Celestial tapestry is born of uncertain parentage

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Gemini Legacy image of the complex planetary nebula Sh2-71 as imaged by the Gemini Multi-Object Spectrograph on Gemini North on Mauna Kea in Hawai‘i. The long-assumed central star is the brightest star near the center, but some astronomers wonder if the much dimmer and bluer star (just to the right and down a bit) might be the parent of this beautiful object. The image is composed of three narrow-band images, and each is assigned a color as follows: H-alpha (orange), HeII (blue) and [OIII] (cyan). Each image is 15 minutes in duration, the field-of-view is 5.3 x 3.6 arcminutes, and the image is rotated 110 degrees clockwise from north up, east left. Credit: Gemini Observatory/AURA

(Phys.org) -- A new Legacy Image from the Gemini Observatory reveals the remarkable complexity of the planetary nebula Sharpless 2-71 (Sh 2-71). Embroiled in a bit of controversy over its “birth parents” the nebula likely resulted from interactions between a pair of two old and dying stars. Legacy images like this one share the stunning beauty of the universe as revealed by the twin 8-meter Gemini telescopes in Hawai‘i and Chile.

Often what seems obvious isn’t.

Take this new Gemini Legacy Image of the elaborate planetary nebula Sharpless 2-71. For most of its recorded history, astronomers assumed that it formed from the death throes of an obvious bright star (a known binary system) near its center. Arguments against that claim, however, have turned this case into a classic mystery of uncertain parentage.

The Gemini Legacy Image shows the long-assumed central star shining as the brightest object very close to the center of the nebula’s beautiful gas shell. But new observations have shown that the nature of a dimmer, bluer star – just to the right, and a bit lower than the obvious central star – might provide a better fit for the nebula’s “birth parent.”

The uncertainty arises from the fact that the brighter central star doesn’t appear to radiate enough high-energy (ultraviolet) light to cause the surrounding gas to glow as intensely as it does, whereas the dimmer, bluer star likely does. On the other hand, the brighter star’s binary nature would help explain the nebula’s asymmetrical structure. Astronomers do not yet known if the dimmer, bluer star also has a companion.

Another unresolved issue is whether the brighter star’s unseen companion might be hot enough to excite the gas to glow. If so, this pair might be able to hold on to its parental connection to the nebula.

A research team, led by Australian astronomers David Frew and Quentin Parker (Macquarie University, Sydney) are studying the dimmer, bluer star to understand its nature. “At the assumed distance to the nebula (roughly 1 kiloparsec or about 3,260 light-years), the faint star has about the right brightness to be the fading remnant of the nebula’s progenitor star,” says Frew.

Then again, the brighter binary star is an uncommon one that shows strong and broad hydrogen-alpha emission, which are seen in some planetary nebulae. According to Frew, this star is also unlikely to be a chance projection or alignment with the nebula, “So there could be at least three stars in this system,” he says.

Putting aside the complex issue of which star or stars formed this object, the nebula’s striking morphology also poses difficult questions. “The nebula presents a multi-polar structure and several pairs of bipolar lobes at different orientations,” says Luis Miranda of Spain’s Instituto de Astrofísica de Andalucía (CSIC) who has also studied this object extensively. “These lobes most certainly formed at different times and likely involved a binary progenitor – in particular with mass-transfer and multiple episodes of mass ejection along an axis where the orientation changes with time.”

Adding to the puzzle, Parker and Romano Corradi (Instituto de Astrofisica de Canarias, Spain) have recently discovered faint outer wisps and lobes surrounding the planetary on deep hydrogen-alpha images, taken as part of the Isaac Newton Telescope Photometric HydrogenAlpha Survey of the Northern Galactic Plane Survey. These features extend over many arcminutes (not shown in the new Gemini image), suggesting the mass loss history of this object has even more levels of complexity.

Miranda agrees, noting that the nebula’s structure is difficult to explain

without a binary pair for parents. “The chaotic morphology of Sh2-71 implies that very complex processes have been involved in its formation,” says Miranda. Unfortunately, not much is known about either possible central star’s known or speculated companions. So the mystery of the nebula’s uncertain parentage remains unsolved ... for now.

Image Background Information: Gemini’s Multi-Object Spectrograph (GMOS) captured the light of Sh2-71 in its imaging mode using filters that selectively allow specific colors of visible light to reach the detector. Each color is produced by energized gas in the nebula glowing in a manner similar to a neon sign. Travis Rector of the University of Alaska Anchorage assembled the data from three filters (hydrogen alpha, helium II, and oxygen III) to form the composite color image.

Planetary nebulae are the end-state of stars like our Sun. They form when old, medium-sized stars run low on nuclear fuel, become unstable, and begin expelling their outer layers of gas into space. Often these objects appear quite symmetrical, but when multiple stars are involved, their structure looks much more complex. In such cases, astronomers believe that the transfer of gas from one star to another results in explosions and eruptions that disrupt the symmetry of the nebula - as is clearly seen in this new Gemini image.

Discovered in 1946 by Rudolph Minkowski, the nebula is located in the direction of the constellation Aquila and visible in amateur telescopes. Sh2-71 is the 71st object in a catalogue of nebulae originally assembled by the U.S. astronomer Stewart Sharpless of the US Naval Observatory in Flagstaff, Arizona. It is from his second catalogue, of 313 nebulae, published in 1959.

Provided by Gemini Observatory