Towards a global and multi-purpose EoS: quasi-clusters for an explicit treatment of short-range correlations

S. Burrello[1,†], S. Typel[1,2],

[1] *Technische Universität Darmstadt, Fachbereich Physik, Institut für Kernphysik, Darmstadt, Germany*

[2] *GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany*

The formation of nuclear clusters constitutes an essential feature for the construction of global equation-of-state (EoS) tables. They emerge as many-body correlations, which can be attributed to the nucleon-nucleon (NN) interaction, and exist at sub-saturation densities in nuclear matter.

Phenomenological models that make use of energy density functionals (EDFs) offer a convenient approach to account for the presence of these bound states of nucleons when clusters are introduced as additional degrees of freedom. However, these models are constructed in such a way that clusters dissolve when the density approaches the nuclear saturation density, so that only nucleons survive as independent quasi-particles at higher densities. These models reveal thus inconsistencies with recent findings that evidence the existence of sizeable NN short-range correlations (SRCs) even at a larger density, in a regime where the cluster dissolution is usually predicted. It would be advisable to include these features to improve EoS models.

In our work, we propose a novel approach which allows, within the EDF framework, for an explicit treatment of SRCs at supra-saturation densities, by using effective clusters immersed in dense matter as a surrogate for correlations. Our idea is to embed the SRCs within generalized relativistic energy density functionals through the introduction of suitable in-medium modifications of the cluster properties. As a first exploratory step, the example of a quasi-deuteron in a relativistic mean-field model with density dependent couplings is currently explored. In contrast to previous studies, a relativistic deuteron wave functions is introduced with an effective in-medium interaction that consistently describes the cluster as well as characteristic properties of nuclear matter.

Implications in the widest scope of astrophysical applications are envisaged and the impact of these studies for general aspects of reactions dynamics, such as the clustering processes emerging in heavy-ion collisions will be also discussed.

† Alexander-von-Humboldt research fellow