TRANSITION PROBABILITIES IN INTRUDER BANDS OF EVEN-MASS Sn ISOTOPES

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Intraband $B(E2)$ values in the intruder bands of ^{112,114,116,118}Sn are analyzed within the framework of the interacting boson model (IBM1). A detailed comparison of these bands with ground state bands in the even-mass Xe isotopes allows us to find a similarity not only for the energy spaces, but for the $B(E2)$ values as well.

Introduction

The study of nuclei near the $Z = 50$ closed shell had shed light on some interesting aspects of collective excitations in the Sn region. The low-lying deformed 0^+_2 states are well known in the even-mass Sn isotopes. At first, rotational-like bands built on these 0^+_2 states in ^{112,114,116,118}Sn were indentified up to $J^\pi = 12^+$ [1, 2]. Afterwards, these bands were observed in the high-spin region up to $J^\pi = 20 - 22^+$ in ^{112}Sn [3], ^{114}Sn [4 – 6], and ^{116}Sn [7]. The low-spin part of these bands has been interpreted as the proton '2 particle – 2 hole“ excitations across the $Z = 50$ shell gap [8,9], i.e., as the transition of the proton pair coupled to zero angular momentum from the closed shell to a higher one. The reason for anomalous low energies of the band-heads was explained by increasing the effective proton number (particles and holes), which induces the enhancement of the residual interaction with a valence neutron [8, 9]. The energy spaces in these bands are close to the yrast-band ones in the even-mass Xe isotopes different by $\Delta Z = 4$ from the Sn isotopes with equal neutron numbers. This must be a hint to a sharp growth of collectivity in the intruder bands of the Sn isotopes, but, for a detailed analysis, the $B(E2)$ values of intraband transitions are needed. In this case, the interpretation of these bands as four-quasiparticle proton excitations is one of the possible hypotheses explaining the collectivity growth. At the same time, recent results for $B(E2)$ values in the ground state bands in even-mass Xe isotopes allow us to do a more critical analysis of the existing experimental $B(E2)$ values in Sn isotopes. The calculations of transition probabilities in the framework of IBM2 for even-mass Sn nuclei were published recently in [10] for the low spin part of bands only.

The present work is aimed at a systematic analysis of the $B(E2)$ behaviour in the even-mass Sn and Xe isotopes having the same number of neutrons. Such an analysis in the framework of the IBM1 allows us to find the similarity not only for the energy spaces,but for the $B(E2)$ values as well.

1. Identical Bands in Even-Mass Tin and Xenon Isotopes

The energy spaces in the intruder bands of Sn isotopes are close to the yrast band ones in Xe isotopes different by $\Delta Z = 4$ from Sn ones with equal neutron numbers. This offers the question of the band identity of the intruder bands in Sn isotopes and the ground state bands in Xe ones.

The discovery [11] of the phenomenon of 'identical bands“ aroused a considerable interest. It was found that the transition energies in various nuclei are much close than expected. At the first time, this phenomenon was noticed in [11] at high spins of superdeformed states in even-even and odd nuclei. Also it had been identified at low spins in the region of stable deformation in the even-even actinide nuclei and the neighbouring rare-earth even and odd nuclei [12]. It was noticed in [13] that the existence of identical bands at low spins is not restricted by the stable deformation region, but are a widespread event and may take place in the pairs of even-even nuclei, like ^{156}Dy and ^{180}Os.

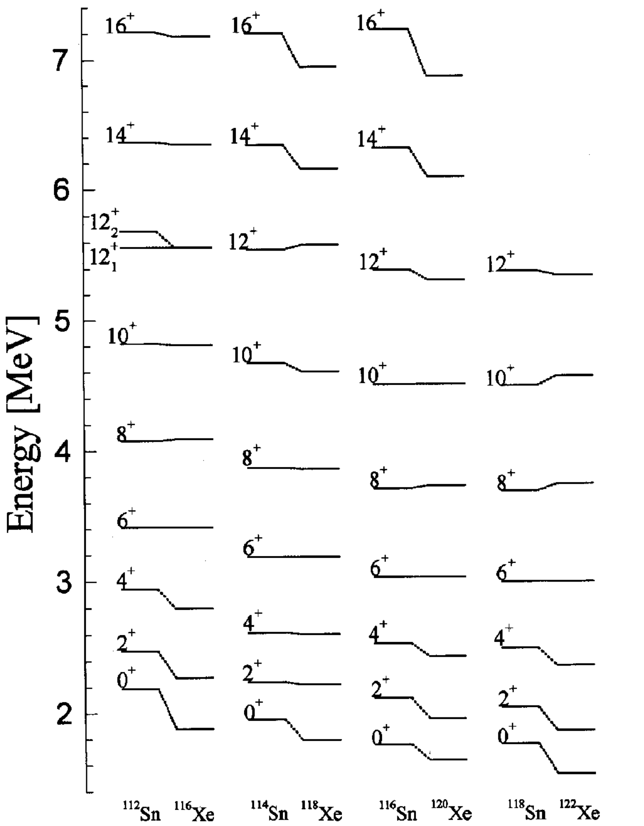

Fig. 1. Comparison of the experimental intruder bands in the Sn isotopes with the ground state bands in the Xe isotopes. The level energies of the Xe isotopes are shifted for the coincidence of the 6^+ state energies in the pairs of the Sn and Xe isotopes. The experimental data: ^{112}Sn – [3]; ^{114}Sn – [4 – 6]; ^{116}Sn – [7]; ^{118}Sn – [1, 2]; ^{116}Xe – [15]; ^{118}Xe – [16]; ^{120}Xe – [16]; ^{122}Xe – [17]

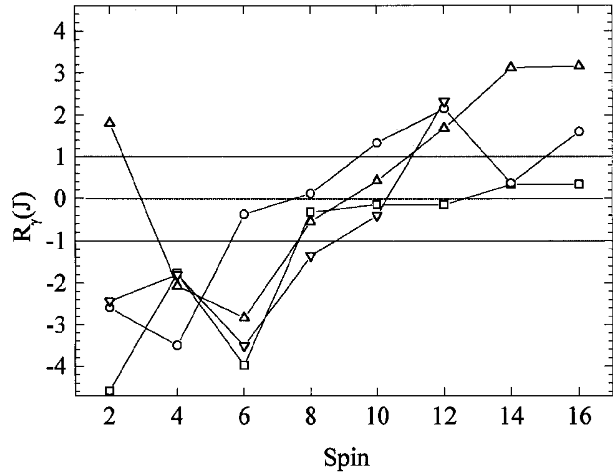

Fig. 2. Parameter $R_\gamma(J)$ for the pairs of the Sn and Xe isotopes: square – ^{112}Sn and ^{116}Xe; circle – ^{114}Sn and ^{118}Xe; up triangle – ^{116}Sn and ^{120}Xe; down triangle – ^{118}Sn and ^{122}Xe. The experimental data as in Fig. 1

To find the reasons for such appearance of 'identical bands" at low spins in even-even nuclei had been countered in [14], where it has determined that the presence of identical bands in nuclei at low spins depends on the balance between the deformation ε and pairing parameter Δ and is correlated with ε/Δ. Let's take that the deformation (i.e., the degree of collectivity) is proportional to $N_\pi N_\nu$ and the pairing is proportional to $N_\pi + N_\nu$. Then this relation may be substituted into $P = N_\pi N_\nu/(N_\pi + N_\nu)$. Thus, if the normal states of the Sn isotopes are compared with the system $N_\pi = 0, N_\nu$, then the bands built on $2p - 2h$ proton configurations form the system $N_\pi = 2$, N_ν. That is, $N_\pi N_\nu$ system is similar to the Xe ones. According to [14], the identical bands must be observed in the Sn and Xe isotopes. Fig. 1 presents the intruder band states in the Sn isotopes in comparison with the ground state bands in the Xe isotopes. The Xe states are shifted for the coincidence of the 6^+ state energies in the pairs of the Sn and Xe nuclei and this allows us to emphasize the band similarity.

It is useful to have a convenient standard for comparison of the bands in various nuclei. The mass dependence of the rigid rotor moment of inertia. i.e., $J \sim A^{5/3}$, may be used as such a standard. The degree of band similarity for two nuclei with mass numbers A_1 and A_2 can be found from the relation [13]:

$$R_\gamma(J) = (\Delta E_\gamma/E_{\gamma 2})/[(A_1/A_2)^{5/3} - 1], \qquad (1)$$

where $A_2 > A_1$; $E_{\gamma 2} = E(J) - E(J-2)$; $\Delta E_\gamma = E_{\gamma 1}(J) - E_{\gamma 2}(J)$; $E_{\gamma 1,2}(J)$ is the energy of state with spin J in the first and second nuclei, respectively. If the bands are identical, then $R_\gamma(J) = 0$.

If the change of energies is close to the change of $A^{5/3}$, then $R_\gamma(J) \approx 1$ and bands may be regarded as identical. If the energies are changed faster than $A^{5/3}$, then $R_\gamma(J)$ may be much greater than 1, and the bands are not identical in this case. Fig. 2 presents $R_\gamma(J)$ values for different pairs of the Sn and Xe isotopes with the equal neutron number. As the figure shows, the similarity occurs for $8^+ \to 6^+$ and $10^+ \to 8^+$ transitions for each of four considered pairs. The states lower $J^\pi = 6^+$ in the Sn isotopes lie in the energy region where the quasiparticle neutron states are distinguished. This affects the states of the viewed bands and breaks similarity.

2. IBM1 Calculations for the Even-Mass Xenon Isotopes

The summary of the experimental $B(E2)$ values in the intruder bands of the Sn isotopes and the ground state bands of the Xe isotopes are presented in Tab. 1. As follows from this Table, the dependence of the $B(E2)$ values on the spin values in the Xe isotopes has an unexpected character. Moreover, it is clear that the experimental data of the different works for ^{120}Xe and ^{122}Xe are in contradiction. In particular, the $B(E2, 6_1^+ \rightarrow 4_1^+)$ values have not only the same magnitude as the $B(E2, 2_1^+ \rightarrow 0_1^+)$ ones, but they are even lower. It seems that such $B(E2, 6_1^+ \rightarrow 4_1^+)$ values would be an evidence of the band crossing at $J^{\pi} = 6^+$. At the same time, one of the first case of the IBM2 application to the even-mass Xe nuclei [30] gave an adequate description not only of the 6^+ states, but of the 8^+ ones too.

Looking at the $B(E2)$ values in the intruder bands of the Sn isotopes, one can conclude that their behaviour with increase in spin must correspond to the calculated one in the framework of IBM1. The Hamiltonian of normal and intruder states in the Sn isotopes was assumed to have the form

$$H = H_{\text{IBM1}}(N_{\pi} = 0, N_{\nu})(1 - \hat{n}_{4qp}) +$$

$$+ H_{\text{IBM1}}(N_{\pi} = 2, N_{\nu})\,\hat{n}_{4qp} + H_{4qp} + V_{\text{int}}, \qquad (2)$$

where $\hat{n}_{4qp} = 0$ corresponds to the normal configurations in the Sn isotopes; $\hat{n}_{4qp} = 1$ corresponds to the intruder ones; H_{4qp} is the energy of the proton four-quasiparticle configuration; and $V_{\text{int}} \sim \alpha(s^+ s^+ + ss) + \beta(d^+ d^+ + dd)^0$. So far as the normal states

T a b l e 1. Lifetimes of excited states and reduced transition probabilities in the intruder bands of the Sn isotopes and ground state bands of the Xe isotopes

	Transition						
	$2^+ \rightarrow 0^+$	$4^+ \rightarrow 2^+$	$6^+ \rightarrow 4^+$	$8^+ \rightarrow 6^+$	$10^+ \rightarrow 8^+$	$12^+ \rightarrow 10^+$	Refs.
1	2	3	4	5	6	7	8
^{112}Sn							
E_{γ},keV	285	468	468	664	742	745	
τ, ps	–	–	0.9(4)	1.4(4)	0.65(20)	>2.0	[18]
$B(E2)$,W.u	–	–	144^{+115}_{-44}	140^{+56}_{-31}	174^{+77}_{-41}	<56	
^{114}Sn							
E_{γ},keV	286	375	574	682	802	876	
τ, ps	–	$2.0^{+2.0}_{-1.0}$	$3.1^{+0.9}_{-0.5}$	$1.4^{+0.6}_{-0.4}$	0.90(25)	0.95(25)	[19]
$B(E2)$, W.u.	–	50^{+50}_{-25}	123^{+24}_{-28}	120^{+48}_{-36}	83^{+32}_{-18}	51^{+18}_{-10}	
^{116}Sn							
E_{γ},keV	355	417	505	680	794	884	
τ, ps	2.73(14)[a]	<100[a]	2.0(6)[b]	$1.3^{+0.7}_{-0.3}$	1.1(4)	$1.3^{+0.9}_{-0.4}$	[20]
$B(E2)$,W.u.	22(8)	>12	134^{+58}_{-31}	128^{+38}_{-45}	70^{+40}_{-18}	35^{+15}_{-14}	
^{118}Sn							
E_{γ},keV	285	446	510	693	803	884	
τ, ps	4.18(58)[c]	>80[c]	0.8÷3.0[d]	1.2(5)	1.4(6)	$0.95^{+0.45}_{-0.35}$	[20]
$B(E2)$,W.u.	39(7)	<760	93÷314	124^{+88}_{-36}	51^{+38}_{-15}	46^{+27}_{-15}	
^{116}Xe							
E_{γ},keV	394	524	616	677	751	783	
τ, ps	35.1(13)	4.8(2)	2.4(2)	1.7(2)	1.1(2)	–	[23]
$B(E2)$, W.u.	72(3)	125(5)	113(10)	100(12)	113(21)	–	
^{118}Xe							
E_{γ},keV	337	473	586	677	743	776	
τ, ps	64.9(29)	10.8(2)	4.6(4)	4.0(14)	<1.7	–	[22]
$B(E2)$, W.u.	83(4)	92.8(17)	74^{+7}_{-6}	42^{+23}_{-11}	>62	–	

T a b l e 1. Continue

1	2	3	4	5	6	7	8
				^{120}Xe			
E_γ, keV	323	473	601	702		774	
τ, ps	124(15)	8.8(18)	<5	0.9(4)		–	
$B(E2)$, W.u.	54(7)	116(24)	>59	151^{+120}_{-47}		–	
τ, ps	53(2)	7.6(4)	<4	1.5(2)		–	
$B(E2)$, W.u.	124(5)	128(7)	>74	91^{+14}_{-11}		–	
τ, ps	64(5)	8.1(8)	2.5(3)	2.6(3)[e]		–	
$B(E2)$, W.u.	103^{+9}_{-7}	120^{+13}_{-11}	118^{+16}_{-13}	>52		–	
				^{122}Xe			
E_γ, keV	331	497	639	751	822	780	
τ, ps	89(8)	8.0(12)	3.9(7)	<3.5	–	–	[24]
$B(E2)$, W.u.	64(6)	93^{+16}_{-12}	54^{+12}_{-8}	>27	–	–	
τ, ps	51^{+10}_{-3}	$5.3^{+3.0}_{-0.6}$	9(3)	–	–	–	[27]
$B(E2)$, W.u.	112^{+7}_{-29}	140^{+18}_{-50}	24^{+11}_{-7}	–	–	–	
τ, ps	70(2)	6.5(3)	1.5(2)	0.7(2)	0.5(2)	–	[28]
$B(E2)$, W.u.	81(9)	115(5)	142^{+22}_{-17}	136^{+54}_{-30}	120^{+80}_{-45}	–	
τ, ps	72(4)	8.0(4)	2.9(2)	1.8(3)	<0.6	–	[29]
$B(E2)$, W.u.	79(5)	93(5)	74(5)	53^{+11}_{-8}	>100	–	

N o t e s. [a]Taken from [21]. [b]Lifetime of the level was determined by γ-transition 641 keV. [c]Taken from [22]. [d]Lifetime of the level was determined by γ-transition 719 keV. [e]Effective lifetime of the level.

are noncollective beginning from $J^\pi = 6^+$ and have the neutron two-quasiparticle character. Therefore, the interaction term V_{int} can be neglected for the intruder states with spins higher than $J^\pi = 6^+$. Moreover, the term H_{4qp} gives an additive contribution only for intruder states and must be neglected in this case. Thus, two terms remain in the Hamiltonian, where the first of them corresponds to the usual case of Sn nuclei and the second one describes Xe ones. Therefore, the present calculations are performed directly for the appropriate Xe isotopes, and this gave an opportunity to apply them to the intruder bands of Sn isotopes.

The properties of positive parity states in the even-mass Xe isotopes with $A = 114 - 124$ were calculated within the framework of IBM1.

The model Hamiltonian has a form

$$H_{\mathrm{IBM1}} = \varepsilon_d \hat{n}_d + k_1 (d^+ d^+ ss + \mathrm{h.c.}) + $$
$$+ k_2 ([d^+ d^+]^{(2)} ds + \mathrm{h.c.}) +$$
$$+ 1/2 \sum_L C_L [d^+ d^+]^{(L)} [dd]^{(L)}. \quad (3)$$

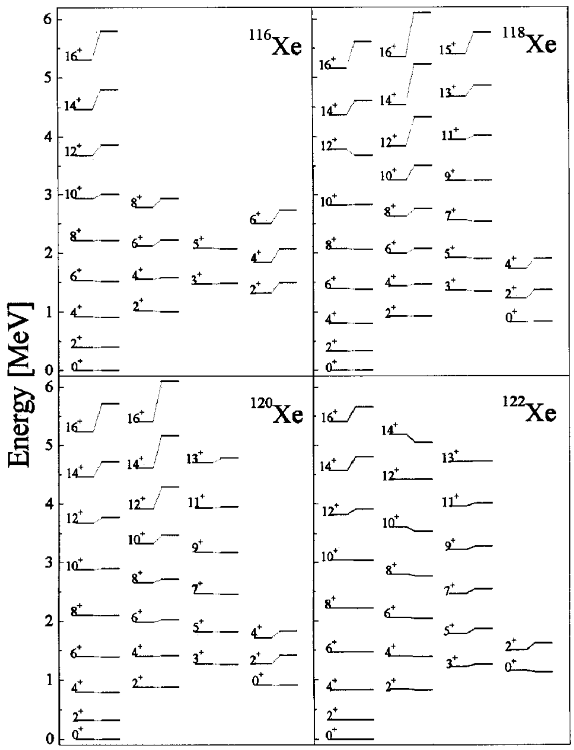

Fig. 3. Comparison of the experimental (left) and calculated (right) level excitation energies in the even mass Xe isotopes. The experimental data as in Fig. 1 for the Xe isotopes

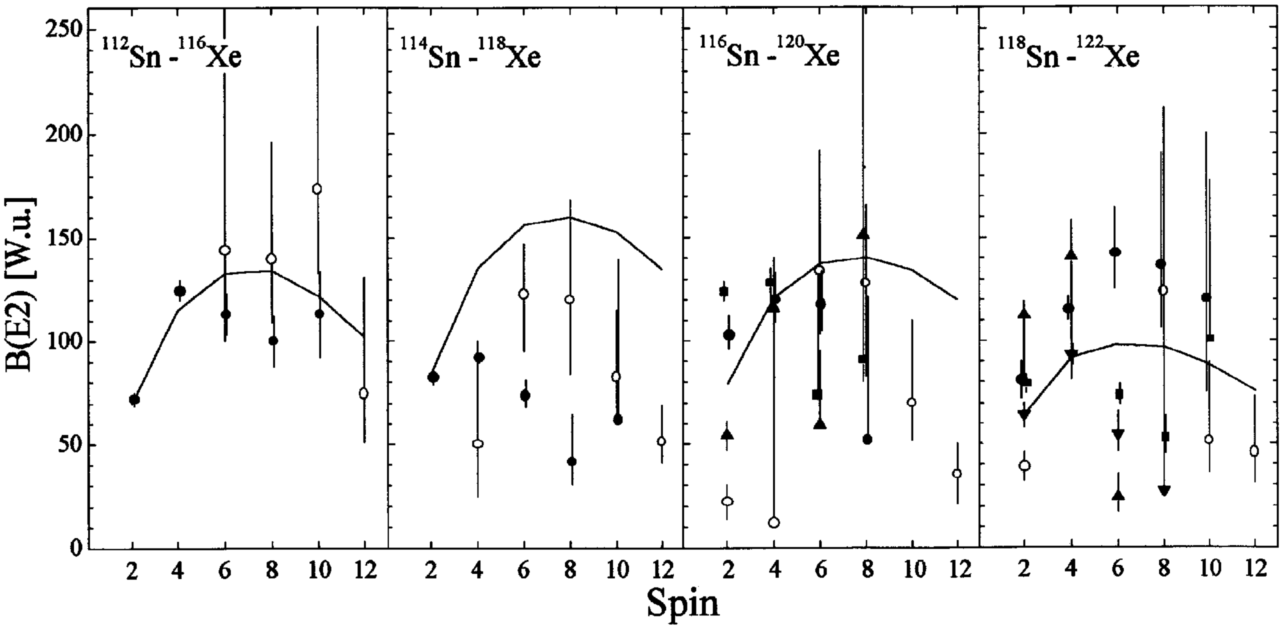

Fig. 4. Comparison of the transition probabilities in the intruder bands of the Sn isotopes and ground state bands of the Xe isotopes. Experimental data for the Sn isotopes are denoted by open circles [18 ¯ 20], for the Xe isotopes by full symbols: ^{116}Xe ¯ square [23]; ^{118}Xe ¯ square [22]; ^{120}Xe ¯ square [25], circle [26], up triangle [24]; ^{122}Xe ¯ square [29], circle [28], up triangle [27], down triangle [24]. The dotted eror bars correspond to the lifetime limits (see Tab. 1). The solid lines are the result of calculations

The $B(E2)$ values were calculated with the parameters e^* and χ by means of

$$T_{\rm IBM1}(E2) = e^* (d^+ s + s^+ d + \chi d^+ d)^{(2)}. \qquad (4)$$

The Hamiltonian parameters for each isotope were selected from the yrast states up to $J^\pi = 10^+$ as well as from the known 0_2^+, 2_2^+, 3_1^+, and 4_2^+ states. We made no attempt to choice the parameter set having a smooth dependence of the parameter values from one isotope to other. At first, such a choice allows us to understand more better the possibilities of the description of different states within the framework of IBM1. Secondly, it was shown on the base of microscopical calculations of the Hamiltonian parameters [31] that their resulting theoretical values must be obtained as a result of compensation of several large components. In this case, not smooth changes of the parameter values for the neighbouring nuclei are possible. The parameter sets used in the present calculations for each Xe isotope are presented in Tab. 2.

3. Discussion

In Fig. 3, the comparison of the experimental and calculated excitation energies is given for the ^{116,118,120,122}Xe nuclei. The calculated $B(E2)$ values in the ground state bands of the Xe nuclei are presented in Tab. 3. The comparison of the experimental and calculated $B(E2)$ values for the Xe isotopes with the experimental ones in the intruder bands of the Sn isotopes is shown in Fig. 4.

T a b l e 2. IBM1 parameters (e^* – $e \cdot b$; others ¯ MeV), $\chi = k_2/k_1$

	ε_d	k_1	k_2	C_0	C_2	C_4	e^*	N
^{114}Xe	0.4074	˜0.0319	0.0056	0.0004	˜0.0296	0.1102	0.124	7
^{116}Xe	0.4628	˜0.0275	0.0318	˜0.0145	˜0.0506	0.0587	0.126	8
^{118}Xe	0.4293	˜0.0268	0.0284	˜0.0196	˜0.0640	0.0618	0.124	9
^{120}Xe	0.4280	˜0.0338	0.0206	˜0.0408	˜0.1050	0.0551	0.108	10
^{122}Xe	0.2420	˜0.0593	0.0149	˜0.0060	˜0.0982	0.0515	0.102	9
^{124}Xe	0.1610	˜0.0724	0.0144	˜0.0780	˜0.0910	0.0518	0.119	8

T a b l e 3. Calculated $B(E2)$ values in the ground state bands of the Xe isotopes

$J_i^{\pi} \rightarrow J_f^{\pi}$	$B(E2, J \rightarrow J-2)$ [W.u.]					
	^{114}Xe	^{116}Xe	^{118}Xe	^{120}Xe	^{122}Xe	^{124}Xe
$2_1^+ \rightarrow 0_1^+$	58	70	84	79	64	71
$4_1^+ \rightarrow 2_1^+$	85	114	136	121	91	98
$6_1^+ \rightarrow 4_1^+$	94	132	157	137	98	103
$8_1^+ \rightarrow 6_1^+$	92	133	160	140	97	95
$10_1^+ \rightarrow 8_1^+$	80	122	152	134	89	83
$12_1^+ \rightarrow 10_1^+$	60	102	135	120	75	62

One can see from Fig. 3 that the parameter sets used for the calculations gave the excellent description of the excitation energies at least up to $J^{\pi} = 10 - 12^+$ for each of the Xe isotopes not only for the ground state bands, but for others too. Such agreement between the calculated and experimental energies was obtained within the framework of the usual IBM1 without any modifications. This is a confirmation that just the collective states of the Xe isotopes have an adequate description in the framework of this model.

At the same time, a dramatic divergence exists between the calculated and experimental $B(E2)$ values in the Xe isotopes, except for ^{116}Xe. Also the experimental $B(E2)$ values in the Sn and Xe isotopes are significantly different. However, we note that the curves calculated for the Xe isotopes $B(E2)$ describe the $B(E2)$ behaviour in the Sn isotopes more better. At least for the $8^+ \rightarrow 6^+$ and $6^+ \rightarrow 4^+$ transitions, we can see a good agreement. This would be an additional evidence of the collectivity growth in the intruder bands of the Sn isotopes in comparison with the normal ones. The degree of collectivity growth can be estimated from the calculated ratio $B(E2, 2_2^+ \rightarrow 0_2^+)/B(E2, 2_1^+ \rightarrow 0_1^+)$ which is equal to about 5. Moreover, the experimental $B(E2)$ values in the Xe isotopes put the question about their validity at all, because the data from different works are in contradiction.

Conclusion

Here, the systematic analysis was done for the intraband transition probabilities of the intruder bands of the Sn isotopes and the ground state bands of the Xe ones with equal neutron numbers. On the base of the experimental and calculated values, we find not only a similarity of the energy spaces in the bands having an essentially different nature, but a partial similarity of their $B(E2)$ values too. This must be a strong evidence for the proton system reconstruction in the intruder bands of the Sn isotopes by considering these bands as the proton $2p - 2h$ excitations across the $Z = 50$ shell gap. At the same time, we note that the existing experimental $B(E2)$ values in the Xe isotopes not allow one to do a more definite conclusion, and these values must be likely renovated for some nuclei.

1. *Bron J., Hesselink W.H.A., van Poelgeest A. et al.*//Nucl. Phys. A.¯ 1979.¯ **318.**¯ P.335.
2. *Van Poelgeest A., Bron J., Hesselink W.H.A. et al.*//Ibid.¯ 1980.¯ **346**.¯ P.70.
3. *Harada H., Murakami T., Yoshida K. et al.*//Phys. Lett. B.¯ 1988.¯ **207**.¯ P.17.
4. *Bentley M.A., Riley M.A., Khazaie F.*//Daresbury Laboratory, 1989 ¯ 1990 Annual Report, 17.
5. *Harada H., Sugawara M., Kusakari H. et al.*//Phys. Rev. C.¯ 1989.¯ **39.**¯ P.132.
6. *Schimmer M., Wirowski R., Albers S. et al.*//Nucl. Phys. A.¯ **539.**¯ P.527.
7. *Savelius A., Juutinen S., Helariutta K. et al.*//Ibid.¯ 1998.¯ **637**.¯ P.491.
8. *Heyde K., van Isacker P., Waroquier M., et al.*//Phys. Repts.¯ 1983.¯ **102**.¯ P.292.
9. *Wood J.L., Heyde K., Nazarevicz W. et al.*/ / Ibid.¯ 1992.¯ **215**.¯ P.101.
10. *Singh A.K., Gangopadhyay G., Banerjee D.*//Phys. Rev. C.¯ 1997.¯ **55.**¯ P.968.
11. *Byrski T., Beck F.A., Curien D. et al.*//Phys. Rev. Lett.¯ 1990.¯ **64.**¯ P.1650.
12. *Ahmad I., Carpenter M.P., Chasman R.R. et al.*//Phys. Rev. C.¯ 1991.¯ **44.**¯ P.1204.
13. *Casten R.F., Zamfir N.V., von Brentano P. et al.*//Ibid.¯ 1992.¯ **45**.¯ P.R1413.
14. *Zhang J.-Y., Casten R.F., Chou W.-T. et al.*//Phys. Rev. Lett.¯ 1992.¯ **69**.¯ P.1160.
15. *Sears J.M., Fossan D.B., Gluckman G.R. et al.*//Phys. Rev. C.¯ 1998.¯ **57**.¯ P.2991.
16. *Tormanen S., Juutinen S., Julin R. et al.*//Nucl. Phys. A.¯ 1994.¯ **572**.¯ P.417.
17. *Serris M., Papadopoulos C.T., Vlastou R. et al.*//Z. Phys. A.¯ 1997.¯ **358**.¯ P.37.
18. *Vishnevsky I.N., Krygin G.B., Kudojarov M.F. et al.*// .¯ 1991.¯ **36**.¯ C.982.
19. *Vishnevsky I.N., Krygin G.B., Lobach Yu.N. et al.*/ / ‡ ƒ ¥.¯ .1132.
20. *Kudojarov M.F., Kuzmin E.V., Pasternak A.A., Lobach Yu.N.* //42nd Conf. on Nuclear Spectroscopy and Structure of Atomic Nuclei, Alma-Ata, 1992.¯ P.63.
21. *Blachot J., Marguier G.*//Nucl. Data Sheets.¯ 1994.¯ **73**.¯ P.81.
22. *Kitao K.*//Ibid.¯ 1995.¯ **75**.¯ P.99.
23. *DeGraaf J., Cromaz M., Drake T.E. et al.*//Phys. Rev. C.¯ 1998.¯ **58.**¯ P.164.
24. *Kutschera W., Dehnhardt W., Kistner O.C. et al.*//Ibid.¯ 1972.¯ **5**.¯ P.1658.
25. *Dewald A., Harissopulos S., von Brentano P.*//Z. Phys. A.¯ 1989.¯ **334**.¯ P.163.
26. *Walpe J.C., Davis B.F., Naguleswaran S. et al.*//Phys. Rev. C.¯ 1995.¯ **52**.¯ P.1792.
27. *Droste Ch., Morek T., Rohozinski S.G. et al.*//J. Phys. G.¯ 1992.¯ **18**.¯ P.1763.
28. *Petkov P., Kruecken R., Dewald A. et al.*//Nucl. Phys. A.¯ 1994.¯ **568**.¯ P.572.
29. *Govil I.M., Kumar A., Iyer H. et al.*//Phys. Rev. C.¯ 1998.¯ **57**.¯ P.632.
30. *Puddu G., Scholten O., Otsuka T.*//Nucl. Phys. A.¯ 1980.¯ **348**.¯ P.109.
31. *Efimov A.D., Mikhajlov V.M.*//Izv. RAS, Ser. Fiz.¯ 1992.¯ **56**.¯ P.57.

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