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Drilling into a neutron star with X-ray transients[1]

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Over the last decade, advances in X-ray astronomy have greatly improved our knowledge of nuclear-powered phenomena on accreting neutron stars, such as type I X-ray bursts, superbursts, and cooling from quiescent neutron star transients. Spurred by these observations, theorists are beginning to reconstruct the nuclear evolution of accreted matter as it journeys from the low-density, proton-rich photosphere to the high-density, neutron-rich core. Knowledge of the interior thermal and compositional structure of the crust is important for understanding the detectability of gravitational wave emission from crust "mountains," the strength of neutrino cooling in the core, the magnetic field evolution of the star, and the ignition of bursts at low mass accretion rates. These phenomena are potentially useful for constraining the dense matter equation of state. In this talk, I shall review our current understanding of the reactions in the neutron star crust. I shall then highlight new observations of cooling neutron star transients and what they reveal about the distribution of nuclei in the crust and the neutrino emissivity of the core. The rapidly cooling lightcurves of neutron star transients imply a highly conductive, cool crust, but the inferred ignition depths of superbursts, if powered by ${}^{12}\mathrm{C} + {}^{12}\mathrm{C}$ fusion, require a hot crust. I will discuss the tension between these phenomena and possible resolutions.

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