Theoretical analysis of ^{132}Xe by generator coordinate method

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Xe, Ba, and Ce nuclei in the mass $A \sim 130$ region exhibit γ-instability in low-lying states, which is characterized by energy staggering of the even-odd spin states in the quasi-γ band and by some forbidden transition rates between the yrast and quasi-γ bands. The energy levels and decay properties of the low-lying states were discussed in the framework of the interacting boson model[1)], where quadrupole collective excitations are described in terms of the angular momenta zero (s) and two (d) bosons.

Another characteristic feature of even-even nuclei is the irregular level sequence in the yrast band, i.e., the backbending phenomenon, which is interpreted as band crossing between the ground-state band and the s band originating from the alignment of two neutrons in $0h_{11/2}$ orbitals. Sudden decreases in the level spacing and the $E2$ transition rates are observed around the states of spin 10. Recently, full-fledged shell-model calculations have been performed for the even-even, odd-mass and doubly-odd nuclei in this mass region[2)]. The shell-model calculations well reproduce the experimental energy levels and electromagnetic transition rates.

In the present study, we apply the quantum-number-projected generator coordinate method (GCM) to ^{132}Xe under the same interaction used in the previous shell model studies[2)]. All the five orbitals, $0g_{7/2}$, $1d_{5/2}$, $1d_{3/2}$, $0h_{11/2}$ and $2s_{1/2}$, in the major shell of $50 \leq N(Z) \leq 82$ are considered, and valence neutrons (protons) are treated as holes (particles).

In the present scheme, spins of the neutron and proton systems (I_ν and I_π) are projected separately, and the total spin is constructed by angular momentum coupling. To generate functions for the GCM in a neutron or proton system ($\tau = \nu$ or π), we employ the Nilsson BCS intrinsic states $\left|\Phi_\tau(\beta,\gamma)\right\rangle$, where β and γ indicate axial and triaxial quadrupole deformations, respectively. The ρth GCM wave function with angular momentum I_τ in neutron or proton space is given by

$$\left|\Psi^{(\tau)}_{I_\tau M_\tau \rho}\right\rangle = \sum_i \sum_{K_\tau=-I_\tau}^{I_\tau} \mathcal{F}^{I_\tau i}_{K_\tau \rho} \hat{P}^{I_\tau}_{M_\tau K_\tau} \hat{P}_{N_\tau} \left|\Phi_\tau(\beta_i,\gamma_i)\right\rangle, \quad (1)$$

where $\hat{P}^{I_\tau}_{M_\tau K_\tau}$ is the spin projection operator, $\hat{P}_{N_\tau}$ is the particle-number projection operator, $\mathcal{F}^{I_\tau i}_{K_\tau \rho}$ is the weight function to be determined by solving the Hill-Wheeler equation, and i stands for a representative point with deformation (β,γ). Then, the wave function

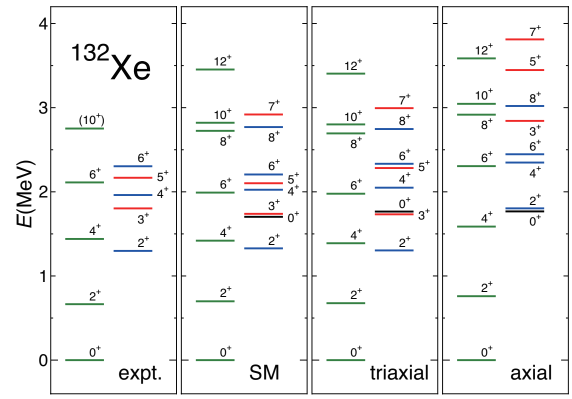

Fig. 1. Comparison of the experimental energy levels (expt.) with the shell-model (SM) results, those in the triaxial GCM (triaxial), and those in the axial GCM (axial).

for an even-even nucleus can be written as

$$\left|\Psi_{IM}(I_\nu \rho I_\pi \sigma)\right\rangle = \left[\left|\Psi^{(\nu)}_{I_\nu \rho}\right\rangle \otimes \left|\Psi^{(\pi)}_{I_\pi \sigma}\right\rangle\right]^{(I)}_M, \quad (2)$$

where I is the total spin and M is its projection. GCM calculations are carried out for two cases: (i) triaxial deformations (9 points) with $\beta = 0.10$, 0.20, 0.30, $\gamma = 10°$, 30°, 50°; (ii) only axial deformations (49 points) with $\beta = 0.00, 0.02, 0.04, \cdots, 0.48$ and $\gamma = 0°$, 60°. In Fig. 1, experimental energy levels are compared with the shell-model results, and those in the GCM. In both cases of triaxial and axial deformations, the GCM well reproduces the experimental energy levels of the even-spin yrast band and those obtained by the shell model. In the case of other excited states, the GCM calculations performed by assuming triaxial deformation are in good agreement with the shell model results, especially for the 2^+_2, 3^+_1, 4^+_2, and 5^+_1 states, which are members of the γ-band. However, energy levels calculated by assuming only axial deformation for the 3^+_1, 5^+_1, and 7^+_1 states are much higher than those calculated using the shell model. Apparently, the description of the 2^+_2, 3^+_1, 4^+_2, and 5^+_1 states is not satisfactory when assuming only the axially symmetric shape. The triaxial components play an essential role in the description of these states.

References
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