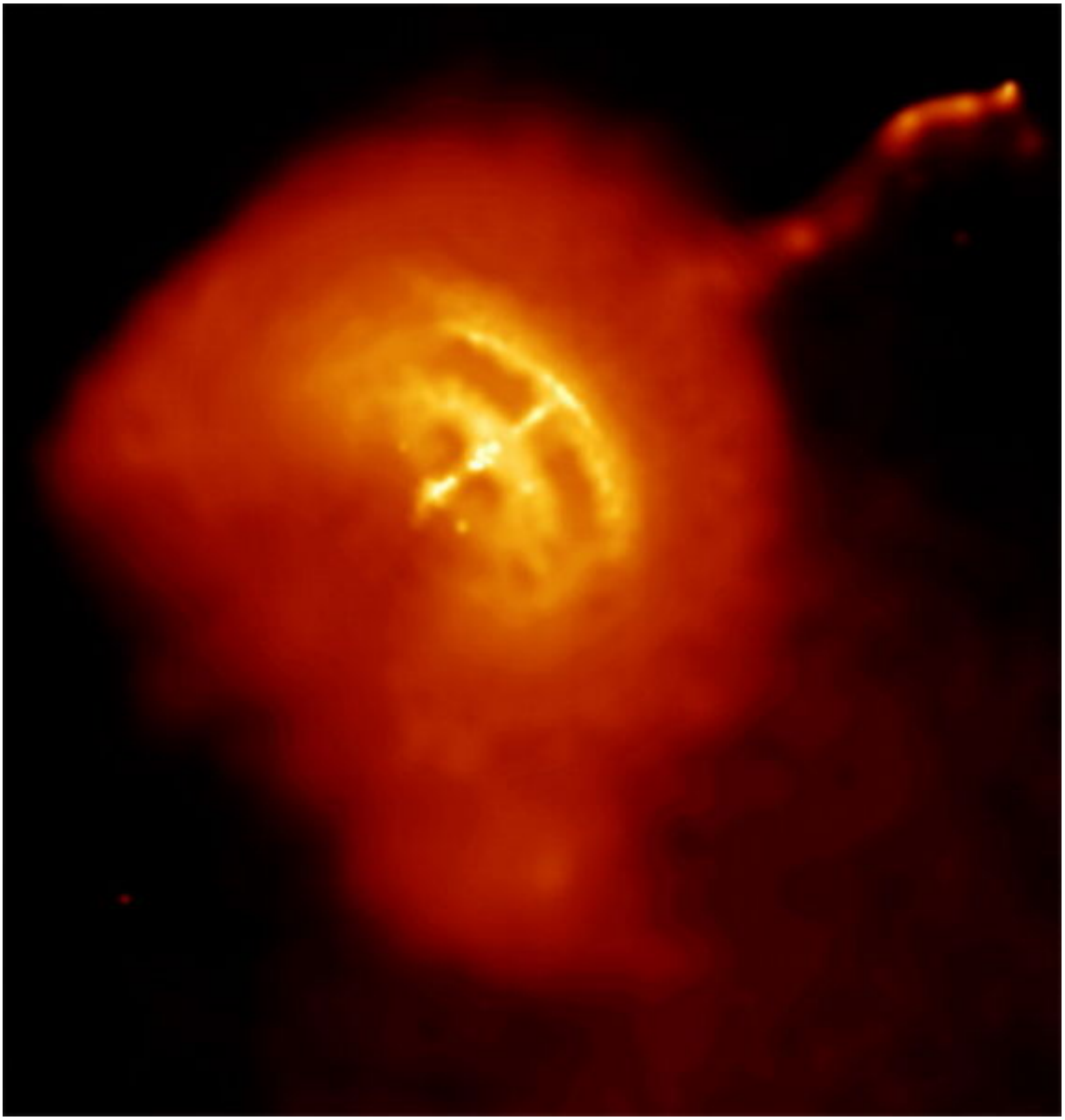
The 'glitching' of the Vela pulsar

February 9 2016, by Tomasz Nowakowski



The Vela pulsar, a neutron star corpse left from a titanic stellar supernova explosion, shoots through space powered by a jet emitted from one of the neutron star's rotational poles. Now a counter jet in front of the neutron star has been imaged by the Chandra X-ray observatory. The Chandra image above shows Vela as a bright white spot in the middle of the picture, surrounded by hot gas shown in yellow and orange. The counter jet can be seen wiggling from the hot gas in the upper right. Chandra has been studying this jet so long that it's been able to create a movie of the jet's motion. The jet moves through space like a firehose, wiggling to the left and right and up and down, but staying collimated: the "hose" around the stream is, in this case, composed of a tightly bound magnetic field. Credit: NASA/CXC/PSU/G.Pavlov et al.

(Phys.org)—A team of Australian astronomers has conducted an intensive observation of a curious young pulsar to investigate changes in its rotation frequency known as 'glitching'. Located about 910 light years from the Earth, the Vela pulsar is very young in astronomical terms, only 11,300 years old, and has captured astronomers' attention with its 'glitching' nature. In a paper published online on Feb. 5 on arXiv.org, Jim Palfreyman of the University of Tasmania, together with his teammates, try to provide more insights on the pulsar's violent behavior.

The astronomers conducted a long-term and single pulse study of Vela, using a 26 m radio telescope at the Mount Pleasant Radio Observatory, located near Hobart, Australia. The observation campaign, lasting 18 months, began in March 2014 and collected over 6,000 hours of single-pulse data. A total of 1.5 petabytes of data were collected, describing about 237 million single pulses.

It is known from previous studies that Vela regularly speeds up in rotation frequency, approximately every three years and also experiences 'micro-glitches' a number of times per year. The new research showed Vela's pulse width change over time, as it changes sharply after a micro-

glitch, and that the rate of bright pulse activity also changes with micro-glitches.

"What is affecting pulse width is affecting the entire pulse shape. Our observations show that after the second and larger micro-glitch, the pulse has decreased in width," the scientists wrote in the paper.

What puzzled Palfreyman's team is that the first micro-glitch coincides with a sudden increase in bright pulse rates, with no change in pulse width, while the second micro-glitch coincides with a reverse situation, showing sudden decrease in pulse width with no change in bright pulse rate.

"Our data shows a pattern of pulse width increase and then decrease following the small micro-glitch. After the much larger micro-glitch, we see a sharp decrease in pulse width followed by a steady increase," the researchers noted.

To explain this phenomenon, the scientists suggest that the pulsar's emission zones might be mathematically chaotic in nature and note that width changes could also be caused by a change in the width of the emission cone. However, this theory relies on the emission zones occurring in the cone, whereas young pulsars like Vela should have main core emission rather than conal emission.

The astronomers also found out that secular changes in Vela's pulse width have three possible cyclic periods that match with X-ray periodicities of a helical jet, implying free precession. The helical X-ray jet streaming from the rotational axis of the pulsar, potentially caused by precession, has periods of 122, 73 and 91 days, what was revealed in previous research papers.

"We see three definite periods in our pulse width data and the ranges of

these fall within the ranges of the 'acceptable' periods," the paper reads.

The researchers concluded that their study is crucial for the understanding of Vela's daily integrated pulse profile width, which is changing both slowly over time and has a discontinuity after a micro-glitch. According to the new findings, these micro-glitches also affect bright-pulse rates, but in an inconsistent manner.

Palfreyman and his colleagues hope that their results might shed some new light on the pulsar emission and glitching process. They also intend to produce further research papers from the large data set acquired during the 18-month intensive observing campaign.

More information: Temporal Evolution of the Vela Pulsar's Pulse Profile, arXiv:1602.01899 [astro-ph.HE] arxiv.org/abs/1602.01899

Abstract
The mechanisms of emission and changes in rotation frequency ('glitching') of the Vela pulsar (J0835-4510) are not well understood. Further insight into these mechanisms can be achieved by long-term studies of integrated pulse width, timing residuals, and bright pulse rates. We have undertaken an intensive observing campaign of Vela and collected over 6000 hours of single pulse data. The data shows that the pulse width changes with time, including marked jumps in width after micro-glitches (frequency changes). The abundance of bright pulses also changes after some micro-glitches, but not all. The secular changes in pulse width have three possible cyclic periods, that match with X-ray periodicities of a helical jet that are interpreted as free precession.