Shape fluctuation in low-lying states in neutron-rich $N \approx 40$ nuclei

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Atomic nuclei exhibit a variety of shapes, such as spherical and quadrupole (prolate, oblate and triaxial) shapes. Observations of spectroscopic properties in some nuclei suggest the existence of shape fluctuations and shape coexistence phenomena. To describe such phenomena, it is obvious that a mean-field approach, which treats a small-amplitude dynamics around a single-reference state, is not enough, and a beyond-mean-field approach is necessary. The five-dimensional quadrupole collective Hamiltonian method, which describes large-amplitude collective dynamics in the β–γ deformation space, has been often employed. Most works of the collective Hamiltonian method based on the energy density functional (EDF) employ the so-called cranking approximation for the collective inertial functions in the vibrational and rotational kinetic energies, which ignores dynamical residual effects in the collective dynamics. Only a few works have included those residual effects in the collective inertial functions by using the local quasiparticle random-phase approximation (QRPA) with the pairing-plus-quadrupole force in the β–γ plane [1] and by the local QRPA with the Skryme EDF restricted to the axially symmetric shapes [2]. In Ref. [3], we applied the local QRPA to the description of the collective inertia along the mass-symmetric spontaneous fission path restricted to axial shapes. These results clearly indicate the importance of the dynamical residual effects in the inertial functions.

Recently, we have developed the local QRPA with the Skyrme EDF to evaluate the collective inertial functions at any triaxial shapes in the β–γ plane in the collective Hamiltonian method [4]. Thanks to the finite amplitude method (FAM) [5], we solve the local QRPA equations in the β–γ plane with a reasonable computational cost.

In this contribution, we show results of low-lying states obtained using the collective Hamiltonian method for neutron-rich Cr isotopes and $N = 40$ isotones, where recent advances in experiments start providing much spectroscopic information. We will show that the residual effects increase the collective inertial functions, compared with those with the cranking approximation and give better reproduction of the excitation energies of the experimental low-lying levels, as shown in Fig. 1. In particular, the low-lying excited 0^+ states are considerably affected by the collective inertial functions using the local QRPA in these neutron-rich nuclei.

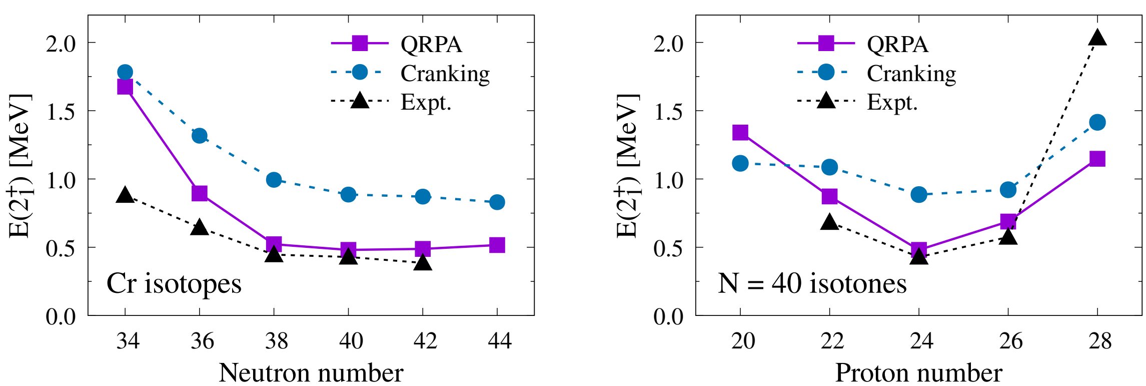

FIG. 1. First 2_1^+ energies in the Cr isotopes (left) and $N = 40$ isotones (right). The solid and dashed lines denote the results of the collective Hamiltonian method using the QRPA inertial functions and the cranking ones, respectively, compared with the experimental data by the triangles.

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