Astronomers Find Most Stable Optical Clock In Heavens

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After 31 years of tracking the light- output of a burnt-out star from telescopes at McDonald Observatory, astronomer S.O. Kepler of Brazil's Universidade Federal do Rio Grande do Sul, and a slew of University of Texas colleagues have found the most stable optical clock in the heavens.

The finding has implications for theories of how stars live and die, and places limits on where planets can exist around this white dwarf.

Their results are being published in today's edition of The Astrophysical Journal in what is being called a "landmark paper" by one of that journal's editors.

The star in question is a 400 million-year-old white dwarf called G117-B15A, located in Leo Minor. Its pulses of light are so regular that it loses one second in 8.9 million years. This makes the pulses of G117 more accurate and much more stable than the ticks of an atomic clock, Kepler said.

Some may suggest that the so-called "millisecond Pulsars" are better timekeepers than G117. Kepler Doesn't think so. Millisecond pulsars are the spinning remnant cores of massive stars that have exploded as supernovae. Their lighthouse-like beacon of radio waves and X-rays sweep by Earth regularly, acting as extremely accurate clocks. While it is true that a few pulsars are somewhat more accurate than G117, their clocks are not as stable -- that is, their accuracy breaks down sooner, Kepler said.

As a white dwarf, G117 is the corpse of a Sun-like star that has exhausted its supply of nuclear fuel, and shed its outer layers of gas so that only the core remains. This dead core slowly cools over billions of years.

If astronomers could measure the rate of cooling, it would be a boon to understanding how stars evolve and die. In fact, this can now be done. "The use of white dwarfs as chronometers is a sport we invented here at McDonald Observatory in 1987," said white dwarf expert Don Winget of The University of Texas at Austin, one of the co- authors on the paper. "White dwarfs are now a standard chronometer for stellar evolution."

The key is that some white dwarfs pulsate -- that is, give off bursts of light in a regular rhythm. As the white dwarf cools over time, the pulse arrival time slows down. By measuring how the pulses slow over time, astronomers can measure how fast the white dwarf is cooling.

"What we[1]re measuring is the pulse arrival time of the main pulsation of the star, which is a 215-second pulsation," Winget said. "We've exploited the fact that time is the most accurate physical quantity that human beings can measure. So over the years we've accumulated timings of the pulsations of this star, which have turned out to be remarkably stable. And in fact we[1]ve finally measured a change in the pulsation period.

"This is a direct measure of the evolution of a star," he said. That feat has only been reached once before. In 1987, Winget and a team of Texas astronomers measured the cooling rate of a pre-white dwarf star called PG1159-035. "Its evolutionary timescale was four orders of magnitude shorter

- - faster than G117," Winget said. "So this new result is an extension by a factor of 10,000 over the only previous measure of stellar evolution."

And because white dwarfs are some of the oldest stars in the galaxy, measuring how long they've been cooling is one way to measure the age of the Milky Way itself.

"The other thing that this does is set limits on extrasolar planets that might be present around this star," Winget said. Kepler explained that both the star and any planets orbiting it would orbit around the entire system's center of mass. "This will affect the pulse arrival time," he said, allowing detection of the planet(s).

The decades of data on G117 show no Jupiter-mass planet at Jupiter's distance or any closer, Kepler said. The orbital distance from the parent star is an important factor, Winget said. "This whole area has never been probed by any other method ever before ... we[1]re sort of plowing a new field here."

Texas astronomer Rob Robinson and his graduate student John McGraw began timing the pulses from G117 in 1974, using the

2. 1-meter and 0.9-meter telescopes at McDonald Observatory. Kepler joined the work as a graduate student at Texas in 1979. Kepler continued the project after he completed his PhD at Texas and returned home to Brazil.

"No one thought the project could be done," Winget said. "You'd never get the telescope time. Even 20 years ago, we knew it was going to take another 20 years. This result is a testimony to perseverance," Winget said. "Kepler has seen this through."

The reconnaissance of G117 continues. "My students will be observing G117," Kepler said. He traces the "family tree" from Rob Robinson, to John McGraw, to himself, to his Brazilian graduate student Barbara Castanheira, who is spending a year visiting The University of Texas at

Austin.

Source: McDonald Observatory