# Effect of pairing on the wobbling motion in odd-A nuclei†

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As an indicator of a triaxial rotor, wobbling motion was proposed by Bohr and Mottelson,[1)] and experimental data showing wobbling modes have been reported only in odd-Z nuclei of Lu isotopes,[2)] $^{167}$Ta,[3)] and $^{135}$Pr.[4)] The wobbling motion is originally defined in classical mechanics[5)] as a precessional motion of angular momentum $\vec{I}$ around the axis either with the maximum or the minimum moment of inertia (MoI) of the rotating body. Quantum mechanically, the incremental alignment of $\vec{I}$ along the wobbling axis with the maximum or the minimum MoI is in one unit[1,6,7)]. In odd-Z nuclei, we found that in addition to the incremental alignment of $\vec{I}$ along the wobbling axis, the incremental alignment of $\vec{R} = \vec{I} - \vec{j}$ along the same axis is also in one unit (see Fig. 9 and Fig. 15 in Ref. 7)), where $\vec{j}$ is the single-particle angular momentum. Moreover, the $D_2$ invariance requires that the yrast wobbling band appears for the levels for which $I - j$=odd.

The microscopic theory for nuclear rotational motion includes an important Coriolis anti-pairing (CAP) effect,[8)] *i.e.*, the Coriolis force originating from the rotation starts to dissolve the pair in the special high-spin single-particle orbital, and finally the cranking formula for MoI reduces to the rigid (rig) MoI. We have obtained the analytical formula for the $I$ dependence of MoI[9)] for both odd- and even-Z nuclei by applying the second-order perturbation approximation to the self-consistent Hartree-Fock-Bogoliubov (HFB) equation under the number and $I$ constraints. To simulate the behavior of the $I$ dependence of MoI, we assume a two-parameter fit for the rigid MoI $\mathcal{J}_0$, $\mathcal{J}_0(I-b)/(I+a)$ for highly excited states as in Lu isotopes,[6)] and $\mathcal{J}_0/[1+\exp\{-(I-b)/a\}]$ for slightly excited states as in $^{135}$Pr.[7)]

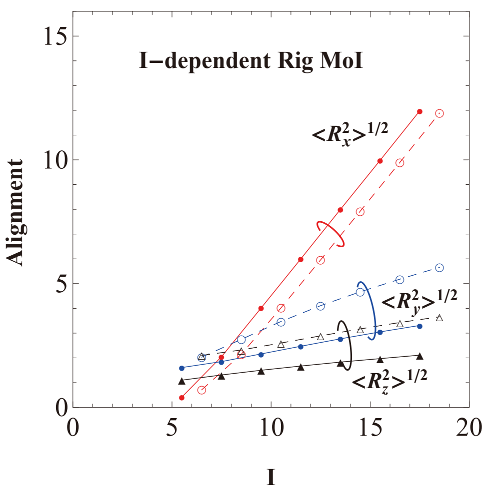


Fig. 1. Alignments of $\langle R_x^2\rangle^{1/2}$, $\langle R_y^2\rangle^{1/2}$, and $\langle R_z^2\rangle^{1/2}$ for the $I$-dependent MoI as functions of $I$. The solid and open circles correspond to $\langle R_x^2\rangle^{1/2}$ and $\langle R_y^2\rangle^{1/2}$, while solid and open triangles correspond to $\langle R_z^2\rangle^{1/2}$. The solid lines are for the levels with $I-j$=even, while the dashed lines for those with $I-j$=odd.

Figure 1 shows the alignments of $\vec{R}$ for the case of the slightly excited states in $^{135}$Pr, where the $x$-axis represents the maximum MoI. The parameter set $\mathcal{J}_0$=25 MeV$^{-1}$, $a$=7.5 and $b$=15.5 for $j$=11/2 simulates the experimental data quite well (see Figs. 17 and 18 in Ref. 7)). Figure 1 shows that $\langle R_x^2\rangle_I^{1/2} \sim \langle R_x^2\rangle_I^{1/2}$ for $I-j$ =even and $\langle R_x^2\rangle_{I+2}^{1/2} - \langle R_x^2\rangle_I^{1/2}$ ~2. Therefore, the difference of $\langle R_x^2\rangle^{1/2}$ between the solid and dashed lines is almost one, indicating that the incremental alignment of $\langle R_x^2\rangle^{1/2}$ for $I-j$=odd is less by one unit compared with that for $I-j$=even, which is associated with the excitation of the wobbling motion. A similar behavior is found for $\langle I_x^2\rangle^{1/2}$ in this $I$-dependent rig MoI.

Because the wobbling mode is related to the rotational motion of the rotor, the RPA treatment, which is useful for small-amplitude vibrational motion, is not applicable to the wobbling mode.


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