ID de Contribution: **10** Type: **Talk**

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

lundi 28 mai 2018 14:30 (20 minutes)

Collective excitations are observed and analyzed in several many-body systems such as, for instance, atomic nuclei, trapped atomic gases or metallic clusters. A model which is widely 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 excited states in nuclei, both low-lying states and giant resonances.

However, being based on a mean-field or independent-particle picture, the RPA model fails in reproducing the fragmentation and the spreading width of the excitations. For example if one wishes to describe 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 it is to add 2 particle-2 hole configurations in the model, which is known as Sedond RPA (SRPA). Yet the standard SRPA model presents some severe limitations related to instabilities and ultraviolet divergences. Several directions may be followed to handle and cure such instabilities.

One of them is based on a subtraction procedure that I will describe. The first part of my thesis work consisted in applying the subtracted SRPA model to the dipole resonance in ^{48}Ca and to a systematic study of giant quadrupole resonances in several nuclei. These results will be discussed.

These limitations may also be cured by including correlations in the ground state using fractional occupation numbers. I will present some preliminary results based on fractional occupation numbers computed with the RPA amplitudes, within a renormalized SRPA model.

The perspectives of this thesis work include the addition of pairing and non-zero temperature as well as the study of their effects on the excitation spectra. These effects are expected to have an important impact on the ground state correlations and, consequently, on the renormalized SRPA results.

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Classification de Session: Nuclear Physics - Theory