Article:

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A transiting planet in the stellar graveyard

In the last few decades the number of planets discovered beyond our solar system has rapidly expanded and current estimates are that around a third of all Sun-like stars host planetary systems[1]. Given that the Milky Way contains around 10 billion Sun-like stars, there are likely to be billions of planets in our Galaxy. All of these planet-hosting stars will eventually die, leaving behind a burnt-out remnant known as a white dwarf. What becomes of their planetary systems when this happens is unclear, but in some cases planets are thought to survive the death of their star and remain in orbit around a white dwarf[2]. On page XX Vanderburg et al.[3] report the discovery of a planet transiting the white dwarf WD 1856+534 every 1.4 days. Their work not only proves that planets can indeed survive the death of their star, but may also offer us a glimpse of the far future of our own solar system.

Stars like the Sun fuse hydrogen into helium in their cores, producing copious amounts of energy that they use to support themselves against gravitational collapse. Stars are born with huge reserves of hydrogen, but eventually every star will exhaust its supply. The Sun has burned through roughly half of it's hydrogen supply and when this runs out, in 5 billion years, the Sun, and by extension the rest of the solar system, will undergo a fundamental change. Initially, hydrogen fusion will continue in a shell around the Sun's core. This will cause the outer envelope of the Sun to swell up to an enormous size. At it's peak the surface of the Sun may reach all the way to the Earth's orbit, engulfing Mercury, Venus and potentially the Earth itself. From this point the Sun will start to rapidly eject it's outer envelope into interstellar space. The decreasing mass of the Sun means that it's gravitational grip on the planets will loosen, causing them to move outwards, away from the Sun. When the last of the envelope is ejected the core of the Sun will be revealed; a smouldering Earth-sized ball that will slowly cool for the rest of time, a object astronomers call a white dwarf.

When looking at the future of our own solar system it is clear that the closest planets to the Sun are likely to be engulfed and destroyed. However, Mars, the asteroid belt and all the gas giant planets are likely to survive this phase. While the mass lost from the Sun will cause their orbits to expand, these outer planets are likely to remain gravitationally bound to the white dwarf left behind. Hence we might expect that many white dwarfs should host remnant planetary systems. Indeed, there has been growing evidence of this in the form of asteroids that have wandered too close to white dwarfs and have been torn apart by the intense gravitational forces[4]. Debris from these asteroids rains down onto the surfaces of many white dwarfs where we can detect it[5]. However, until now no direct detection of a planet in orbit around a white dwarf existed.

Vanderburg et al. used data collected by NASA's Transiting Exoplanet Survey Satellite (TESS) mission to detect the periodic dimming of the white dwarf WD 1856+534 caused by a planet passing between the white dwarf and Earth. Because white dwarfs are so small the planetary transit is actually very deep (56% of the white dwarf's light is blocked), compared to the typical 1-2% transit depths from planets around normal stars. In this case the transiting planet has a similar size to Jupiter and is therefore around 10 times larger than the white dwarf. In principle such a deep transit should be easy to detect, so it might seem odd that such systems have escaped discovery for so long. However, the small size of the white dwarf also means that the transits are very brief, lasting just 8 minutes in this case (compared to several hours for normal stars). Therefore, finding these planets requires that white dwarfs be both rapidly and constantly monitored, something that has only become possible in recent years.

One of the biggest mysteries to emerge from this study is how the planet managed to end up where it is. The planet is located just 4 solar radii from the white dwarf (or roughly 20 times closer to the white dwarf than Mercury is to the Sun). Since the inner planetary system was likely to have been swallowed up by the expanding star, it seems extremely unlikely that this planet has always existed this close to its star. Vanderburg et al. conclude that either the planet managed to avoid being destroyed when it was engulfed (by tearing off the outer layers of the star as it plunged into it) or that several distant planets survived the death of the star, but their altered orbits (due to the mass lost when the star died) caused them to interact with each other, resulting in this planet being thrown towards the white dwarf by another. This latter explanation seems the most likely and offers the tantalising opportunity of detecting additional planets in this system in the future. Given that WD 1856+534 is located only 25 parsecs away, the gravitational effects of any additional planets on the white dwarf could be detectable with missions such as Gaia. This system therefore opens up an entirely new field of exoplanetary research.

References:

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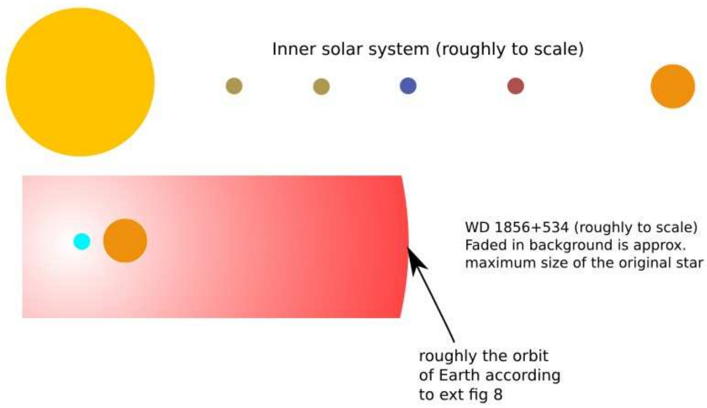
Figure idea:



The WD 1856+534 system compared to the solar system. The planet around WD 1856+534 orbits extremely close to the white dwarf. However, in the past the white dwarf was a giant star extending out well beyond this orbit. The planet was likely scattered into it’s current orbit by another distant planet.