Astronomers Find Origin Of Extreme-Helium Stars

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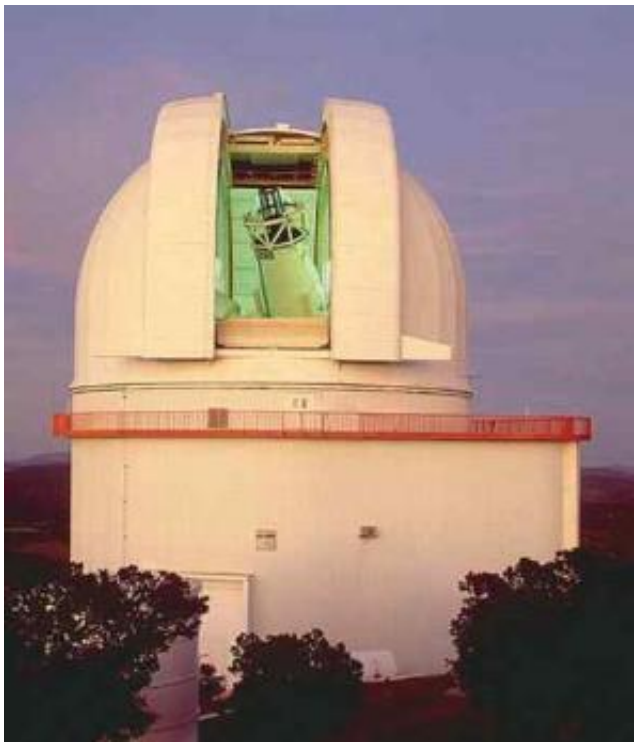

The 2.7-meter (107-inch) Harlan J. Smith Telescope at the University of Texas McDonald Observatory. Photo by Marty Harris/McDonald Observatory.

Astronomers have determined the origin of a very unusual and rare type of star. New data indicate that extreme-helium stars, as they are called, form from the merger of two white dwarfs.

Astronomers used the Hubble Space Telescope as well as instruments in India and Texas to obtain detailed spectrographic observations to determine the exact proportions of more than two dozen elements present in several extreme-helium stars.

"It's taken more than 60 years after the first discovery at McDonald to get some idea of how these formed," said team leader N. Kameswara Rao of the Indian Institute of Astrophysics in Bangalore. "We are now getting a consistent picture."

The first extreme-helium star, HD 124448, was discovered at McDonald Observatory in Austin in 1942 by Daniel M. Popper of the University of Chicago. Only about two-dozen such stars have been found since.

The stars are supergiants, less massive than the Sun but many times larger and hotter. They are remarkable because they contain almost no hydrogen, the most abundant chemical element in the universe and the most basic component of all stars. Instead, they are dominated by helium, with significant amounts of carbon, nitrogen and oxygen and traces of all other stable elements.

The origin of extreme-helium stars cannot be traced back to protostellar clouds of helium gas, because no such clouds ever existed in the Milky Way. Moreover, nuclear reactions in stars like the Sun convert hydrogen to helium, but confine the helium to their hot cores, where it cannot be detected spectrally.

A star must lose vast amounts of hydrogen gas before its helium can escape to the surface and be seen by telescopes. No known mechanism inside the star can drive off the overlying layers to expose the helium.

Two decades ago, astronomers Ronald Webbink and Icko Iben of the University of Illinois hypothesized that extreme helium stars formed from the merger of two white dwarfs.

White dwarfs are the end product of the evolution of Sun-like stars. They contain very little hydrogen. Some are rich in helium and others in carbon and oxygen. A pair of white dwarfs can result from the normal evolution of standard stars.

Reporting in a recent issue of the Astrophysical Journal, Webbink and Iben said that, in some

cases, one star in the binary could evolve as a helium-rich white dwarf, and the other as a carbon-oxygen-rich white dwarf. Over billions of years of orbiting each other, the two stars lose energy and move steadily closer.

Eventually, the helium white dwarf is consumed by the more massive carbon-oxygen white dwarf, and the resulting single star swells up to become a helium-rich supergiant.

To test this idea, the research team obtained observations from Hubble, from the 2.7-meter Harlan J. Smith Telescope at McDonald Observatory at the University of Texas in Austin, and the 2.3-meter Vainu Bappu instrument in Kavalur, India.

They found Hubble's results match up well with predictions of the compositions of stars formed by the merger of two white dwarfs, in which the helium-core white dwarf is torn apart and forms a thick disk around the carbon-oxygen white dwarf.

In a process that takes only a few minutes, the disk is gravitationally pulled into the carbon-oxygen white dwarf.

What happens next depends of the mass of the new, resulting star. If it is above a certain mass, called the Chandrasekar limit, it will explode as a Type Ia supernova. If its mass lies below this limit, the newly merged star will balloon into a supergiant, eventually becoming an extreme-helium star.

"It's interesting to note that the namesakes of these two telescopes, Harlan J. Smith and Vainu Bappu, were the very best of friends in graduate school at Harvard," said David L. Lambert, McDonald's director. Smith later served as director of McDonald Observatory from 1963 to 1989, and Vainu Bappu founded the Indian Institute of Astrophysics. "Today, with collaborations like this project," Lambert added, "we're maintaining the important international and personal ties that astronomy thrives upon."