Nature article turns theory of stellar evolution upside-down

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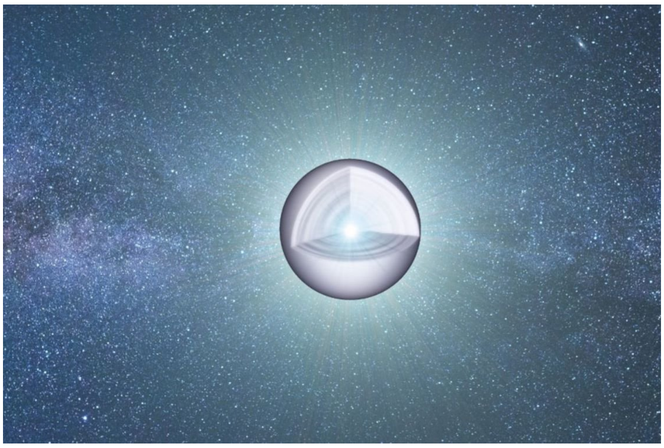

Credit: University of Montreal

This week, *Nature* published an article that could challenge the theory of stellar evolution.

"I think that, over the coming months, stellar astrophysicists will have to redo their calculations," said Gilles Fontaine, a physics professor at Université de Montréal and one of the authors of the article, titled "A large oxygen-dominated core from the seismic cartography of a pulsating white dwarf."

Its lead author is Noemi Giammichele, who completed her doctorate in 2016 under the joint supervision of Fontaine and his colleague Pierre Bergeron, both of whom co-authored the article along with six other researchers. The piece reports on a study of data collected by the Kepler Space Telescope.

"We were able to map the interior of a pulsating white dwarf star with precision, as if we'd sliced it into cross-sections to study its composition," said Giammichele, now a post-doctoral fellow at Université de Toulouse, in France. The map showed the star's vibrations sometimes reach all the way to its centre.

White dwarfs "are the core remnants of nearly 97% of the stars in the Universe," explained Robert Lamontagne, head of media relations at UdeM's Centre for Research in Astrophysics. "As stars slowly die, inexorably cooling down in the form of white dwarfs, they experience periods of instability in which they vibrate. These deep vibrations – or starquakes – are the key to seeing right into the very interior of these stellar remnants."

From a distance of 1,375 light-years from Earth, white dwarf KIC08626021 emits light that is barely visible by telescopes on Earth. The Kepler, however, can focus on it over an extended period, resulting in significantly more detailed images. Because the Montreal researchers were able to access the space telescope, the authors were able to take a close look at this small star – about the size of the Earth – and its vibrations.

Nearly 300 experts worldwide specialize in studying white dwarfs. Giammichele's initial goal was to verify a theory on this final stage of a star's life cycle. The theory proved correct, but the team's observations led to a number of surprising discoveries.

A bigger core

When examining the star, located at the edges of the Cygnus and Lyra constellations, the researchers discovered that its carbon and oxygen core was twice as big as the theory predicted. "This is a major discovery that will force us to re-evaluate our view of how stars die," said Fontaine. "That said, more work must be done to confirm whether this observation holds true for other stars. It may just be an anomaly."

"We must try to reproduce these results with other celestial bodies before we can make any conclusions," Giammichele agreed. Although

KIC08626021 was the first pulsating white dwarf identified by the Kepler telescope, approximately 60 more have since been discovered, she added. "I have enough data to spend the next 20 years analyzing them one by one."

Ground-breaking method

The new article is Fontaine's fourth in *Nature*, one of the world's top scientific magazines, and its publication closes a circle in his career. In 1978, the professor glimpsed the potential for determining the internal structure of a pulsating white dwarf through a solid understanding of the theory of stellar evolution. "But there was still a long way to go," he recalled. "First, we had no access to high-quality images because terrestrial telescopes gave us very imprecise images of these bodies. Then we had to create the analytical tools, the software, etc. And last but not least, we had to find the right person to pursue this lead."

Fontaine praised his former student, who developed an innovative approach to achieve her goals. As a graduate of Polytechnique Montréal with a master's in mechanical engineering, Giammichele applied methods used for calculating the aerodynamics of airplane wings to astrophysics. "I believe this approach is what allowed us to move forward," said Fontaine, adding that five of the other co-authors studied under him as well.

For her part, Giammichele is pleased that one of the five articles comprising her doctoral thesis will now reach a broader audience. "What I want to do now, in terms of my career, is keep doing research," she said. "That's what I like most: figuring out how to solve problems."

More information: N. Giammichele et al. A large oxygen-dominated core from the seismic cartography of a pulsating white dwarf, *Nature* (2018). DOI: 10.1038/nature25136

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