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NASA's Chandra Finds Source of Star's Mysterious Outbursts

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AT 2016blu in NGC 4559
Credit: X-ray: NASA/CXC/Univ. of Virginia/M. Aghakhanloo et al.; Optical: SDSS; Image Processing: NASA/CXC/SAO/P. Edmonds
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Using NASA's Chandra X-ray Observatory, astronomers have discovered what is triggering repeated outbursts from a giant, unstable star.

A **new paper**, published in the latest issue of The Astrophysical Journal, details the discovery of a previously hidden companion object that keeps pulling material away from the massive star every 113 days as they orbit one another. This partner is either a stellar-mass black hole, or the dense collapsed core of a massive star called a neutron star.

This is the first X-ray detection of one of this class of erupting stars. It is also the first of these objects found with a black hole or neutron star companion.

The volatile star, known as AT 2016blu, is in the spiral galaxy NGC 4559, located about 30 million light-years from Earth. Astronomers estimate the mass of this star is at least 33 times that of the Sun.



[ENLARGE]

AT 2016blu in X-ray & Optical Light, labeled.

A composite NASA Chandra X-ray and Sloan Digital Sky Survey (SDSS) optical image of the galaxy NGC 4559 located about 30 million light-years from Earth. The Chandra data shows X-ray point sources represented in purple, and the SDSS data shows the galaxy and foreground and background objects in red and blue. The luminous blue variable and supernova impostor AT 2016blu is in the middle of the small square.

Credit: X-ray: NASA/CXC/Univ. of Virginia/M. Aghakhanloo et al.; Optical: SDSS; Image Processing: NASA/CXC/SAO/P. Edmonds

“For 15 years, astronomers have been watching this star get really bright and then dim again on a regular basis,” said Mojgan Aghakhanloo of the University of Virginia in Charlottesville, who led this study. “Until we were able to get Chandra data at the right time, we couldn’t figure out what was making this happen.”

The star AT 2016blu is a type of luminous blue variable, which are hot, massive stars characterized by large changes in brightness. Eta Carinae, for example, is a particularly well-known luminous blue variable. AT 2016blu is a special type of luminous blue variable that undergoes rapid and repeated increases in brightness. The spikes in brightness are so extreme that they resemble supernova explosions, where a massive star collapses onto itself and material then hurtles outward into space. However, unlike in a supernova explosion, the star is not destroyed, so astronomers refer to AT 2016blu as a “supernova impostor.”

Between 2012 and 2026, astronomers detected at least 27 bursts of optical light, which includes wavelengths that are visible to our eyes, from AT 2016blu roughly every 113 days.

“This star’s behavior was confusing at first because it kept acting like a supernova, but clearly it’s not because it keeps surviving these outbursts about three times a year,” said co-author Núria Torres-Albà, also of the University of Virginia. “To understand the cause of these eruptions, we realized we needed X-ray data that was timed so that we’d observe the star when it was in an outburst.”

The team used Chandra because it is the only X-ray telescope with sharp enough vision to distinguish AT 2016blu from another nearby bright X-ray source.

“We suspected that the bright repeating flashes at optical wavelengths might actually be powered by periodic blasts of high-energy X-rays,” said co-author Nathan Smith of the University of Arizona in Tucson. “The dense gas surrounding the system is heated by the X-rays and then glows in the optical. So, we needed to plan the Chandra X-ray observations carefully to be simultaneous with an optical outburst.”

Chandra data from March 2026 revealed that AT 2016blu was at least 100 times brighter in X-rays than in Chandra data from 2001 to 2002, which is before the outbursts began. The best explanation for this is that material from the star is falling onto a neutron star or black hole during the closest approach in their oval-shaped orbit around one another. When they come close together, material ejected by the star gets captured by the black hole or neutron star. The material orbits at very high speeds close to the speed of light, getting so hot that it shines brightly in X-rays.

AT 2016blu is bright enough in X-rays to be classified as an ultra-luminous X-ray source candidate. These are rare, bright X-ray sources found with telescopes like Chandra that astronomers have yet to fully understand. Scientists’ current thinking is that some of them contain neutron stars, and others have black holes.

These new observations suggest there could be a link between ultra-luminous X-ray sources and the kind of violent stellar eruptions seen in AT 2016blu, especially because many ultra-luminous X-ray sources undergo large changes in X-ray brightness.

The discovery of this system may also help studies of stars that change in brightness before they undergo supernova explosions. Astronomers suspect that much of this behavior may be caused by systems containing a massive star orbiting a compact object or another massive star.

To collect the optical data, the team used the Katzman Automatic Imaging Telescope, the Las Cumbres Observatory Global Supernova Project, and observations from the American Association of Variable Star Observers, including those from more than 30 amateur astronomers, to monitor the star's brightness.

When these observations showed that the star was in outburst in early 2026, Chandra observations were triggered and obtained in March 2026 as part of its "Target of Opportunity" program designed to take account of special events.

NASA's Marshall Space Flight Center in Huntsville, Alabama, manages the Chandra program. The Smithsonian Astrophysical Observatory's Chandra X-ray Center controls science operations from Cambridge, Massachusetts, and flight operations from Burlington, Massachusetts.

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