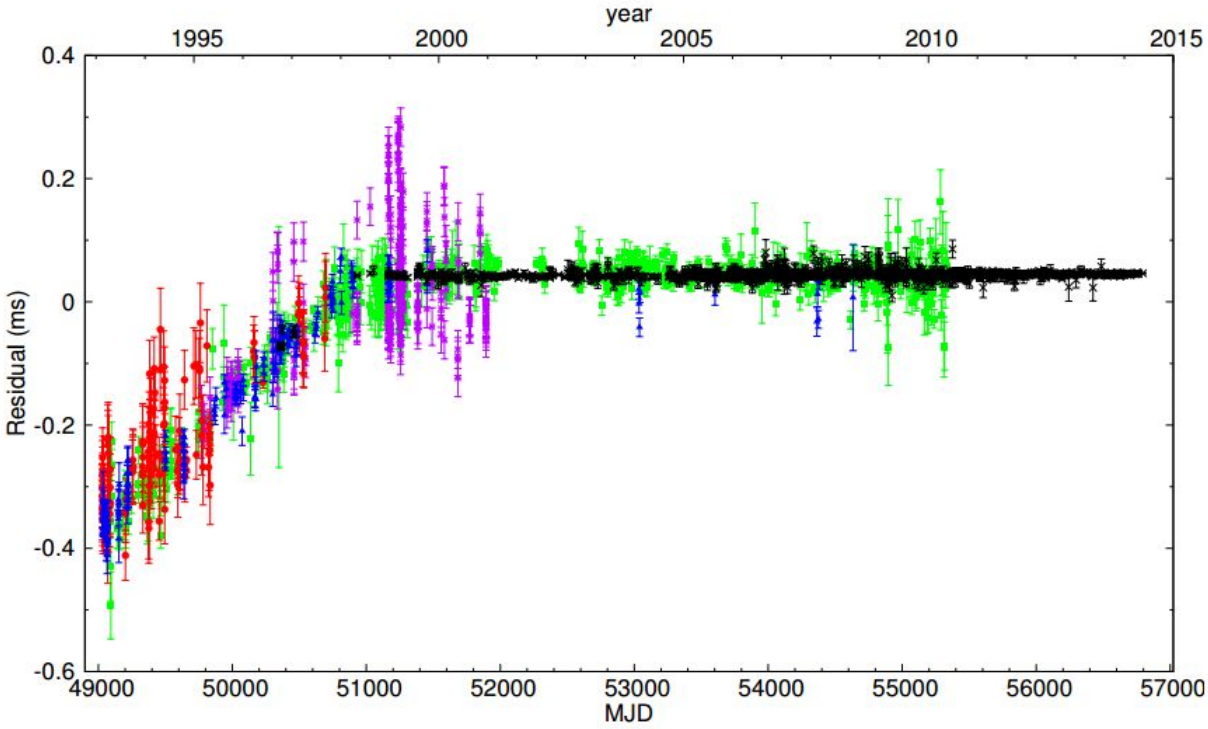
Astronomers detect glitch in a millisecond pulsar

June 17 2016, by Tomasz Nowakowski



Timing residuals for PSR J0613−0200 (purple stars: EPOS 1390 MHz green squares: AFB 1400 MHz blue triangles: AFB 600 MHz red circles: AFB 400 MHz black crosses: DR1 including earlier EBPP 1410 MHz). Credit: arXiv:1606.04098 [astro-ph.HE]

(Phys.org)—European astronomers have uncovered evidence of a small glitch in the spin of a millisecond pulsar. According to a research paper

published on June 13 on arXiv.org, the pulsar, designated PSR J0613-0200, exhibits sudden changes in spin frequency, known as timing glitches. It is so far the smallest glitch size recorded and the second detection of a glitch in a millisecond pulsar to date.

Millisecond pulsars have highly stable rotation, thus they are used as extremely precise clocks in timing experiments, and the most stable are used as probes of space-time in pulsar timing array (PTA) experiments. PSR J0613-0200 in particular, is used in gravitational wave searches with pulsar timing arrays.

Recently, a team of European researchers, led by James McKee of the Jodrell Bank Centre for Astrophysics, U.K., detected the glitch in PSR J0613-0200, using data from four different telescopes across Europe. For their study, the astronomers employed the Lovell Telescope at Jodrell Bank in the U.K., the Nançay Radio Telescope in France, the Effelsberg Radio Telescope in Germany, and the Westerbork Synthesis Radio Telescope in the Netherlands.

According to the scientists, the small glitch was easy to detect with a data set covering a long baseline. They noted that during a detailed analysis of the available data, the effect of the glitch was easily removed without loss of timing precision and concluded that this anomaly does not affect the timing stability of this and other pulsars studied in PTA experiments.

"As the glitch is small and the red noise of the pulsar is not well-defined, it is therefore likely that potential unmodeled glitches outside the timing baseline for other PTA pulsars have no significant effect on timing array sensitivity," the researchers wrote.

The team is convinced that the observed anomaly in PSR J0613-0200 is, indeed, a glitch and rules out other possibilities, such as magnetospherically induced variations in rotation and pulse shape, or a

gravitational wave burst with memory, caused by a merger of a supermassive black hole binary.

"A magnetospherically induced change in pulse shape related to a change in frequency derivative was considered as an alternative [explanation]... but no significant change of the pulse profile associated with the glitch was observed," the paper reads.

When it comes to the 'burst with memory' theory, the researchers concluded that although the change in spin-down rate is consistent with zero, the small glitch is still relatively too large for this scenario to take this possibility into account.

McKee and his team predict that for the current set of millisecond pulsars included in the PTA experiment, there is a probability of about 50 percent that another glitch will be observed in a timing array pulsar within 10 years. However, it won't be an easy task.

"For future glitches in PTA pulsars, only the pre-glitch data would be usable until sufficient time had passed for the post-glitch spin parameters to be measured, or for any post-glitch pulse profile variation to be recognized in the case of a magnetospheric variation," they concluded.

The research confirmed that glitches are very rare in millisecond pulsars. The results presented in the paper could also encourage the scientific community to conduct further studies regarding the difference between the number of glitches in millisecond pulsars and the general pulsar population.

More information: A glitch in the millisecond pulsar J0613-0200, arXiv:1606.04098 [astro-ph.HE] arxiv.org/abs/1606.04098

Abstract

We present evidence for a small glitch in the spin evolution of the millisecond pulsar J0613−0200, using the EPTA Data Release 1.0, combined with Jodrell Bank analogue filterbank TOAs recorded with the Lovell telescope and Effelsberg Pulsar Observing System TOAs. A spin frequency step of 0.82(3) nHz and frequency derivative step of $-1.6(39)\times10^{-19}$Hz s^{-1} are measured at the epoch of MJD 50888(30). After PSR B1821−24A, this is only the second glitch ever observed in a millisecond pulsar, with a fractional size in frequency of $\Delta\nu/\nu=2.5(1)\times10^{-12}$, which is several times smaller than the previous smallest glitch. PSR J0613−0200 is used in gravitational wave searches with pulsar timing arrays, and is to date only the second such pulsar to have experienced a glitch in a combined 886 pulsar-years of observations. We find that accurately modelling the glitch does not impact the timing precision for pulsar timing array applications. We estimate that for the current set of millisecond pulsars included in the International Pulsar Timing Array, there is a probability of ~50% that another glitch will be observed in a timing array pulsar within 10 years.