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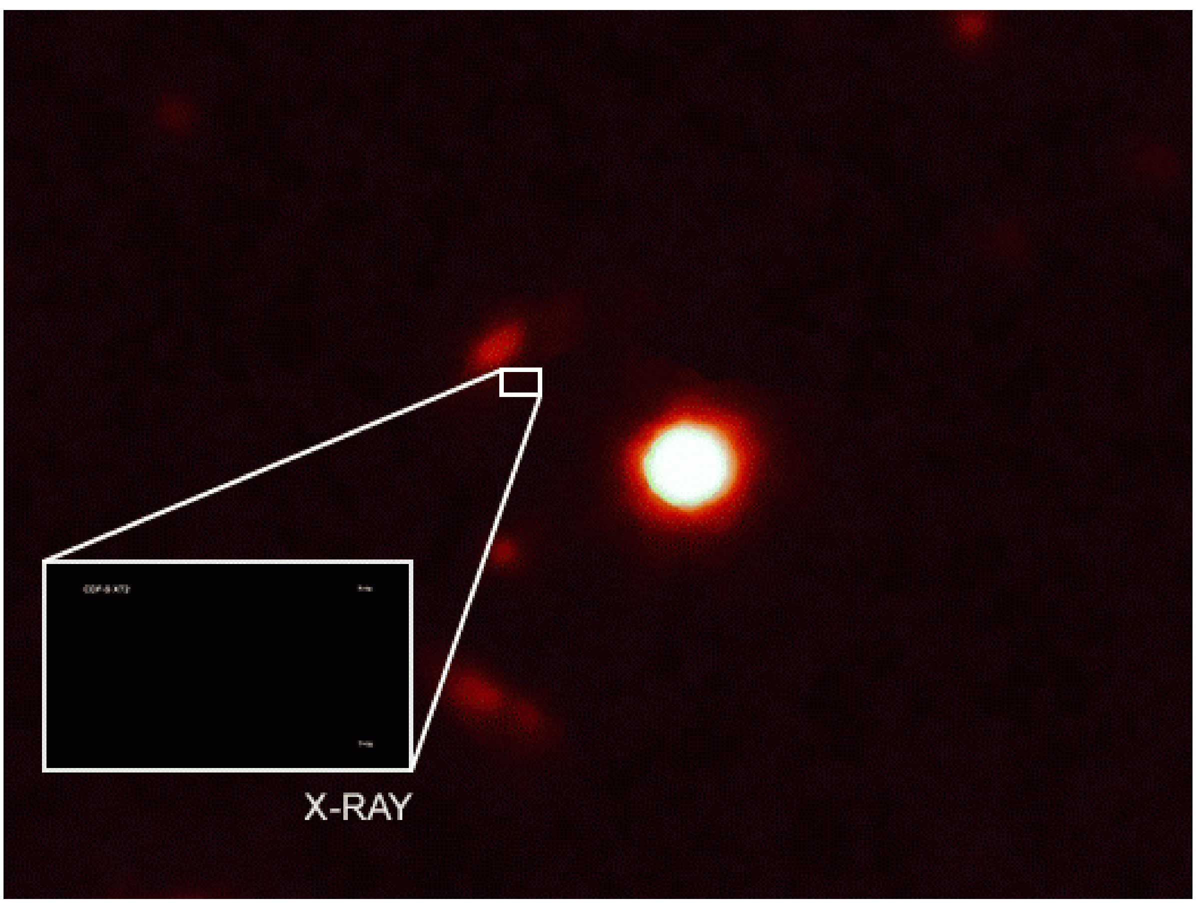
RESEARCH

A new signal for a neutron star collision discovered



UNIVERSITY PARK, Pa. — A bright burst of X-rays has been discovered by NASA's Chandra X-ray Observatory in a galaxy 6.6 billion light years from Earth. This event likely signaled the merger of two neutron stars — dense stellar objects packed mainly with neutrons — and could give astronomers fresh insight into how neutron stars are built. A **paper describing the research**, conducted by an international team of astronomers, including researchers and alumni from Penn State, appears in the journal Nature.

When two neutron stars merge they produce jets of high-energy particles and radiation fired in opposite directions. If the jet is pointed along the line of sight to Earth, a flash, or burst, of gamma rays can be detected. If the jet is not pointed in our direction, a different signal is needed to identify the merger, such as the detection of gravitational waves — ripples in space time.

Now, with the observation of a bright flash of X-rays, astronomers have found a different kind of signal that could indicate a merger, and discovered that two neutron stars likely merged to form a new, heavier and fast-spinning neutron star with an extraordinarily strong magnetic field.

"We've found a completely new way to spot a neutron-star merger," said Yongquan Xue, professor at the University of Science and Technology of China (USTC) and lead author of the paper; Xue was formerly a postdoctoral fecundity repeatedly transcends human imagination," said co-author Niel Brandt, Verne M. Willaman Professor of Astronomy and Astrophysics and professor of physics at Penn State, and principal investigator of the relevant Chandra Deep Field-South data.

The researchers identified the likely origin of XT2 by studying how its X-ray light varied with time, and comparing this behavior with predictions made in 2013 by Bing Zhang, professor and associate dean for research at the University of Nevada, Las Vegas, and an author of the paper; Zhang also formerly was a postdoctoral researcher at Penn State. The X-rays showed a characteristic signature that matched those predicted for a newly-formed magnetar — a neutron star spinning around hundreds of times per second and possessing a tremendously strong magnetic field about a quadrillion times that of Earth's.

The team thinks that the magnetar lost energy in the form of an X-ray-emitting wind, slowing down its rate of spin as the source faded. The amount of X-ray emission stayed roughly constant in X-ray brightness for about 30 minutes, then decreased in brightness by more than a factor of 300 over 6.5 hours before becoming undetectable. This behavior indicates that the neutron star merger produced a new, larger neutron star that survived at least a few hours rather than collapsing immediately into a black hole.

This result is important because it gives astronomers a chance to learn about the interior of neutron stars, objects that are so dense that their and an afterglow in light detected by many other telescopes, including Chandra. The research team thinks that XT2 would also have been a source of gravitational waves, however it occurred before Advanced LIGO started its first observing run, and it was too distant to have been detected in any case.

The team also considered whether a different phenomenon, the collapse of a massive star, could have caused XT2 rather than a neutron star merger. However, XT2 is in the outskirts of its host galaxy, which aligns with the idea that supernova explosions that left behind the neutron stars kicked them out of the center a few billion years earlier. The galaxy itself also has certain properties — including a low rate of star formation compared to other galaxies of a similar mass — that are much more consistent with the type of galaxy where the merger of two neutron stars is expected to occur. Massive stars, by contrast, are young and are associated with high rates of star formation.

“The host-galaxy properties of XT2 indeed boost our confidence in explaining its origin,” said co-author Ye Li, from Peking University.

The team estimated the rate at which events like XT2 should occur, and found that it agrees with the rate deduced from the detection of GW170817. However, both estimates are highly uncertain because they depend on the detection of just one object each, so more examples are needed.

“There must be more exciting transients that are still undiscovered in Chandra’s archival X-ray data,” said Guang Yang, graduate student in

The team also includes Xuechen Zheng, Xu Kong, JY Li and Junxian Wang at the USTC, Binbin Zhang at Nanjing University, and Hui Sun and Xue-Feng Wu at the Chinese Academy of Sciences.

The relevant data collected for this research were gathered by Chandra's Advanced CCD Imaging Spectrometer (ACIS), built by a team from Penn State and the Massachusetts Institute of Technology. NASA's Marshall Space Flight Center in Huntsville, Alabama, manages the Chandra program for NASA's Science Mission Directorate in Washington. The Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, controls Chandra's science and flight operations.

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