UNIVERSITY of TASMANIA

Thursday, 12 April 2018

Scientists capture neutron star's glitch, offering new insights into how matter behaves

For the first time scientists have been able to capture the Vela Pulsar glitch using a large radio telescope, offering new insights into how matter behaves in extreme environments.

PhD candidate Jim Palfreyman, from the University of Tasmania's School of Natural Sciences, worked with Professor John Dickey and colleagues at CSIRO Astronomy and Space Science and Auckland University of Technology in monitoring the Vela Pulsar over four years to capture the glitch.

Pulsars are rapidly rotating neutron stars, with some pulsars abruptly changing rotation rates for no apparent reason. This sudden change of spin rate is called a glitch.

"We knew a glitch happens about every three years, but like an earthquake, no one can predict one," Mr Palfreyman said.

"We knew that if we could capture the glitch and the individual pulses it would provide us a wealth of information, including how matter behaves at extreme temperatures and pressures."

Discovered in 1968, the Vela Pulsar is a neutron star about 1,000 light years away from Earth. It is 20 km in width and rotates 11 times a second. It weighs one and a half times the mass of the sun.

"A cup full of the material from this neutron star would weigh as much as Mount Everest," Mr Palfreyman said.

Mr Palfreyman recorded 640MB of data every 10 seconds for 19 hours a day for most days over four years using the University of Tasmania's 26-metre radio telescope at the Mount Pleasant Observatory, near Hobart, and the 30-metre radio telescope at Ceduna in South Australia.

The collection resulted in three petabytes of data (*1 petabyte = 1 000 000 gigabytes*).

"The way the glitch occurs is quite complex where the superfluid core of the star spins separately from the hard crust on the outside," Mr Palfreyman said.

“Then after about three years the core grabs the crust, which is slowing down, and speeds it up, causing the glitch to occur.

“By capturing the glitch, and the individual pulses, it helps us to better understand the ‘equation of state’ – which is how matter behaves in different environments.

“A pulsar is a laboratory we simply cannot recreate here on Earth. It has amazingly high temperatures and pressures and a massive magnetic field.

“The information gained might be useful in a variety of ways, such as building devices or machines that operate at extreme temperatures and pressures like a fusion reactor.”

Professor John Dickey said scientists have been observing pulsars since the late 1960s, and have only been able to see the exterior of the neutron stars.

“This is the first time we have been able to get an indication of what’s happening in the core which we haven’t been able to see,” he said.

The research, ‘Alteration of the magnetosphere of the Vela Pulsar during a glitch’, was published today in *Nature*.

Mr Palfreyman and Professor Dickey collaborated with co-authors Aidan Hotan (CSIRO Astronomy and Space Science), Simon Ellingsen (University of Tasmania) and Willem Van Straten (Auckland University of Technology).

At a glance:

- The Vela Pulsar is a neutron star, 20 kms in width that rotates 11 times a second. It weighs one and a half times the mass of the sun.
- The neutron star glitches approximately every three years.
- For the first time, scientists have captured the glitch, with a radio telescope large enough to see individual pulses.
- Recording the glitch allows scientists to gain a better understanding of the ‘equation of state’ – how matter behaves at extreme temperatures and pressures.
- The glitch caused the pulsar to ‘null’ or miss a pulse, which means the magnetosphere was disrupted by the glitch. The glitch appeared to take about five seconds to occur. This was a bit quicker than expected.

For media:
A list of assets including interviews with Jim Palfreyman and Professor Dickey, audio of the Vela Pulsar glitch, images of the 26-metre radio telescope and Vela Pulsar can be found here https://cloudstor.aarnet.edu.au/plus/s/JZhZ2vIEUBhb6yX

(NB: Images of the 26-metre radio telescope to be credited to Monte Bovill)

Jim Palfreyman also features in a *Nature* podcast:
www.nature.com/nature/podcast/index.html

Media interviews: contact Jim Palfreyman, PhD candidate (School of Natural Sciences), jim77742@gmail.com/ +61 407 882 718.

Information released by:
Communications and Media Office
University of Tasmania
+61 3 6226 2124
Media.Office@utas.edu.au
Twitter.com/utas_newsroom