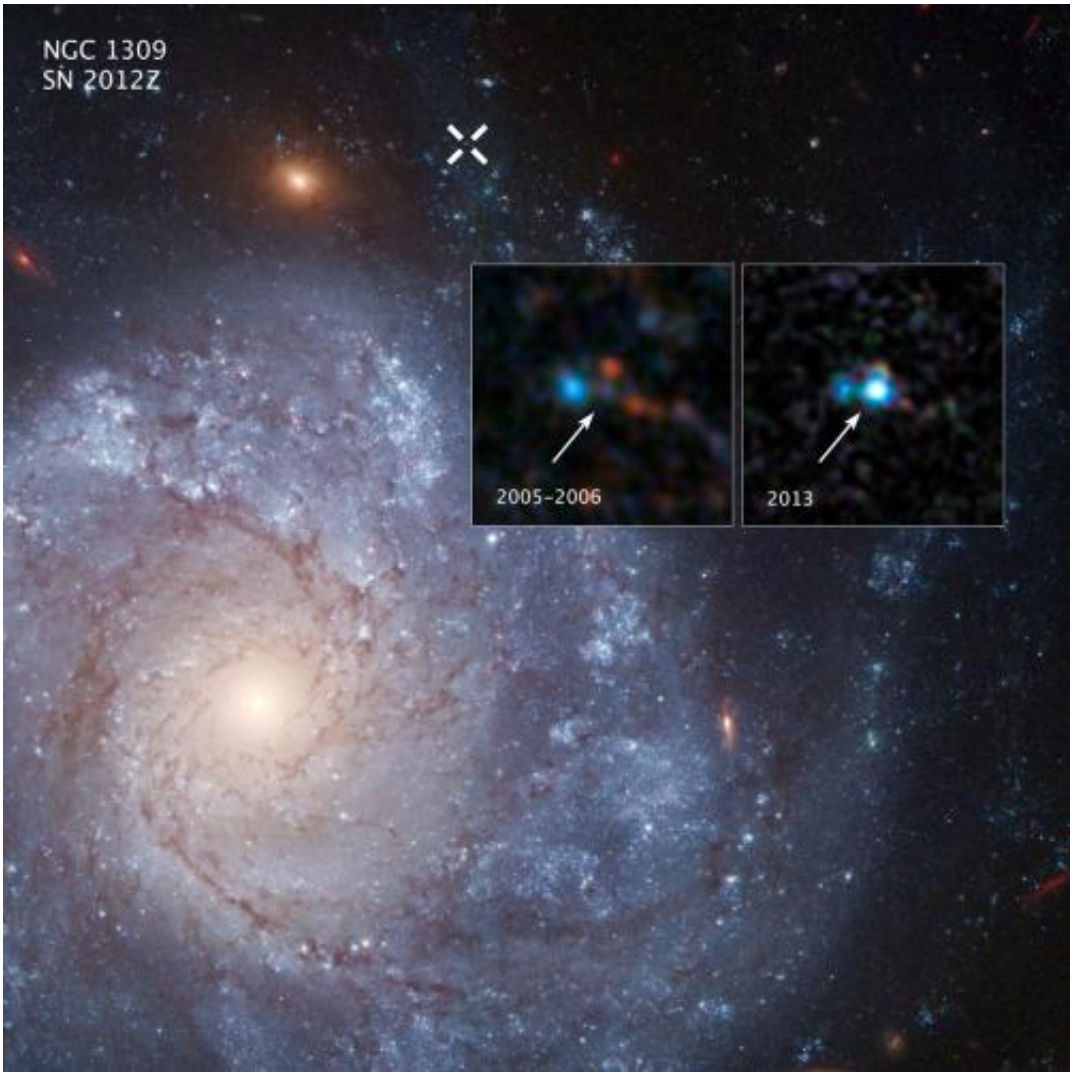
Hubble finds supernova star system linked to potential 'zombie star'

August 6 2014



The two inset images show before-and-after images captured by NASA's Hubble Space Telescope of Supernova 2012Z in the spiral galaxy NGC 1309. The white X at the top of the main image marks the location of the supernova in the galaxy. Credit: NASA, ESA

(Phys.org) —Using NASA's Hubble Space Telescope, a team of astronomers has spotted a star system that could have left behind a "zombie star" after an unusually weak supernova explosion.

A supernova typically obliterates the exploding white dwarf, or dying star. On this occasion, scientists believe this faint supernova may have left behind a surviving portion of the dwarf star—a sort of zombie star.

While examining Hubble images taken years before the stellar explosion, astronomers identified a blue companion star feeding energy to a white dwarf, a process that ignited a nuclear reaction and released this weak supernova blast. This supernova, Type Iax, is less common than its brighter cousin, Type Ia. Astronomers have identified more than 30 of these mini-supernovas that may leave behind a surviving white dwarf.

"Astronomers have been searching for decades for the star systems that produce Type Ia supernova explosions," said scientist Saurabh Jha of Rutgers University in Piscataway, New Jersey. "Type Ia's are important because they're used to measure vast cosmic distances and the expansion of the universe. But we have very few constraints on how any white dwarf explodes. The similarities between Type Iax's and normal Type Ia's make understanding Type Iax progenitors important, especially because no Type Ia progenitor has been conclusively identified. This discovery shows us one way that you can get a white dwarf explosion."

The team's results will appear in the Thursday, Aug. 7 edition of the journal *Nature*.

The weak supernova, dubbed SN 2012Z, resides in the host galaxy NGC 1309 which is 110 million light-years away. It was discovered in the Lick Observatory Supernova Search in January 2012. Luckily, Hubble's

Advanced Camera for Surveys also observed NGC 1309 for several years prior the supernova outburst, which allowed scientists to compare before-and-after images.

Curtis McCully, a graduate student at Rutgers and lead author of the team's paper, sharpened the Hubble pre-explosion images and noticed a peculiar object near the location of the supernova.

"I was very surprised to see anything at the location of the supernova. We expected the progenitor system would be too faint to see, like in previous searches for normal Type Ia supernova progenitors. It is exciting when nature surprises us," McCully said.

After studying the object's colors and comparing with computer simulations of possible Type Iax progenitor systems, the team concluded they were seeing the light of a star that had lost its outer hydrogen envelope, revealing its helium core.

The team plans to use Hubble again in 2015 to observe the area, giving time for the supernova's light to dim enough to reveal any possible zombie star and helium companion to confirm their hypothesis.

"Back in 2009, when we were just starting to understand this class, we predicted these supernovae were produced by a white dwarf and helium star binary system," said team member Ryan Foley of the University of Illinois at Urbana-Champaign, who helped identify Type Iax supernovae as a new class. "There's still a little uncertainty in this study, but it is essentially validation of our claim."

One possible explanation for the unusual nature of SN 2012Z is that a game of seesaw ensued between the bigger and smaller of the star pair. The more massive star evolved more quickly to expand and dump its hydrogen and helium onto the smaller star. The rapidly evolving star

became a white dwarf. The smaller star bulked up, grew larger and engulfed the white dwarf. The outer layers of this combined star were ejected, leaving behind the white dwarf and the helium core of the companion star. The white dwarf siphoned matter from the companion star until it became unstable and exploded as a mini-supernova, leaving behind a surviving zombie star.

Astronomers already have located the aftermath of another Type Iax supernova blast. Images were taken with Hubble in January 2013 of supernova 2008ha, located 69 million light-years away in the galaxy UGC 12682, in more than four years after it exploded. The images show an object in the area of the supernova that could be the zombie star or the companion. The findings will be published in The Astrophysical Journal.

"SN 2012Z is one of the more powerful Type Iax supernovae and SN 2008ha is one of the weakest of the class, showing that Type Iax systems are very diverse," explained Foley, lead author of the paper on SN 2008ha. "And perhaps that diversity is related to how each of these stars explodes. Because these supernovae don't destroy the white dwarf completely, we surmise that some of these explosions eject a little bit and some eject a whole lot."

The astronomers hope their new findings will spur the development of improved models for these white dwarf explosions and a more complete understanding of the relationship between Type Iax and normal Type Ia supernovae and their corresponding star systems.

More information: *Nature* paper: www.nature.com/nature/journal/ … ull/nature13615.html

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