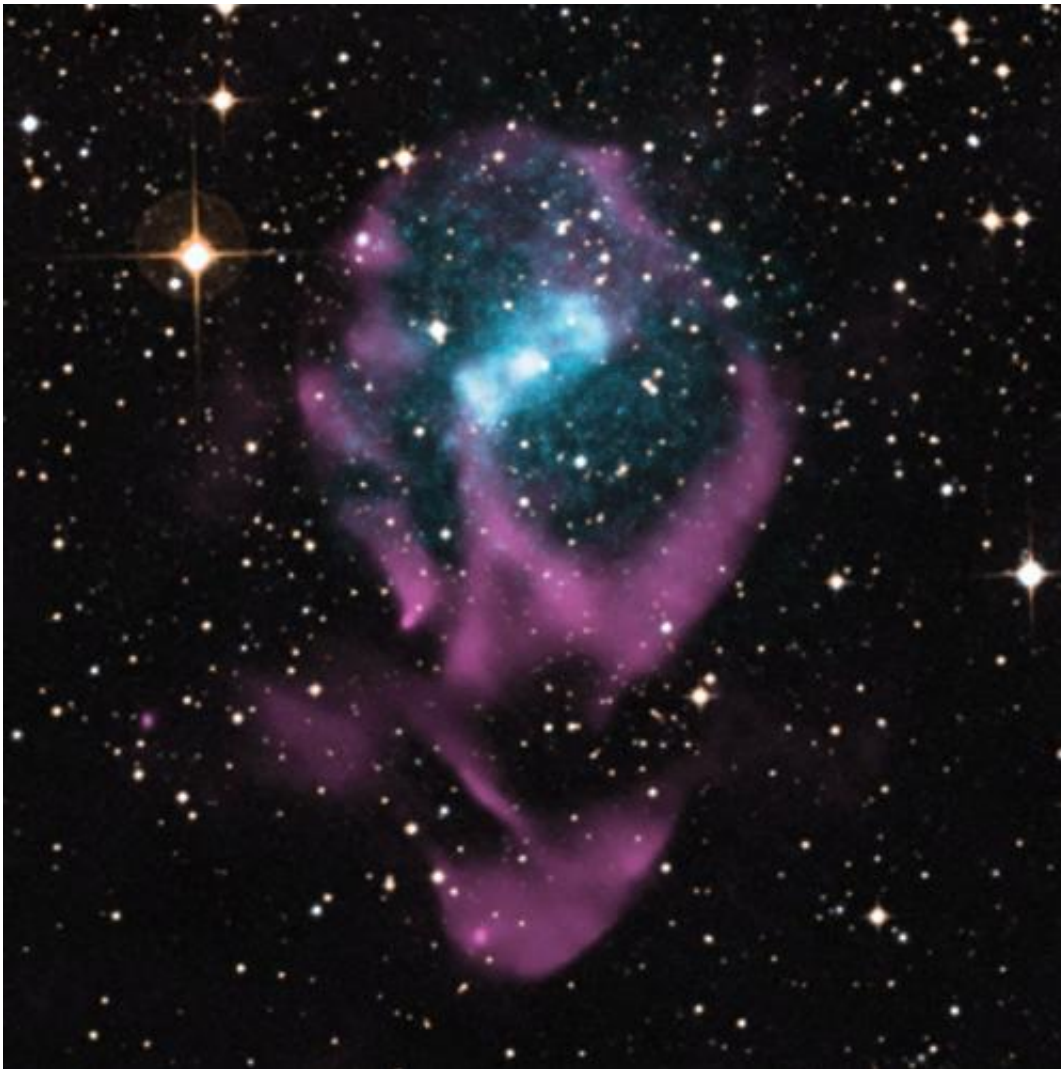


## A blast from its past dates the youngest neutron-star binary

December 4 2013, by Megan Watzke

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The youngest member of an important class of objects in space has been found by a team that includes Penn State Distinguished Professor of Astronomy and Astrophysics Niel Brandt. This composite image shows the energies streaming toward Earth from this object -- X-rays in blue and the radio emission in purple.

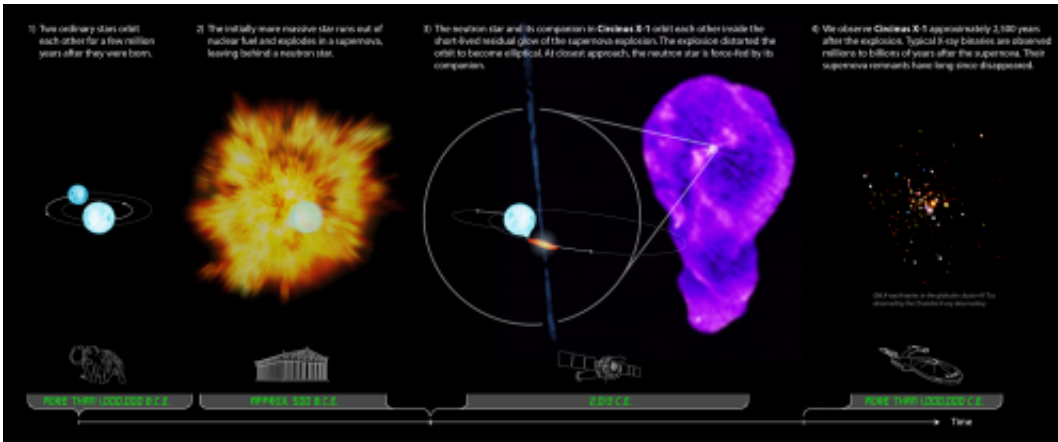
These energy detections have been overlaid in this image on an optical field of view from the Digitized Sky Survey. This discovery allows scientists to study a critical phase after a supernova and the birth of a neutron star. [Click here](#) for more information about this image. Credit: X-ray: NASA/CXC/Univ. of Wisconsin-Madison/S. Heinz et al; Optical: DSS; Radio: CSIRO/ATNF/ATCA

X-rays streaming toward Earth from the region near a neutron star that is cannibalizing its companion star have revealed the pair to be the youngest "X-ray binary" yet known. The discovery by a team that includes a Penn State astronomer is being published in this week's issue of the *The Astrophysical Journal*.

The team discovered the age of this record-breaking pair, named Circinus X-1, by using data from NASA's Chandra X-ray Observatory, which revealed faint remnants of the supernova explosion that created the neutron star.

"I have been perplexed by the unusually strong evolution of the orbit of Circinus X-1 since my graduate-school days," said Niel Brandt, Distinguished Professor of Astronomy and Astrophysics. "The discovery now of this system's youth provides a satisfying explanation for why its orbit evolves so strongly—because the system likely still is settling down after its violent birth."

The research team, which was led by Sebastian Heinz at the University of Wisconsin-Madison, determined that Circinus X-1 is less than 4,600 years old. "X-ray binaries provide us with opportunities to study matter under extreme conditions that would be impossible to recreate in a laboratory," Heinz said. "For the first time, we can study a newly minted neutron star in an X-ray binary system."



This is an artist's conception of the life of X-ray binary systems and the young and turbulent history of *Circinus X-1*, which formed in a supernova explosion less than 4,600 years ago, approximately 500 B.C.E., making it the youngest known X-ray binary. Credit: University of Wisconsin-Madison

X-ray binaries are star systems made up of two parts: a compact stellar remnant—either a neutron star or a black hole; and a [companion star](#)—a normal star like our Sun. The new discovery, made in parallel with a radio telescope in Australia, provides scientists with unique insight into the formation of [neutron stars](#) and supernovas, and the effect of the supernova's explosion on a nearby companion star. As the two objects orbit one another, the neutron star or black hole pulls in gas from the companion star, heating the gas to millions of degrees, producing intense X-ray radiation, and making these star systems some of the brightest X-ray sources in the sky.

To determine the age of *Circinus X-1*, the astronomers needed to examine the material around the orbiting pair of stars. However, the overwhelming brightness of the neutron star made it too difficult for researchers to observe that interstellar gas. The team recently caught a break, however, when they observed the neutron star in a very faint

state—dim enough for scientists to detect the X-rays from the [supernova shock wave](#) that plowed through the surrounding interstellar gas.

The youth of Circinus X-1 helps to explain its wild swings in brightness and the highly unusual orbit of its two stars, which had puzzled Brandt and other astronomers for years. "For a system this young that recently has gone through a supernova event, the orbit is likely to be eccentric, and the neutron-star's spin axis, the companion-star's spin axis, and the binary pair's orbital axis are likely to be quite misaligned," Brandt said. "Such misalignment will induce changes over time, which can help to explain the peculiarly strong long-term changes in the X-ray light that we see coming from Circinus X-1."

The team's research provides the missing context for understanding why the orbital time of the two Circinus X-1 stars is decreasing by several minutes every year. Brandt explained that this dynamic is plausibly the behavior that would be expected for a young X-ray binary affected by a supernova explosion before the gravitational pull of the stars on each other has had time to stabilize the orbit fully. Brandt contributed to the interpretation of the data and to the assessment of the scientific implications of the findings, and his calculations provided information about the expected orbital and other properties of the young binary system.

In addition to the Chandra data, radio observations from the Australia Telescope Compact Array were critical in these findings. NASA's Marshall Space Flight Center in Huntsville, Ala., manages the Chandra program for NASA's Science Mission Directorate in Washington. The Smithsonian Astrophysical Observatory in Cambridge, Mass., controls Chandra's science and flight operations.

**More information:** [arxiv.org/abs/1312.0632](https://arxiv.org/abs/1312.0632)

Provided by Pennsylvania State University

Citation: A blast from its past dates the youngest neutron-star binary (2013, December 4)  
retrieved 26 April 2024 from

<https://phys.org/news/2013-12-blast-dates-youngest-neutron-star-binary.html>

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