Thesis Abstract Geoffrey ZIETEK

« Towards a generalized effective nuclear Gogny interaction extended to finite-range spin–orbit and tensor forces »

Soon after its development in the late 1960s, Daniel Gogny's interaction became a reference in the landscape of nuclear, effective and phenomenological interactions.
Its intrinsically finite-range nature makes it possible to treat the mean field and pairing correlations on an equal footing, while avoiding ultraviolet divergences, even beyond the mean field. On the other hand, the tensor force, an essential component of realistic interactions, has often been sidelined in effective formulations. Yet, very early on, it proved necessary to reproduce the elementary properties of the most rudimentary nuclear system, the deuteron.
Since then, its action has manifested in many ways, from the arrangement of single-particle energies, through the description of giant resonances and Gamow–Teller states, to impacting the magicity of superhearvy nuclei.
In this thesis work, we propose to extend the analytical expression of the Gogny interaction to finite-range spin–orbit and tensor terms. The resulting form, which is intended to be entirely of finite range, enables to recover most of the analytical expressions established to date. It is in that sense referred to as the “generalized Gogny interaction”. The numerical code used to deduce the parameters is adapted to the newly introduced terms, and a parametrization entitled DG, produced by the global fitting of all the parameters, is extracted. In particular, the proton–neutron pairing properties are controlled for the first time in a Gogny interaction, via constraints on the appropriate matrix elements. The consistency of the generalized Gogny interaction is first evaluated in infinite nuclear matter, in comparison with various previous parametrizations and realistic calculations. The equations of state for symmetric and neutron matter, as well as physical quantities such as the potential energy decomposed into (S,T) channels, partial waves or stability criteria associated with Landau parameters in the theory of Fermi liquids are analyzed. The results obtained in finite nuclei, both at the mean field level, from the Hartree–Fock–Bogoliubov approximation, and beyond, via the multiparticle–multihole configuration mixing method, are decisive. Substantial features of the main Gogny interactions are preserved, while numerous amendments are identified. At the mean-field level, the kink in the charge radii of lead isotopes is more accurately described, inversions between single-particle states are observed, the destruction of part of the pairing energy occurs in isotopic and isotonic chains, the nature of the axial quadrupole deformations of certain soft nuclei is modified and the fission barrier heights lowered in several pre-actinides and actinides.
Beyond the mean field, the reproduction of first excitation energies of many light even–even and odd nuclei is considerably improved. This effect is most of the time interpreted as the signature of a subtle interplay between spin–orbit and tensor forces in the shell evolution.