Benchmark calculations of pure neutron matter with realistic nucleon-nucleon interactions

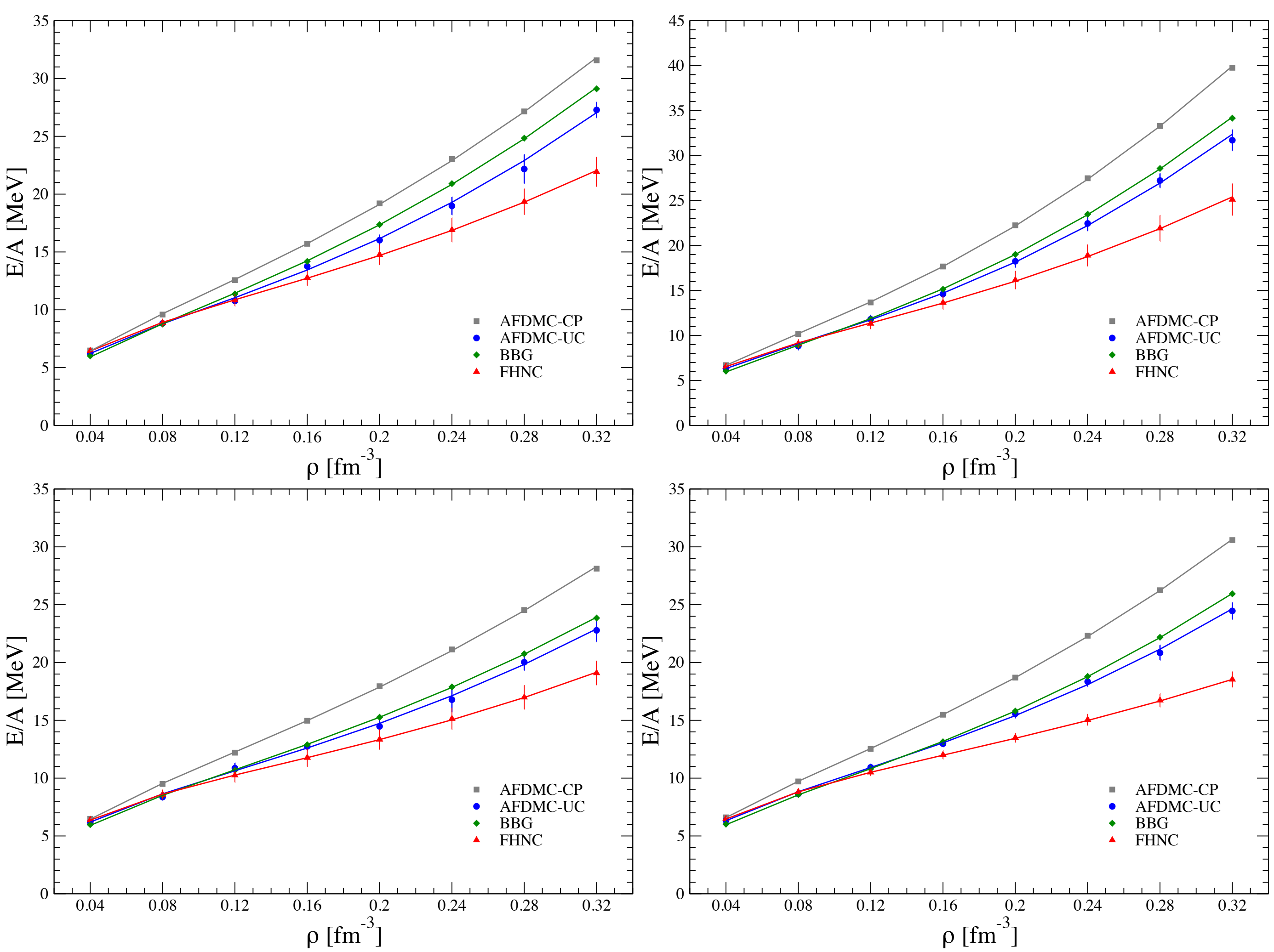
U.S. DEPARTMENT OF ENERGY | Office of Science

Theory Alliance FACILITY FOR RARE ISOTOPE BEAMS

NUCLEI Nuclear Computational Low-Energy Initiative

Objectives

- Perform benchmark calculations of the equation of state (EOS) of pure neutron matter (PNM) using three independent many-body methods: Brueckner-Bethe-Goldstone (BBG), Fermi hypernetted chain/single-operator chain (FHNC/SOC), and auxiliary-field diffusion Monte Carlo (AFDMC-CP and AFDMC-UC).
- The calculations are made for the standard Argonne v18 interaction and four of the new Norfolk Delta-full chiral effective field theory potentials (see figure).



Impact

- The multiple measurements of two-solar masses neutron stars are posing intriguing questions about how dense matter can support such large masses against gravitational collapse.
- The PNM EOS can play an important role for testing the microscopic model Hamiltonians fit to NN scattering data and few-body observables against astrophysical constraints.
- Microscopic calculations of the EOS with reliable error estimates up to two times saturation density provide useful insights on how measurements of the tidal polarizabilities from binary neutron-star mergers can unravel properties of matter at supra-nuclear densities.
- Microscopic calculations of the EOS are also affected by the approximations inherent to the method used for solving the many-body Schrödinger equation. To gauge them, it is important to perform benchmark calculations.

Accomplishments

- M. Piarulli, I. Bombaci, D. Logoteta, A. Lovato, R.B. Wiringa, PRC **101**, 045801 (2020) Editors' Suggestion

Caption: Energy per particle of PNM calculated with the BBG (green diamonds), FHNC/SOC (red triangles), AFDMC-CP (grey squares) and AFDMC-UC (solid blue points) many-body approaches.