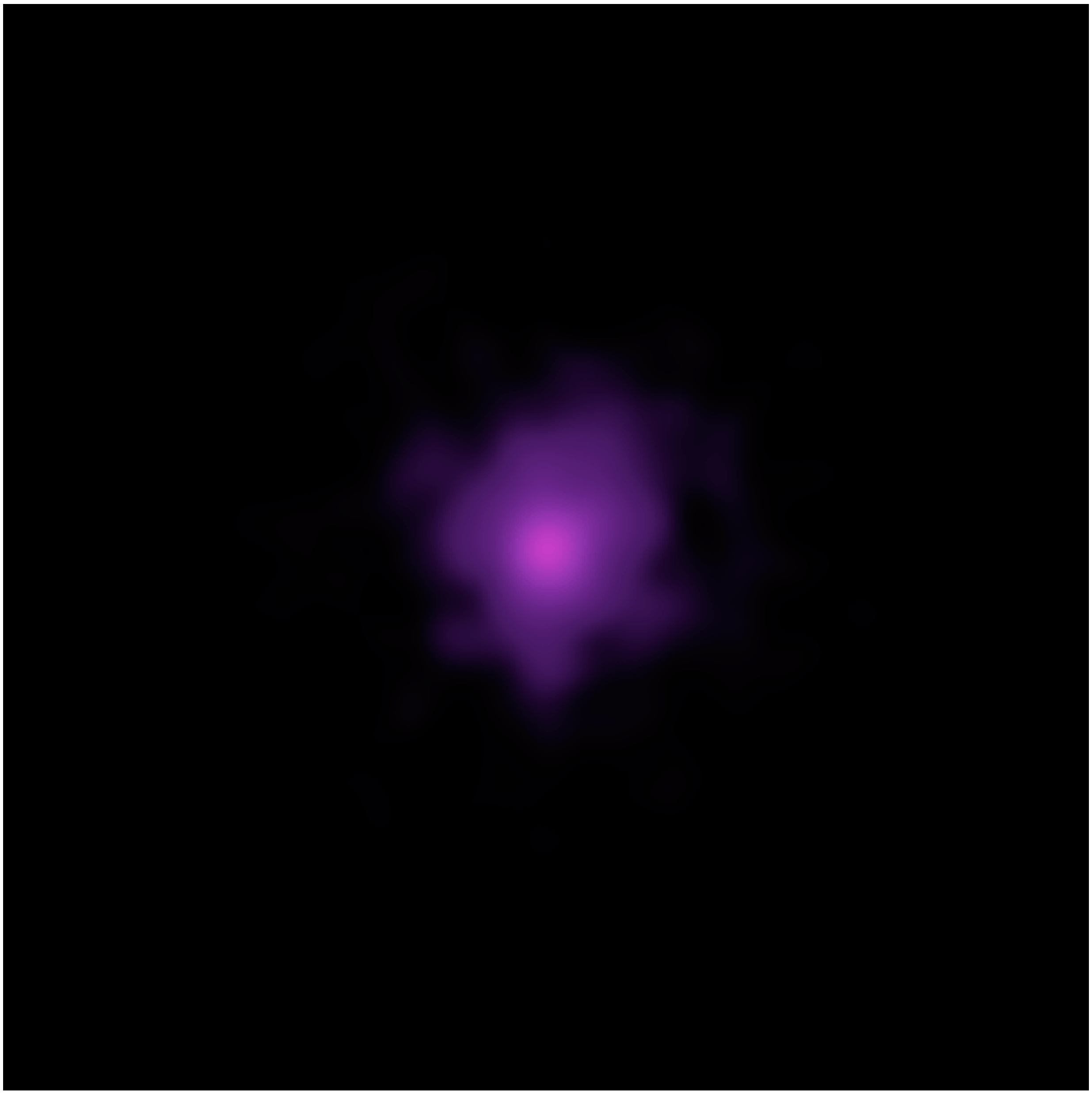
Two sides of the same star

May 30 2018



The pulsar pictured here, which resides in the Messier 82 galaxy 12 million light-years away, sends out X-ray beams that pass Earth every 1.37 seconds. Scientists studying this object with NuSTAR originally thought it was a massive black hole, but its X-ray pulse revealed its true pulsar identity. Credit: NASA/JPL-Caltech

If you've ever heard of the phrase two sides of the same coin, you know it means two things that at first appear to be unrelated are actually parts of the same thing. Now, a fundamental example can be found in the deep recesses of space in the form of a neutron star.

A neutron star comes from a large star that has run out of fuel, and exploded as a supernova. As gravity forces the star to collapse to the size of a small city, the star becomes so dense that a single teaspoon of the collapsed star would have as much mass as a mountain. The star's core, now a neutron star, can be rotating as fast as 10 times a second or more. Over time the rotation of the core can start speeding up by pulling matter from its surroundings, rotating over 700 times a second!

Some neutron stars, called radio pulsars, have strong magnetic fields and emit radio waves in predictable, reliable pulses. Other neutron stars have even stronger magnetic fields, displaying violent, high-energy outbursts of X-ray and gamma ray light. These are called "magnetars", and their magnetic fields are the strongest known in the universe, a trillion time stronger than that of our sun.

Since the 1970s, scientists have treated pulsars and magnetars as two distinct populations of objects. But in the last decade evidence has emerged that shows they might sometimes be stages in the evolution of a single object. That's right – a neutron star might just be two sides of the same coin – first it's a radio pulsar and later becomes a magnetar. Or maybe it's the other way around.

Some scientists argue that objects like magnetars gradually stop emitting X-rays and gamma rays over time. Others propose the opposite theory: that the radio pulsar comes first and then, over time, a magnetic field emerges from the neutron star causing those magnetar-like outbursts to start.

Tom Prince is a Professor of Physics at Caltech and a Senior Research Scientist at NASA's Jet Propulsion Laboratory. He says, "It's a bit tricky to observe these restless bodies. First, magnetars don't last long – just a year to a few years, before colossal waves of x-rays dissipate the magnetic energy. Second, pulsars are really quite old by our standards. One of the most famous pulsars, the crab pulsar for example, exploded in the early 1,000's. Third, it doesn't happen often. The last known supernova to explode in our vicinity occurred in 1987 in a satellite Galaxy of the Milky Way."

Prince also notes that while a ground based radio telescope observed the first known radio pulsar/ magnetar transition, it's been NASA's orbiting telescopes – Fermi, Swift, RXTE, and NuSTAR, along with the European Space Agency's XMM-Newton observatory—that have yielded the most interesting data. Observations have included seismic waves rippling through a magnetar, a cloud of high-energy particles called a wind nebula around a magnetar, and a magnetar that is also the slowest spinning neutron star ever detected!

Regardless of which came first, the two sides of these stars have much to teach us about matter at the highest densities and the most powerful magnetic fields in the universe.

Provided by NASA