Research reveals an enormous planet quickly orbiting a tiny, dying star

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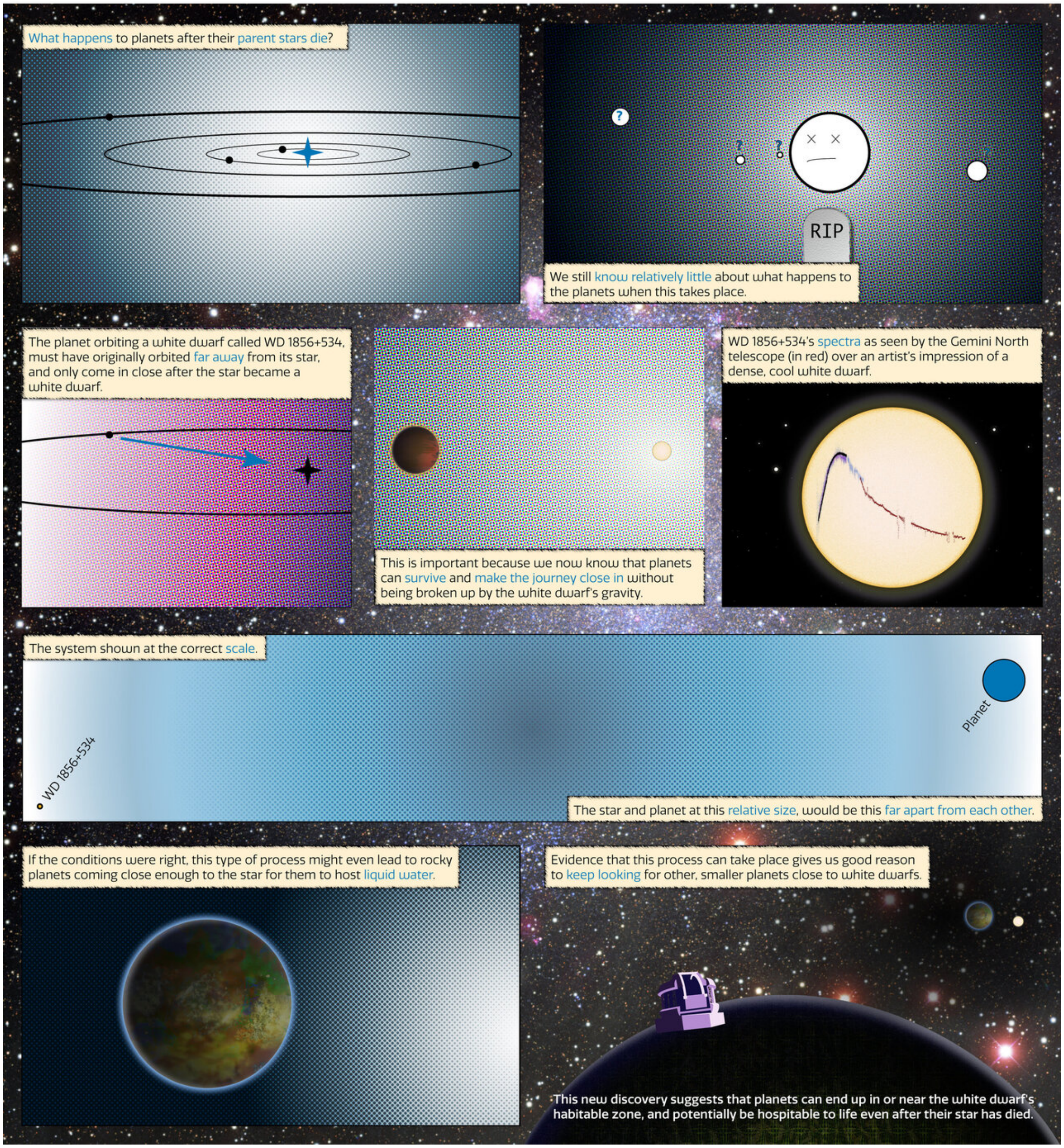
Jupiter Sized Planet Found Orbiting White Dwarf



For the first time, an intact, Jupiter-sized, exoplanet has been discovered orbiting close to a white dwarf star. Credit: International Gemini Observatory/NOIRLab/NSF/AURA/J. Pollard

Thanks to a bevy of telescopes in space and on Earth—and even a pair of amateur astronomers in Arizona—a University of Wisconsin-Madison astronomer and his colleagues have discovered a Jupiter-sized planet orbiting at breakneck speed around a distant white dwarf star. The system, about 80 light years away, violates all common conventions about stars and planets. The white dwarf is the remnant of a sun-like star, greatly shrunken down to roughly the size of Earth, yet it retains half the sun's mass. The massive planet looms over its tiny star, which it circles every 34 hours thanks to an incredibly close orbit. In contrast, Mercury takes a comparatively lethargic 90 days to orbit the sun. While there have been hints of large planets orbiting close to white dwarfs in the past, the new findings are the clearest evidence yet that these bizarre pairings exist. That confirmation highlights the diverse ways stellar systems can evolve and may give a glimpse at our own solar system's fate. Such a white dwarf system could even provide a rare habitable arrangement for life to arise in the light of a dying star.

"We've never seen evidence before of a planet coming in so close to a white dwarf and surviving. It's a pleasant surprise," says lead researcher Andrew Vanderburg, who recently joined the UW-Madison astronomy department as an assistant professor. Vanderburg completed the work while an independent NASA Sagan Fellow at the University of Texas at Austin.

The researchers published their findings Sept. 16 in the journal *Nature*. Vanderburg led a large, international collaboration of astronomers who analyzed the data. The contributing telescopes included NASA's exoplanet-hunting telescope TESS and two large ground-based telescopes in the Canary Islands.

Vanderburg was originally drawn to studying white dwarfs—the remains of sun-sized stars after they exhaust their nuclear fuel—and their planets by accident. While in graduate school, he was reviewing data from

TESS's predecessor, the Kepler space telescope, and noticed a white dwarf with a cloud of debris around it.

"What we ended up finding was that this was a minor planet or asteroid that was being ripped apart as we watched, which was really cool," says Vanderburg. The planet had been destroyed by the star's gravity after its transition to a white dwarf caused the planet's orbit to fall in toward the star.

Ever since, Vanderburg has wondered if planets, especially large ones, could survive the journey in toward an aging star.

By scanning data for thousands of white dwarf systems collected by TESS, the researchers spotted a star whose brightness dimmed by half about every one-and-a-half days, a sign that something big was passing in front of the star on a tight, lightning-fast orbit. But it was hard to interpret the data because the glare from a nearby star was interfering with TESS's measurements. To overcome this obstacle, the astronomers supplemented the TESS data from higher-resolution ground-based telescopes, including three run by amateur astronomers.

"Once the glare was under control, in one night, they got much nicer and much cleaner data than we got with a month of observations from space," says Vanderburg. Because white dwarfs are so much smaller than normal stars, large planets passing in front of them block a lot of the star's light, making detection by ground-based telescopes much simpler.

The data revealed that a planet roughly the size of Jupiter, perhaps a little larger, was orbiting very close to its star. Vanderburg's team believes the gas giant started off much farther from the star and moved into its current orbit after the star evolved into a white dwarf.

The question became: how did this planet avoid being torn apart during the upheaval? Previous models of white dwarf-planet interactions didn't seem to line up for this particular star system.

The researchers ran new simulations that provided a potential answer to the mystery. When the star ran out of fuel, it expanded into a red giant, engulfing any nearby planets and destabilizing the Jupiter-sized planet that orbited farther away. That caused the planet to take on an exaggerated, oval orbit that passed very close to the now-shrunken white dwarf but also flung the planet very far away at the orbit's apex.

Over eons, the gravitational interaction between the white dwarf and its planet slowly dispersed energy, ultimately guiding the planet into a tight, circular orbit that takes just one-and-a-half days to complete. That process takes time—billions of years. This particular white dwarf is one of the oldest observed by the TESS telescope at almost 6 billion years old, plenty of time to slow down its massive planet partner.

While white dwarfs no longer conduct nuclear fusion, they still release light and heat as they cool down. It's possible that a planet close enough to such a dying star would find itself in the habitable zone, the region near a star where liquid water can exist, presumed to be required for life to arise and survive.

Now that research has confirmed these systems exist, they offer a tantalizing opportunity for searching for other forms of life. The unique structure of white dwarf-planet systems provides an ideal opportunity to study the chemical signatures of orbiting planets' atmospheres, a potential way to search for signs of life from afar.

"I think the most exciting part of this work is what it means for both habitability in general—can there be hospitable regions in these dead solar systems—and also our ability to find evidence of that habitability," says Vanderburg.

More information: A giant planet candidate transiting a white dwarf, *Nature* (2020). DOI: 10.1038/s41586-020-2713-y , www.nature.com/articles/s41586-020-2713-y

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