Understanding Neutron Stars Inflated by Extreme Explosions

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Neutron stars are some of the most extreme objects in the Universe. These stars are trillions of times denser than anything that can be found on Earth; they have the same mass as the Sun, but compressed into the size of a city. They provide a unique opportunity to probe dense matter physics, even from thousands of light years away.

Type I X-ray bursts are extreme yet frequent explosions that occur on the surface of a neutron star after it has been "eating away" at the atmosphere of a nearby companion star for some time. Gas from the companion star builds up a disk, which slowly falls onto the surface of the neutron star. A Type I X-ray Burst is triggered when the new gas layer explodes by nuclear fusion. Some of these bursts are so bright that the atmosphere of the neutron star gets lifted up by the radiation force, generating winds that expel hot plasma into space at 1% the speed of light, and increasing a hundredfold the apparent size of the star itself.

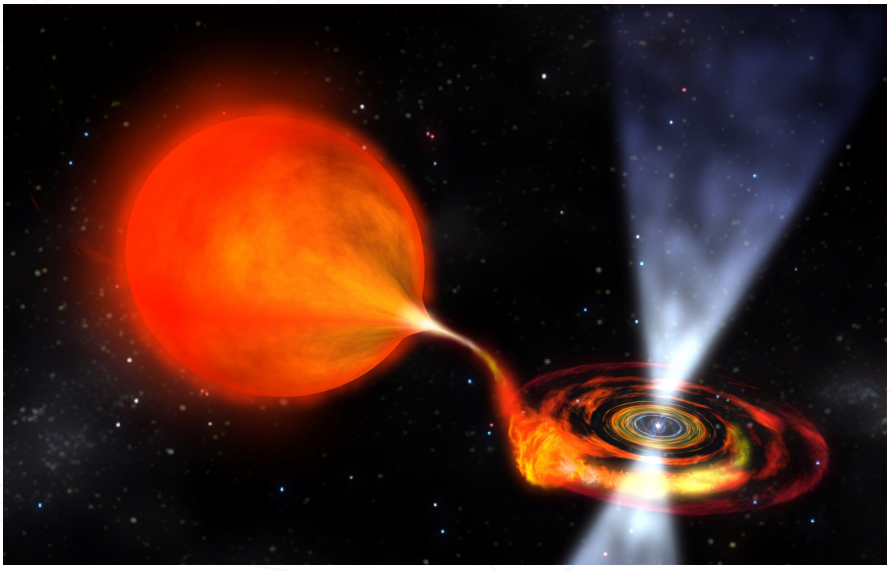
PhD student Simon Guichandut's work involves calculations of the structure of the atmosphere of the neutron star as it is being inflated during a burst. These calculations allow for extrapolating the limited information gathered by X-ray telescopes to the actual conditions of the star. Guichandut's calculations lend support to recent observations by the NICER telescope that suggest that metals such as iron and nickel, created by nuclear fusion during the burst and ejected by the wind, leave a gravitationally distorted imprint on the X-ray light that we receive. While previous studies have mostly focused on winds, this study shows that another type of expansion is possible, one in which the atmosphere is not outflowing as a wind but rather remains in equilibrium.

The existence of this regime cautions a more careful analysis of the properties of the neutron star. In particular, it makes determining a neutron star's radius using bursts a more challenging task than previously thought.

Citation: Guichandut et al. (2021). Expanded Atmospheres and Winds in Type I X-Ray Bursts from Accreting Neutron Stars.ApJ, Vol 914, Issue 1.

Why is this important?

Type I X-ray bursts encode a wealth of information about the physics of neutron stars. This study presents modern models that can be used to interpret observations of these bursts.



Right: Neutron star (the tiny white dot at the centre of the disk) "eating" its sun-like companion star. A Type I X-ray burst is triggered when the new gas layer explodes by nuclear fusion. Image Credits: ESA/NASA.