Monster star found hiding in plain sight

Massive stars are rare, but they are sources of some of the most energetic phenomena seen in the Universe today. A high-mass candidate has now been found in a star-forming region that has been observed for more than 50 years.

DONALD F. FIGER

The most massive stars in the Universe captivate the imagination of laymen and experts alike. They represent an extreme form of star and produce outsized effects on their environment. Although stars with masses greater than 20 times the Sun's mass comprise only about 1% of all stars in a young star cluster, their ionizing radiation, stellar winds and ejecta from supernovae dominate some of the most observable phenomena in the Galaxy. Massive stars are among the few bodies that can be seen in other galaxies, and they are probably linked to the most massive explosions in the Universe. Finally, they are thought to have seeded the early Universe with heavy elements (those heavier than helium), which are now seen in even the oldest stars. Writing in *Astronomy & Astrophysics*, Wu *et al.*[1] identify the next heavyweight contender — a star with the decidedly unsexy name of W49nr1.

Wu and colleagues claim a mass for this star that would place it among the most massive known, but a sceptic might say "extraordinary claims require extraordinary evidence". Indeed, astronomers have, on further inspection, often thrown such assertions on the rubbish heap of history.

This kind of claim relies on models that translate the amount of observed starlight into an estimate of the mass of the star. Generally, the more massive the star, the brighter it is. As is almost always the case, Wu *et al.* observe light from the star over only a fairly narrow range of wavelengths, representing much less than 1% of the total emitted light. It would be useless to convert that relatively small portion of the total light into a mass estimate were it not for the fact that the observed wavelength range contains several key spectral features (nitrogen and helium lines) that are powerful diagnostics of the temperature of the star. On the basis of the strengths of these features, Wu *et al.* find that W49nr1 seems to be one of the hottest stars known. With the temperature in hand, it is relatively straightforward to extrapolate the observed light to the total emitted light by using spectral energy distributions of well-studied massive stars.

Also crucial to the authors' assertion is an estimate of the distance to the star and of the absorbing effects of dust that lies between Earth and the object. A star might look bright merely because it is close to us, just as a nearby candle might look bright even though its power output is actually feeble. Likewise, a star might look faint simply because a large amount of interstellar dust lies between it and an observer on Earth. Wu *et al.* used an existing estimate[2] of the star's distance based on the relatively accurate method of trigonometric parallax, which had been applied to observations of radio signals, from sources called masers, that are associated with the excitation of water molecules in the star-forming region around W49nr1 (Fig. 1).

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Figure 1 | Nestled in a young star cluster. The arrow indicates the location of W49nr1, a massive star identified by Wu *et al.*[1] in the central star cluster of the star-forming region W49. Scale bar, 1 arcminute.

Another key requirement for this claim is that the light is emitted by a single star. In fact, the most common fate for claims that a massive star has been observed is the subsequent discovery that the light is actually produced by two or more stars, in which case the light from any individual star in the system suggests a star much less massive than proposed. One famous example is a star in R136, a star cluster in the Large Magellanic Cloud — a satellite galaxy orbiting the Milky Way. In this case, the putative supermassive star, which was predicted to weigh up to a few thousand solar masses[3,4], turned out to be at least a dozen stars[5]. However, some think that it contains several stars as massive as 150–300 solar masses[6]. If true, those stars would violate an apparent limit of 150 solar masses[7].

Another famous example is η Carinae, which is located in the Milky Way. It was once thought to be the most massive star known, but is now accepted to be composed of at least two stars. The mighty Pistol Star, near the centre of our Galaxy, is another potential heavyweight champion. It is known to be solo down to a very small distance, but it could still contain more than one star in a close binary system. There are insufficient data to determine whether the Pistol Star or any of the stars in R136 are coupled into multiple-star systems.

Taking all the uncertainties together, Wu and colleagues estimate that W49nr1 could have a mass of between 90 and 250 solar masses — quite a wide range. At the upper end, the star would be one of the few most massive stars known. The best estimate of stellar mass comes from observing eclipses in a binary system, when one star passes in front of the other, and applying Kepler's laws of orbital motion. Using this method, the most massive stars known are about 100 times more massive than the Sun[8].

As is often the case, the newly weighed star has been seen before; it lies in a massive young cluster of stars that was first reported[9,10] more than ten years ago and that is part of a star-forming region that has been studied for more than five decades[11]. It is only with new observations and a refined analysis that Wu and colleagues have been able to make their claim. Their work demonstrates once again that we know relatively little about massive stars because so few of them have been thoroughly studied. Indeed, even in regions that have been observed for more than 50 years, astronomers are still finding monster stars hiding in plain sight. ■