Searching for Radio Pulsars in 3EG Sources at Urumqi Observatory

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Abstract A pulsar searching system has been operating at 18-cm band at the Urumqi Observatory 25-m radio telescope since mid-2005. Test observations for known pulsars show the system can perform pulsar searching. Perspective of using this system to observe 3EG sources and other target searching are prepared and discussed.

Key words: pulsar, search, radio

1 INTRODUCTION

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

The Compton Gamma Ray Observatory (CGRO) was the second of NASA’s Great Observatories which was operated from April 5, 1991 to June 4, 2000. 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 operating at these high energies 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 next section we will introduce the pulsar searching system at Nanshan, Urumqi Observatory, and discuss using of small radio telescope (SRT) to do pulsar search and possible transient radio source search (Cordes, J.M., et al., 2004). We report the prime results and discuss the perspective of future observations in Section 3.

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2 THE FACILITIES AT URUMQI OBSERVATORY

The 25-m radio telescope at Nanshan is operated by Urumqi Observatory. It locates close to the geographic center of Asia, with an altitude of 2029 m above sea level, longitude 87° and latitude +43°.

A pulsar timing system at 18 cm was built in 1999 (Wang et al., 2001). For this band, the telescope has cassegrain focus and uses a horn feed receiving 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 80400 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. The online program of Pulsar Searching Data Acquisition is written in Visual C++ and run in windows NT system. Our sampling interval is 256 µs or higher so that it is sensitive for detecting millisecond pulsar (MSP) (Roberts et al. 2004).

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

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

The technique of resample 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.

\(^1\) http://sigproc.sourceforge.net/
\(^2\) http://www.mpifr-bonn.mpg.de/staff/peter/ffades.en.html
\(^3\) http://www.cv.nrao.edu/~sransom/
3 PRIMARY RESULTS AND PROSPECT

3.1 Primary Results

We have set up a data acquisition system at Urumqi Observatory. Observations for known pulsars show that after summing two polarizations offline, our data can perform pulsar searching using Sigproc & Presto. Fig. 1 and Fig. 2 present the de-dispersion and Fourier transform results on PSR B0329+54 using Presto software.

3.2 Prospect

Some 3EG sources (Hartman et al. 1999) and one Tev source were observed, the data reduction are continuing at present. It needs ten points to cover ~1.5° error box of for each source for the beam size of 0.5° at 18 cm (Lorimer & Kramer, 2005). Every pointing lasts at least 5-hour observation. Recording format is similar to Parkes.

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

1. They must not be listed as identified sources in the catalog.
2. They should be located at galactic latitudes within the following band: 5° < |b| < 30°.
3. They should have hard spectra, with γ-ray photon indices Γ < 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 − σ level (Torres et al., 2001b).
5. They do not exist in the lists of the other group (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 big radio telescopes including ALFA (Cordes et al., 2006), GBT (Ransom, 2005), updated Lovell Telescope in the northern Hemisphere are active for pulsar survey. With our telescope, the advantage of adequate telescope time might give us a chance to find pulsars in target searching. It is also possible to find transient radio sources (Cordes, J.M., et al., 2004,
Mclaughlin M.A., 2001, O’Brien, J. T., et al., 2005), especially those having relatively high flux density (Hyman, S.D., et al 2005). Additionally, GLAST will find hundreds of Gamma-ray sources(McLaughlin & Cordes, 2000) which indicates an increasing searing cadidates.

It will be excellent to find a pulsar using domestic radio telescope. However gaining experience from this system is an important goal. Big radio telescopes, such as FAST, 50 m of Miyun telescope etc will have better chance in finding pulsars.

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