sources (Cordes et al. 2004; Mclaughlin 2001; O'Brien et al. 2006), especially those having relatively high flux density (Hyman et al. 2005). Additionally, as GLAST is expected to find hundreds of Gamma-ray sources (McLaughlin & Cordes 2000), there will be an increased pool of candidates.

While it would be excellent to find a pulsar using a domestic radio telescope, just gaining experience from this system is intrinsically valuable. We recognize that large radio telescopes, such as FAST, and the 50 m Miyun telescope will have a better chance of finding pulsars.

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