Rare, double-lobe nebula resembles overflowing cosmic 'jug'

July 13 2023

A billowing pair of nearly symmetrical loops of dust and gas mark the death throes of an ancient red-giant star, as captured by Gemini South, one half of the International Gemini Observatory, operated by NSF's NOIRLab. The resulting structure, said to resemble an old style of English jug, is a rarely seen bipolar reflection nebula. Evidence suggests that this object formed by the interactions between the dying red giant and a now-shredded companion star. The image was obtained by NOIRLab's Communication, Education & Engagement team as part of the NOIRLab Legacy Imaging Program. Credit: International Gemini Observatory/NOIRLab/NSF/AURA Image processing: T.A. Rector (University of Alaska Anchorage/NSF's NOIRLab), J. Miller (Gemini Observatory/NSF's

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The glowing nebula IC 2220, nicknamed the Toby Jug Nebula owing to its resemblance to an old English drinking vessel, is a rare astronomical find. This reflection nebula, located about 1200 light-years away in the direction of the constellation Carina (the keel), is a double-lobed, or bipolar, cloud of gas and dust created and illuminated by the red-giant star at its center.

This end-of-life phase of red giant stars is relatively brief, and the celestial structures that form around them are rare, making the Toby Jug Nebula an excellent case study into stellar evolution.

This image, captured by the Gemini South telescope, one half of the International Gemini Observatory, operated by NSF's NOIRLab, showcases the Toby Jug Nebula's magnificent, nearly symmetrical double-looped structure and glowing stellar heart. These features are unique to red giants transitioning from aging stars to planetary nebulae and therefore offer astronomers valuable insight into the evolution of low- to intermediate-mass stars nearing the end of their lives as well as the cosmic structures they form.

At the heart of the Toby Jug Nebula is its progenitor, the red-giant star HR3126. Red giants form when a star burns through its supply of hydrogen in its core. Without the outward force of fusion, the star begins to contract. This raises the core temperature and causes the star to then swell up to 400 times its original size.

Though HR3126 is considerably younger than our sun—a mere 50 million years old compared to the sun's 4.6 billion years—it is five times

the mass. This allowed the star to burn through its hydrogen supply and become a red giant much faster than the sun.

As HR 3126 swelled, its atmosphere expanded and it began to shed its outer layers. The expelled stellar material flowed out into the surrounding area, forming a magnificent structure of gas and dust that reflects the light from the central star. Detailed studies of the Toby Jug Nebula in infrared light have revealed that silicon dioxide (silica) is the most likely compound reflecting HR3126's light.

Astronomers theorize that bipolar structures similar to those seen in the Toby Jug Nebula are the result of interactions between the central red giant and a binary companion star. Previous observations, however, found no such companion to HR3126. Instead, astronomers observed an extremely compact disk of material around the central star. This finding suggests that a former binary companion was possibly shredded into the disk, which may have triggered the formation of the surrounding nebula.

In about five billion years from now, when our sun has burned through its supply of hydrogen, it too will become a red giant and eventually evolve into a planetary nebula. In the very distant future, all that will be left of our Solar System will be a nebula as vibrant as the Toby Jug Nebula with the slowly cooling sun at its heart.

The image was processed by NOIRLab's Communication, Education & Engagement team as part of the NOIRLab Legacy Imaging Program. The observations were made with Gemini South on Cerro Pachón in Chile using one of the dual Gemini Multi-Object Spectrographs (GMOS). Though spectrographs are designed to split light into various wavelengths for study, the GMOS spectrographs also have powerful imaging capabilities, as demonstrated by this exceptional view of the Toby Jug Nebula.