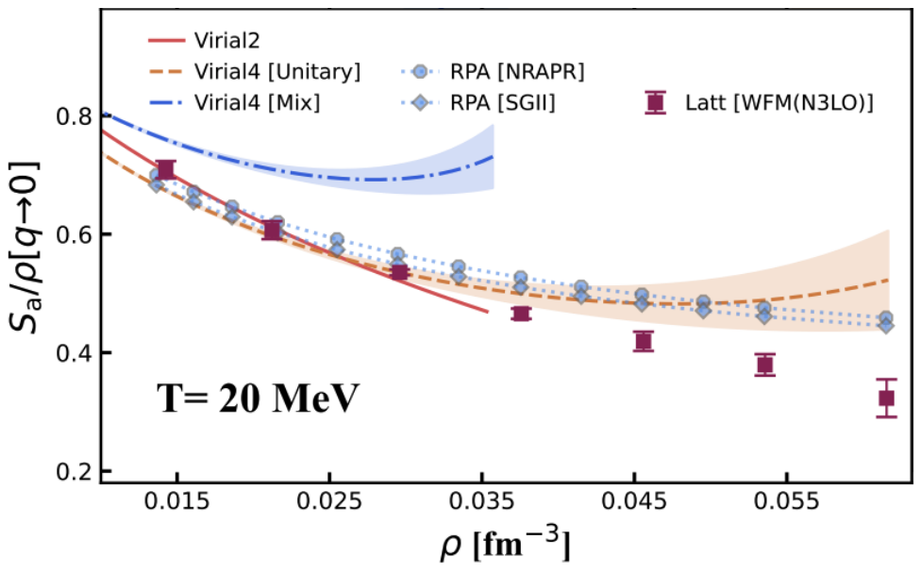
Structure Factors for Hot Neutron Matter from *Ab Initio* Lattice Simulations

U.S. DEPARTMENT OF ENERGY | Office of Science

NUCLEI Nuclear Computational Low-Energy Initiative

Objectives

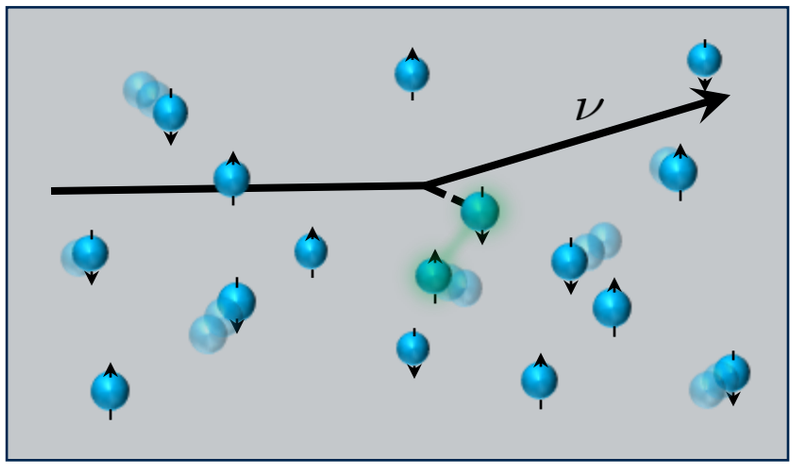
- A team of researchers has calculated spin and density correlations in neutron matter using realistic nuclear interactions. These correlations determine key aspects of neutrino scattering and heating during core-collapse supernovae. The work also introduces the rank-one operator method, a new algorithm that greatly reduces the computational effort needed to calculate observables involving several particles.



The axial structure factor S_a at zero momentum and temperature T = 20 MeV. Virial2 denotes 2nd-order virial calculations for physical neutrons. Virial4 [Unitary] corresponds to 4th virial calculations at the unitary limit. Virial4 [Mix] is a hybrid of the two. The random phase approximation (RPA) calculations are carried out with four different interactions (NRAPR, SGII, SVmin and UNEDF). WFM(N3LO) represents the NLEFT calculations with the wavefunction matching N3LO interaction.

Impact (as of now)

- The results of this new study can be used in realistic simulations of supernova explosions. Nearly all of the energy released in core-collapse supernovae is carried away by neutrinos. The outward flow of neutrinos energizes the neutron-rich matter, thereby increasing the likelihood of an explosion. This work calculates many-body correlations affecting the neutrino-induced heating of neutron-rich matter and provides important data that can be used to calibrate codes used in supernova simulations.



Accomplishments (as of now)

- "Structure Factors for Hot Neutron Matter from *Ab Initio* Lattice Simulations with High-Fidelity Chiral Interactions", Ma et al., Phys. Rev. Lett. 132, 232502 (2024)