Tops-on-top model applied to TSD bands in ^{164}Lu†

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The top-on-top model with moments of inertia (MoI) dependent on angular-momentum (I) works quite well in describing triaxial strongly deformed (TSD) bands in odd-mass nuclei.[1–3] In this paper, the top-on-top model is extended to the tops-on-top model for an odd-odd nucleus ^{164}Lu, in which one proton and one neutron in each single-j orbital are coupled to the triaxial rotor.

Both positive- and negative- parity TSD bands in ^{164}Lu are well reproduced by taking account of attenuation factors in the Coriolis interaction, which includes the effect of the partially filled single-j shell. In order to observe the effect of the attenuation factor, we compared numerical results with and without the attenuation factor and confirmed its importance for the excitation energies relative to the reference, i.e., $E^* - aI(I+1)$ with $a = 0.0075$ MeV.[4,5]

For a pure-rotor case without single-particle potentials, an explicit algebraic formula for the TSD band levels is obtained. The level is classified by three quantum numbers $(n_\alpha, n_\beta, n_\gamma)$, where n_α is related to the rotor wobbling quantum number, and n_β and n_γ to the precession quantum numbers for a proton and a neutron. Under the condition of D_2-invariance,[6] three quantum numbers take limited integers depending on the value of $I - j_1 - j_2$ and $n_\alpha - n_\beta - n_\gamma$. As an example, we assume $j_1 = j_2 = 13/2$, and compare the energy eigenvalues from this boson model with the result obtained from the exact diagonalization of the rotor Hamiltonian in Fig. 1 for odd number I where $I - j_1 - j_2$ is even. In this case n_β and n_γ appear as the combination $n_\mathrm{p} = n_\beta + n_\gamma$. The yrast has quantum numbers $(0,0)$ and the yrare $(0,2)_3$. On the other hand, for even number I where $I - j_1 - j_2$ is odd, the yrast has quantum numbers $(1,0)$ and the yrare $(2,1)_2$. The boson model reproduces the exact results in good accuracy.

It is easy to derive the stability condition for a pure-rotor case. We found that there is no wobbling around the axis with the intermediate MoI. The wobbling motion exists only around the axis with the maximum or minimum MoI, which agrees with the result in classical mechanics.[7] Consequently, we can state that there is no stable rotation around the axis with the intermediate MoI, and that stable rotational motion exists only around the axis with the maximum or minimum MoI.

The difference in quantum numbers between the yrast and yrare TSD bands in ^{164}Lu, in which single-particle potentials are included, is confirmed by direct estimation of spin alignments. It is confirmed that the yrast TSD band with even $I - j_1 - j_2$ has quantum numbers $(n_\alpha, n_\beta, n_\gamma)$=(0,0,0), while the yrare TSD band with odd $I - j_1 - j_2$ has (1,0,0).

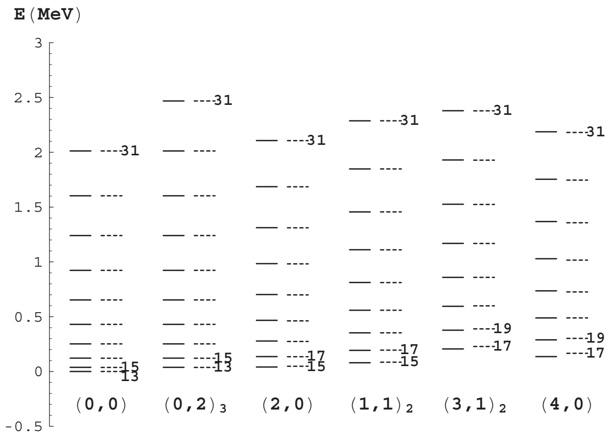

Fig. 1. Comparison of the energy levels of odd spin I ($13 \le I \le 31$) between the boson model (solid lines) and the exact result (dashed lines). Quantum numbers and degeneracy of levels $(n_\mathrm{p}+1)$ are given by $(n_\alpha, n_\mathrm{p})_{n_\mathrm{p}+1}$ below each rotational band. Angular momentum values are assigned to the lowest two levels and the highest level in the right-hand side of each band.

The electromagnetic transition rates of $B(M1)$ are reduced by a factor of 1/20 because the signs of g-factors of a proton and a neutron are different in comparison with the odd-A case, while the electromagnetic transition rates of $B(E2)$ are in the same order but reduced by a factor of 1/2. These reductions of electromagnetic transition rates will make the observation of TSD bands in even-even nuclei difficult.

References

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