

Discovery of an intermittent pulsar: PSR J1839+15

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Abstract. We report the discovery of a new pulsar PSR J1839+15, having a period of 549 ms and a DM of 68 pc cm^{-3} . We also present its timing solution and report the intermittent behaviour of its radio emission.

Keywords. pulsars: general, pulsars: individual (J1839+15)

1. Introduction

A blind search for pulsars along the Galactic plane covering 10% of the region between Galactic longitude $45^\circ < l < 135^\circ$ and Galactic latitude $0^\circ < |b| < 5^\circ$ was recently carried out with the Giant Metrewave Radio Telescope (GMRT). It was named ‘GMRT Galactic Plane Pulsar and Transient Survey’. The survey was carried out at 325 MHz with a bandwidth of 16 MHz, divided into 256 filterbank channels. Each field (circular region of radius $\sim 1^\circ$) was observed for 1800 s with a sampling time of $256 \mu\text{s}$.

The advantage of observing at 325 MHz was the wide field of view ($\sim 4 \text{ deg}^2$) paired with a sensitivity of 0.6 mJy. The observations were carried out using the incoherent array (IA) mode of the GMRT. The data were written to magnetic tapes. They were extracted to network attached storage (NAS) disks of the high performance computing cluster which consists of 64 dual-core nodes. The pulsar search was carried out using SIGPROC† with extensive RFI mitigation algorithms written by one of the authors. The trial DM range used for the search was $0\text{--}1200 \text{ pc cm}^{-3}$. The analysis was parallelised such that the DM search for a particular field was divided among the nodes. The results were written back to the NAS disks from where, they could be copied to other machines. The candidate plots thus generated, were manually scrutinised for identifying good candidates.

The follow-up timing observations continued with a new software back-end at GMRT. This provided 512 filterbank channels across a bandwidth of 33 MHz with $122.88 \mu\text{s}$ sampling. The integration time was 1800 s. The timing analysis was done using TEMPO2‡ (Hobbs *et al.* 2006).

2. Results

PSR J1839+15 came out as a strong candidate and was successfully confirmed in later follow-up observations. The accumulated profile from 23 detections on the pulsar is shown in Figure 1. It shows a very narrow peak. A weaker second component can be seen just before the main pulse. The region before this component may also have another, still weaker component buried in the noise. Overall, it may consist of two or

† www.sigproc.sourceforge.net
‡ www.atnf.csiro.au/research/pulsar/tempo2

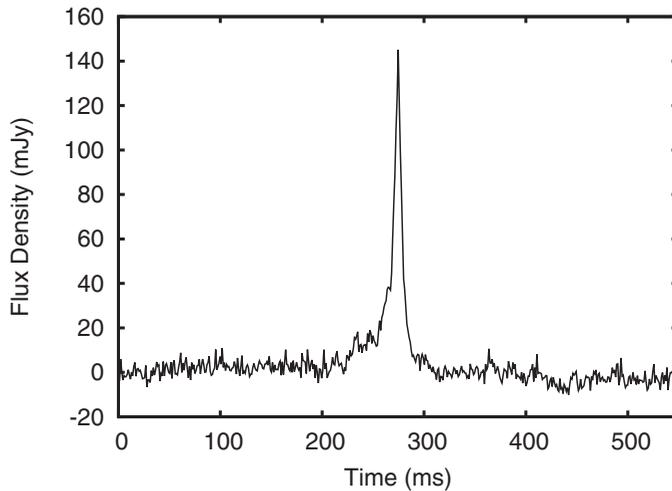


Figure 1. The accumulated pulse profile for PSR J1839+15 at 325 MHz. The ordinate was scaled using that radiometer equation.

more components although polarization studies are required to confirm the same. The timing solution obtained so far is given in Table 1.

During the follow-up timing observations, the pulsar could not be detected for 278 days from 30 August 2011 to 3 June 2012. It could be detected regularly then onwards until on 2 September 2012, when it was again not detected. The estimated mean flux densities for the detections are plotted in Figure 2. As can be clearly seen, the 8σ upper limits on non-detections are below the 98% confidence limit on the expected flux density. Thus, we are fairly confident that PSR J1839+15 is an intermittent pulsar with an OFF time scale of roughly 278 days. We are currently working on calculating the \dot{P} in the ON and OFF states. Two different values of \dot{P} would confirm this as an intermittent pulsar. There are only three more such pulsars known currently. PSR B1931+24 shows a quasi periodic ON-OFF cycle of about 30-40 days (Kramer *et al.* 2006), PSR J1841–0500 shows an OFF time scale of 580 days (Camilo *et al.* 2012) while J1832+0029 remained OFF for 650 days and 850 days in the two sampled OFF states (Lorimer *et al.* 2012). The reason for this behavior is not understood. Further investigations and discoveries of new members of this class may shed some light on the underlying physics.

RA	18h39m06.6(2)s
DEC	+15°06'57(6)''
P	0.54916053388(8) s
\dot{P}	$2.613(6) \times 10^{-14}$ s/s
DM	68.1(8) pc cm ⁻³
Characteristic age $\tau = P/2\dot{P}$	0.33 Myr
Surface Magnetic Field B_S	3.83×10^{12} G
DM Distance = DM/ n_e	3 kpc ^a

^aDM distance calculated using the model given by Cordes & Lazio (2002)

Table 1. Important parameters of PSR J1839+15. Numbers in brackets indicate 2σ errors as reported by TEMPO2 in the last digit of the given value. The error on the DM comes from local search done on the time series data.

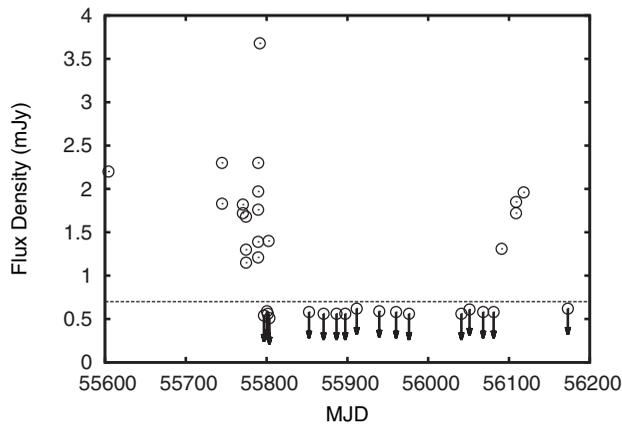


Figure 2. Estimated mean flux density of PSR J1839+15 versus MJD. Arrows indicate 8σ flux density limits on non-detections. The dashed horizontal line indicates 98% confidence limit for the lowest expected flux density given the variations in the observed flux densities.

3. Discussion

Intermittent pulsars are a rare breed of pulsars showing very long period nulls. The cause of these nulls is a mystery. To add to the already puzzling phenomenon, it was reported (Kramer *et al.* 2006, Camilo *et al.* 2012 and Lorimer *et al.* 2012) that the spin-down rate is considerably higher in the ON state than in the OFF state indicating that the particle flow forming the magnetospheric currents, is different in the ON and OFF states. Another puzzling fact is that these pulsars belong to the normal pulsar population in the P–P diagram. The cause of cessation of radio emission altogether may be attributed to the reduced particle flow or it may just be a failure of coherent emission. These pulsars certainly challenge the current emission models and if well studied, may provide vital inputs for coming up with more realistic emission mechanisms.

Given the ON-OFF nature of these pulsars, they provide great motivation for extending the existing blind searches and embarking on new, sensitive blind searches even in the previously searched areas of sky. Assuming a typical duration of a big survey as 3 to 4 years and given the OFF state time scales of these pulsars, a rough estimate of the intermittent pulsar population may go up considerably, thus opening up the possibility of discovering many more of such objects.

4. Acknowledgements

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