Spectacular 'honeycomb heart' revealed in iconic stellar explosion

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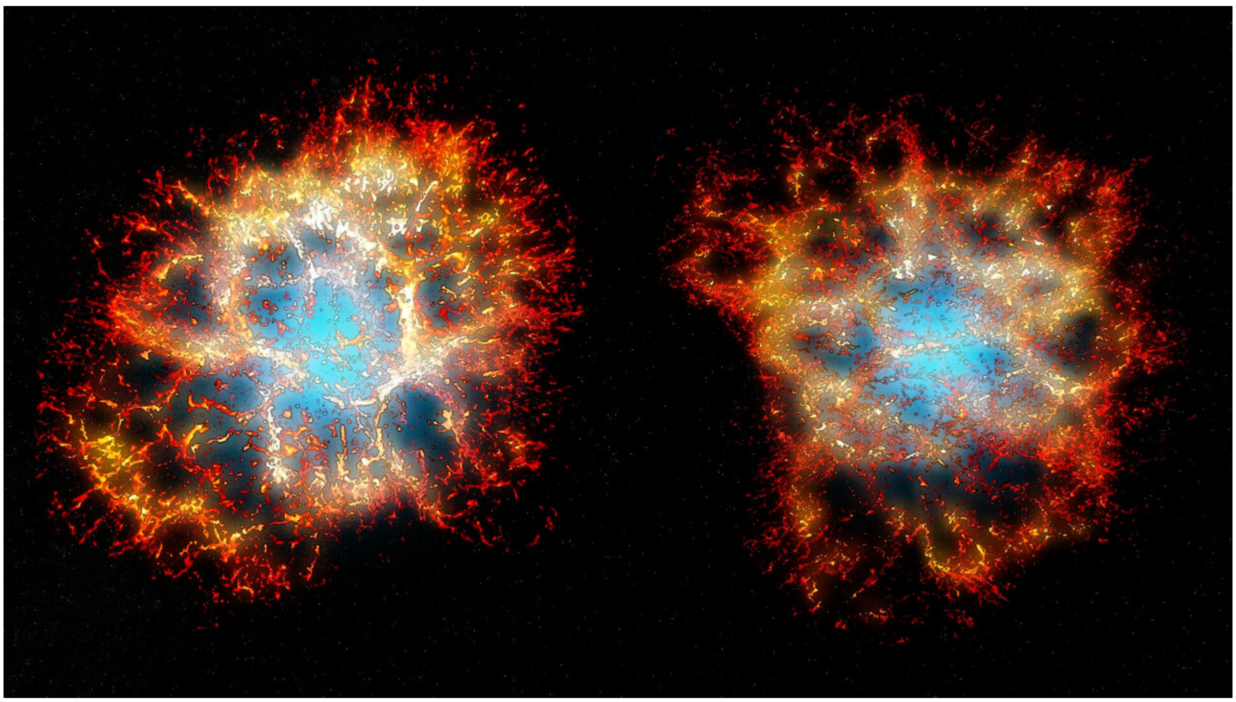

3D reconstruction of the Crab nebula remnant as seen from Earth (right), and from another point of view showing its heart-shaped morphology (left). Credit: Thomas Martin, Danny Milisavljevic and Laurent DrissenLicence typeAttribution (CC BY 4.0)

A unique heart shape, with wisps of gas filaments showing an intricate honeycomb-like arrangement, has been discovered at the center of the iconic supernova remnant, the Crab Nebula. Astronomers have mapped the void in unprecedented detail, creating a realistic three-dimensional reconstruction. The new work is published in *Monthly Notices of the Royal Astronomical Society* .

The Crab, formally known as Messier 1, exploded as a dramatic supernova in 1054 CE, and was observed over the subsequent months and years by ancient astronomers across the world. The resulting nebula—the remnant of this enormous explosion—has been studied by amateur and professional astronomers for centuries. However, despite this rich history of investigation, many questions remain about what type of star was originally there and how the original explosion took place.

Thomas Martin, the researcher at Université Laval who led the study, hopes to answer these questions using a new 3-D reconstruction of the nebula. "Astronomers will now be able to move around and inside the Crab Nebula and study its filaments one by one," said Martin.

The team used the powerful SITELLE imaging spectrometer on the Canada-Hawaii-France Telescope (CFHT) in Mauna Kea, Hawaii, to compare the 3-D shape of the Crab to two other supernova remnants. Remarkably, they found that all three remnants had ejecta arranged in large-scale rings, suggesting a history of turbulent mixing and radioactive plumes expanding from a collapsed iron core.

Co-author Dan Milisavljevic, an assistant professor at Purdue University and supernova expert, concludes that the fascinating morphology of the Crab seems to go against the most popular explanation of the original explosion.

"The Crab is often understood as being the result of an electron-capture supernova triggered by the collapse of an oxygen-neon-magnesium core, but the observed honeycomb structure may not be consistent with this scenario," Milisavljevic said.

The new reconstruction was made possible by the ground-breaking technology used by SITELLE, which incorporates a Michelson interferometer design allowing scientists to obtain over 300,000 high-resolution spectra of every single point of the nebula.

"SITELLE was designed with objects like the Crab Nebula in mind; but its wide field of view and adaptability make it ideal to study nearby galaxies and even clusters of galaxies at large distances," said co-author Laurent Drissen.

Supernova explosions are among the most energetic and influential phenomena in the universe. Consequently, Milisavljevic adds: "It is vital that we understand the fundamental processes in supernovae which make life possible. SITELLE will play a new and exciting role in this understanding."

More information: V Domček et al. Mapping the spectral index of Cassiopeia A: evidence for flattening from radio to infrared, *Monthly Notices of the Royal Astronomical Society* (2020). [DOI: 10.1093/mnras/staa3896](https://dx.doi.org/10.1093/mnras/staa3896)

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