Type 1a Supernovae

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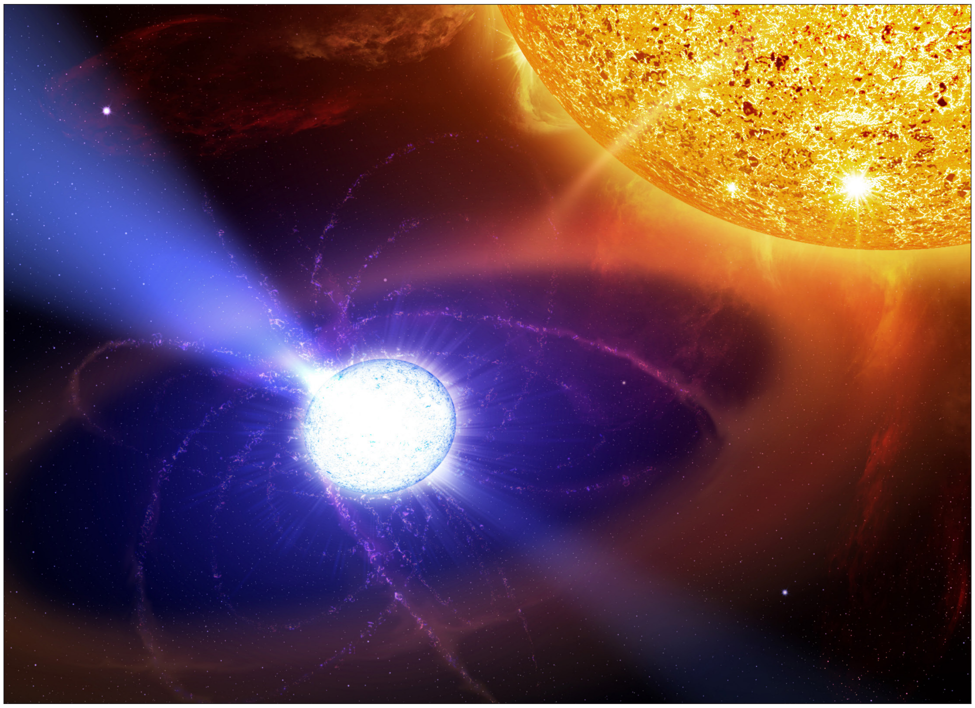
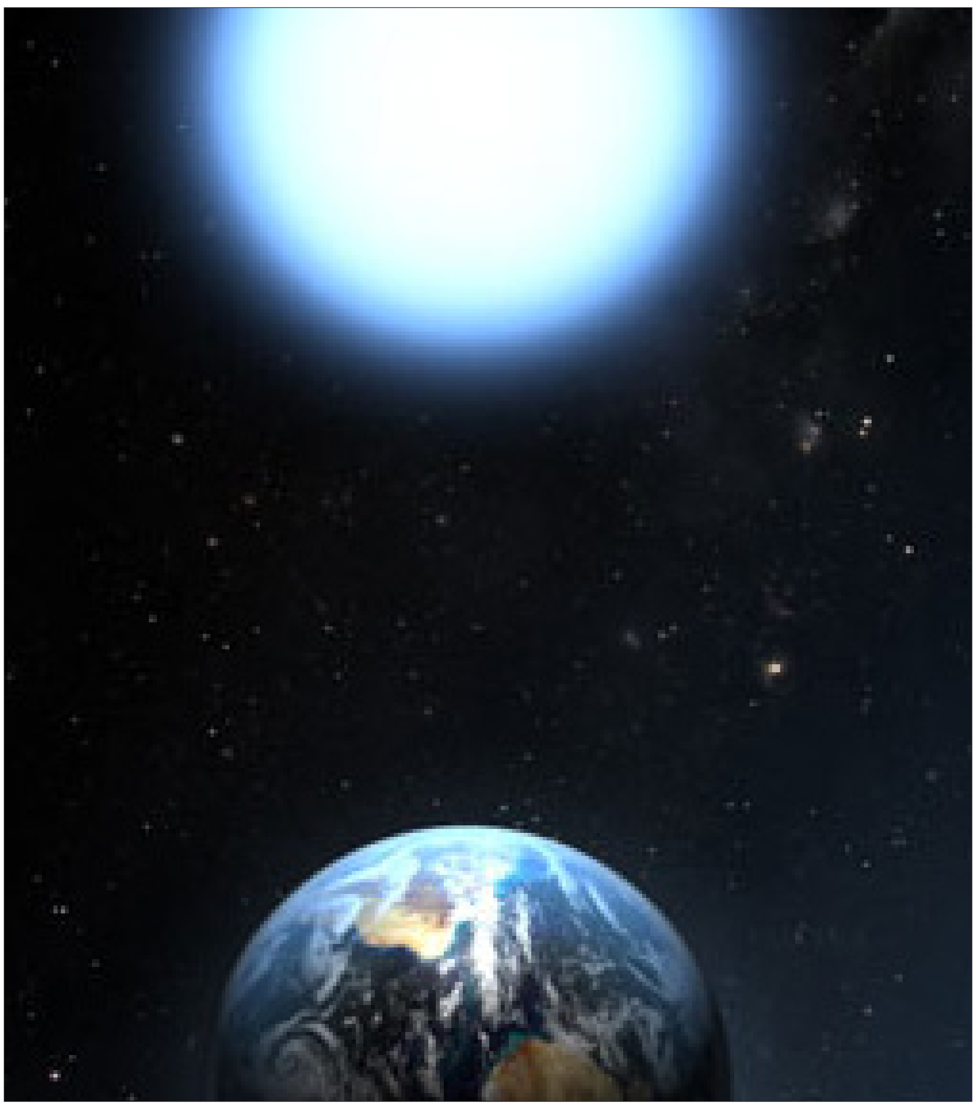
Little is more rule-based and yet mysterious as the interactions of celestial bodies. As a result, modeling them can yield fascinating results.

Outer space is known to be chaotic, with mere gravity causing bright stars and black holes. In fact, when people think of supernovae, they often consider the explosion and collapse of a huge star. However, the Type 1a supernova occurs only in the case of a binary star system. Thus, it outshines a singular star explosion in both intricacy and actual luminosity, making it a compelling subject both scientifically and visually.

Hubble Space Telescope Image of Supernova 1994D below galaxy NGC 4526[a]



A white dwarf in the AE Aquaril System[b]



A white dwarf with the same mass as the sun, compared to the size of earth[c]

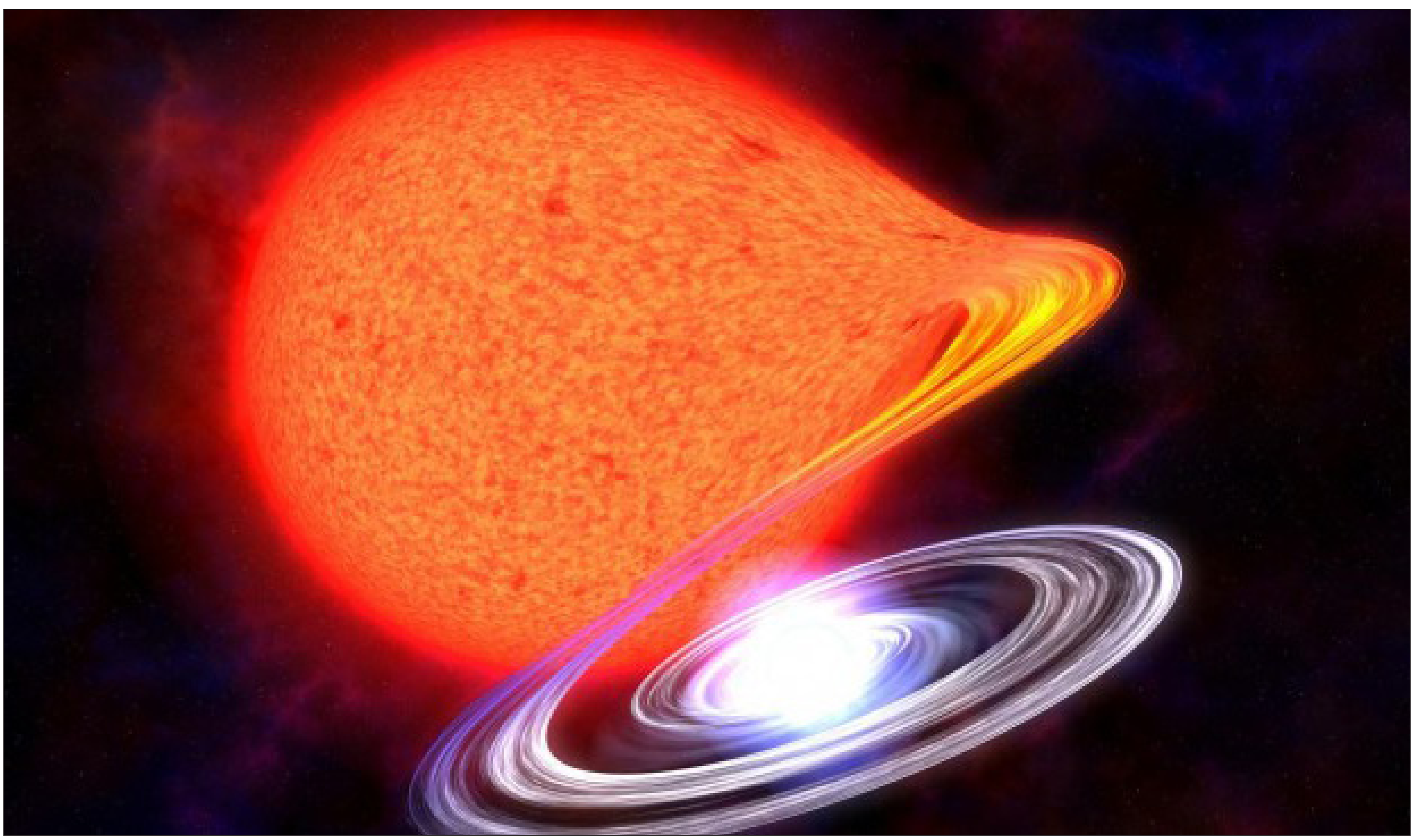
Interactions in space all come down to the four fundamental forces of physics—the most prominent of which is gravity. Just as the Earth revolves around the Sun and the Moon revolves around the Earth, there exist systems in this galaxy and others where a star revolves around yet another star.

While most star deaths are, well, stellar, the death of a binary star system can create a Type 1a supernova—the brightest of all novae—as long as one of the stars is a white dwarf.

A white dwarf is a star at the end of its life, extremely dense with carbon and oxygen.[1] So dense, in fact, that a tablespoon of matter from it would weigh about 100 tons.[2] Without interference, it remains as the last of a star, held together by so much gravity that its size is purely maintained by the pressure between its electrons (known as electron degeneracy pressure).[1]

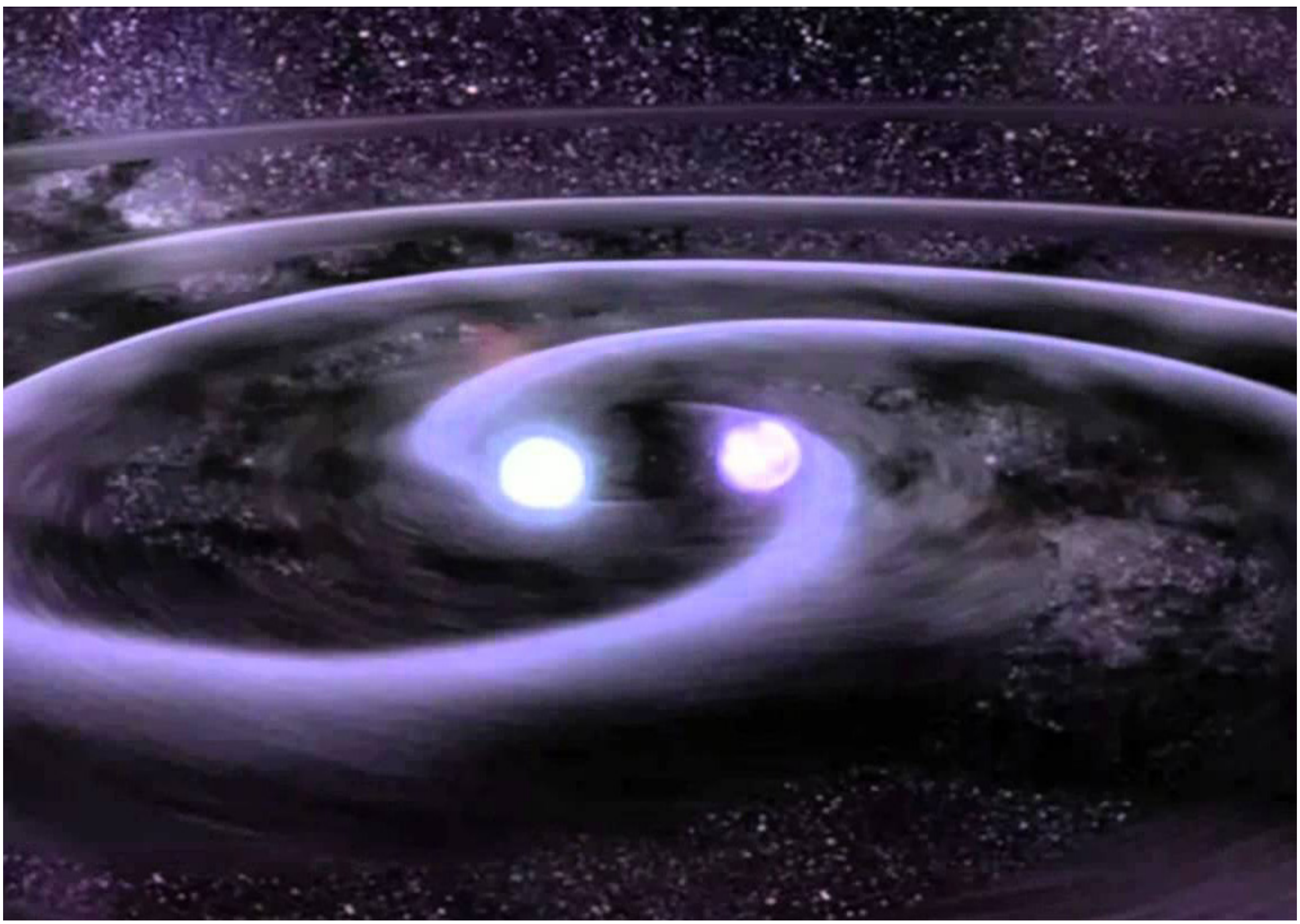
While white dwarfs are normally stable for billions of years, in binary star systems, matters become more complex.

If the other star is a sun-like star, usually in its red giant phase, this is a single-degenerate situation. The white dwarf's immense gravitational force can siphon off the gases from the red giant, allowing it to grow in mass. Once the white dwarf reaches the Chandrasekhar limit—about 1.4 solar masses—gravity overcomes the electron degeneracy pressure, which would normally cause a collapse. However, the star is now also massive enough fuse carbon, starting a thermonuclear reaction that nearly instantly releases enough energy to tear the star apart.[1]



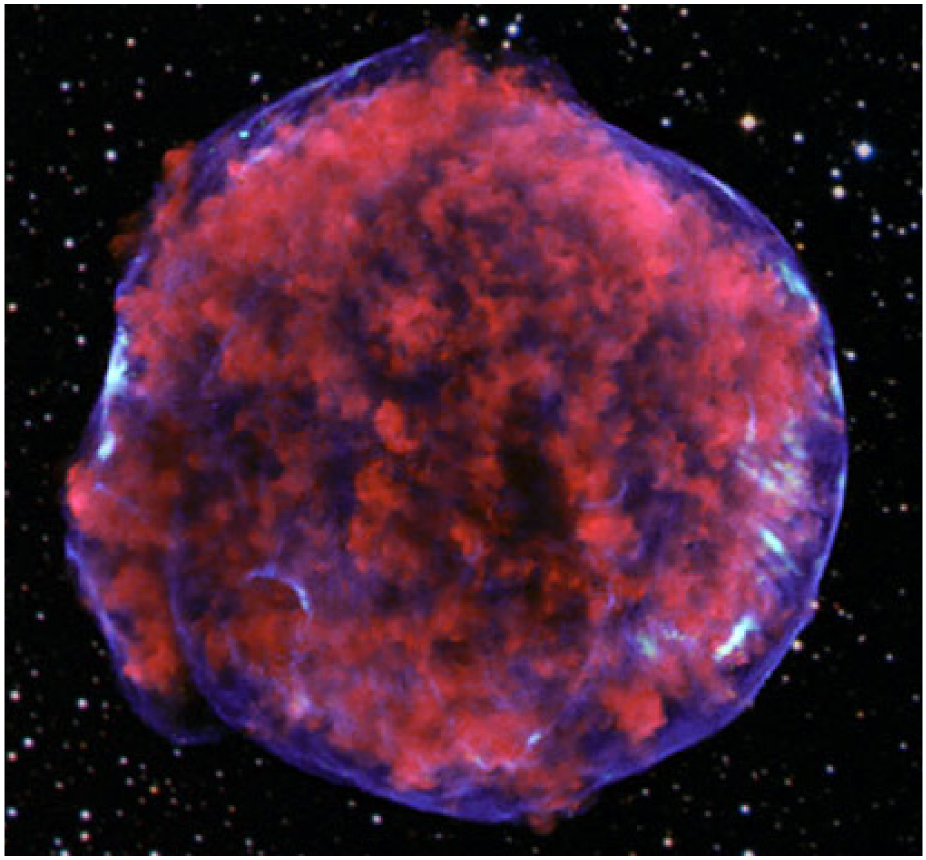
A white dwarf accreting mass from its red giant companion star[d]

But what if the companion star is yet another white dwarf? In this, the double-degenerate case, the two stars might actually merge, resulting in a huge change in mass that allows the merged star to far exceed the Chandrasekhar limit, thus spurring fusion and, yet again, explosion—but this time, no star is ejected, since all that remains is debris from the explosion of the merged star.[3]



White dwarf stars in a so-called “death spiral”[e]

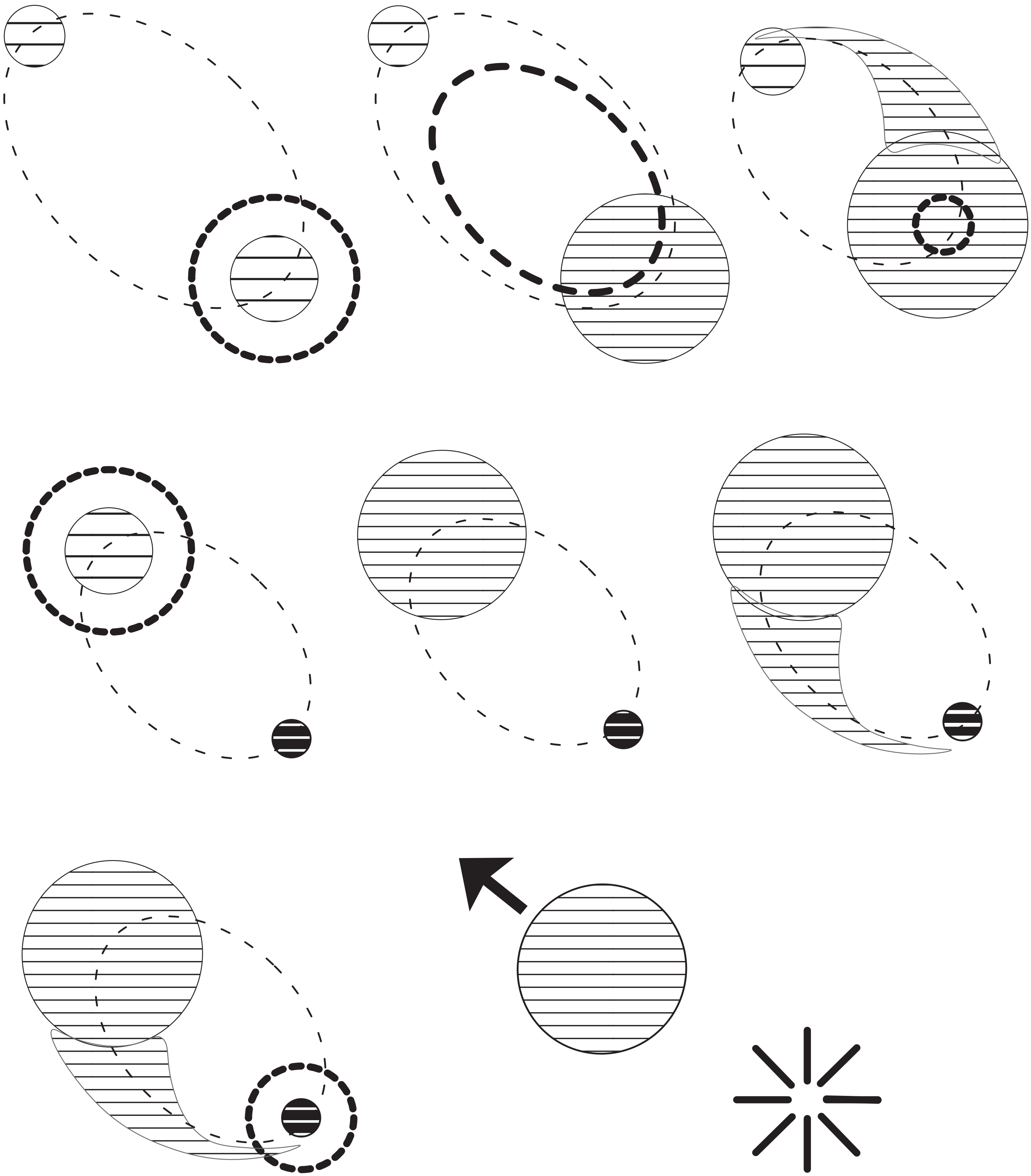
When it finally explodes, the companion is ejected into the universe, and a cloud of colorful cosmic dust remains as proof that a supernova happened there. The shape is bounded by the expanding shock wave from the explosion.[4]



Tycho supernova remnant--the explosion occurred over 400 years ago[f]

The different colors are affected by different factors. The blue ring is the shock wave expanding fastest, the center variations in color are from the material from the star or stars that exploded, and the red in the center is the now heated interstellar dust that encountered the explosion. Therefore, these remnants show a lot about how long ago the explosion occurred and what materials were involved in it. This in part reflects whether the supernova was single degenerate or double degenerate.[4]

E0102-72, a supernova remnant that is visible as it was 1000 years past explosion[g]



Citations

Information:

[1] Drake, Nadia. “Type 1a Supernovae: Why Our Standard Candle Isn’t Really Standard.” Phenomena. National Geographic | Phenomena, 29 Aug. 2014. Web. 13 Feb. 2017.
[2] Miller, Jonah. “Type 1a: The Other Type of Supernova.” The Physics Mill. N.p., 22 Feb. 2016. Web. 16 Feb. 2017.
[3] “White Dwarfs in Death Spiral Poised for a Spectacular Supernova.” The Daily Galaxy. N.p., 10 Feb. 2015. Web. 16 Feb. 2017.
[4] Williams, Brian. “An Introduction to Supernova Remnants.” An Introduction to Supernova Remnants. NCSU, n.d. Web. 16 Feb. 2017.
Nave, Rod. “Supernovae.” Supernovae. Georgia State University, n.d. Web. 21 Feb. 2017.

Images:

Cover Image: *Merging White Dwarfs Will Explode in a Supernova | Video*. Digital image. YouTube. CoconutScienceLab, 11 Feb. 2015. Web. 15 Feb. 2017.
[a] *Supernova 1994D*. Digital image. Hubble Space Telescope. NASA/ESA, 25 May 1999. Web. 13 Feb. 2017.
[b] NASA/Casey Reed. *Red Giant and White Dwarf*. Digital image. Discover Magazine. N.p. n.d. Web. 13 Feb. 2017.
[c] ESA and NASA. *Artist’s Impression of the sizes of Sirius B and the Earth*. Digital Image. Hubble Space Telescope. NASA/ESA, 13 Dec. 2005. Web. 13 Feb. 2017.
[d] *Binary Star Cataclysm*. Digital Image. Wikimedia. Antonello Zito, 8 Sept. 2012. Web. 13 Feb. 2017.
[e] Credit: Tod Strohmayer (GSFC), CXC, NASA; Illustration: Dana Berry (CXC). *White Dwarf Star Spiral*. Digital Image. Astronomy Picture of the Day. NASA, 1 Jun. 2005. Web. 13 Feb. 2017.
[f] X-Ray: NASA, CXC, Rutgers, K. Eriksen, et. al.; Optical: DSS. *Tycho Supernova Remnant*. Digital image. SciTechDaily. N.p., 8 May 2012. Web. 16 Feb. 2017.
[g] NASA, CXC, MIT, D. Dewey et al., SAO, J. DePasquale, STScI. *E0102-72, a supernova remnant in the Small Magellanic Cloud*. Digital image. Supernovae and Supernova Remnants. N.p. n.d. Web. 13 Feb. 2017.