First Direct Evidence for the Fastest Neutrino Emission Mechanism in a Neutron Star

U.S. DEPARTMENT OF ENERGY | Office of Science

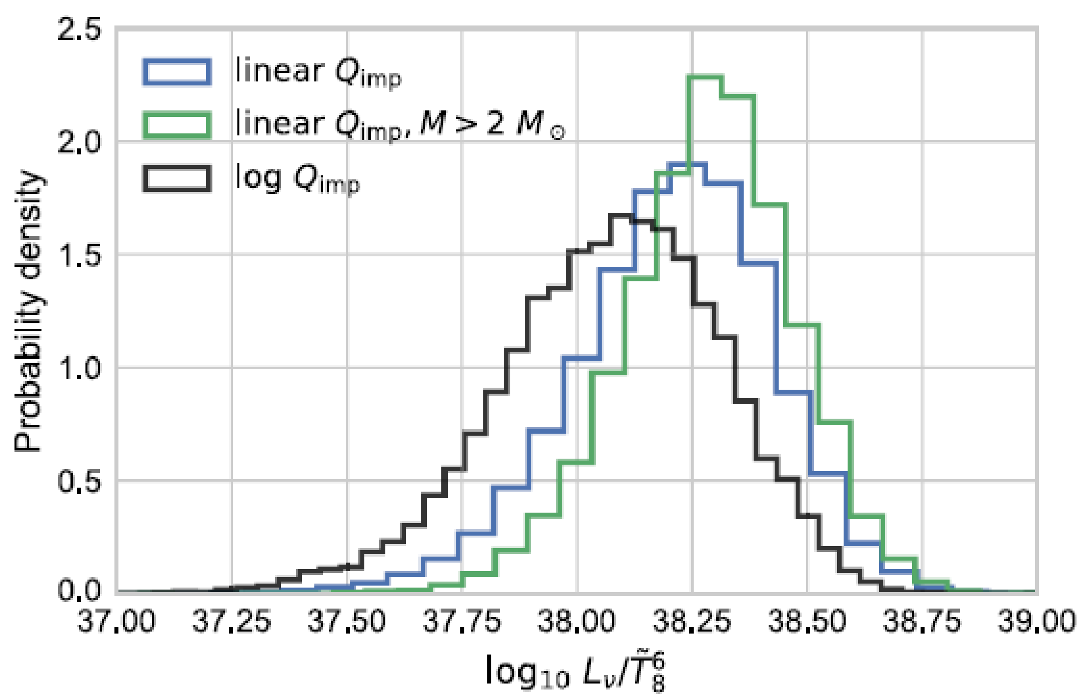
NUCLEI Nuclear Computational Low-Energy Initiative

Objectives

- Observations of the thermal relaxation of the neutron star crust in the transient system MXB 1659—29 following 2.5 years of accretion allow us to measure the energy deposited into the core during accretion.
- This energy is then re-radiated as neutrinos in about 20 years which allows us to infer the neutron star core temperature.
- MXB 1659-29 had previously been in an outburst and went into quiescence. If the outburst-quiescent cycles observed to date represent the long-time average accretion behavior of the source, then the core neutrino luminosity can be obtained.

Impact

- We found that the neutron star MXB 1659-29 is the first with a firmly detected thermal component in its x-ray spectrum that needs a fast neutrino-cooling process.
- In particular, we found that it has a core luminosity that substantially exceeds that of a modified Urca reaction and is consistent with the direct Urca reaction operating in a small fraction of the core.
- Future measurements of the temperature variation of the neutron star core during quiescence should place an upper limit on the core specific heat and serve as a check of the fraction of the neutron star core in which nucleons are unpaired.



Posterior distribution of the neutrino cooling prefactor from the MCMC fits to the MXB 1659-29 cooling curve is consistent with the fast neutrino cooling scenario such as the direct Urca reaction.

Accomplishments

- Publication:

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  Phys. Rev. Lett. 120, 172701 (2018).
- Highlighted as Editors' Suggestion.
- Featured in Physics (phys.aps.org) as Viewpoint: A rapidly cooling neutron star.
- Featured by Science News, Interesting Engineering, and many international news outlets.