Nuclear and neutron-star matter from local chiral interactions

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.

Impact

• Predicted nuclear matter saturation density ($\rho_0$) 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 $\rho_0/3$, $\rho_0$, 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.

Accomplishments