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Search for and study of pulsars with the Nançay Radio Telescope

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Abstract. Since the discovery of the first pulsar in 1967, over 2500 pulsars have been discovered. Pulsars enable a broad range of studies: from the study of the properties of the interstellar medium and of pulsar magnetospheres to tests of gravity in the strong-field regime and the characterisation of the cosmological gravitation wave background. These reasons are the main drive for searching for more pulsars. A blind pulsar survey, named SPAN512, was initiated with the Nançay Radio Telescope in 2012. Conducted at 1.4 GHz with a sampling time of 64μs and 500-kHz frequency channels, SPAN512 was designed to search for fast and distant pulsars in the Galactic plane. Here we describe the current status of the survey and present the latest discovery, PSR J2055+3829, a 2.08-ms pulsar in a black widow system.

Keywords. surveys, (stars:) pulsars: individual (PSR J2048+49, PSR J2205+60, PSR J2055+3829)

1. The SPAN512 pulsar survey with the Nançay Radio Telescope

The Nançay Radio Telescope (NRT) is a transit telescope located in France with a 4'(right ascension α) × 22' (declination δ) beam size and a collective area equivalent to a 94-m diameter parabolic dish. Motivated by the aim to discover more exotic pulsar systems and, more specifically, millisecond pulsars (MSPs), whose spin stability might be suitable for pulsar timing array programs (Desvignes *et al.* 2016), the pulsar survey SPAN512 has been conducted at Nançay since 2012. This survey inspects the sky at L-band at intermediate galactic latitudes ($3.5° < |b| < 5°$) away from the inner Galaxy ($74° < l < 150°$). The large bandwidth of 512 MHz and the time resolution of 64 μs allow this survey to be sensitive to very faint and distant MSPs. Moreover, the long integration time of 18 minutes increases the likelihood of detecting transient pulsars and for the total observing time predicts the detection of about one Fast Radio Burst (Petroff *et al.* 2016). A total of 50 terabytes of data have been produced from the 6034 sky pointings which amount to 1810 hours of observing time. All the data were processed at the IN2P3 supercomputer in Lyon†. After the processing, 750000 candidates were produced. To select the most promising ones, to be re-observed and possibly confirmed,

† http://cc.in2p3.fr/

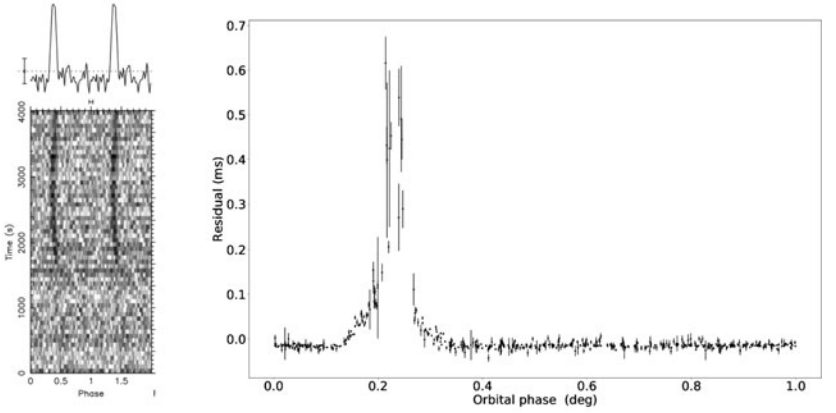

Figure 1. Left: Profile of PSR J2055+3829. Note the presence of an eclipse during the observation in the time-vs-phase plot. **Right:** Timing residuals for PSR J2055+3829. Eclipses occur at the orbital phase $\phi \approx 0.25$.

we use a neural network algorithm like as the one developed by Zhu *et al.* (2014) which uses image pattern recognition. After inspection, a list of around 60 candidates have been prioritized for re-observation.

2. Results: Discovery of three new pulsars

Soon after the start of the observations in 2012, the SPAN512 survey revealed two new pulsars: PSR J2048+49 (P $\approx$ 0.56 s and DM $\approx$ 221 pc.cm^{-3}) and PSR J2205+60 (P $\approx$ 2.4 ms and DM $\approx$ 157 pc.cm^{-3}). Recently, using the Zhu *et al.* (2014) neural network, we have discovered a new 2.08-ms pulsar, PSR J2055+3829 (see Fig. 1). The current data allowed us to obtain a phase-connected solution and determine that the new pulsar is in a black widow (BW) system (see Roberts 2013 for reviews) where the pulsar is ablating its companion and the mass lost by the companion creates clouds of ionized material. Almost every BW system exhibits more or less variable eclipses in their radio signal. At 1.4 GHz, PSR J2055+3829 is no exception, as it found to be eclipsing for around 10% of its orbit around the orbital phase $\phi \approx 0.25$ (see Fig. 1).

3. Conclusions and perspectives

A blind pulsar survey SPAN512 is being conducted with the NRT to scan the intermediate Galactic latitudes. 95% of the total survey pointings have been observed and we were able to discover three new pulsars, two of them having millisecond spin periods. More data are required to characterise the BW pulsar J2055+3829.

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