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Nuclear matter under extreme conditions and finite nuclei with finite range simple effective interaction

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The study of nuclear phenomena from finite nuclei to nuclear matter under extreme conditions in a given model is an area of current nuclear research interest. In the present work we have made such an attempt within the framework of non-relativistic mean field theory using the finite range simple effective interaction (SEI). At difference with other effective interactions of Skyrme and Gogny type, almost all the parameters of the SEI (ten of eleven) are fitted in symmetric nuclear matter and pure neutron matter using informations coming from optical model analysis of scattering data at intermediate energies, transport model analysis of flow data in heavy-ion collisions, thermal evolution of nuclear matter properties and constraints from the neutron star mass measurements and cooling phenomenology [1]. Under this protocol of fixation of parameters, it is possible to vary the density dependence of the equation of state (EOS) of isospin asymmetric nuclear matter (ANM) leaving the momentum dependence of the mean field unchanged. This may provide a theoretical advantage in the analysis of heavy-ion collision data in transport model calculations [2]. The high density behavior of symmetry energy predicted, within this protocol of parameter determination, is neither stiff nor very soft. The mass-radius relation, direct URCA process and crust-core transition density in neutron stars are studied with the SEI. The influence of the presence of hyperons in the core is also examined.
Using the SEI and the Extended Thomas-Fermi expansion of the density matrix [3], a local Energy Density Functional is derived to study finite nuclei [4]. This Energy Density Functional has only an additional open parameter, which is fixed from the binding energy of the doubly closed shell magic nucleus 40Ca, plus the strength of the spin-orbit force which is determined from the binding energy of the nucleus 208Pb . With this formalism the binding energies and radii of 161 even-even spherical nuclei reproduced the experimental values with root mean square (rms) deviations 1.5 MeV and 0.015 fm , respectively. These results are of a quality similar to the one found using traditional interactions [5]. This formalism also predicts the kink in 208Pb in the charge radii of lead isotopes. Study of the deformation properties predicted by the SEI in finite nuclei using the Hartree-Fock-Bogoliubov (HFB) formalism are underway and preliminary results obtained are encouraging.

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