B(E2) VALUE OF ^{82}Se, ^{84}Kr AND ^{86}Sr ISOTONES FOR N=48 BY USING INTERACTING BOSON MODEL-1.

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Abstract

The reduced transition probability B(E2)↓ of ^{82}Se, ^{84}Kr and ^{86}Sr isotones has been studied by using the Interacting Boson Model-1(IBM-1) . Using this model the reduced transition probabilities B(E2) of these isotones have been calculated for the gamma transition from $8^+ \rightarrow 6^+$, $6^+ \rightarrow 4^+$, $4^+ \rightarrow 2^+$ and $2^+ \rightarrow 0^+$states. For the first 4^+ and 2^+ excited states, the excitation energy ratio ($R_{4/2}$) has been also calculated.

Keywords: Reduced transition probabilities, ^{82}Se, ^{84}Kr and ^{86}Sr isotones, IBM-1.

1. Introduction

Arima and Lanchello has invented the Interaction Boson Model-1(IBM-1) (F Iachello and A Arima, 1975; A Arima and F Iachello, 1975). This model is helpful to describe the nuclear structure predicting the low-lying states. In this model the first approximation is only pairs with angular momentum L = 0 (called s-bosons) and L = 2 (called d-bosons) are considered. This model is also associated with an inherent group of structure, which allows the limiting symmetries called U(5), SU(3) and O(6) (F Iachello and A Arima, 1975; A Arima and F Iachello, 1975; R Kumar et al., 2010)

In the previous time, $\pi g_{9/2}^{-4}$ configurations for the Z=50 closed shell, the yrast states $I^{\pi} = 8^+$ in Z=46 isotopes were investigated. The investigation for even-even nuclei Z=46, which have been studied both theoretically and experimentally because they exist near the magic number 50 (Y B Wang and J Rissanen, 2012; R Krucken et al., 2001; K B Moore et al., 1999; X O Zhang et al., 2001; H Hua et al., 2003).

Neutron rich nuclei are particularly interesting since they might excess of neutron. The yrast state up to I^{π} = 8^{+} in N=48 isotones can be ascribed to the two-hole state $\nu g_{9/2}^{-2}$ for the N=50 close shell. Neutron rich nuclei study is more important because the configurations $\upsilon g_{9/2}^{-2}$ are closer than that of $\pi g_{9/2}^{-4}$ to the magic number 50. Recently, Abdullah et. al has studied the reduce transition probability B(E2)↓ and other parameters of 8^{+} isomers even-even nuclei from ^{76}Ni to ^{94}Pd for N=48 for the energy $8^{+} \rightarrow 6^{+}$ (H. Y. Abdullah et al, 2001). In this study, we have calculated the reduced transition B(E2) of the 8^{+} isomers in the N=48 isotones $^{82}_{34}Se_{48}$, $^{84}_{36}Kr_{48}$, $^{86}_{38}Sr_{48}$ for the $8^{+} \rightarrow 6^{+}$, $6^{+} \rightarrow 4^{+}$, $4^{+} \rightarrow 2^{+}$ and $2^{+} \rightarrow 0^{+}$states using IBM-1.

2. Theoretical calculation

2.1 Reduced transition probabilities B(E2)

We have calculated the reduced transition probabilities B(E2) from the reduced matrix elements of the E2 transition operator (T^{E2}) of the form (A Arima and F Iachello, 1975).

$$T^{E2} = \alpha_2 \left[d^{*}s + s^{*}d\right]^{(2)} + \left[d^{*}d\right]^{(2)} \qquad (1)$$

Where α_2 is the role of effective boson charge and the low –lying levels of even-even (L_i = 2,4,6,8,….) decay E2 transition to the lower yrast states with $L_f = L_i - 2$. IBM-1 gives the reduced transition probabilities B(E2)↓ for the U(5)-O(6) (O Scholten and F Iachello, 1978) by

$$B(E2; L+2 \rightarrow L)\downarrow = \frac{1}{4}\alpha_2^2 (L+2)(2N-L) \qquad (2)$$

Where N is the boson number and L is the translate state. The boson number N is equal to half the number f valence nucleons. Here α_2^2 has been determined from the experimental value B(E2) of transition ($8^{+} \rightarrow 6^{+}$). The parameter α_2^2 has been also calculated for each isotones which means square of the effective charge. The calculated value is used for the transition of $8^{+} \rightarrow 6^{+}$, $6^{+} \rightarrow 4^{+}$, $4^{+} \rightarrow 2^{+}$ and $2^{+} \rightarrow 0^{+}$states.

3. Result and discussion

Table shows the boson number, transition levels and the downward reduced transition probabilities B(E2)↓ for the $8^{+} \rightarrow 6^{+}$, $6^{+} \rightarrow 4^{+}$, $4^{+} \rightarrow 2^{+}$ and $2^{+} \rightarrow 0^{+}$ states of $^{82}_{34}Se_{48}$, $^{84}_{36}Kr_{48}$, $^{86}_{38}Sr_{48}$ isotones. The pair of valence nucleons is boson. And the boson number is calculated as the sum of pairs of valence nucleons. Total bosons is $N = (N_P + N_n)/2 = n_\pi + n_\nu$. Where N_p is valence proton and N_n is valence neutron. $n\pi$ is the pair of valence proton and $n\nu$ is pair of valence neutron. From the experimental value of B(E2)↓ from 8+ → 6+ transition, the reduced transition probabilities of $6^+ \rightarrow 4^+$, $4^+ \rightarrow 2^+$, $2^+ \rightarrow 0^+$ transitions of ${}^{82}_{34}Se_{48}$, ${}^{84}_{36}Kr_{48}$, ${}^{86}_{38}Sr_{48}$ isotones using IBM-1 and shown in the Table.

3.1 $R_{4/2}$ classification

The excitation energies ratio of first 4^+ and first 2^+ states is:

$$R_{4/2} = \frac{E(4_1^+)}{E(2_1^+)}$$

This ratio classifies the even-even nuclei (F Iachello and A Arima, 1987). The limit of the ratio 2.0~2.4 is an harmonic vibrator U(5), 2.4~2.7 represents the limit of O(6), 2.7~3.0 shows the transitional nuclei and the limit 3.0~3.3 indicates an axially symmetric rotor SU(3). The variation of R4/2 values are plotted as a function of even-even proton numbers of ${}^{82}_{34}Se_{48}$, ${}^{84}_{36}Kr_{48}$, ${}^{86}_{38}Sr_{48}$ isotones in figure.

Table: Reduced transition probability B(E2)↓ in ${}^{82}_{34}Se_{48}$, ${}^{84}_{36}Kr_{48}$, ${}^{86}_{38}Sr_{48}$ nuclei (Habibur Rahman, 2010).

Nuclei.	**Boson (#)**	**L^+**	**$Energy_{exp}$ / keV ***	**Transition level**	**E_γ (keV)**	**B(E2) /w.u. ****	**$B(E2)_{IBM-1}$ /w.u.**
^{82}Se	4	2	655	$2^+ \rightarrow 0^+$	655		0.53
		4	1735	$4^+ \rightarrow 2^+$	1080		0.795
		6	3145	$6^+ \rightarrow 4^+$	1410		0.795
		8	3519	$8^+ \rightarrow 6^+$	374	0.53(3)	0.53
^{84}Kr	5	2	882	$2^+ \rightarrow 0^+$	882		1.456
		4	2095	$4^+ \rightarrow 2^+$	1213		2.33
		6	3173	$6^+ \rightarrow 4^+$	1078		2.621
		8	3236	$8^+ \rightarrow 6^+$	63	2.33(6)	2.33
^{86}Sr	6	2	1077	$2^+ \rightarrow 0^+$	1077		1.415
		4	2230	$4^+ \rightarrow 2^+$	1153		2.358
		6	2857	$6^+ \rightarrow 4^+$	627		2.833
		8	2956	$8^+ \rightarrow 6^+$	99	2.83(10)	2.83

***** Habibur Rahman, 2010; ****** H. Y. Abdullah et al. 2001.

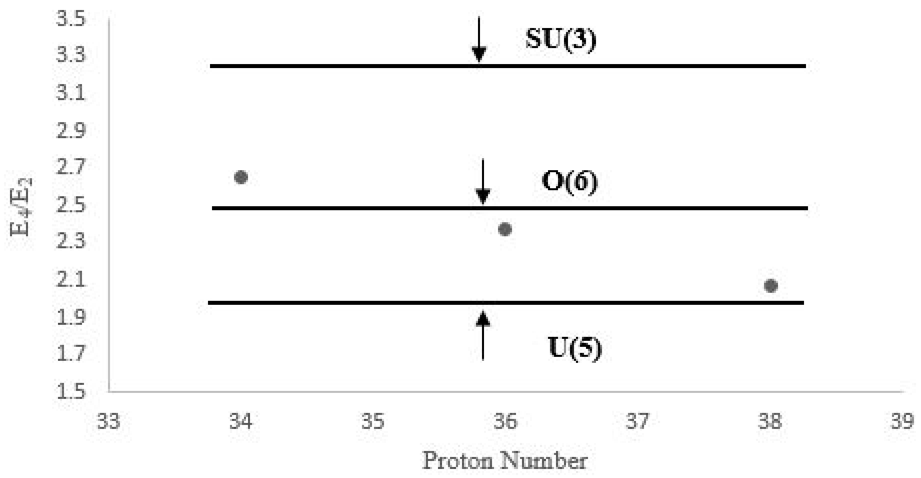

Figure: Variation of $R_{4/2}$ values versus proton number of ${}^{82}_{34}Se_{48}$, ${}^{84}_{36}Kr_{48}$, ${}^{86}_{38}Sr_{48}$ isotones.

4. Conclusion

Here we have used the IBM-1 to calculate the reduced transition probability B(E2)↓ for the B(E2)↓ in ${}^{82}_{34}Se_{48}$, ${}^{84}_{36}Kr_{48}$, ${}^{86}_{38}Sr_{48}$ nuclei. The analytical calculation of IBM-1 B(E2)↓ values of these isotones have been performed in U(5)-O(6) character. This result is very much helpful for compiling the nuclear data table.

References

A Arima and F Iachello, Collective Nuclear States as Representations of a SU(6) Group, Phys. Rev. Lett. 35 1069, 1975.

F Iachello and A Arima, Boson symmetries in vibrational nuclei, Phys. Lett. B 53 309 (1974)

F Iachello and A Arima, The Interacting Boson Model , Cambridge: Cambridge University Press, 1987.

H Hua et al., The sudden onset of the band crossing for the aligned πg9 /2 orbitals: a possible transition of a triaxial shape from prolate to oblate, Phys. Lett. B 562 201 , 2003.

Habibur Rahman, MS Thesis, Systematic study of $(\nu g_{9/2}^{-2})_{8^+}$ isomers in ^{80}Ge, ^{82}Se, ^{84}Kr, ^{86}Sr, ^{88}Zr, ^{90}Mo, ^{92}Ru and ^{94}Pd nuclei, 2010.

H. Y. Abdullah et al.; Calculation of 8^+ Isomers of even-even Nuclei from ^{76}Ni to ^{94}Pd for N=48 Neutrons, 6(4) 901-7, 2001.

K B Moore et al., High-spin states in neutron-rich even-even Pd isotopes, J. Phys. G: Nucl. Part Phys. 25 2253, 1999.

O Scholten and F Iachello, *Interacting boson model of collective nuclear states. III-The transition from SU(5) to SU(3),* Annals Phys. 115 325, 1978.

R Krucken et al., Spectroscopy of ^{112} Pd in heavy-ion-induced Fission, Eur. Phys. J A 10 151, 2001.

R Kumar, S Sharma and J B Guta, Character of quasi-bands in 150sm using IBM , Arm. J. Phys. 3 150, 2010.

X O Zhang et al., Observation of a vh11/2 pair alignment in neutron-rich ^{118}Pd, Phys. Rev. C 63 027302, 2001.

Y B Wang and J Rissanen, Collective properties of neutron-rich Ru, Pd and Cd isotopes, Hyerfine Int. doi: 10 1007/s10751-012-0615-6, 2012.