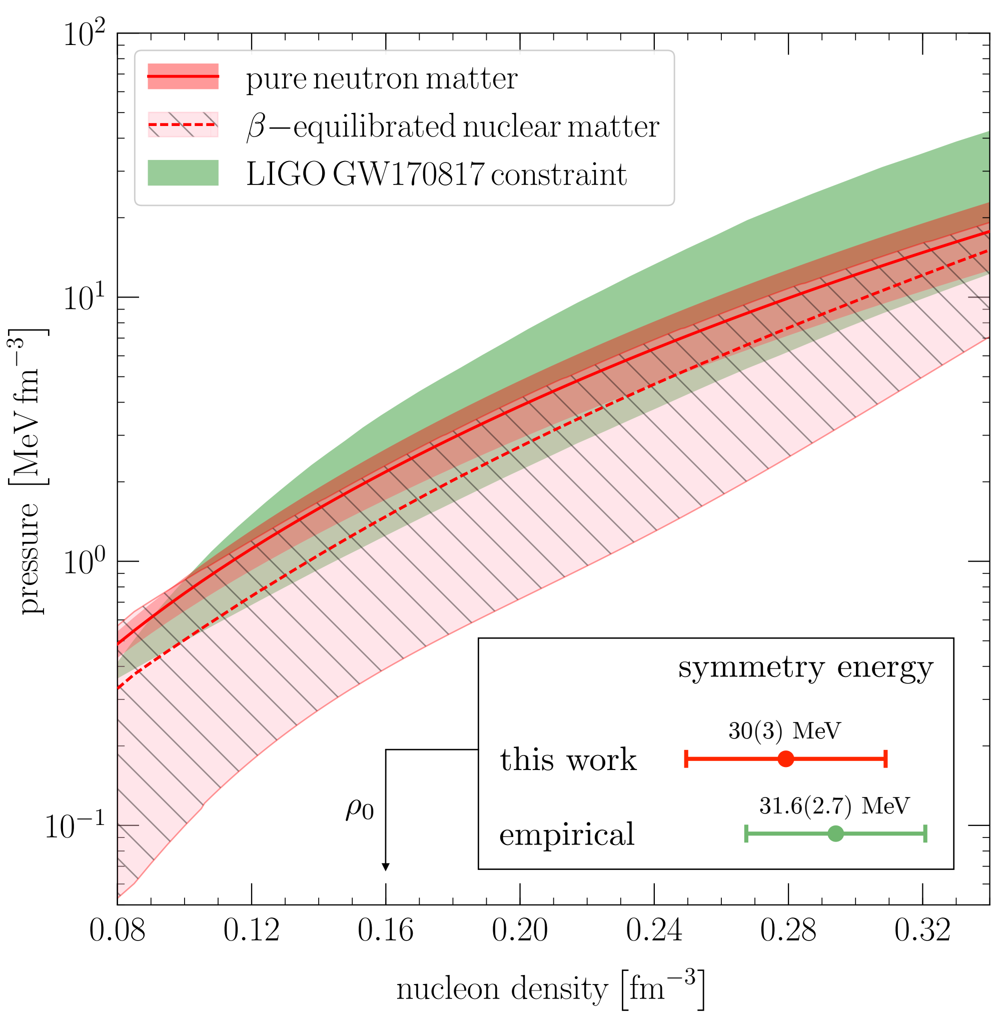
Nuclear and neutron-star matter from local chiral interactions

U.S. Department of Energy | Office of Science

Theory Alliance — Facility for Rare Isotope Beams

Objectives

- We use quantum Monte Carlo (QMC) methods to perform exact *ab-initio* calculations of the nuclear equation of state (EOS) and the symmetry energy.
- We employ local chiral interactions up to next-to-next-to-leading (N^2LO) fit to few-body observables only, and provide a comprehensive uncertainty quantification.



Nuclear matter EOS and symmetry energy predictions (red). Experimental/observational constraints in green.

Impact

- Predicted nuclear matter saturation density (ρ_0) and saturation energy are compatible with empirical values within the quoted statistical and systematic uncertainties.
- The symmetry energy as a function of the density is consistent with current constraints at $\rho_0/3$, ρ_0, and $2\rho_0$.
- The expectation values of the symmetry energy and its slope (L) at saturation density are compatible with empirical values. Prediction for L at $2\rho_0$ is also provided.
- The pressure as a function of the density is given for neutron matter and beta-equilibrated matter. Results are in good agreement with constraints extracted from gravitational waves of the neutron-star merger GW170817 by the LIGO-Virgo collaboration.
- In QMC calculations of nuclear matter, the dominant source of uncertainty is theoretical: truncation of the chiral expansion, regulator and cutoff artifacts.
- Chiral Hamiltonians, fit to few-body observables only, can simultaneously describe the ground-state physics of light and medium-mass nuclei and nuclear-matter properties.

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Accomplishments

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