Chandra finds stellar duos banished from galaxies

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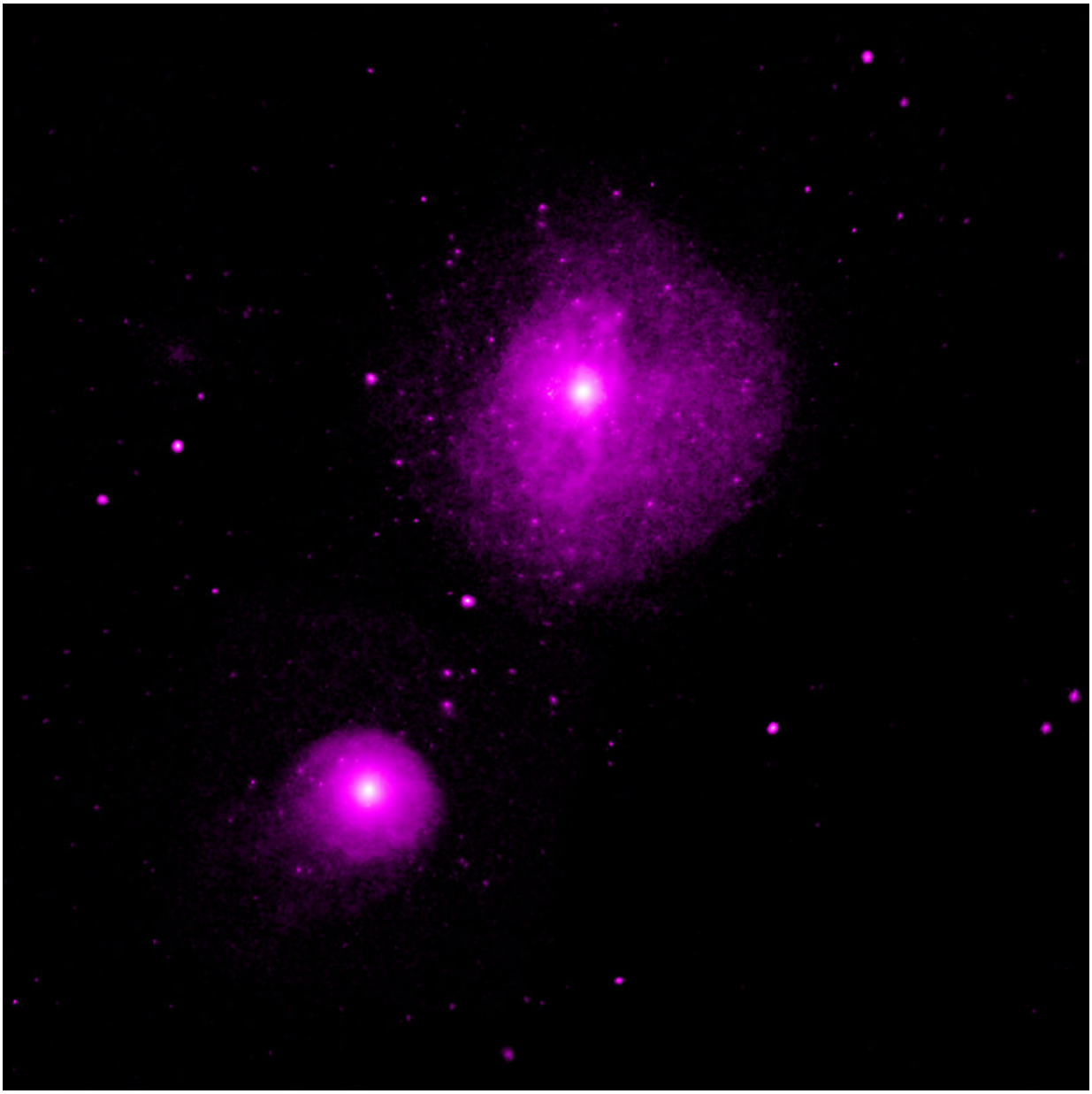

Credit: NASA/CXC/Nanjing University/X. Jin et al.

Scientists have found evidence that pairs of stars have been kicked out of their host galaxies. This discovery, made using data from NASA's Chandra X-ray Observatory, is one of the clearest examples of stellar pairs being expelled from their galactic base.

Astronomers use the term "binary" system to refer to pairs of stars orbiting around each other. These stellar pairs can consist of combinations of stars like our Sun, or more exotic and denser varieties such as neutron stars or even black holes.

Neutron stars form when a massive star explodes as a supernova and the core of the star collapses onto itself. Under certain conditions, these gargantuan blasts that create the neutron star are not symmetric. The recoil effect can kick the star with such force that it is expelled from the galaxy where it resides. These new Chandra results show that sometimes a companion star is forced to exit the galaxy as well.

"It's like a guest that's asked to leave a party with a rowdy friend," said Xiangyu Jin of McGill University in Montreal, Canada, who led the study. "The companion star in this situation is dragged out of the galaxy simply because it's in orbit with the star that went supernova."

How do astronomers look for these banished pairs? If the companion star is close enough, then matter from it will swirl toward the denser neutron star and form a disk around the neutron star. The strong gravitational forces from the neutron star cause the material in this disk to move more rapidly as it approaches the neutron star, and frictional forces in the disk heat the gaseous disk to tens of millions of degrees. At these temperatures, the disk glows in X-ray light.

Jin and her collaborators found signatures of so-called X-ray binaries outside of galaxies in a comprehensive study of the Fornax galaxy cluster made with Chandra data taken between 1999 and 2015. This cluster is relatively nearby at a distance of some 60 million light-years from Earth in the constellation sharing its name.

By combining the large Chandra dataset with optical observations, researchers made a census of X-ray sources within about 600,000 light-years of the central galaxy in the Fornax cluster. Astronomers concluded that about 30 sources in the Fornax cluster were likely to be pairs of stars that had been kicked out of the center of their host galaxies.

"Rather than being tethered to a particular galaxy, these pairs of stars now exist in the space between galaxies, or are on their way out of their home galaxy," said co-author Meicun Hou, from Nanjing University in China.

The team also found about another 150 sources that appear to be outside the stellar boundaries of the galaxies within the cluster. These were determined, however, to have origins other than expulsion. One possibility is that they reside in the halos, or far outer reaches, of the Fornax cluster's central galaxy, where they were formed. A second possibility is that they are X-ray binaries that were pulled away from a galaxy by the gravitational force of a nearby galaxy during a flyby, or X-ray binaries left behind as part of the remnants of a galaxy stripped of most of its stars by a galactic collision. Such interactions are expected to be relatively common in a crowded region like the one in the Fornax cluster.

"This is like the end of a party, where the people attending head off in different directions, and only the hosts are left behind," said co-author Zhenlin Zhu, also of Nanjing University. "In the case of Fornax, the extreme case is that the original galaxies don't really exist any more."

The Chandra observations involved a total exposure time of 15 days, enabling the team to discover 1,177 X-ray sources within their search region, which covers 29 galaxies in the Fornax cluster. The team estimated how many of these sources likely belong to galaxies in the cluster, and how many are much more distant sources not contained in the cluster. This left them with about 180 sources located well outside the main stellar regions of galaxies in the cluster.

"While we are very excited about what we found, our data suggest that there may be many more of these evicted binaries that are too faint to be seen in the Chandra data," said co-author Zhiyuan Li, also of Nanjing University. "We will need longer Chandra observations to detect this population of fainter sources."

A paper describing these results appears in the May 1st, 2019 issue of The *Astrophysical Journal* and is available online.

More information: Chandra Detection of Intra-cluster X-ray Sources in Fornax, arXiv:1902.03733 [astro-ph.GA] arxiv.org/abs/1902.03733

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