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Nuclear collective excitation within finite-amplitude method

Giant resonances provide us important information on nuclear collective properties. For the nuclear density functional theory (DFT), the giant resonance will determine the coupling constants that are not very well constrained from the ground-state properties. In order to assess the giant resonances in a wide region of the nuclear chart, an efficient technique to compute the giant-resonance energy is necessary for constraining the coupling constants in the nuclear energy density functional.

The quasiparticle random-phase approximation (QRPA) is a standard theory for describing various kinds of small-amplitude collective modes including giant resonances based on the nuclear DFT. The widely used technique for the QRPA problem is, however, based on the matrix diagonalization, and is too demanding to perform repeatedly in medium and heavy systems as the dimension of the two-quasiparticle space become large.

The finite-amplitude method (FAM) technique for the linear-response theory [1] allows us to derive efficient solutions for the QRPA problem within the nuclear DFT. In this presentation, I will show the technique for evaluating the QRPA sum rules using the contour integration of the FAM response function in the complex-energy plane [2]. From the ratio of the sum rule, the giant-resonance peak energy can be evaluated. Typical examples of the giant-resonance energies of doubly magic systems are discussed. Among the sum rules of different energy moments, the energy-weighted and inverse-energy-weighted sum rule are the most important ones. I will extend the Thouless theorem for the energy-weighted sum rule in the case of the generalized nuclear DFT. The Thouless theorem has been conventionally derived from the expectation value of the double commutator of the Hamiltonian, but such a Hamiltonian operator does not exist in the case of the nuclear DFT. I will derive the theorem without using the double commutator of the Hamiltonian, and show the extended version of the theorem for the nuclear DFT [3].

[1] T. Nakatsukasa, T. Inakura, and K. Yabana, Phys. Rev. C 76, 024318 (2007).

[2] N. Hinohara, M. Kortelainen, W. Nazarewicz, and E. Olsen, Phys. Rev. C 91, 044323 (2015).

[3] N. Hinohara, in preparation.

Summary

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