Progenitor for Tycho's supernova was not hot and luminous

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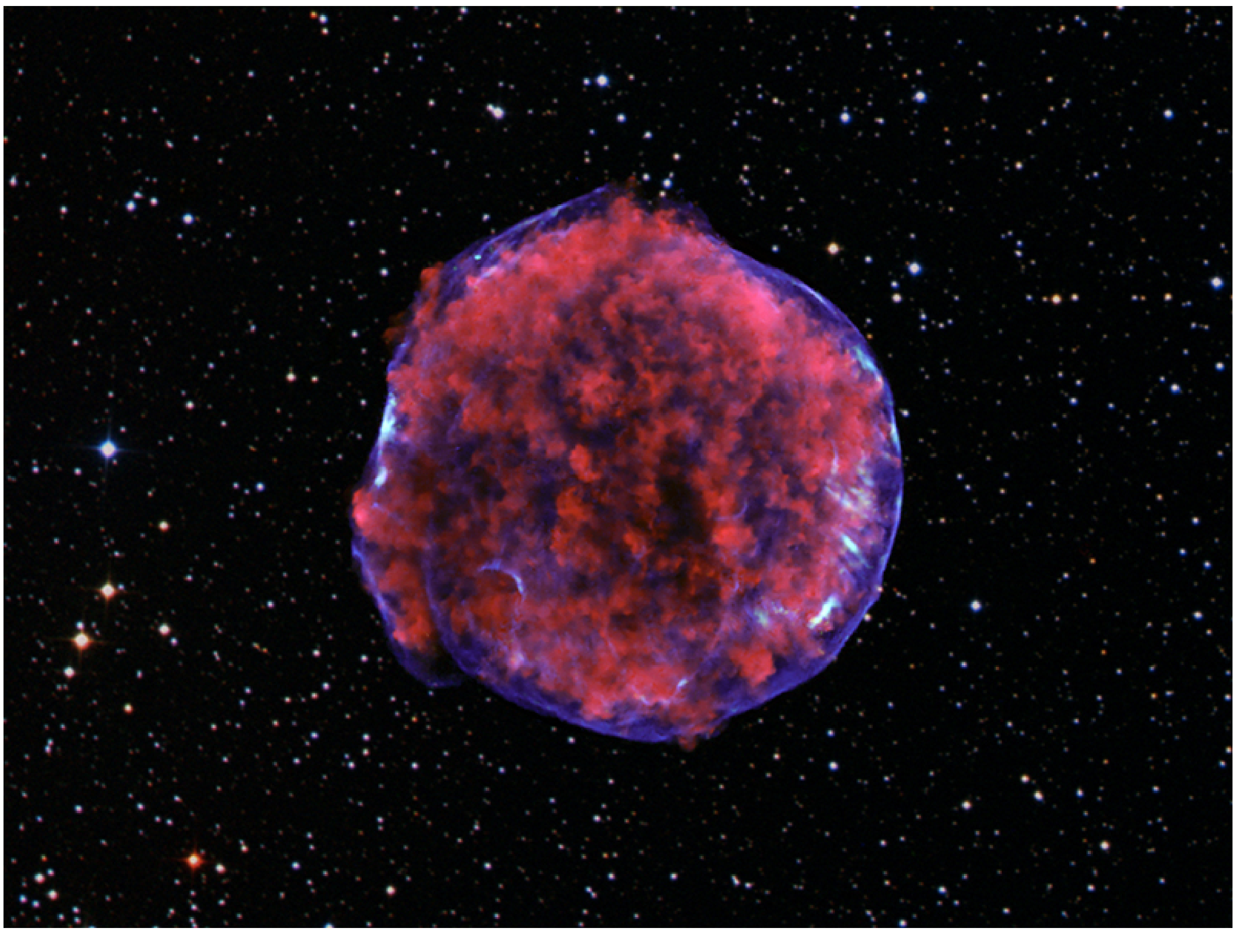
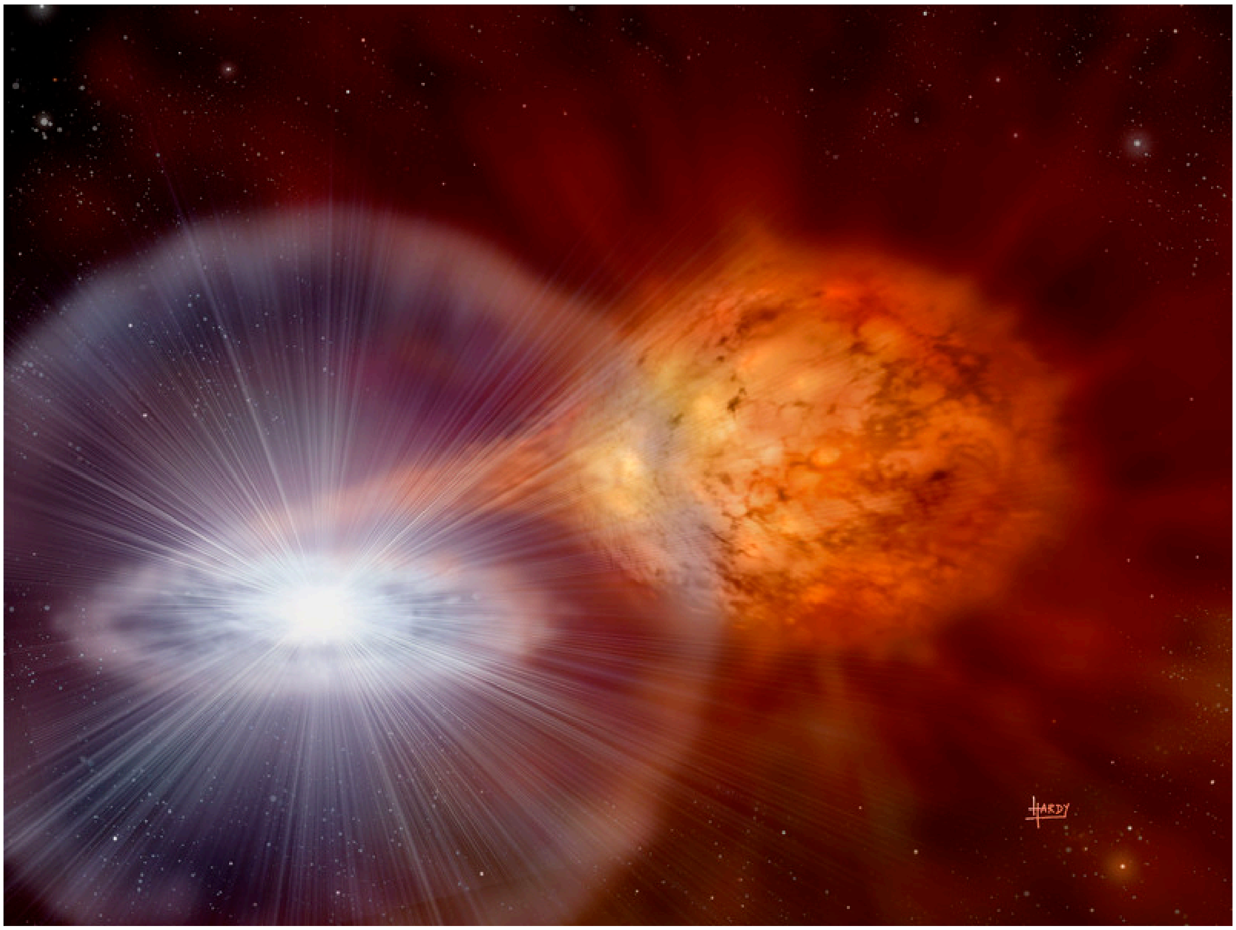


The remnant of Tycho’s supernova as seen in X-rays, showing the expanding shock wave. Credit: X-ray: NASA/CXC/Rutgers/K.Eriksen et al.; Optical: DSS

An international team of scientists from the Monash University (Melbourne, Australia), the Towson and Pittsburgh Universities (USA) and the Max Planck Institute for Astrophysics, has shed new light on the origins of the famous Tycho's supernova. The research, published in *Nature Astronomy*, debunks the common view that Tycho's supernova originated from a white dwarf, which had been slowly accreting matter from its companion in a binary system.

Type Ia supernovae (SNe Ia) serve as standard candles of modern observational cosmology; they also play a vital role in galactic chemical evolution. However, the origin of these gigantic cosmic explosions remains uncertain. Although there is a nearly universal consensus that SNe Ia are a result of the thermonuclear disruption of a white dwarf consisting of carbon and oxygen reaching the Chandrasekhar mass limit (about 1.4 times the mass of our Sun), the exact nature of their progenitors is still unknown. The white dwarf could have been gradually accumulating matter from a companion star thus reaching the Chandrasekhar mass limit, at which point the nuclear runaway began; or the nuclear explosion could have been triggered by the merger of two white dwarfs in a compact binary system. These two scenarios differ dramatically in the level of electromagnetic emission expected from the progenitor during millions of years prior to the explosion.

A white dwarf that is accreting material from the donor star becomes a source of copious X-ray and extreme UV photons – the canonical accretion scenario implies a hot and luminous progenitor that would ionize all surrounding gas within a radius of ~10–100 parsecs (up to about 300 light-years), the so called Strömgren sphere. After the white dwarf is disrupted in the supernova explosion, the source of ionizing emission disappears. However, it takes quite a long time for the interstellar gas to recombine and to become neutral again – an ionized nebula will continue to exist around the supernova for about 100,000 years after the explosion. Thus, the detection of even small amounts of neutral gas in the vicinity of a supernova can help scientists to place tight constraints on the temperature and luminoisty of the progenitor.

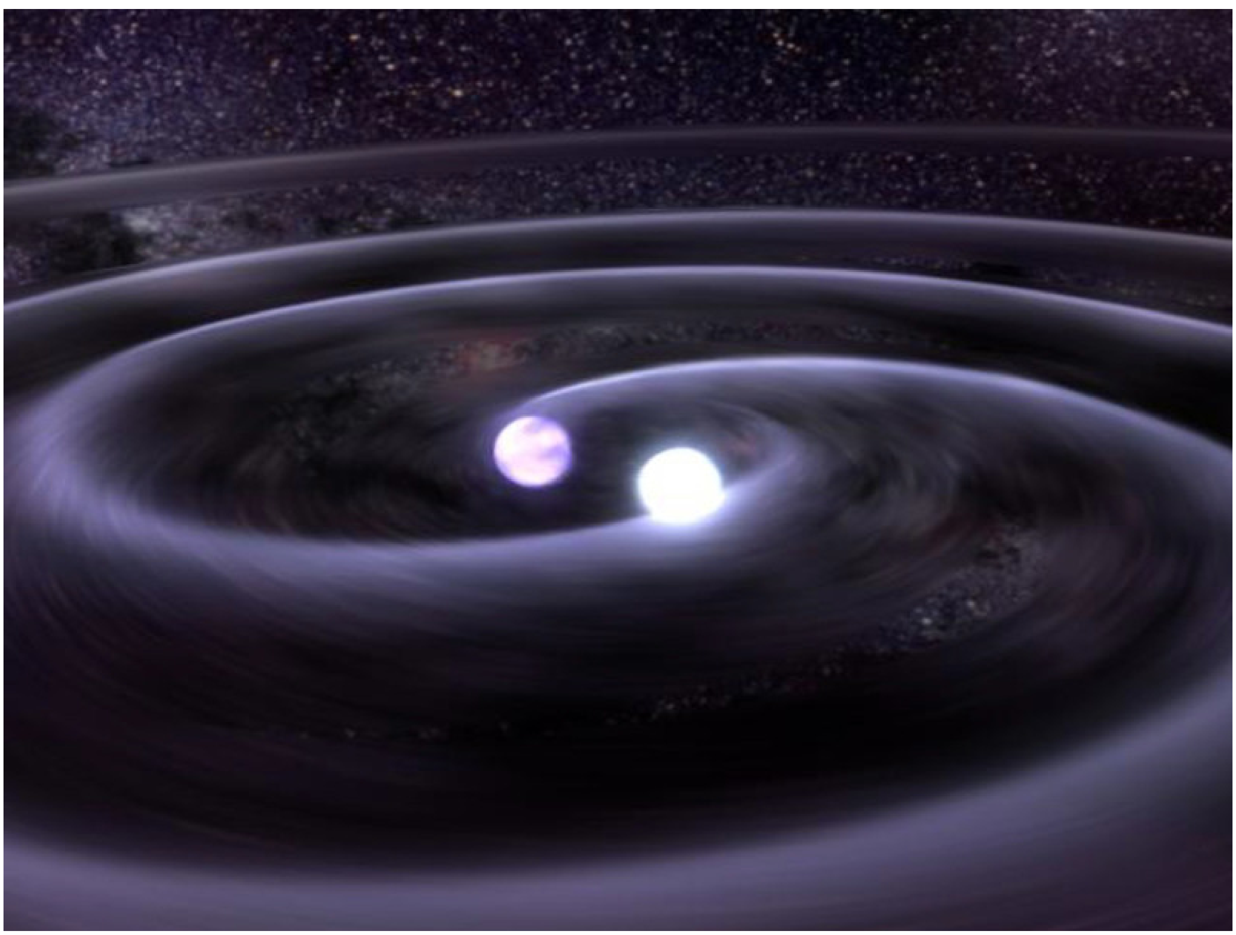


Artist’s conception of a white dwarf slowly accreting matter from a companion star. Credit: David A. Hardy & PPARC

445 years ago, Tycho Brahe observed a stella nova ("new star") in the night sky. Brighter than Venus when it first appeared, it faded over the following year. Today, we know that Tycho had observed a nuclear disruption of a white dwarf – a type Ia supernova. Due to its history and relative proximity to Earth, Tycho's supernova is one of the most well-

documented examples of a Type Ia supernova.

In particular, we know from optical observations that the supernova remnant today is expanding into the mostly neutral gas. Thus, using the remnant itself as a probe of its environment, scientists could exclude hot luminous progenitors that would have produced a Strömgren sphere larger than the radius of the present remnant (~3 parsecs). This conclusively rules out steadily nuclear-burning white dwarfs (supersoft X-ray sources), as well as disk emission from a Chandrasekhar-mass white dwarf accreting more than one solar mass in approximately 100 million years (recurrent novae). The lack of a surrounding Strömgren sphere is consistent with the merger of a double white dwarf binary, although other more exotic scenarios may be also possible.



Artist’s conception of a binary white dwarf system. Credit: Tod Strohmayer (GSFC), CXC, NASA, Illustration: Dana Berry (CXC)

More information: T. E. Woods et al. No hot and luminous progenitor for Tycho's supernova, *Nature Astronomy* (2017). DOI: 10.1038/s41550-017-0263-5

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