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Surface properties of nuclei embedded in a nucleon gas in the framework of the Extended Thomas-Fermi theory

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It is nowadays well established that the properties of the nuclear effective interaction through the equation of state have a very important influence in different astrophysical phenomena, from the dynamics of the Core Collapse Supernovae, to the cooling of Proto-Neutron Stars and the structure of Neutron Stars. The self-consistent mean-field theory is an appealing framework to establish a connection between astrophysical observations and fundamental properties of nuclear interactions. However the problem exists that the nuclear energy functional is still not sufficiently constrained in the isovector sector, inducing uncertainties in the modelization.

In particular, it is very well known [1] that sub-saturation baryonic matter in such stars is organized as a Wigner-Seitz lattice of clusters embedded in a dilute nucleon gas. In the self-consistent mean-field theory, only the bulk properties of the cell can be analytically calculated from the basic isoscalar and isovector properties of the energy functional. A clear connection of the observables in star matter to the functional properties are thus not transparent. However, analytical expressions can be obtained in the framework of the Extended Thomas-Fermi (ETF) approximation [2, 3].

In this presentation, we discuss an ETF analytical model to describe the surface properties of such matter [4, 5]. More specifically, we derive analytical expressions for the density profile diffuseness and the corresponding surface energy for any cell, as a function of the underlying couplings of the energy functional. This model can be directly implemented in realistic finite temperature calculations of the stellar equation of state [6]. A special focus is given on the energetic modifications induced by the interaction between the cluster and the dilute medium, and a comparison to full HF calculations will be shown.

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