Astronomers discover a large cavity around the Tycho's supernova

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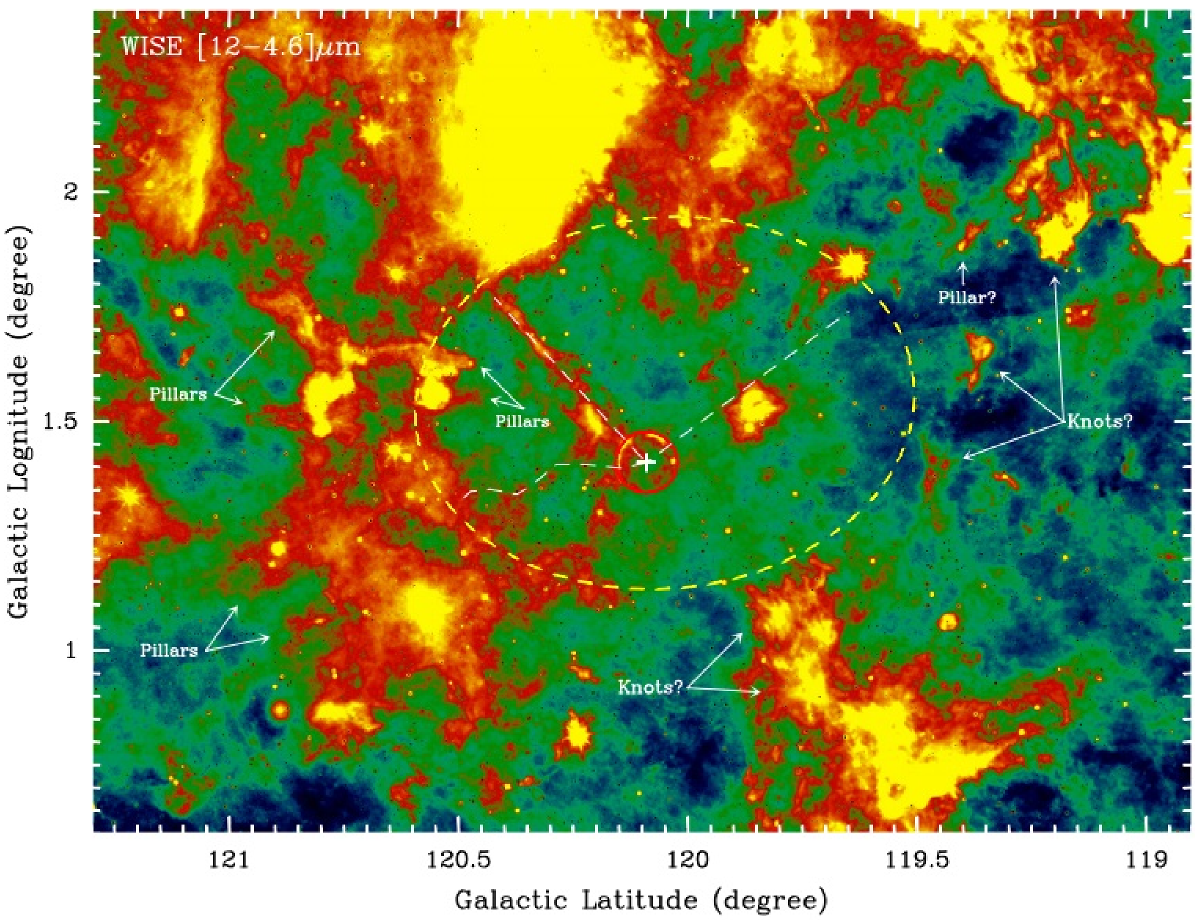

The large-field WISE [12–4.6] μm infrared image around the Tycho's supernova remnant (SNR). The red circle shows the position and size of the shell-like structure in the Tycho's SNR, while the yellow dashed ellipse shows the cavity found in the MWISP CO images. The three white dashed lines are shown to guide the eye for the stream-like structures seen in the CO images. The white arrows mark the positions of the pillar-like structures found in the WISE image. Credit: Chen et al., 2016.

Chinese astronomers have detected a large cavity existing around Tycho's supernova, also know as SN 1572, exhibiting stream-like structures. The findings, reported in a paper published Aug. 18 on arXiv.org, show that the environments of the supernovae may be much more complicated than previously thought.

SN 1572 lies between 8,000 to 10,000 light years from the Earth in the constellation Cassiopeia. It is a well-established type Ia supernova, one of about eight supernovae visible to the naked eye in historical records. As one of the most popular supernova remnants in our galaxy, it has been widely observed in the entire electromagnetic spectrum, and astronomers have discovered a shell-like structure produced by the shocks from the explosion as well as circumstellar material and dust.

More recent observations of Tycho's supernova were conducted by a team of Chinese astronomers led by Xuepeng Chen of the Purple Mountain Observatory (PMO) in Nanjing, China. They used the 13.7-meter millimeter-wavelength telescope of the Qinghai station of PMO at Delingha in China to perform large-field and high-sensitivity carbon monoxide (CO) molecular line observations of SN 1572. The scientists observed the supernova from November 2011 to February 2016 as part of the Milky Way Imaging Scroll Painting (MWISP) survey, which investigates the nature of the molecular gas along the northern Galactic Plane.

"We present large-field CO (1-0) molecular line observations toward the Tycho's supernova remnant, using the PMO 13.7-meter telescope. Based on the CO observations, we find a large cavity with radii of 0.3 degrees by 0.6 degrees around the remnant, which is further confirmed by the complementary infrared images from the space telescopes," the researchers wrote in the paper.

The team estimated that the cavity is located about 8,000 light years away and has radii of 42 and 88 light years. Their calculations allowed them to estimate that this cavity is expanding at a velocity of approximately 4 km s^{-1}.

Moreover, the astronomers distinguished stream-like structures in the cavity that could be part of a larger cavity seen along the line of sight. They noted that these structures may also record the accretion winds from the progenitor system. Due to these uncertainties, the team calls for further observations that could illuminate the real nature of these structures.

"In the wind-regulated accretion models, the accretion wind could last for few million years, and the white dwarf may explode as a type Ia supernova while the accretion wind is still active. Therefore, another possible explanation is that these stream-like structures actually record the accretion winds from the progenitor system. This scenario is somehow supported by the infrared observations, in which knot-like structures are also found in the southwest and west of the cavity," the paper reads.

The scientists also investigated the origin of the cavity. They excluded the possibility that it could be produced by bright star in the region or the option that it was randomly distributed. According to the paper, the most plausible hypothesis taken into account is that it could be explained by the accretion wind from the progenitor system of the Tycho's supernova.

"The discovery of the Tycho's cavity also gives us an alert that the environments of the supernovae Ia may be much more complicated than we thought before," the researchers concluded.

More information: Discovery of A Large Cavity around the Tycho's Supernova Remnant, arXiv:1608.05329 [astro-ph.GA] arxiv.org/abs/1608.05329

Abstract
We present large-field (3x2 deg^2) and high-sensitivity CO(1-0) molecular line observations toward the Tycho's supernova remnant, using the 13.7-meter radio telescope of the Purple Mountain Observatory. Based on the CO observations, we discover a large cavity around the remnant, with radii of about 0.3x0.6 deg (or ~13x27 pc at a distance of 2.5 kpc), which is further supported by the complementary infrared images from the space telescopes. The observed CO line broadenings and asymmetries in the surrounding clouds, the infrared pillar-like structures found around the remnant, in concert with enhanced 12CO(2-1)/(1-0) intensity ratio detected in previous studies, indicate strong interaction of the large cavity with a wind in the region. After excluding the scenario of a large bubble produced by bright massive stars, we consider that the large cavity could be most likely explained by the accretion wind from the progenitor system of the Tycho's supernova. The CO gas kinematics indicates that the large cavity is expanding at a velocity of about 4 km/s. The estimated velocity (~1000 km/s, with a mass-loss rate of ~10^(-6)*M_sun*yr^(-1)) and timescale (~4x10^6 yr) of the wind needed for creating such a cavity are consistent with the predictions from the wind-regulated accretion model. We conclude that Tycho's supernova, the prototypical Type-Ia supernova in the Milky Way, arose from accretion onto a white dwarf.

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