Detection of a glitch in PSR J0908−4913 by UTMOST

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Neutron star glitches can originate from either a transfer of angular momentum from the core to the crust via the unpinning of superfluid vortices (Anderson & Itoh 1975) or cracking of the star’s crust (Baym et al. 1969; Ruderman 1969). Independent of the underlying mechanism, glitches result in a near instantaneous increase in the observed spin frequency and are sometimes associated with a change in spin-down. Occasionally, the change in spin frequency is observed to exponentially recover toward the pre-glitch value. Studies of large catalogues of glitches have provided insights to the internal dynamics of neutron stars and the behaviour of matter under super-nuclear densities (e.g. Yu et al. 2013).

We report the first detection of a glitch in the radio pulsar PSR J0908−4913 (PSR B0906−49) during regular timing observations by the Molonglo Observatory Synthesis Telescope (MOST) as part of the UTMOST project (Bailes et al. 2017). MOST is a 1.6-km long cylindrical aperture synthesis telescope with a diameter of 11.7 m, located approximately 40 km to the South-East of Canberra, Australia. It currently observes right-hand circularly polarised radio emission at a centre frequency of 835 MHz with a bandwidth of 31.25 MHz.

PSR J0908−4913 was initially discovered by MOST 31 years ago (D’Amico et al. 1988). It is a bright (35 ± 3 mJy at 843 MHz) pulsar with a spin period of 107 ms and dispersion measure of 180.37 ± 0.05 pc cm−3. It has been regularly timed by the Parkes 64-m telescope for over two decades (Weltevrede et al. 2010; Yu et al. 2013, Johnston, private communication) and as part of the UTMOST pulsar timing programme since May 2015 (see Jankowski et al. 2019). It has not been observed to glitches throughout its entire timing history, until now.

We can parameterise the associated change in rotation phase from a glitch by measuring the permanent changes in spin-frequency (∆νp) and spin-down frequency (∆νd), in addition to an exponential spin recovery (∆νd) over some timescale (τd) as

\[ \phi(t) = \Delta \phi + \Delta \nu_p(t - t_g) + \frac{1}{2} \Delta \nu_p(t - t_g)^2 - \Delta \nu_d \tau_d e^{-(t - t_g)/\tau_d}, \]

(1)

where ∆φ is an unphysical jump in phase to account for ambiguities in the exact number of rotations since the glitch epoch (tg). The glitch we detected occurred between observations taken on MJD 58762.92 and MJD 58771.90. After fitting over a grid of tg to find the date with the smallest ∆φ, we constrained the glitch epoch to MJD 58765.05 ± 0.05 (UTC 2019-10-09:01:26:00 ± 12 minutes). Performing parameter estimation with TempoNest (Lentati et al. 2014), we find the glitch is best described by a permanent change in spin-frequency of ∆νp = 203.6 ± 1.2 × 10−9 Hz, with no
Table 1. Median posterior glitch values and 68% confidence intervals.

| Parameter       | Value                          |
|-----------------|--------------------------------|
| \( t_g \) (MJD) | 58765.06 ± 0.05                |
| \( \Delta \nu_p \) (Hz) | 203.6 ± 1.2 \times 10^{-9}     |
| \( \Delta \dot{\nu}_p \) (Hz s\(^{-1}\)) | \( \lesssim -1.61 \times 10^{-15} \) |
| \( \Delta \nu_g / \nu \) (\( \times 10^{-9} \)) | 21.7 ± 0.1                      |

evidence for a change in spin-down or spin recovery to date. Additional post-glitch observations will better constrain any changes in spin-down or recovery. The measured glitch parameters and upper-limits are summarised in Table 1

With an amplitude of \( \Delta \nu_g / \nu = 21.7 ± 0.1 \times 10^{-9} \), this glitch is similar to those seen in pulsars with similar spin-down rates. Continued monitoring of this pulsar is being undertaken by UTMOST. Attempts to measure any long-term recovery and pulse shape changes will be the subject of future works.

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\(^1\) A figure showing the timing residuals can be found here: astronomy.swin.edu.au/research/utmost/?p=1805