

Magnetic field may cause white dwarf to breach Chandrasekhar limit: IISc study

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Bengaluru: Strong magnetic fields could allow some dying stars to grow heavier than the limit astronomers long considered possible, according to a new study by researchers from IISc and collaborators. The researchers' computer simulations show that a dense stellar remnant called a white dwarf could reach about 2.4 times the mass of the Sun, well above the established upper limit of about 1.4 solar masses. The findings, published in *The Astrophysical Journal Letters*, may help explain unusually bright stellar explosions and refine measurements of the universe's expansion.

When a star runs out of fuel, it sheds its outer layers, leaving behind a compact core that can become a white dwarf, roughly the size of Earth. For a white dwarf that isn't strongly rotating or magnetised, the Chandrasekhar limit — named after Indian astrophysicist S Chandrasekhar, who first calculated it in 1930 — sets its maximum mass at about 1.4 times the Sun's mass. Near this limit, a carbon-oxygen white dwarf can ignite its core, potentially triggering a thermonuclear explosion called a "Type Ia supernova". Because the limit is fixed, these blasts



Banibrata Mukhopadhyay (left) and Zenia Zuraiq from the Indian Institute of Science

shine with near-identical brightness, making them cosmic yardsticks.

"The idea started in 2011, when a summer student came to me and I gave him a problem quite casually: to check whether the Chandrasekhar limit can be violated by a magnetic field," Banibrata Mukhopadhyay, professor in IISc's Department of Physics and corresponding author of the study, said. Observations of exceptionally bright Type Ia supernovae have suggested some may originate from white dwarfs heavier than the conventional limit, potentially reaching 2.8 solar masses.

"The important question was not simply whether a super-Chandrasekhar white dwarf is possible, but whether a star can actually evolve into one. Our simulations allowed us to follow that evolu-

tionary pathway from the main-sequence star to the white dwarf, and show that under certain conditions, such a pathway is possible," Zenia Zuraiq, the study's first author and a PhD student, said.

To trace this process, the team modified STARS, a computer code developed at the University of Cambridge to model stellar evolution. They incorporated magnetic field effects and the cooling of white dwarfs, then simulated a two-star system in which a white dwarf gains matter from a companion star.

As the white dwarf accumulates matter, it contracts and becomes denser, strengthening its magnetic field. The field provides additional internal pressure, helping the star resist its own gravity and accommodate more mass.

In one simulation, a white dwarf that began with 1.02 solar masses grew to about 2.4 solar masses. The corresponding model without magnetic fields reached only about 1.4 solar masses.

The findings may also explain why some low-mass white dwarfs have larger radii than expected. If these blasts come from stars with differing masses and magnetism, their brightness would vary, which could affect how scientists measure the universe's expansion.