Cluster excitation and alpha radioactivity within covariant energy density functional framework.

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The use of Energy Density Functional (EDF) method within a relativistic framework showed, this last decades, that it can both describe the bulk properties of nuclei (radii, GS energy, binding energy, ...) [1] as well as clusters formation [2]. The study of cluster structures allow for many applications ranging from α or cluster decay to many different kinds of excitations. This last few years, new techniques such as the Finite Amplitude Method (FAM) [3, 4, 5] open new possibilities in the computation of collective response of nuclei: a fully microscopical calculation for axially deformed nuclei is made possible within this framework. Such deformed calculations are necessary to describe clusters behaviors.

Many experimental results show significant transition strengths in light nuclei at low energy below giant resonance transition. In some cases, these low energy excitations can be associated with α cluster states. The use of FAM provides an efficient tool, less demanding on the numerical side than the usual QRPA method. The ground state calculations are performed over several isotopic chains using relativistic energy density functional method. This approach allows for a fully microscopic treatment from the nucleonic degree of freedom, and does not require any ansatz on the nature of the single particle wave-function nor the ground state itself. The same universal pattern at low energy is found in the case of Ne, Mg and other isotopes, for the different multipoles [6]. The associated transition densities show a cluster structure linked with α or cluster oscillations.

A more extreme phenomenon to be studied within the covariant EDF framework is the one of radioactivity where cluster are pre-formed and emitted. Previous studies showed that a reliable description of cluster radioactivity in heavy nuclei was achievable [7]. The description of α radioactivity has recently been carried through within RMF framework at both qualitative and quantitative levels [8]. A new 2α decay mode is even predicted for some heavy nuclei with lifetime close to cluster emission [9].

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