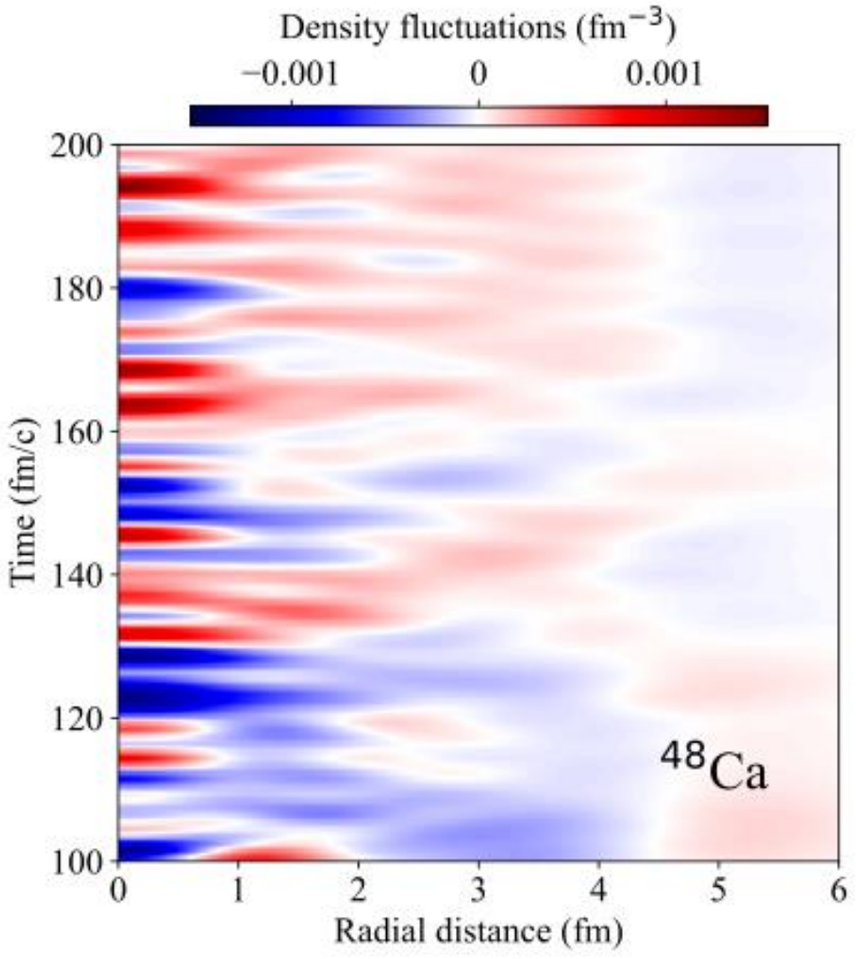
First-principles computations discover fast, noise-like fluctuations inside atomic nuclei

U.S. DEPARTMENT OF ENERGY | Office of Science

NUCLEI Nuclear Computational Low-Energy Initiative

Objectives

- Fusion and fission in medium-mass nuclei are usually described with mean-field methods, which treat each proton and neutron as moving in an average potential generated by all its neighbors.
- First-principles methods can now track how the density of a nucleus evolves in time by accounting for pairs of particles interacting and correlating with each other.
- We investigate this in ^{16}O, ^{24}O, and ^{48}Ca.



Time evolution of density fluctuations in the atomic nucleus calcium-48. One easily identifies fluctuations that are fast and of short range. These are stochastic in nature.

Impact (as of now)

- We find fast, short-range density fluctuations, about ten times quicker than the slower mean-field oscillations, that behave like white noise.
- This behavior is universal: it appears across different nuclei and nuclear force models.
- This reveals a short timescale of nuclear motion, which impacts simulations of fission, fusion, and reactions relevant to nuclear astrophysics.

Accomplishments (as of now)

- F. Bonaiti, G. Hagen, and T. Papenbrock, “Dynamics of density fluctuations in atomic nuclei”, arXiv:2604.12089, accepted for publication in Physical Review Letters, DOI:10.1103/xdr8-4tp3.