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E2/M1 MULTIPOLE MIXING RATIOS OF ^{162}Dy NUCLEUS IN ROTATION - VIBRATION MODEL

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Abstract

The extended rotation-vibration model containing different deformations for protons and neutrons is applied to ^{162} Dy nucleus. The mixing ratios we obtained for the E2/M1 transitions are in reasanably good agreement with previous experimental and theoretical values.

1.INTRUDUCTION

Interest in the problem of band mixing in doubly even deformed nuclei has been rising in the last few years, stimulated by a great deal of new experimental data, and in particular by the observation of the back bending effect in a number of rare earth nuclei[1]. When the selection rules allow, E2 radiation often dominates the M1 componet. The domination of the E2 radiation occurs because nuclear structure effect everride the angular momentum dependence of the transition probabilities. The mixing of β and γ bands may be important for the understanding of the observed rotational spectrum; the rotation-vibration interaction formalisim attempted to extract mixing parameters Z_γ and Z_β from the γ and β bands, respectively, to the ground band transitions. With much new experimental and theoretical work being carried out, particularly on E2/M1 mixing ratios in even-even nuclei, a critical survey of both areas is needed to point the way for further work. İn the present study the rotation-vibration model has been shown to be capable of describing the transitional nuclei equally well.

2.ROTATION-VIBRATION MODEL

İn the rotation-vibration model (RVM), pioneered by Bohr and Mottelson [2], the low-lying, even-parity states of even-even nuclei are ascribet to the collective quadrupole motion of the nucleus as a whole. The collective Hamiltonian, appropriate for a perturbation treatment, is written as

$$H_C = H_{rot} + H_{vib} + H_{int} \tag{1}$$

where

$$H_{rot} = \sum_{k=1}^{3} J_k^2 /(2I_k) \tag{2}$$

J_k is the projection of J on the intrinsic axis k and I_k is the k-th component of the nuclear moment of inertia.

$$H_{vib} = V + T_{vib}\,, \tag{3}$$

and

$$H_{int} = T_{rot}(\beta,\gamma) - H_{rot} \tag{4}$$

Consider γ-ray transitions from an initial nuclear state with angular momentum J_1 and parity π_1 to a final state (J_2, π_2). Let the initial and final states be such that both E2 and M1 transitions are allowed ($J_1 + J_2 \geq 2$, $|J_1 - J_2| \leq 1$, $\pi_1\pi_2 = +1$).

$$\delta(E2/M1; J_1 \rightarrow J_2) = 0{,}835.E_\gamma \text{ (in MeV) } \frac{\langle J_2\ II\ M(E2)\ II\ J_1 \rangle \text{ in } exb}{\langle J_2\ II\ M(M1)\ II\ J_1 \rangle \text{ in } nm} \tag{5}$$

The E2 matrix element for a $J_\gamma \rightarrow J$ transition is

$$< J \,||\, M(E2) \,||\, J_\gamma > = Y\, \beta_0\, (2\, J_\gamma+1)^{1/2}\, C^{J_\gamma 2 J}_{2-20} \langle\, n_\gamma =.0 |\, \gamma |\ n_\gamma$$
$$= 1>[1+ \frac{1}{2}\, Z_2\{J(J+1)-J_\gamma(\, J_\gamma + 1 +4\}] \tag{6}$$

where

$$Z_2 = \sqrt{3}\ (\partial\, I /\partial\gamma)_0\, [(\hbar W_\gamma)\, I_0^2\ ]^{-1} \tag{7}$$

$$Y = 3(4\pi)^{-1}\, ZeR_0^{\,2} \tag{8}$$

and $\hbar W_\gamma$ is the energy of a γ vibrational phonon [3]. The M1 matrix element for a $J_\gamma \rightarrow J(=J_g)$ transition is given by

$$<J \,||\, M\,(M1) \,||\, J_\gamma> = (-1)^{(J_\gamma -1)}\, C^{J1J_\gamma}_{011}\, [3(2J+1)(\, J_\gamma\text{-}1)$$

$$x(\, J_\gamma+2)/(16\pi)]^{1/2} (\partial g_r/\partial\gamma)_0 < n_\gamma=0|\ n_\gamma=1> \tag{9}$$

On substituing Eqs.(6) and (9) into Eq.(5), we find the δ-value for a $J_\gamma \rightarrow J$ transition to be

$$\delta(E2/M1;\, J_\gamma \rightarrow J)=0{,}835\ E_\gamma(\text{in MeV})[32\pi B(E2;0\rightarrow 2)\text{in } e^2 x\ b^2]^{1/2}$$

$$x F(J,J_\gamma)[(\partial g_J/\partial\gamma)_0 \text{ in nm/rad}]^{-1} \tag{10}$$

where

$$F(J, J_\gamma) = \frac{\left[1+(1/2)Z_2\left\{J(J+1)-J_\gamma(J_\gamma+1)+4\right\}\right]}{\left[(J+J_\gamma-1)(J+J_\gamma+3)(J-J_\gamma+2)(J_\gamma-J+2)\right]^{1/2}} \tag{11}$$

3.RESULTS AND DISCUSSION

The E2/M1 mixing ratios of the electromagnetic transitions between the energy states of ^{162}Dy nucleus was calculated by using equation[10]. The calculated values and energy levels are given in Table-1 and Table-2.

Table 1: Energy Levels of ^{162}Dy Nuclei

Band K^π	Spin-Parity I^π	Enegy Levels (keV)
Graund State Band	0^+	0
$K^\pi=0^+$	2^+	81
	4^+	266
	6^+	549
Gamma Band	2^+	888
$K^\pi=2^+$	3^+	963
	4^+	1061
	5^+	1183
	6^+	1325
Octupol Band	2^-	1148
$K^\pi=2^-$	3^-	1210
	4^-	1297
	3^-	1357
	5^-	1390
	5^-	1486
	5^-	1519
2 β Band $K^\pi=0^+$	$4^+, 5^\pm, 6^+$	1574

Table 2: E2/M1 multipole mixing ratios for ^{162}Dy

Spin-Parity	Transition	E2/M1	Mixing	Ratio
$I_i \rightarrow I_f$	Energy (keV)	This Work	Experimental	Theory
$2^+ \rightarrow 2^+$	808	-7,02(-4,2, +0,8)	$-30 \leq \delta \leq 30$ [4] $-8{,}3 < \delta < 3{,}4$ [5] $-2{,}9 < \delta < 11{,}4$ [6] $-7 < \delta < -1$ [7] $-20 < \delta < 20$ [8]	-25 [10]
$3^+ \rightarrow 2^+$	882	-7,43(-4,3,+0,8)	$-26(-\infty, +18)$ [4] +2,6(-1,6,+5,3) [5] $-6{,}3 < \delta < 19{,}1$ [6]	-13,5 [10]
$3^+ \rightarrow 4^+$	697	-5,34(-3,2,+0,5)	$-10{,}4 < \delta < 11{,}7$ [5]	-32,5 [10]
$4^+ \rightarrow 4^+$	795	-3,98(-2,1,+0,4)	$-2{,}0 \leq \delta \leq 13$ [8] -5,3(-12,6,+2,1) [5] -2,4(-4,7,+0,8) [9] $-0{,}4 < \delta < 2{,}0$ [6]	-17,0 [10]
$5^+ \rightarrow 4^+$	917	-4,47(-2,9,+0,5)	$-62{,}7 < \delta < 4{,}8$ [5] $-2{,}7 < \delta < 14{,}3$ [6] $-9(-\infty, +6)$ [4]	-6,0 [10]
$5^+ \rightarrow 6^+$	634	-3,26(-1,7,+0,3)	-3,9(-1,5,+4,1) [5]	-34,5 [10]
$6^+ \rightarrow 6^+$	776	-3,07(-1,7,+0,3)	--	-20,5 [10]

It can be seen from the tables that our results are in better agreement with the previous experimental data. This certifies that the method is applicable for the deformed region.

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