Oddball stars explained

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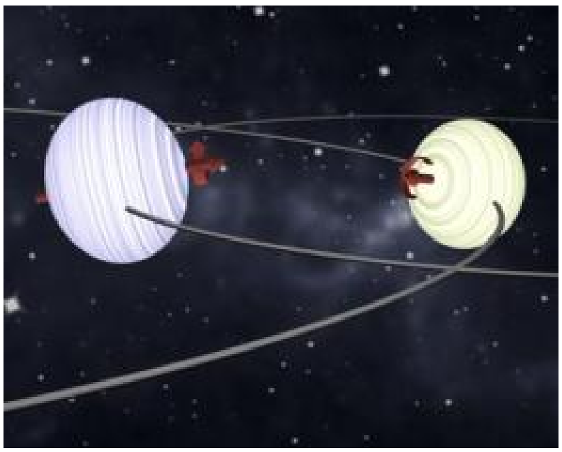

This artist's conception of the double-star system DI Herculis illustrates the key findings from the new research. Spectroscopic observations showed that the two stars are both tipped over almost horizontally, relative to the plane of their orbits around each other. Because they are rotating rapidly which creates equatorial bulges, the tidal interactions between the two slows down a regular variation in the plane of the orbits, called precession -- a slowing that had been a mystery for three decades. Photo - Courtesy of Simon Albrecht

(PhysOrg.com) -- New observations solve longstanding mystery of tipped rotation. In addition to shedding light on how binary stars form, the explanation knocks down a possible challenge to Einstein's theory of relativity.

A pair of unusual stars known as DI Herculis has confounded astronomers for three decades, but new observations by MIT researchers and their colleagues have provided data that they say solve the mystery once and for all.

It has long been clear that there was something odd going on in this double-star system, but it wasn't clear just what that was. The precession of the orbits of the two stars around each other — that is, the way the plane of those orbits change their tilt over time, like the wobbling of a top as it winds down — seems to take place four times more slowly than established theory says it should. The anomaly is so unexpected that at one point it was seen as possible evidence against Einstein's long-accepted theory of relativity.

But the true explanation seems to be much less radical, though still unique among observed stars. Both of them, it turns out, are rotating tipped over on their sides, relative to the plane of their orbits around each other, instead of straight upright like most binary stars. Because stars rotate fast enough to have significant equatorial bulges (just like on Earth, which is wider at the equator than pole-to-pole), these tipped-over bulges produce an unusual tidal interaction between them that counteracts the forces that would normally cause the expected rate of precession, and that accounts for the observed slowing of this effect. And so, relativity has dodged another bullet.

"It's been a riddle for 30 years," says MIT postdoctoral researcher Simon Albrecht, co-author of a new paper appearing in the Sept. 17 issue of *Nature* that describes the solution. New observations of the stars, which are about 2,000 light years from Earth but orbit each other with a separation of only about one-fifth the distance from the Earth to the sun, were carried out by Albrecht, assistant professor of physics Joshua Winn, and others. Using a high-resolution spectrograph called Sophie on a 1.93-meter telescope at the Observatoire de Haute-Provence in France, they found an answer to the mystery.

The new observations, after detailed analysis, reveal that one of the two stars is tipped over by at least 70 degrees from the vertical, and the other is tipped the opposite way by more than 80 degrees.

One lesson of this finding, says Winn, is to "check your assumptions." The more astronomers learn about the details of stars and planetary systems, the more odd variations keep turning up. "Everyone always assumed that planets orbit in the same plane as their star's rotation," until some recent discoveries of exceptions to that rule, "and that binary stars are aligned. These assumptions are just not true."

The assumption has been that binary stars should always have their spin axes aligned, because they are believed to have formed from a single swirling cloud of dust and gas, whose direction of rotation should be inherited by the resulting stars. Now that this drastically misaligned pair of stars has been found, theorists might be forced to rethink how such binary systems form. "Maybe most binary stars are formed misaligned," but then most of them become aligned as a result of their gravitational interaction, Winn says. Or maybe it's the opposite: most form aligned and some become tidally disturbed and lose their alignment.

Other star and planet systems are "certainly more dynamic than we would have guessed, based on our solar system orbits," Albrecht says.

It's also possible that these two stars formed separately and one was captured by the gravitational attraction of the other after a close encounter, but Albrecht says that is unlikely, because the stars are near-twins. "These are so similar in mass and lifetime that we wouldn't expect that," he says.

The work was carried out in collaboration with Sabine Reffert of the Zentrum fur Astronomie in Heidelberg, Germany, and Ignas Snellen of the Leiden Observatory in the Netherlands (where Albrecht earned his

PhD). It was partly supported by grants from NASA's Origins program, the Optical Infrared Coordination network, and a Rubicon fellowship from the Netherlands Organisation for Scientific Research.

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