Contribution ID: **25** Type: **Oral presentation**

Finite amplitude method applied to calculation of nuclear photo absorption cross section and rotational moment of inertia

Wednesday 23 May 2018 10:20 (20 minutes)

The response of the atomic nucleus to external stimulation provides crucial information about its structure and the complex forces acting between constituent nucleons. To access these excited modes, within the framework of superfluid nuclear density functional theory, linear response theory, that is, the quasiparticle random-phase-approximation, (QRPA) is one of the commonly used method. Traditionally, the QRPA has been formulated in its matrix form (MQRPA). The disadvantage of the MQRPA formulation is the fact that dimension of the QRPA matrix becomes large, in particularly when spherical symmetry is broken, preventing fully self-consistent calculations. To circumvent the large computational cost of MQRPA, the finite-amplitude-method (FAM) solves the linear response problem by iterative means.

As a first application of the FAM-QRPA, we have done a systematic computation of the nuclear photo absorption cross sections for the heavy rare-earth nuclei [1]. For most of the calculated cases, where experimental data existed, we could reproduce measured photo absorption cross section well, although with heavier rare earth isotopes some deficiency was seen. A simple modification of the Thomas-Reiche-Kuhn sum rule enhancement factor cannot cure this deficiency.

For a second application, we investigated Nambu-Goldstone (NG) mode connected to spontaneous symmetry breaking of rotational symmetry, caused by nuclear deformation. The NG mode represents a special case of collective motion and allows access to corresponding Thouless-Valatin inertia parameter. With FAM-QRPA we have calculated the moment of inertia for low-lying rotational states in several rare-earth and actinide isotopes [2], obtaining a good correspondence with experimental values. Computationally, FAM-QRPA is less demanding compared to cranked HFB calculation.

References

[1] T. Oishi, M. Kortelainen, and N. Hinohara, Phys. Rev.C 93, 034329 (2016).
[2] K. Petrik and M. Kortelainen, arXiv:1709.08534 [nucl-th] (2017).

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Session Classification: Session 5