Study of nuclear structure of ^{146}Sm from asymmetric rotor model

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Introduction

The structure of samarium isotopes is very interesting because the shape phase transition takes place from SU(5) to SU(3) limit of interaction boson model (IBM) [1]. This feature has attracted many researchers to study these isotopes experimentally and theoretically. The (^{11}B, 4n) reaction at 54 MeV on natural La target evaporated on gold was used [2] to study the lifetimes measurement of various energy levels of ^{146}Sm. The radioactive decay of ^{146}Eu [3] has given spin parity assignment in ^{146}Sm and angular distribution of 68 γ–rays. Peker [4] also compiled the experimental data for A = 146. The 0_2^+ state earlier observed [3] at 1.452MeV was not adopted in recent compilation [5] but new 0_2^+ and 0_3^+ states at 2.211 and 2.331 MeV were reported. Newly adopted [5] $5^+\gamma$, $8^+\gamma$ and $9^+\gamma$ states of $K^\pi = 2^+_1$ band at 2.8983, 3.0431 and 3.5674 MeV, respectively are included in the present work.

Several theoretical calculations, using IBM-1 [3, 6, 7], IBM-2 [8] and DPPQ [9] were carried out to explain the structure of ^{146}Sm. The compilations of experimental data [2- 5] enable us to present more elaborate analysis. Unfortunately, insufficient data is available for ^{146}Sm, therefore we have used data for other N=84 isotones for useful comparison for B(E2) values for inter and intra band transitions. The asymmetric rotor model [10] has been used for calculating the levels energy and transition probabilities.

The parameters used for calculation are A=146, Z=64, $E2^+g$ = 0.74724 KeV, γ= 26.44° and β= 0.0917°. The energy ratios are computed from experiment [5] and compared with the previous theoretical calculations [7-9] and present ARM calculation in Table 1. The calculated values are close to the experimental values indicating the vibrational nature of ^{146}Sm. The reduced transition ratios are given in Table 2 for g- and γ- bands. The present ARM results are compared with the observed [3-5, 9] and other theoretical calculations from DDPQ [9] and IBM [6- 8]. Most of the ratios are close to the observed values. Some of the γ-rays are having M1 admixture [5] (see Table 2). The energy values for ground state rotational and γ-vibrational bands are given in Table 3 and the experimental values [5] are compared with IBM-1 [3, 7], DPPQ [9] and ARM results. The B(E2) values for the transitions from g- and γ- band are also compared with other N=84 isotones for useful comparison (results will be presented).

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Table 1. The energy ratios for g-and γ- bands.

Ratios	Expt. [5]	ARM	DPPQ [9]	IBM1 [7]	IBM2 [8]	SU(5)	O(6)	SU(3)
E4g+/E2g+	1.85	2.7	1.846	1.877	2.09	2	2.5	3.33
E2γ+/E2g+	2.206	2.2	2.282	2.046	2.21	2	2.5	3.33
E3γ+/E2g+	3.038	3.2		2.989	3.11	3	4.5	7
E4γ+/E2g+	3.264	2.7		3.381	3.70	4	7	12

Table 2. The B(E2; Ii → If/If') ratios.

Transition	Experimental Ratios			IBM1		IBM2	DPPQ	ARM
	[3]	[4]	[5]	[6]	[7]	[8]	[9]	
4g→2g/2g→0g	≥1.27(26)	≥1.30	1.82[9]	1.82	1.613	1.613	1.94	1.409
6g→4g/4g→2g	0.98(4)	<0.74			1.21	1.21		1.254
8g→6g/6g→4g		~0.16(5)						1.106
2γ→0g/2g*	0.0012(4)	>0.01*	0.01**	0.01	0.014	0.014	0.018	0.025
3γ→2g/2γ	0.019(5)	0.049	0.018#		0.027	0.027	0.10	0.028
4γ→2g/4g	0.007	0.007	0.017$		0.005	0.005	0.1	0.079
9γ→8g/8_2		0.023	0.023&		0.15			0.000 1

*Multiple assignments. ** (2γ→2g) 900.797 KeV γ – ray has M1 admixture.
#1522.712 KeV (3γ→2g) and 621.85 KeV (3γ→2γ) γ-rays have the M1 admixture.
$1691.643 KeV (4γ→2g) and 1057.62 KeV (4γ→4g) γ-rays have the M1 admixture.
&524.3 KeV (9γ→8_2) γ – ray is M1 type transition.

Table 3. The energy levels of ground state rotational and γ- vibrational bands.

State	Expt. [5]	IBM1 [7]	IBM1 [3]	DPPQ [9]	ARM
2g	0.747115	0.7804	0.733	0.756	0.75
4g	1.38128	1.4648	1.353	1.375	2.06
6g	1.811682	2.0500	1.869	-	3.87
8g	2.7372	2.5331	2.287	-	6.20
2γ	1.647929	1.5969	1.610	1.725	1.65
3γ	2.26983	2.3333	2.417	-	2.40
4γ	2.438981	2.6387	2.256	-	2.76
5γ	2.898268	2.9296	-	-	4.64