Progress in nuclear structure beyond the mean-field approximation

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Self-consistent mean-field models, or models based on the Density Functional Theory (DFT), are widely used for the microscopic description of the atomic nucleus. They achieve, as a rule, successful results for the bulk properties, covering almost the whole nuclear chart. Nonetheless, some specific observables such as the density of single-particle states around the Fermi energy, the spectroscopic factors of those states, and the damping properties of collective excitations, require the introduction of correlations beyond mean-field.

In this contribution, some recent results obtained within a fully microscopic model beyond mean-field will be reviewed. Our model is based on the coupling between single-particle and collective degrees of freedom; zero-range effective forces are employed, withot any adjustable parameter. Our focus will be on the energies of single-particle states in magic nuclei, and on the lineshape of both non charge-exchange and charge-exchange giant resonances. In particular, the damping properties of the Giant Dipole Resonance and of the Gamow-Teller Resonance, and the gamma decay of the Giant Quadrupole Resonance, will be discussed in detail.

The main limitation of our model is the use of effective interactions that have been fitted at the mean-field level. One should aim at refitting the forces, by including the desired contributions beyond mean-field in the refitting procedure. If zero-range interactions are used in a beyond mean-field framework, divergences arise and the parameters of the resulting interaction have to properly reabsorb them. This refitting procedure has already been shown to be doable in infinite nuclear matter. We will discuss the problems that show up, and the possible solutions, when one wants to apply a similar procedure in finite systems.