Contribution ID: **16** Type: **Contributed talk**

Fermion Operator Expansion: Approach to Study Neutron Star Inner Crust

Tuesday, January 28, 2025 3:45 PM (25 minutes)

The pasta phases in the inner crust of neutron stars are crucial for understanding their behavior. However, simulating these phases using coordinate-space density functional theory is computationally expensive. In this contribution, we propose to perform such simulations effectively by the fermion operator expansion method. We apply this method to investigate the slab phases described by finite-temperature Hartree-Fock-Bogoliubov theory with band structure, and show that a concise identity exists between the generalized density matrix and the Fermi-Dirac distribution of the Hamiltonian (treated as a matrix function). We introduce an algorithm to compute the Fermi-Dirac distribution based on Chebyshev expansion. It yields results in good agreement with directly solving the equation of motion, but the time complexity is lower. Once nearsightedness is assumed, this method can further accelerate the computation. Therefore, the fermion operator expansion method is a powerful tool to study the nontrivial phases in neutron stars.

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Session Classification: Oral Presentation