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Energy functionals grounded in ab initio calculations: a systematic ladder of approximations

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Ab initio methods [1] hold the promise of allowing to determine all the structural properties of nuclei and infinite nucleonic matter, starting from the individual interactions between protons and neutrons. Despite recent remarkable progress, full-scale studies of heavy nuclei are still out of reach.

By contrast, Density Functional Theory (DFT) [2] can be readily applied to ground-state and excited-state properties across the whole nuclear chart. However, the Energy Density Functionals (EDFs), the key quantities in DFT, are phenomenological and biased towards stable nuclei close to magicity. Shortcomings of the empirical EDFs manifest themselves far from the stability valley, e.g. in neutron-rich nuclei or pure neutron matter (PNM). To accompany the growing experimental research efforts devoted to unstable nuclei at the limits of the nuclear chart, there is a strong need for improving the theoretical tools at our disposal.

In this contribution, we wish to discuss our approach, inspired by the "Jacob's ladder" of condensed matter DFT [3], that aims at constructing ab initio-constrained EDFs. We shall first present the first rung [4], called local density approximation (LDA), that exploits the equation of state of nucleonic matter as sole input. Then, we describe our current work, in which the static response [5] of both PNM and symmetric nuclear matter to an external potential is studied by means of ab initio techniques, namely the Quantum Monte Carlo and the Self-consistent Green's functions approach, and exploited to constrain the gradient terms of the nuclear EDF.

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Auteur principal: MARINO, Francesco (University of Milan and INFN)

Co-auteurs: Prof. BARBIERI, Carlo (University of Milan and INFN); Dr CARBONE, Arianna (INFN–CNAF); Prof. COLÒ, Gianluca (University of Milano and INFN); Dr LOVATO, Alessandro (Argonne National Laboratory and INFN-TIFPA); Prof. PEDERIVA, Francesco (University of Trento and INFN-TIFPA); Prof. ROCA-MAZA, Xavier (University of Milano and INFN); Dr VIGEZZI, Enrico (INFN Milano)

Orateur: MARINO, Francesco (University of Milan and INFN)

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