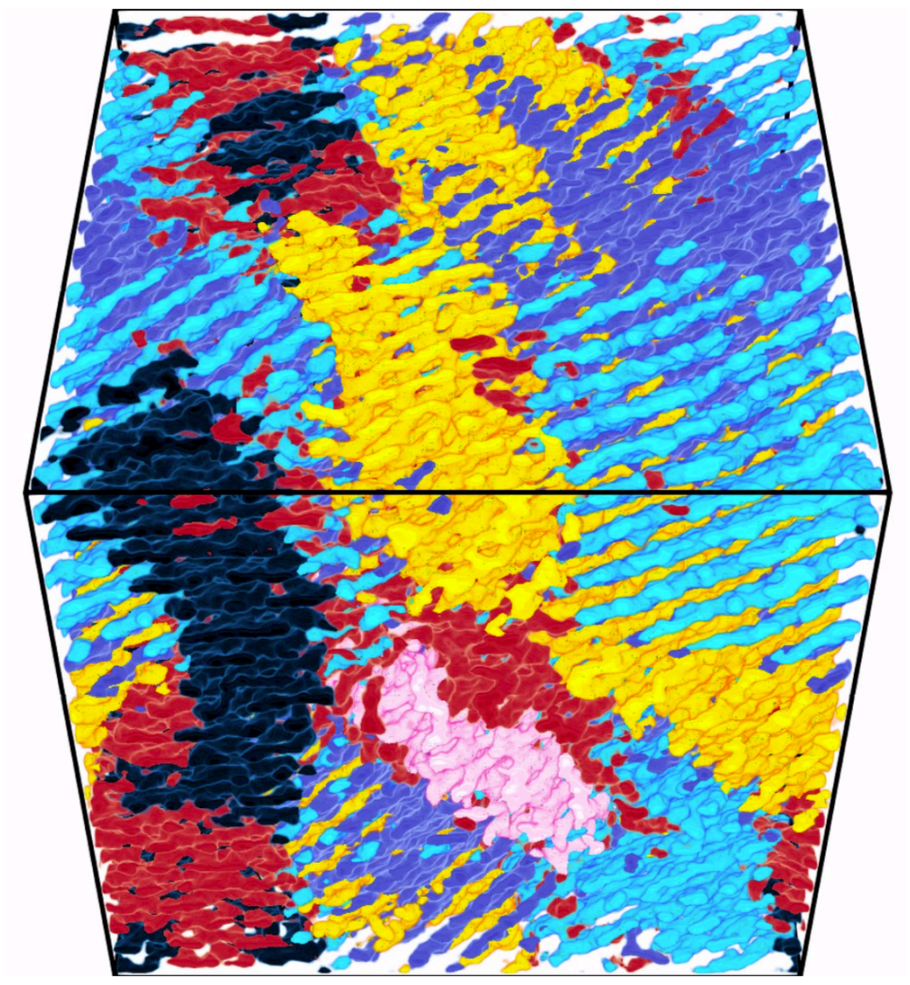
Nuclear Pasta: strongest material in the universe

U.S. DEPARTMENT OF ENERGY | Office of Science

NUCLEI Nuclear Computational Low-Energy Initiative

Objective

- Use large scale GPU computing to perform detailed molecular dynamics (MD) simulations of neutron star crust, including complex nuclear pasta phases, and to determine its elastic properties such as sheer modulus and breaking strain.



Largest ever simulation of nuclear pasta, containing over three million protons and neutrons. The colors show "domains" where nuclear pasta is locally ordered.

Impact

- Computations of the shear modulus determine frequency of neutron star crust oscillations.
- We find very strong breaking strain that can pin strong twisted magnetic fields and help explain huge energy released in Magnetar (neutron stars with very strong magnetic fields) giant flares.
- Our very strong breaking strain can support large crust mountains (mass concentrations) that on rotating neutron stars can efficiently radiate gravitational waves. These could be observed in near future LIGO searches.

Accomplishments

- We find nuclear pasta is strongest material in the universe.
- Publication: M. E. Caplan, A. S. Schneider, and C. J. Horowitz, Phys. Rev. Lett. 121, 132701 (2018).
- Featured in ScienceNews, Newsweek, The Atlantic, Smithsonian, Space, Phys.org