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A microscopic treatment of correlated nucleons: Collective properties in stable and exotic nuclei

Collective excitations are a common feature of several many-body systems and a widely observed phenomenon throughout the nuclear chart. A model which is often used to describe collective excitations is the random-phase approximation (RPA), where the excited modes are superpositions of 1 particle-1 hole configurations only. The RPA allows in general for a satisfactory description of excitations in nuclei, both low-lying states and giant resonances.
However, being based on a mean-field or independent-particle picture, the RPA model fails to reproduce the fragmentation and the spreading width of excitations. For example if one wishes to account for the spreading width of resonances, which can be observed experimentally, one has to go beyond this simple mean-field-based model. A possible way to do so is to add 2 particle-2 hole configurations in the model, which is known as Second RPA (SRPA). Yet SRPA in its standard form presents severe drawbacks, such as the double-counting of correlations, instabilities or divergences. All these limitations can be overcome by a correction method, consisting in a subtraction, the so-called Subtracted SRPA (SSRPA). A systematic application to the giant quadrupole resonances of selected spherical nuclei, ranging from ^{30}Si to ^{208}Pb, will be shown to demonstrate its corrective power.
A first extension of this scheme can be carried out to treat also open-shell nuclei. A second extension amounts to using a correlated ground state, thereby allowing to include pairing correlations for instance. Such methods will be presented with the corresponding first results.

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