DETECTION OF A GLITCH IN THE PULSAR J1709−4429

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INTRODUCTION

Pulsar glitches are thought to result from either quakes in the neutron star crust (Baym et al. 1969), or by a transfer of angular momentum between the superfluid interior and the outer crust (Anderson & Itoh 1975). The event manifests as a sudden increase in the observed spin period and spin-down of the pulsar, which can be followed by a recovery phase where the period exponentially returns to its pre-glitch evolution.

We report here the detection of a glitch event in the pulsar J1709−4429 (also known as B1706−44) during regular monitoring observations with the Molonglo Observatory Synthesis Telescope (MOST). MOST is an aperture synthesis radio telescope located 40 km East of Canberra, Australia, operating in the 820–850 MHz frequency range. The UTMOST backend upgrade to the MOST (Bailes et al. 2017) has enabled study of the dynamic radio sky on millisecond timescales, and is well suited to pulsar timing, pulsar searches, observing single pulses from pulsars and discoveries of Fast Radio Bursts (FRBs) (Caleb et al. 2017; Farah et al. 2018). The glitch was found during timing operations, in which we regularly observe over 400 pulsars with up to daily cadence, while commensally searching for Rotating Radio Transients, pulsars, and FRBs.

GLITCH PARAMETERS

J1709−4429 is a bright (7.3 mJy at 1400 MHz) pulsar with a period of 0.102459 s and a dispersion measure of 75.7 pc cm$^{-3}$, for which 90 timing measurements have been made at UTMOST since May 2015. We constrain the epoch at which the glitch occurred ($t_g$) to MJD 58178 ± 6. This is the median MJD between observations made on 02-23-2018 and 03-07-2018 UTC. The uncertainty in the glitch epoch is half the difference in time between the last pre-glitch and first post-glitch observations. As the glitch epoch is relatively unconstrained, an unphysical jump in the pulsar phase of $\Delta \varphi_g = 3.39 \pm 0.01$ is required to achieve phase-connected timing residuals.

Using the TEMPO2 (Hobbs et al. 2006; Edwards et al. 2006) and TEMPO Nest (Lentati et al. 2014) pulsar timing packages, we estimate the instantaneous change in spin frequency, spin frequency derivative and spin frequency second derivative to be $\Delta \nu = (516.07 \pm 3.6) \times 10^{-9}$ Hz, $\Delta \dot{\nu} = (-6.46 \pm 0.11) \times 10^{-14}$ s$^{-2}$ and $\Delta \ddot{\nu} = (-22.42 \pm 1.8) \times 10^{-22}$ s$^{-3}$ respectively.

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The upper panel of Figure 1 shows the timing residuals for J1709-4429 prior to fitting the recovered glitch parameters (solid blue points) and the best-fit glitch model (red line). The lower two panels show the evolution of $\Delta \nu$ and $\dot{\nu}$ with time.

Four previous glitches in J1709-4429 are recorded in the Australian National Telescope Facility and Jodrell Bank glitch catalogues (Espinoza et al. 2011). With a fractional size of $\Delta \nu / \nu = 52.4 \pm 0.1 \times 10^{-9}$, the glitch reported here is by far the smallest known for this pulsar, attesting to the efficacy of glitch searches with high cadence using UTMOST. Continued observations of J1709-4429 are being undertaken with UTMOST. We encourage monitoring of this pulsar by other timing programs.

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REFERENCES

Anderson, P. W., & Itoh, N. 1975, Nature, 256, 25
Bailes, M., Jameson, A., Flynn, C., et al. 2017, PASA, 34, e045
Baym, G., Pethick, C., Pines, D., & Ruderman, M. 1969, Nature, 224, 872
Caleb, M., Flynn, C., Bailes, M., et al. 2017, MNRAS, 468, 3746
Edwards, R. T., Hobbs, G. B., & Manchester, R. N. 2006, MNRAS, 372, 1549
Espinoza, C. M., Lyne, A. G., Stappers, B. W., & Kramer, M. 2011, MNRAS, 414, 1679.
http://www.jb.man.ac.uk/pulsar/glitches.html
Farah, W., Flynn, C., Bailes, M., et al. 2018, MNRAS, 478, 1209
Hobbs, G. B., Edwards, R. T., & Manchester, R. N. 2006, MNRAS, 369, 655
Lentati, L., Alexander, P., Hobson, M. P., et al. 2014, MNRAS, 437, 3004