Variational method with an explicit energy functional for symmetric nuclear matter taking into account the spin-orbit force

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A variational method with an explicit energy functional taking into account the central, tensor, and spin-orbit components of the two-body nuclear force is applied to symmetric nuclear matter.

This variational method was proposed in Ref. [1] for strongly correlated fermion systems at zero temperature. In this method, the energy per particle of a uniform fermion system is explicitly expressed as a functional of spin-dependent radial distribution functions. In particular, an expression for the kinetic energy caused by the correlation among fermions is constructed to include at least two-body cluster terms and the main components of three-body cluster terms. Subsequently, the Euler-Lagrange equations are derived from the energy expression via the variational procedure and solved numerically to obtain fully minimized energies. The necessary conditions on structure functions are automatically guaranteed via the variational procedure.

This variational method was extended in Ref. [2] to take into account the tensor and spin-orbit components of the nuclear force for pure neutron matter. The energy per neutron of pure neutron matter calculated using this variational method with the AV8' two-body nuclear potential [3] agrees well with the results obtained using the auxiliary field diffusion Monte Carlo method [4].

In this study, we extend the above variational method to treat symmetric nuclear matter. Preliminary calculations using the energy expression without three-body-cluster two-particle-exchange and higher-order contributions show that the obtained energy per nucleon for symmetric nuclear matter is lower than that obtained using other many-body techniques. In this presentation, we report the improved results, including the appropriate higher-order three-body-cluster terms.

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