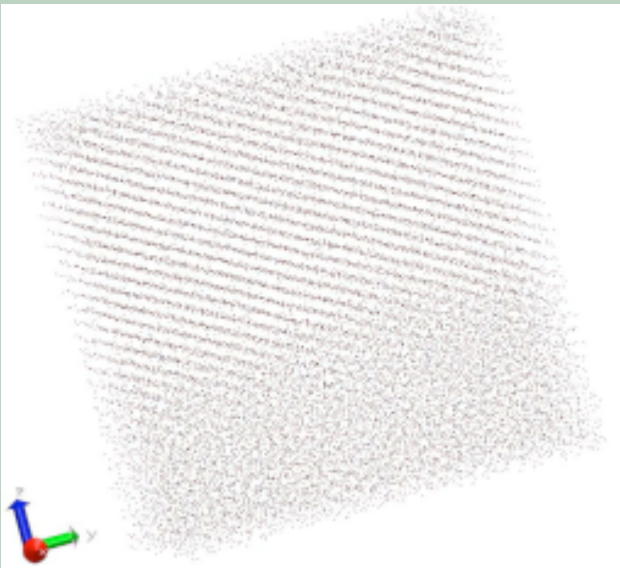
Freezing and burning the ashes of X-ray bursts



A rendering of the nuclei in a molecular dynamics simulation. The mixture of isotopes was taken from calculations of Gupta et al. (2007). The image is oriented so that the crystalline planes are visible in the top half of the cube, with the disordered liquid phase visible in the bottom portion. From Horowitz et al. (2007).

A JINA collaboration between Michigan State University, Los Alamos National Laboratory, and Universität Mainz has computed the crustal reactions that transform the ashes of X-ray bursts into the neutron-rich crust material of an accreting neutron star. These reactions occur in the ashes of the regular X-ray bursts as it is pushed through the neutron star crust by the ongoing accretion of matter from the companion star. This calculation incorporated more realistic nuclear physics in the neutron star crust model and tracked hundreds of isotopes. The results of this study have been applied to two exciting studies.

Professor Charles Horowitz (Indiana University) and collaborators have simulated the freezing of this neutron star crust mixture (see the image above). They found that the mixture froze at a much lower temperature than would a plasma composed of only one species. In addition, the material was found to separate at crystallization, with lighter nuclei (such as oxygen) diffusing into the liquid portion, and heavier nuclei diffusing into the crystalline portion. This makes the crust purer, and hence a better conductor, than previously thought.

This crust composition was also used in a model of the first superburst discovered from a transiently accreting neutron star, discovered by Keek et al. (2008). The crust alternately heats, when the intermittent accretion is active, and cools, when the accretion shuts off. In a challenge to neutron star models, the computed temperature at the time of the observed superburst is too cold for carbon fusion—the most plausible trigger for superbursts—to ignite.

Investigators

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Publications

Gupta et al. (2007) Astrophys. Jour. **662**, 1188

Horowitz et al., (2007) Phys. Rev. E, **75**, 066101

Keek et al. (2008) Astron. and Astrophys. **479**, 177

Support

NASA award (*Chandra*) TM7-8003X; NSF-PFC grant PHY~02-16783 (*JINA*); NSF PHY 0110253; Virtuelles Institüt für Struktur der Kerne und nukleare Astrophysik (*VISTARS*) under HGF grant VH-VI-061; NNSA of the U.S. DOE at Los Alamos Nat'l Lab under Contract DE-AC52-06NA25396

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