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DFT versus many-body perturbation theory for nuclear structure

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The applicability of Density Functional Theory to the nuclear case, its many successes and the open problems, are a vast domain. In this contribution, I will mainly focus on two questions.

First, I will discuss how to obtain realistic values for the bulk nuclear properties, either within the Hartree-Fock or Kohn-Sham scheme. It will be argued that, so far, only the Kohn-Sham scheme has been able to produce nuclear saturation and reasonable nuclear binding energies without too much of a tension with the rest of the nuclear phenomenology, in particular with the single-particle properties and the nucleon effective mass.

Yet, many experimental findings are not explained within Kohn-Sham DFT. I will introduce the Green's function methods for nuclear structure, in particular along the idea of particle-vibration coupling (PVC). The rationale behind it, is that the low-lying spectra of nuclei are indeed governed by the interplay between single-particle and vibrational degrees of freedom. I will show applications to giant resonances, charge-exchange transitions and low-lying states in odd-nuclei. I will try to draw analogies with, e.g., the GW-method for electronic systems; more generally, I will advocate the need of a stronger cross-fertilizations between the study of nucleonic and electronic systems.

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