Angular momentum dependence of moments of inertia due to Coriolis anti-pairing and blocking effects[†]

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In a series of papers,[1,2] we have developed the top-on-top model to systematically describe the level energies, and B(E2) and B(M1) values for in- and out-of-band transitions in the triaxial strongly deformed (TSD) bands in odd-A nuclei. Numerical analysis have been performed for the TSD bands in odd-mass Lu isotopes,[1] ^{167}Ta,[2] and for the odd-odd nucleus ^{164}Lu.[3] Without the angular momentum dependence (I-dependence) of the moments of inertia, the level energies along the TSD bands cannot be reproduced.

In order to investigate how the I-dependence arises, we take into account both the Coriolis anti-pairing (CAP) effect[4] and the blocking effect within the framework of the HFB theory. The cranking effect is described in terms of the second-order perturbation to the cranking term in the HFB equation based on the BCS solution.[7] In dealing with the gap equation, we pay special attention to an integral wherein the finiteness of the system becomes tangible.

For the case of axially symmetric deformation, the moment of inertia J_x is introduced through the constraint for the x-component of angular momentum I_x, i.e., $\langle I_x \rangle = I - I_0 = J_x \Omega_x$, where $\langle\,\rangle$ stands for the quasivacuum expectation value. We have assumed that the system is independent of rotation (i.e., $\Omega_x = 0$) in the band-head state with $I = I_0$. Based on Refs.[5,6], we assume that only large matrix elements of single-particle angular momentum $(j_x)_{\alpha\beta}$ have a common excitation energy of $\delta(= \varepsilon_\beta - \varepsilon_\alpha)$ between two single-particle energy levels. Then, using the closure approximation, we get the relation J_x and the rigid-body moments of inertia J_x^{rig} for both even and odd nuclei.

In order to relate the gap value Δ to the angular momentum I, we need to solve the gap equation for both even and odd nuclei.[7] We apply a technique similar to the one we used for deriving the relation between J_x and J_x^{rig} for both even and odd nuclei. Assuming that Δ is still not too small, relevant summations over the single-particle energies with a level density ρ $(= 1/d)$ (d is the average distance between single-particle energy levels) can be replaced by integrals. On the other hand, when Δ is much smaller than d, we carry out the summation without converting it into an integral, because an abnormal enhancement is found when $\Delta \ll d$. We adopt the picket fence approximation for the single-particle energies. The sum is expanded into an asymptotic series, and we derive the formula using a functional value of the Riemann Zeta function and Euler constant.

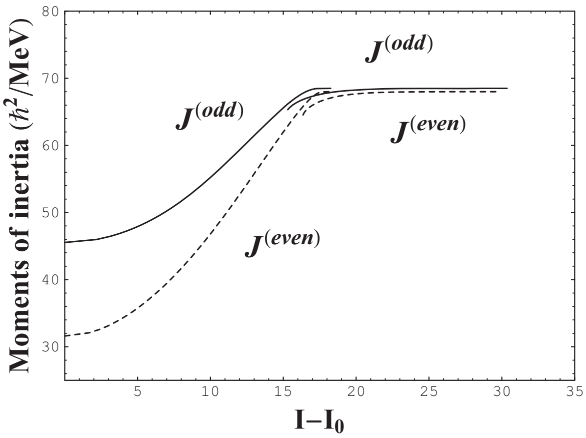

Fig. 1. Angular momentum dependence of moments of inertia for even and odd-A nuclei.

In Fig. 1, we compare $J^{(odd)}$ (solid line) and $J^{(even)}$ (dashed line) for the cases of $\Delta \geq d$ (low-spin part) and $\Delta \ll d$ (high-spin part). We adopt $\delta = 2$ MeV and $J_x^{\mathrm{rig}} = 68$ MeV^{-1}; the starting pairing gap Δ is 0.8 MeV for an even nucleus and 0.6 MeV for an odd nucleus, and the last single-particle energy in an odd nucleus is 0.6 MeV based on measurements made from the fermi surface.

As shown in the figure, the increase in the moments of inertia becomes slow in high-spin parts, whereas the gap values continue to decrease, maintaining a finite value. The curve for $J^{(odd)}$ starts from a higher value than $J^{(even)}$ because of the blocking effect, and it increases gradually, showing concave upward, which agrees with the curve for the values adopted in Ref..[3]

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