Armenian Journal of Physics, 2010, vol. 3, issue 3, pp. 150-154

CHARACTER OF QUASI-BANDS IN ^{150}Sm USING IBM

Rajesh Kumar[1*], Satendra Sharma[2], and J.B. Gupta[3]

[1]*Department of Physics, Noida Institute of Engineering & Technology, Greater Noida – 201306, India*

[2]*Panchwati Institute of Engineering & Technology, Meerut- 250005, India*

[3]*Ramjas College, University of Delhi, Delhi-110007, India*

[*]Email: rajeshkr0673@yahoo.co.in

Received 15 June, 2010

Abstract: The interacting boson model-1 Hamiltonian is used to describe the energy spectrum for six quasi-bands in ^{150}Sm. In this work, g- , β-, and γ- bands in ^{150}Sm isotope are studied by using interacting boson model-1. It is found that the calculated energy values and B(E2) values have good agreement with experimental data. The calculated energy values and B(E2) values are also compared with the Dynamic Pairing-Plus-Quadrupole (DPPQ) Model.

1. Introduction

The interacting boson model-1 (IBM-1) of Arima and Iachello [1] has been successful in describing the collective nuclear properties in the medium mass nuclei. Earlier systematic studies of $^{146-154}$Sm have been performed using interacting boson model [2] and Dynamic Pairing-Plus-Quadrupole (DPPQ) Model [3,4,5]. Very recently Diab [6] presented electrical monopole transition structure of ^{150}Sm isotope. Simpson et al. [7] successfully interpreted the isomers of ^{156,158}Sm using Quasi-particle Rotor Model. Sharma and Kumar [8] presented a fresh analysis of g- , β-, and γ- bands in ^{150}Sm using IBM. This search is now extended to calculate B(E2) values for (g --> g), (β --> g) , (β --> β), (γ --> g) and (γ --> β) transitions using IBM and compare with experimental data [9,10]. The study of quasi-bands in ^{150}Sm has not been studied sufficiently, thus the present study is interesting to investigate. Recent experimental data of energies have been taken from the website of National Nuclear Data center, Brookhaven National Laboratory, USA [16].

2. The Interacting Boson Model

The phenomenological Interacting Boson Model –1 (IBM-1) initially introduced by Arima and Iachello [1] has been rather successful in describing the collective properties of several medium and heavy mass nuclei. In the first approximation, only pairs with angular momentum $L = 0$ (called s-bosons) and $L = 2$ (called d-bosons) are considered. The model has associated with it an inherent group structure, which allows for the introduction of limiting symmetries called SU(5), SU(3) and O(6). However, in a more general case the full IBM-1 Hamiltonian has to be used, which has several forms [1]. The multi-pole form of the interacting boson model-1 Hamiltonian is given by

$$H = \varepsilon\hat{n}_d + a_0\left(\hat{P}^{+}.\hat{P}\right) + a_1\left(\hat{L}.\hat{L}\right) + a_2\left(\hat{Q}.\hat{Q}\right) + a_3\left(\hat{T}_3.\hat{T}_3\right) + a_4\left(\hat{T}_4.\hat{T}_4\right),$$

where the interaction parameters in the PHINT Program are given below: ε = EPS, $a_0 = 2\text{PAIR}$, $a_1 = \text{ELL}/2$, $a_2 = \text{QQ}/2$, $a_3 = 5\text{OCT}$ and $a_4 = 5\text{HEX}$.

2.1. E2 Transitions

The E2 transitions provide more stringent test of the model. The general E2 transition operator is given by

$$T^{(E2)} = \alpha_2 \left[d_+ \hat{S} + S^+ \hat{d} \right]^{(2)} + \beta_2 \left[d_+ \hat{d} \right]^{(2)}.$$

The coefficient α_2 called the boson effective charge is an overall scaling factor for all B(E2) values which is determined from the fit to the $B\left(\mathrm{E}2, 2_1^+ - 0_1^+\right)$ value. The coefficient β_2 may be determined from the quadrupole moment $Q\left(2_1^+\right)$. The ratio $\beta_2/\alpha_2 = \chi = -1.32$ in the SU(3) limit and is reduced to zero in the O(6) limit. In the "FBEM" program the corresponding parameters are $\alpha_2 = \mathrm{E2SD}$, $\beta_2 = \left(1/\sqrt{5}\right)\left(\mathrm{E2DD}\right)$.

3. Results and Discussion

3.1 Energy Spectrum

The triplet of 4_1^+, 2_2^+ and 0_2^+ states is well broken in ^{150}Sm. The 'H' Hamiltonian is used to calculate the spectrum of the ^{150}Sm. In ^{150}Sm isotope, the six positive parity bands, i.e. g-, β- and γ- , β_2-, β_3- and γ_2-bands are well established [15]. Sakai [15] listed the g-band up to 14^+, β_1-band up to 4^+, γ_1– band up to 5^+, β_2 - band up to 4^+, γ_2-band up to 3^+ and β_3- band up to 2^+ states in ^{150}Sm isotope. The results of present calculation for energy spectrum are presented in Table 1 and there is a good agreement between theory and experiment (see Figure 1).

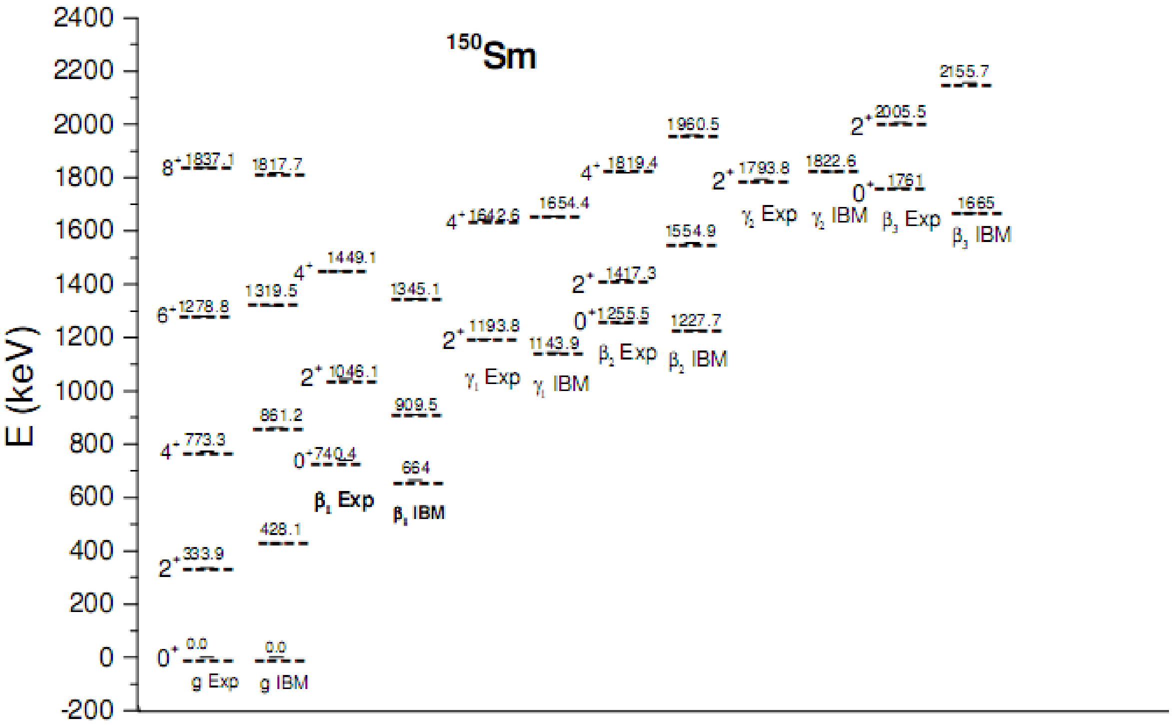

Fig. 1. Comparison of experimental and calculated (IBM) energy spectra of ^{150}Sm.

Table 1. The values of energy (in MeV) for ^{150}Sm.

State	Expt.[15,16]	Present work	DPPQ[5]
2g	0.33395	0.4281	0.338
4g	0.77335	0.8612	0.747
6g	1.27885	1.3195	
8g	1.8371	1.8177	
$0\beta_1$	0.74042	0.6640	1.049
$2\beta_1$	1.04614	0.9095	1.460
$4\beta_1$	1.44917	1.3451	
$2\gamma_1$	1.19381	1.1439	1.782
$3\gamma_1$	1.50453	1.4936	
$4\gamma_1$	1.64260	1.6544	
$5\gamma_1$	2.0204	2.0068	
$0\beta_2$	1.2555	1.2277	
$2\beta_2$	1.4173	1.5549	
$4\beta_2$	(1.8194)	1.9605	
$2\gamma_2$	1.7938	1.8226	
$3\gamma_2$	2.0633	2.1632	
$0\beta_3$	(1.7610)	1.6650	
$2\beta_3$	2.0055	2.1557	

3.2 B(E2) Values

The absolute B(E2) values are presented in table 2, where the experimental data [9,11] is compared with the present calculation and other previous work [5,9,11,12,13]. The B(E2) values are available for 15 transitions. In the present calculation the B(E2) values for (g -> g) transition increases with spin I^+. The same feature is also observed by Yen et al [14], however, in the experiment B(E2) values increases with spin up to 4^+ and decreases when spin increases from 8^+ to 10^+. For (β -> g) , (β -> β), (γ -> g) and (γ -> β) transitions the theoretical values lie very close to the experimental data. In the effective IBM-1 calculation [13] the B(E2; 2g --> 0g) value is 8 times smaller than observed value, for (2β -> 0g) transition it gives 135 times larger value than observed and for (2γ -> 2g) transition the calculated value is 20 times smaller than experiment, but in present calculation all these three B(E2) values lie very close to the observed values. Yen et al. [14] used the effective IBM calculation and included the Z = 64 proton sub-shell effect for N< 90 region. They [12] used two sets of calculation, i.e. MI and MII, in MI the proton boson were counted from Z = 50 closed shell, however, in MII set the Z = 64 sub-shell was included and obtained better results from MII [12]. However, in the present work proton bosons are counted from Z = 50 and we have obtained better results than MII set of Han et al. [12].

Table 2. Absolute B(E2 ; I i -M f) values (in e2 b2 unit) for 150Sm.

I i -> I f	Expt.	Present	DPPQ		BEM	IBM[f]		IBM[g]
	b		d	e	c	MI	MII	
2g-->0g	0.264(12)[a]	0.269	0.41	0.186	0.275	0.355	0.318	0.034
4g-->2g	0.49(4)	0.5339	0.73	0.186	0.51	0.708	0.566	0.54
6g-->4g		0.7465						
8g-->6g	0.435[c]	0.8738				0.934	0.609	
10g-->8g	0.447[c]	0.9076				0.700	0.512	
4g-->2β	0.0106[c]	0.1201			0.139	0.08	0.05	0.006
0β -->2g	0.218(26) 0.26(3)[c]	0.686	0.47	0.43	0.42			
2β -->0g	0.004(2)[c]	0.0146	0.008	0.0074	0.02	0.09	0.021	0.54
2β -->2g	0.27(15) 0.043(20)[c]	0266	0.12	0.108	0.181	0.14	0.11	
2β -->4g	0.55(30) 0.17(10)[c]	0.216	0.10	0.10	0.077			
4β -->2g		0.013		0.0004	0.007			
4β -->4g		0.127		0.063	0.105			
2β -->0β	0.56(31)	0.23	033					
2γ -->0g	0.009(4) 0.009(2)[c]	0.004		0.015	0.02	0.0001	0.004	0.001
2γ -->2g	0.29(11) 0.039(14)[c]	0.082	0.029	0.027	0.024	0.005	0.08	0.002
2γ -->4g	0.028(13) 0.019(10)[c]	0.129	0.059	0.054	0.087	0.036	0.025	
2γ -->0β	0.034(16)	0.1297	0.097					
2γ -->2β	0.4(3)	0.3323	0.55					
4γ -->2g		0.0042		0.009	0.022			
4γ -->4g		0.0677		0.035	0.032			

Reference [9]   [b] Reference [10]   [c] Reference [11]   [d] Reference [4]
Reference [5]   [f] Reference [12]   [g] Reference [13]

4. Conclusion

In the present work we studied systematically the lower and higher states of lower and higher bands, absolute B(E2) values of ^{150}Sm, which lie near the O(6) limit of IBM-1[1] because $R_4 = 2.31$. In ^{150}Sm, the triplet of 4_1^+, 2_2^+ and 0_2^+ is well broken, which have a splitting of 0.4534 MeV and the value of asymmetry parameter γ_0 = 20.41°. The energy difference $\Delta E = \left\{\left(E_{2g} + E_{2\gamma}\right) - E_{3\gamma}\right\} = 7.0$, which indicates ^{150}Sm isotopes are not rotational nuclei because for rotational nuclei $\Delta E = 0$. Thus, present calculations reflects that ^{150}Sm isotope lies in the transition from SU(5) to SU(3) limit of IBM-1[1].

REFERENCES

1. **A.Arima., F.Iachello,** *The interacting boson model*, Cambridge Univ. Press, 1987.
2. **O.Scholten, F.Iachello, A.Arima,** *Ann. Phys.* (*N.Y.*), **115**, 325 (1978).
3. **K.Kumar,** *Phys. A*, **231**, 189 (1974), A **92**, 653 (1967).
4. **J.B.Gupta, K.Kumar,** *J. Phys. G. Nucl. Phys.*, **7**, 673 (1981).
5. **J.B.Gupta,** *Phys. Rev. C*, **28**, 1829 (1983).
6. **S.M.Diab,** *Rom. Journ. Phys.*, **53**, no. 3-4, 475 (2008).
7. **G.S.Simpson, et al.** *Phys. Rev. C*, **80**, 024304 (2009).
8. **S.Sharma, R.Kumar,** *Proc. 96th Indian Sc. Congress, section-XIII*, 75 (2009).
9. **E. der Moteosion,** *Nucl. Data Sheet*, **48**, 345 (1986).
10. **M.Hoshi, et al.** *J. Phys. Soc. Jpn.*, **42**, 1106 (1977).
11. **T.Tamura, et al.** *Phys. Rev. C*, **20**, 307 (1979).
12. **C.S.Han, et al.** *Phys. Rev. C*, **42**, 280 (1990).
13. **D.S.Chuu, et al.** *Phys. Rev. C*, **30**, 1300 (1984).
14. **M.M.King Yen, et al.** *Phys. Rev. C*, **29**, 688 (1984).
15. **M.Sakai,** *At. Data & Nucl. Data Table*, **36**, 399 (1984).
16. http://www.nndc.bnl.gov, (*Recent data have been taken in the month of May 2010*).