Interplay of tensor correlations and vibrational coupling for single-particle states in atomic nuclei

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To study the structure of atomic nuclei, the *ab-initio* methods can nowadays be applied only for mass number A smaller than $\approx$ 10-15. For heavier systems, the self-consistent mean-field (SCMF) approach is probably the most microscopic approach which can be systematically applied to stable and exotic nuclei. In practice, the SCMF is mostly based on parametrizations of an effective interaction. However, the are groups who are intensively working on the development of a general density functional (DF) which is not necessarily extracted from an Hamiltonian. The basic question is to what extent this allows improving on the existing functionals.
In this contribution we analyze the performance of existing functionals as far as the reproduction of single-particle states is concered. We start by analyzing the effect of the tensor terms, on which the attention of several groups have recently focused. Then we discuss the impact of the particle-vibration coupling (PVC). Although the basic idea of this approach dates back to long time ago, we present here for the first time calculations which are entirely based on microscopic interactions without dropping any term or introducing *ad hoc* parameters. We show results both for well-known, benchmark nuclei like ^{40}Ca and ^{208}Pb as well as unstable nuclei like ^{132}Sn. Both single-particle energies and spectroscopic factors are discussed.