A comparative study of statistical models for nuclear equation of state of stellar matter

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We compare three different statistical models for the equation of state (EOS) of stellar matter at sub-nuclear densities and temperatures (0.5-10 MeV) expected to occur during the collapse of massive stars and supernova explosions. The models introduce the distributions of various nuclear species in nuclear statistical equilibrium, but use somewhat different nuclear physics inputs. It is demonstrated that the basic thermodynamical quantities of stellar matter under these conditions are similar, except in the region of high densities and low temperatures. We demonstrate that mass and isotopic distributions have considerable differences related to the different assumptions of the models on properties of nuclei at these stellar conditions. Overall, the three models give similar trends, but the details reflect the uncertainties related to the modeling of medium effects, such as the temperature and density dependence of surface and bulk energies of heavy nuclei, and the nuclear shell structure effects. We discuss importance of new physics inputs for astrophysical calculations from experimental data obtained in intermediate energy heavy-ion collisions, in particular, the similarities of the conditions reached during supernova explosions and multifragmentation reactions.
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