EXTRASOLAR PLANETS

The one that got away

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Hanging around a star that has passed through its red-giant phase doesn't seem a likely place for a planet. But one planet apparently managed to avoid being engulfed by its bloated star — might others, too?

One of the most surprising things that we have learnt about planets during the past 15 years is that they can turn up almost anywhere. On page 189 of this issue, Silvotti *et al.*[1] expand our planet-finding horizon still farther: they have discovered a massive gas-giant planet orbiting an old star in a rare, late stage of the star's evolution. This system allows us to start examining what will happen to planets around stars such as our own Sun as they too evolve and grow old.

The parent star of the newly discovered planet is known as V 391 Pegasi. During its time as a middle-aged star, it had a mass similar to that of the Sun, and stably fused hydrogen into helium for billions of years. But once its core had burnt fully to helium, the star entered its red-giant phase, expanding in radius by more than 100 times. In 5 billion years' time, our Sun will suffer much the same fate, expanding out perhaps as far as to Earth's orbital distance.

Unusually, however, and for reasons that are not altogether clear, V 391 Pegasi lost its hydrogen-rich surrounding envelope in a strong, outflowing wind at the end of its red-giant phase. It was left with only a thin skin of atmosphere atop its burnt-out helium core. This type of compact, dense star is known as a B-type subdwarf, has a surface temperature of around 30,000 kelvin, and is powered not by hydrogen, but by the fusion of helium into carbon.

V 391 Pegasi is one of 40 stars in its rare class known to pulsate. The pulsations, which have periods of several minutes[2], give us clues to the structure of these stars[3] (similarly, the characteristic frequencies of the Sun's pulsations have told us much about its interior). But the pulsations also make it unusually easy to detect planets. The trick is to make precise observations of the timing of the pulses: the gravitational pull of the planet orbiting the star leads to subtle shifts in the distance of the star from Earth, which is reflected in the pulses' arrival times here.

This method has yielded the most exotic planetary systems discovered so far. The first planets found outside our Solar System ('exoplanets' in the jargon), which are in orbit around an ultra-dense neutron star, were discovered in this way[4]. They are in orbit around a pulsar — a radio-wave-emitting, ultra-dense neutron star that is a remnant of a supernova. In V 391 Pegasi's case, as Silvotti *et al.*[1] report, the clincher for the planetary hypothesis is two distinct pulsation modes, each with frequencies around 350 seconds, that vary in phase on the same 3.2-year timescale — probably the time the planet takes to orbit its star (Fig. 1).

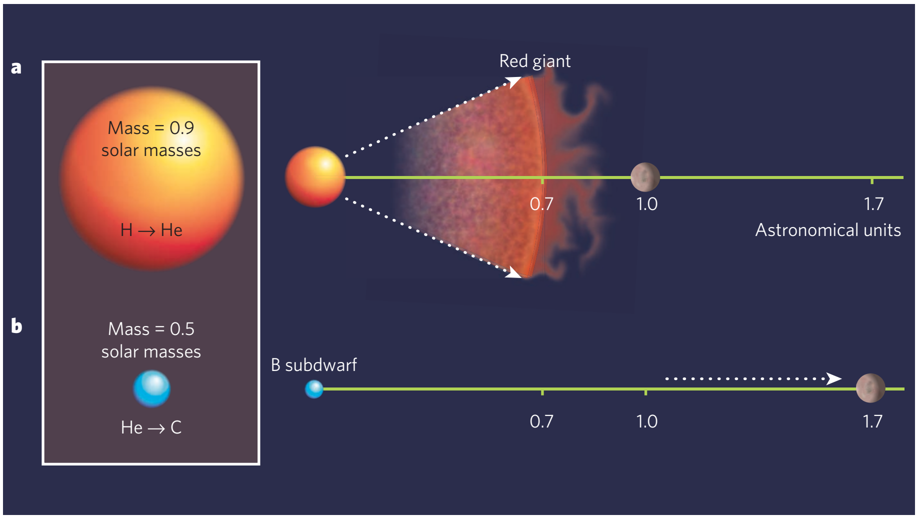

Figure 1 | A picture of things to come. a, When the star V 391 Pegasi was middle-aged — as our Sun is now — it fused hydrogen into helium, and its planet, identified by Silvotti *et al.*[1], sat at 1 astronomical unit, the same distance Earth is from the Sun. As the star evolved into a red giant, it expanded more than 100 times in radius to 70% of the star–planet distance. **b**, But the star later lost almost half of its mass, becoming a B-type subdwarf, for unknown reasons; it is possible that the presence of the planet itself played a part. With the star's gravitational pull reduced, the planet migrated to a more distant orbit, where it now resides, causing a variation in the phase of pulsed signals from V 391 Pegasi with a period of 3.2 years.

The discovery of such an unusual star–planet system represents an opportunity to understand both the star and the planet better. Astronomy is not an experimental science — we can't make a solar system to test a hypothesis — and so astronomers are left to search the skies to find a statistically significant number of samples, at various evolutionary stages, to construct consistent physical interpretations. At present, Silvotti and colleagues' discovery is the only planetary system known to have survived past its parent star's red-giant phase.

The formation of B subdwarfs is poorly understood: 98% of stars that reach the red-giant phase do not undergo the catastrophic mass loss characteristic of V 391 Pegasi and its brethren[5]. The planet's effect on the star's fate is unclear, and could be minimal. But one suggestion[6] is that a massive orbiting companion might deposit angular momentum and energy onto a star's hydrogen envelope, and so enhance its mass loss. To demonstrate convincingly that this mechanism is the dominant mode for forming these stars, however, many more B subdwarfs would need to be found harbouring a planet.

And predicting where planets can and cannot be is a tricky business. For instance, since 1995 we have learnt that in their Sun-like middle age about 1 in 100 'normal' stars have gas-giant planets of a similar mass to Jupiter orbiting within only 5–10 radii of their surface[7]. With a sample so far of almost 250 (and counting) planets around such stars, we are slowly starting to understand the diverse architectures of extrasolar planetary systems. What the configuration of planetary systems might be like around older stars further along in their evolution has been analysed in several studies. These have focused primarily on how planetary orbits might move outwards as stars lose mass, or inwards as planets are dragged in and consumed in the outer envelope of a bloated old star[8,9], and, more recently, on planetary evaporation in the face of intense stellar irradiation[10].

As in all of astronomy, further progress will involve finding additional objects so that we can understand planets around evolved stars as a class. If searches around evolved pulsating stars such as B subdwarfs and around still older, more-compact white dwarfs yield more planets, astronomers will be on the way towards understanding how stellar evolution affects the architecture of planetary systems. This will shed light not only on our own Solar System, in which Mercury, Venus and perhaps Earth will eventually be engulfed by the red-giant Sun[9], but also on the diverse array of planetary systems that are our Galactic neighbours. ■

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