Contribution ID: **112** Type: **not specified**

The low-density EoS under core-collapse supernova and heavy-ion collisions conditions

Thursday, October 10, 2024 3:10 PM (20 minutes)

Light (e.g. deuterons, tritons, helions, particles) nuclei exist in nature in core-collapse supernova matter and neutron star (NS) mergers, where temperatures of the order of 50 to 100 MeV may be attained. These clusters not only form in these astrophysical sites, but also in heavy-ion collisions.
The appearance of these clusters can modify the neutrino transport, and, therefore, consequences on the dynamical evolution of supernovae and on the cooling of proto-neutron stars are expected. However, a correct estimation of their abundance implies that an in-medium modification of their binding energies is precisely derived.

In this talk, we will address the low-density equation of state with the inclusion of light clusters. We will consider not only from the theoretical point of view how these light clusters are calculated for warm nuclear matter in the framework of relativistic mean-field (RMF) models with in-medium effects, but also how these models were calibrated to experimental data from heavy-ion collisions, measured by the INDRA Collaboration.

We will also analyze the effect of including an exotic state state, such as the tetraneutron, that was reported in Duer et al, Nature 606, 678 (2022) as a resonant state, on the yields of the other light clusters. We consider in-medium effects in a two-fold way –that is, via the couplings of the clusters to the mesons, that were calibrated to the experimental data, and via a binding energy shift –to compute the low-density equation of state (EoS) for nuclear matter at finite temperature and fixed proton fraction. We calculate the abundances of the light clusters and chemical equilibrium constants with and without the tetraneutron. We also analyze how the associated energy of the tetraneutron would influence such results.

We find that the low-temperature, neutron-rich systems are the ones most affected by the presence of the tetraneutron, making NSs excellent environments for their formation. Moreover, its presence in strongly asymmetric matter may increase the proton and particle fractions considerably. This may have an influence on the dissolution of the accretion disk of the merger of two NSs.

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