NUCLEAR EQUATION OF STATE FOR CORE-COLLAPSE SUPERNOVAE WITH REALISTIC NUCLEAR FORCES

H. Togashi[1,2], Y. Takehara[3], S. Yamamuro[3], K. Nakazato[3], H. Suzuki[3], K. Sumiyoshi[4], M. Takano[2]

[1] *Institute for Physical and Chemical Research (RIKEN), Saitama, Japan*
[2] *Waseda University, Tokyo, Japan*
[3] *Tokyo University of Science, Chiba, Japan*
[4] *Numazu College of Technology, Shizuoka, Japan*

We propose a new nuclear equation of state (EOS) for core-collapse supernova (SN) simulations using the variational many-body theory with the realistic nuclear forces.
Starting from the realistic nuclear Hamiltonian containing the Argonne v18 two-body potential and Urbana IX three-body potential, free energies per nucleon of uniform asymmetric nuclear matter at finite temperatures are calculated with the cluster variational method. The obtained free energies are in good agreement with those calculated by the Fermi hypernetted chain variational technique [1, 2].
Neutron star masses and radii calculated with the obtained EOS are consistent with recent observational data. We also apply the EOS for hot uniform matter to numerical simulations of spherically-symmetric core-collapse SNe. It is seen in these simulations that the present EOS is softer than the Shen EOS [3], which means that our EOS is more favorable to SN explosions.
Toward a complete SN-EOS table, we are calculating free energies of non-uniform matter with the Thomas-Fermi calculation following the method by Shen et al.[3]: The free energy density of a Wigner-Seitz cell including a single species of heavy nuclei, free protons, free neutrons and alpha particles is minimized with respect to the particle distributions in the cell. Reasonable phase diagrams are obtained at typical temperatures.
We will discuss the properties of the obtained EOS as compared with the Shen EOS.

[1] A. Akmal et al., Phys. Rev. C 58, 1804 (1998).
[2] A. Mukherjee, Phys. Rev. C 79, 045811 (2009).
[3] H. Shen et al., Astrophys. J. Suppl. 197, 20 (2011).
H. Shen et al., Prog. Theor. Phys. 100, 1013 (1998).