Can astronomers predict which stars are about to explode as supernovae?

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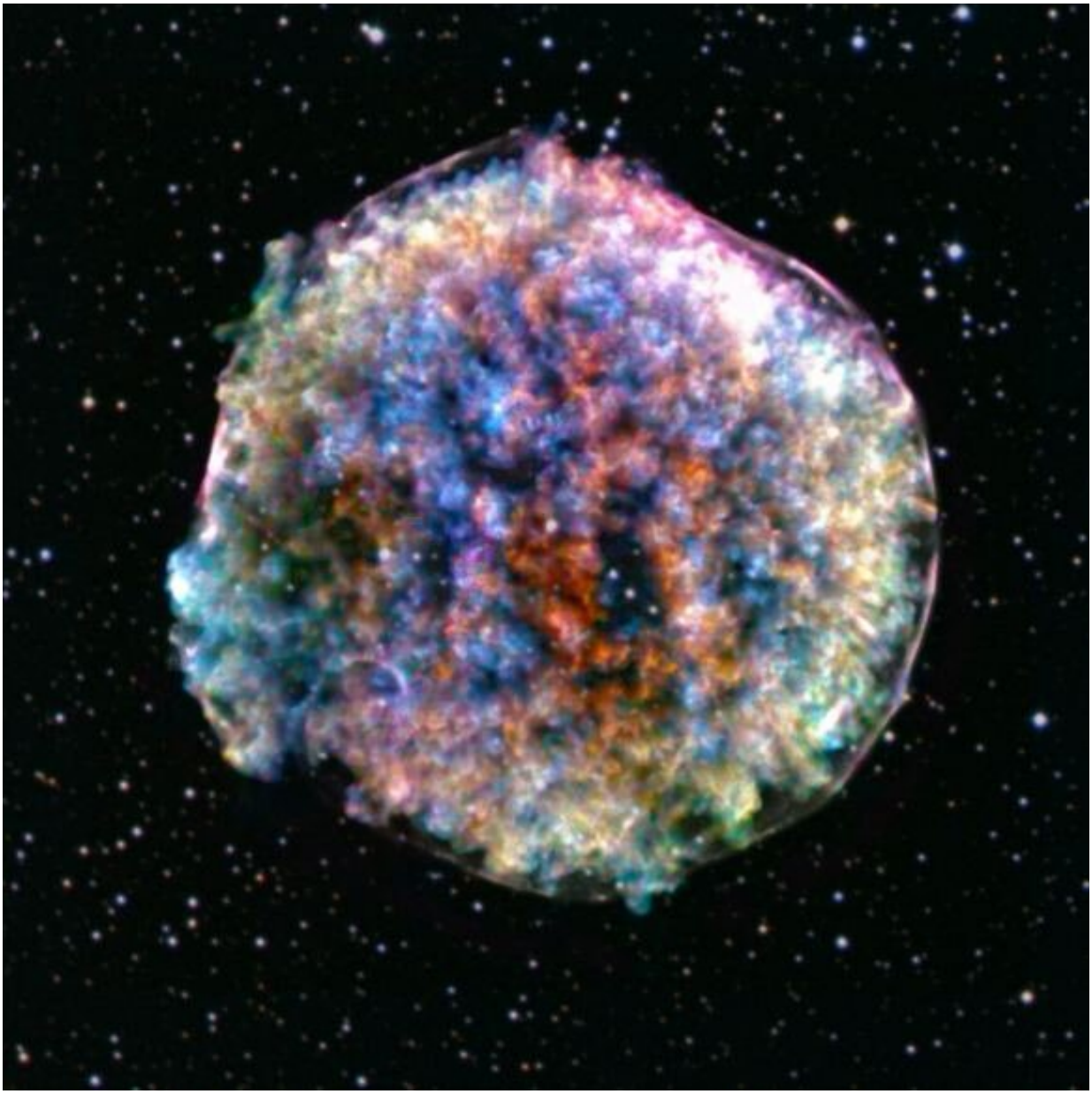

Image of the Tycho supernova from NASA's Chandra X-ray Observatory. Credit: X-ray: NASA/CXC/RIKEN & GSFC/T. Sato et al; Optical: DSS

In a recent study submitted to *High Energy Astrophysical Phenomena*, a team of researchers from Japan discuss strategies to observe, and possibly predict precursor signatures for an explosion from Local Type II and Galactic supernovae (SNe). This study has the potential to help us better understand both how and when supernovae could occur throughout the universe, with supernovae being the plural form of supernova (SN). But just how important is it to detect supernovae before they actually happen?

"From my perspective it is important in two aspects," said Dr. Daichi Tsuna, who is an astrophysicist at the Research Center for the Early Universe at the University of Tokyo, and lead author of the study. "First, while we know that supernovae (SNe) are explosions signaling the death of massive stars, what happens near the end of its life is still a mystery. In fact, SN precursors, suggested by recent observational works, are not predicted from the standard theory of stellar evolution. Our paper claims that we can probe this precursor in depth by future observations, which can help deepen our understanding of stellar evolution and refine the existing theory. Second, finding a SN precursor would allow a very early alert of a near-future SN, and will help extend the available time frame to coordinate multi-messenger (light, neutrinos, and gravitational waves) observations."

For the study, the researchers utilized the open-source code CHIPS (Complete History of Interaction-Powered Supernovae) to create a theoretical model for such a discharge from a red supergiant star's mass eruption. This is intriguing since the star Betelguese, which in 2019 was observed to dim in brightness, sparking discussions about it possibly

going supernovae, is also a red supergiant star. As it turns out, Betelguese is nearing the end of its life, but a 2021 study said it isn't slated to explode for another 100,000 years. But what implications could this research have for Betelguese?

"Betelgeuse is a red supergiant, which is exactly the kind of star we have studied in this paper," explains Dr. Tsuna. "Thus, if Betelgeuse were to explode very soon, it may display this kind of precursor emission just before the SN. Since Betelgeuse is very close to us, neutrino detectors may find neutrinos emitted as early as days before the SN. We can do multi-messenger astronomy even before the SN explosion."

The study's findings state that eruption light curves fueled by a brief shockwave pulse enduring for only a few days, followed by a far longer cooling discharge enduring for hundreds of days. For lower energy eruptions, this period is followed by a dim peak period fueled by what is know as the bound envelope, pulling back. The study concludes by saying that such mass eruptions events "can serve as early warning of a near-future nearby SN, which will be important for multi-messenger studies of core-collapse SNe."

"One thing I would stress is that we have a bright future to detect these kinds of rather dim precursors," said Dr. Tsuna. "For example, in a few years the Rubin Observatory would conduct wide-field survey observations at sensitivity much deeper than present surveys. It would be sensitive enough to actually detect these kinds of emissions and can be a probe of the remarkable end stages of a massive star's life."

More information: Daichi Tsuna, Yuki Takei, Toshikazu Shigeyama, Precursors of Supernovae from Mass Eruption: Prospects for Early Warning of Nearby Core-collapse Supernovae. arXiv:2208.08256v1 [astro-ph.HE], arxiv.org/abs/2208.08256

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