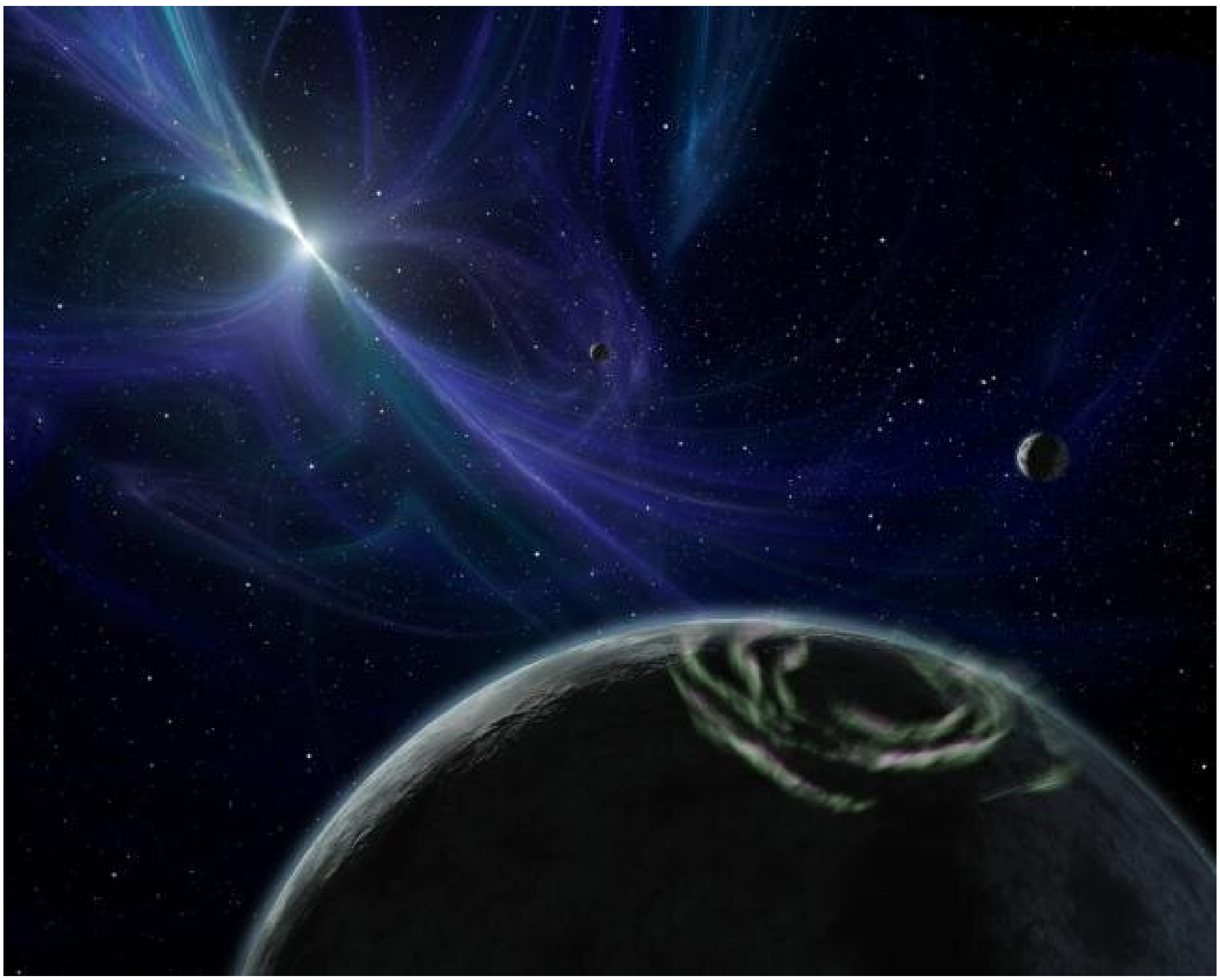
Ticking cosmic clocks reveal the evolution of stars over millions of years

March 19 2020



Artist View of Pulsar Planet System. Credit: NASA/JPL (NASA)

Pulsars, a type of rotating neutron star, are well-known as incredibly stable astrophysical clocks. Their regularity, used to measure their radio pulses, has led to some of the most exciting tests of Einstein's general theory of relativity and allowed scientists to examine the behavior of the extremely dense matter inside neutron stars.

But just like ordinary clocks here on Earth, pulsars are not perfect keepers of time. Much like a watch losing a few seconds each year, the exact rate at which pulsars spin appears to randomly wander by tiny amounts over month- to decade-long timescales.

The spins of a small fraction of pulsars have also been seen to rapidly speed up—they start 'ticking' slightly faster than usual. These effects, called 'spin noise' and 'glitches," change from pulsar to pulsar and may reveal how neutron stars evolved over millions of years; however, this requires precision tracking of hundreds of pulsar spins over many years.

Thanks to a series of upgrades over the last decade, the Molonglo Telescope, which celebrated its 50th birthday in 2015, can perform spin-tracking observations of hundreds of pulsars every two weeks. This enabled researchers from the ARC Centre of Gravitational Wave Discovery (OzGrav) to find three new glitch events and measure the strength of the spin noise in 300 pulsars.

In a recently published study led by OzGrav Ph.D. student Marcus Lower, researchers examined 280 pulsars that are most representative of normal pulsar evolution and developed a statistical method similar to the one used for analyzing gravitational-wave events detected by LIGO and Virgo. The results, presented at CSIRO's Australia Telescope National Facility colloquium, showed that spin noise seems to decrease with pulsar age, and that there is a scaling relationship between spin noise strength, how quickly a pulsar spins and how fast its spin is slowing down over time.

Marcus explains, "As spin noise becomes more obvious the longer you stare at a pulsar, we may be able to add additional pulsars to a re-analysis of the Molonglo data set in the future. We can also apply the statistical method to data from telescopes that have been tracking pulsar spins over multiple decades."

The combination of additional pulsars and longer data sets would improve the study's current measurements and allow researchers to determine the exact cause of spin noise in pulsars.

More information: M E Lower et al. The UTMOST pulsar timing programme II: Timing noise across the pulsar population, *Monthly Notices of the Royal Astronomical Society* (2020). DOI: 10.1093/mnras/staa615

Provided by ARC Centre of Excellence for Gravitational Wave Discovery