New theory suggests uranium 'snowflakes' in white dwarfs could set off star-destroying explosion

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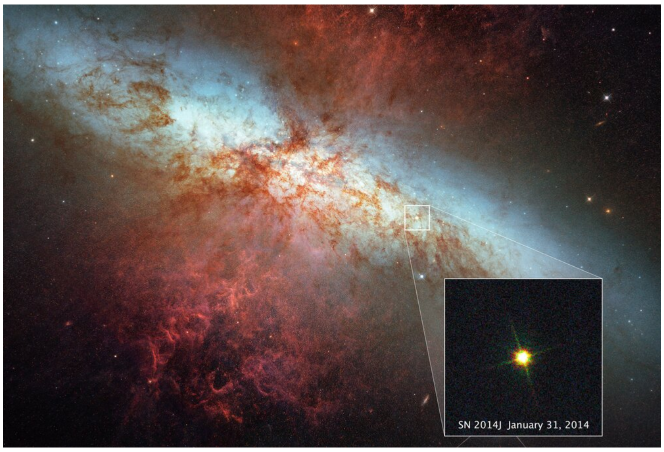

This is a Hubble Space Telescope composite image of a supernova explosion designated SN 2014J in the galaxy M82. At a distance of approximately 11.5 million light-years from Earth it is the closest supernova of its type discovered in the past few decades. The explosion is categorized as a Type Ia supernova, which is theorized to be triggered in binary systems consisting of a white dwarf and another star – which could be a second white dwarf, a star like our Sun, or a giant star. Credit: NASA, ESA, A. Goobar (Stockholm University), and the Hubble Heritage Team (STScI/AURA)

A pair of researchers with Indiana University and Illinois University, respectively, has developed a theory that suggests crystalizing uranium "snowflakes" deep inside white dwarfs could instigate an explosion large enough to destroy the star. In their paper published in the journal *Physical Review Letters*, C. J. Horowitz and M. E. Caplan describe their theory and what it could mean to astrophysical theories about white dwarfs and supernovas.

White dwarfs are small stars that have burned up most of their nuclear fuel—they are typically much cooler than they once were and are very dense. In this new effort, Horowitz and Caplan used data from the Gaia space observatory to theorize that sometimes small grains of uranium could begin to crystalize (due to enriched actinides), forming what they describe as snowflakes. They suggest this could happen because of the differing melting points of the material involved. They further suggest that if this were to occur, it could lead to splitting of atomic nuclei, resulting in a series of fission reactions as the solids become enriched in actinides. And if such reactions were to raise the temperature of the interior of the star by igniting carbon, the result would likely be merging of atomic nuclei and eventually a very large fusion reaction that would result in a large explosion—likely large enough to destroy the star. They note that such an occurrence would be much like a thermonuclear bomb detonating due to fission reactions.

Prior research has shown that white dwarfs sometimes explode—when they do, the result is known as a supernova (type 1a). Prior research has also shown that such explosions tend to happen when a white dwarf pulls material from a second, nearby star. The new theory does not discredit this research, but suggests an entirely new mechanism behind some white dwarf explosions. Instead, they suggest that a supernova that resulted from a thermonuclear explosion would explain the types of supernovae that exhibit sub-Chandrasekhar ejecta masses and have short delay times. They note that their theory is still preliminary and that much more work is required to give it more credence.

More information: C. J. Horowitz et al. Actinide Crystallization and Fission Reactions in Cooling White Dwarf Stars, *Physical Review Letters* (2021). DOI: 10.1103/PhysRevLett.126.131101