Contribution ID: **14** Type: **not specified**

Extended Brueckner Hartree-Fock theory for nuclear matter with realistic nucleon-nucleon interaction

Thursday, 3 November 2011 09:30 (30 minutes)

We study the properties of nuclear matter in the extended Brueckner Hartree-Fock theory with a realistic nucleon-nucleon (NN) interaction. The nuclear wave function is composed of traditional Hartree-Fock states and 2-particle-2-hole (2p-2h) states. The two important characters of the realistic NN interaction, strong tensor force and short range repulsion of the central force can be properly treated by including the 2p-2h states. The content of the 2p-2h states and the wave function of the single particle states are determined by the variational principle for the total energy. We can then extract an effective NN interaction from the equation of motion for the single particle state. This effective interaction has a similar structure to that of the G-matrix interaction in the Brueckner-Hartree-Fock theory, and the above two important characters are properly taken into account. We call our new theoretical framework as an extended Brueckner-Hartree-Fock (EBHF) theory.

Using our new framework, we work out the equation of state of the symmetric nuclear matter with the Bonn potential as a realistic NN interaction. In low density region, the binding energies of the nuclear matter are very similar to those given by the Brueckner-Hartree-Fock theory. As the density increases, more repulsion is obtained due to the 2p-2h correlation in the kinetic energy. It turns out that this additional repulsive energy can improve the saturation properties of nuclear matter significantly, which has never been achieved previously. Now the saturation properties are nicely reproduced consistently with the empirical data in relativistic framework. The neutron matter is also calculated with different Bonn potentials. We discuss the role of the tensor force in those nuclear matter properties.

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