Variational study of hyperon effects on the nuclear equation of state at finite temperature

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The equation of state (EOS) for hot dense matter is one of the important ingredients in the studies of astrophysical phenomena such as core-collapse supernovae, black-hole formations, and neutron-star mergers. In this study, we report a new EOS constructed with the variational method for nuclear matter including Lambda hyperons at zero and finite temperatures.

At zero temperature, we calculate the energy of hyperonic nuclear matter by the cluster variational method starting from the Hamiltonian composed of bare baryon interactions: For the nucleon sector, we employ the Argonne v18 two-nucleon potential and the Urbana IX three-nucleon potential. For the hyperon sector, we use central two-body potentials that are constructed to reproduce the experimental data of Lambda hypernucle.

At finite temperatures, we construct the EOS of hyperonic nuclear matter using an extension of the variational method proposed by Schmidt and Pandharipande. In this method, the average occupation probabilities of single-particle states are parameterized by the effective masses for nucleons and Lambda hyperons. Then, the free energy is minimized with respect to these effective masses. The obtained free energy and related thermodynamic quantities are reasonable. We also confirm thermodynamic self-consistency of the present calculations.

The goal of our project is to tabulate the resulting EOS in a wide range of densities, temperatures, and proton fractions for the use of core-collapse simulations, as an extension of the EOS table of normal nuclear matter we have constructed recently. We will also report possible new results of our project.