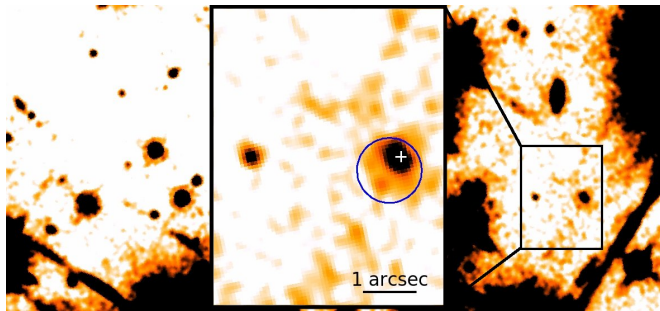


The surprising environment of an enigmatic neutron star

17 September 2018, by Sam Sholtis



Infrared image of a neutron star (source on right in box) with an extended infrared emission obtained from observations with the Hubble Space Telescope. The blue circle indicates the pulsar's X-ray position (obtained with the Chandra X-ray Space Telescope), the cross marks the position of the pulsar in the UV-Optical (measured with the Hubble Space Telescope). Credit: Bettina Posselt, Penn State

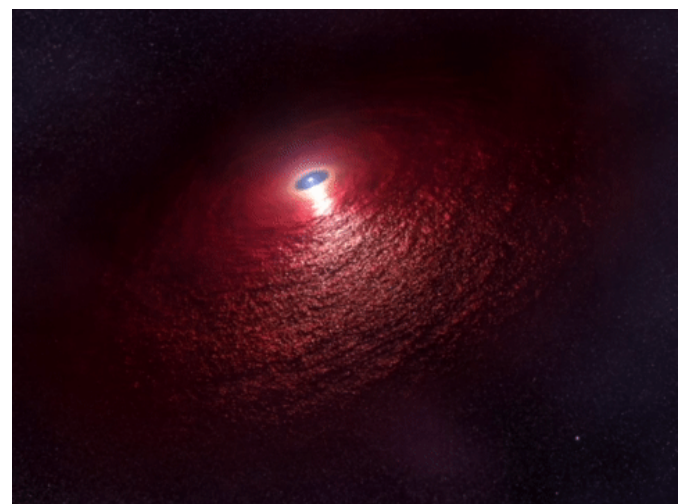
An unusual infrared emission detected by the Hubble Space Telescope from a nearby neutron star could indicate that the pulsar has features never before seen. The observation, by a team of researchers at Penn State, Sabanci University in Turkey, and the University of Arizona, could help astronomers better understand the evolution of neutron stars—the incredibly dense remnants of massive stars after a supernova. A paper describing the research and two possible explanations for the unusual finding appears September 17, 2018 in the *Astrophysical Journal*.

"This particular neutron star belongs to a group of seven nearby X-ray pulsars—nicknamed 'the Magnificent Seven'—that are hotter than they ought to be considering their ages and available energy reservoir provided by the loss of rotation energy," said Bettina Posselt, associate research professor of astronomy and astrophysics at Penn State and the lead author of the paper. "We observed an extended area of infrared emissions around this

neutron star—named RX J0806.4-4123—the total size of which translates into about 200 astronomical units (or 2.5 times the orbit of Pluto around the Sun) at the assumed distance of the [pulsar](#)."

This is the first neutron star in which an extended emission has been seen only in the infrared. The researchers suggest two possibilities that could explain the extended infrared emission seen by the Hubble Space Telescope. The first is that there is a disk of material—possibly mostly dust—surrounding the pulsar.

"One theory is that there could be what is known as a 'fallback disk' of material that coalesced around the neutron star after the supernova," said Posselt. "Such a disk would be composed of matter from the progenitor massive star. Its subsequent interaction with the neutron star could have heated the pulsar and slowed its rotation. If confirmed as a supernova fallback disk, this result could change our general understanding of neutron star evolution."



Neutron star with a circum-pulsar disk. If seen at the proper angle the scattered emission from the inner part of the disk could produce the extended infrared emission observed by astronomers around the neutron star RX

J0806.4-4123. Credit: Nahks Tr'Ehnl, Penn State

The second possible explanation for the extended infrared emission from this neutron star is a "pulsar [wind nebula](#)."

"A pulsar wind nebula would require that the neutron star exhibits a pulsar wind," said Posselt. "A pulsar wind can be produced when particles are accelerated in the electric field that is produced by the fast rotation of a neutron star with a strong magnetic field. As the neutron star travels through the interstellar medium at greater than the speed of sound, a shock can form where the interstellar medium and the pulsar wind interact. The shocked particles would then radiate synchrotron emission, causing the extended infrared [emission](#) that we see. Typically, pulsar wind nebulae are seen in X-rays and an infrared-only [pulsar wind nebula](#) would be very unusual and exciting."

Although [neutron stars](#) are generally studied in radio and high-energy emissions, such as X-rays, this study demonstrates that new and interesting information about neutron [stars](#) can also be gained by studying them in the infrared. Using the new NASA James Webb Space Telescope, due to launch in 2021, astronomers will be able to further explore this newly opened discovery space in the infrared to better understand [neutron](#) star evolution.

More information: B. Posselt et al, Discovery of Extended Infrared Emission around the Neutron Star RXJ0806.4–4123, *The Astrophysical Journal* (2018). [DOI: 10.3847/1538-4357/aad6df](https://doi.org/10.3847/1538-4357/aad6df)

Provided by Pennsylvania State University



Neutron star with a pulsar wind nebula produced by the interaction of the pulsar wind and the oncoming interstellar medium. A pulsar wind nebula could explain the extended infrared emission observed by astronomers around the neutron star RX J0806.4-4123. Such an infrared-only pulsar wind nebula is unusual because it implies a rather low energy of the accelerated particles. Credit: Nahks Tr'Ehnl, Penn State

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