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

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At the end of their life, very massive stars can explode as a Core Collapse Supernova. A hot and dense self-gravitating object remains, called a proto-Neutron Star, that evolves into a cold Neutron Star. Currently, the microscopic processes that are implied are not sufficiently understood to correctly simulate the dynamics of the Core Collapse Supernova. In order to improve these models, one needs a realistic microscopic modelling of the matter composing the star, which determines the Equation of State. The self-consistent mean-field theory is an appealing framework for this task. However the problem exists that the nuclear energy functional is still not sufficiently constrained in the isovector sector, inducing uncertainties in the modelization.
It is very well known [1] that sub-saturation baryonic matter in such stars is organized as a lattice of clusters embedded in a dilute nucleon gas. Each unit cell is called a Wigner-Seitz cell. 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, after having introduced the general context of Compact Stars, 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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