The 239th HENPIC seminar by Bing-Nan Lyu, China Academy of Engineering Physics, 10:30 (Beijing time), December 30th, 2025

Title: Sign-problem-free Nuclear Quantum Monte Carlo Simulation

Abstract: Quantum Monte Carlo (QMC) methods face severe limitations in fermionic systems due to the sign problem, which causes exponentially scaling statistical noise. We overcome this in nuclear physics by developing a novel lattice nuclear force rigorously sign-problem-free for even-even nuclei, enabling polynomial-time ground-state calculations. This interaction achieves a standard deviation of $\sigma = 2.932$ MeV from experimental binding energies for 76 even-even nuclei (N, Z $\leq$ 28), matching state-of-the-art mean-field models. We compute binding energies from ^{4}He to ^{132}Sn, reproduce symmetric nuclear matter saturation, and reveal novel spin-orbit-driven clustering in light nuclei. This work establishes sign-problem-free QMC as a scalable and predictive tool for ab initio nuclear structure calculations. Ref: Phys. Rev. Lett. 135, 222504 (2025)

Brief introduction about the speaker:

Bing-Nan Lyu is a professor at the China Academy of Engineering Physics. His research interests include developing novel quantum Monte Carlo algorithms and investigating nuclear structure using first-principles methods. He earned his Ph.D. from the Institute of Theoretical Physics, Chinese Academy of Sciences, in 2012, and subsequently conducted postdoctoral research in Germany and United States. In 2020, he was selected for the Young Talents Program of the National High-Level Talent Plan and joined the Graduate School of the China Academy of Engineering Physics. To date, he has published over 60 papers, including 9 in Physical Review Letters, with a total citation count 2,600 and h-index 30.

Summary