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STUDYING THE NUCLEAR STRUCTURE OF EVEN-EVEN DEFORMED GERMANIUM $^{70}_{32}Ge_{38}$ NUCLEUS

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Abstract

In the present work, the interacting boson model(IBM-1) for s and d boson is used to calculate the energy levels of the positive parity bands, electric quadrupole moments, E2-transition probabilities B(E2)in particular between states which may be affected by the finite boson number N=NΠ+Nυ=2+5=7 of even-even $^{70}_{32}Ge_{38}$ nucleus . This nucleus is belong to SU(5)-SU(3) dynamical symmetry .

The calculated results of this study are compared with the available experimental data and they found to be in a very good agreement.

Keywords: nuclear structure , even-even deformed Germanium $^{70}_{32}Ge_{38}$ nucleus

Introduction

In 1974 Arima A. and Iachello F. have proposed a new nuclear model, called ; Interacting Boson Model (IBM); [1],which attempts to describe some nuclear properties such as spins and energies of the lowest levels of intermediate and heavy mass nuclei, except those near closed shells[2,3].The simplest versions of IBM called; IBM-1; has to be able to describe the even-even deformed nuclei as an inert core combined with bosons which represent pairs of fermions , which can occupy one of two levels: a ground state with (L=0)called s-boson or an excited state with(L=2)called d-bosons[4].

The dynamical symmetries in this model are depending on the main group U(6) of unitary transformations in 6-dimansions and 36 generators. The analysis of this group leads to three subgroups called chains that end in O(2). They can be written as[3]:

(I) The vibrational SU(5)chain

$U(6) \supset SU(5) \supset O(5) \supset O(3) \supset O(2)$ ….. (1)

(II) The rotational SU(3)chain:

$U(6) \supset SU(3) \supset O(3) \supset O(2)$ …… (2)

(III) The γ -unstable O(6)chain:

$U(6) \supset O(6) \supset O(5) \supset O(3) \supset O(2)$ ….., (3)

One of the basic properties of deformed nuclei is the presence of specific collective rotational states SU(3) in their excitation spectra. These states can only be observed in nuclei with a non-spherical shape [5].

The collective motion of deformed nuclei depends on two facts [6,7]:

1-All deformed nuclei have an electric quadrupole moments in their energy states .

2-The changing in the deformation shape depends on the direction of nucleons and nuclear motion causing rotation of some nucleons around an axis different from nuclear symmetry axis , for this

reason, we can explain two types of deformation as follows:

1-Prolate deformation:

In this deformation, the nucleus rotate around an axis perpendicular to the nuclear symmetry axis . This type has positive quantity of electric quadrupole moment (+QL).

2-Oblete deformation:

In this deformation, the nucleus is rotating in axis parallel to the nuclear symmetric axis. This rotating happened in spherical nuclei , and it has negative quantity of electric quadrupole moment (-QL).Some of the previous studies about this subject are:

Iman T. AL-Alawy(2000)[8],had been calculate the (EO,E2,B(E2),QL) transitions of collective levels of Pt-196 nucleus.

Iman T. AL- Alawy, et al (2005) [9]had studied the electric quadrupole moments, and g-factor for deformed Yb(A=176)nucleus of dynamical symmetry SU(3)-SU(5).

Aobaid A.K.(2006)[10] studied the nuclear structure of some even-even ($^{56}_{26}Fe_{30}$, $^{74}_{34}Se_{40}$, $^{88}_{40}Zr_{48}$, $^{106}_{46}Pd_{60}$, $^{156}_{64}Gd_{92}$, $^{180}_{72}Hf_{108}$, $^{186}_{74}W_{112}$) nuclei. He found a good agreement results with available experimental data.

Theoretical Part:

1-The Hamiltonian Operators In IBM-1:

Scholten, lachello and Arima (1978) [11] proposed a simplest Hamiltonian form as follows:

$$\hat{H} = \varepsilon\hat{n}_d + b_o(\hat{P}^\dagger.\hat{P}) + b_1\hat{L}^2 + b_2\hat{Q} + b_3\hat{T}_3^2 + b_4\hat{T}_4^2 \ldots\ldots\ldots\ldots\ldots(4)$$

Where:

ε is the energy parameter of d-boson operator ($\hat{n}_d$) , b0 is the parameter of the paring operator ($\hat{P}$) , b1 is the parameter of the angular momentum operator ($\hat{L}$),b2 is the parameter of the quadrupole momentum operator($\hat{Q}$),b3 is the parameter of the octupole operator ($\hat{T}_3$),b4 is the parameter of the hexadecapole operator ($\hat{T}_4$) .

The Hamiltonian in equation (4) depends on the type of dynamical symmetry as in equations (1,2,3)and takes the following form[3,4]:

for chain (I) :

$$\hat{H}^{(I)} = \varepsilon\hat{n}_d + b_1\hat{L}^2 + b_3\hat{T}_3^2 + b_4\hat{T}_4^2 \ldots(5)$$

for chain (II) :

$$H^{(II)} = b_1\hat{L}^2 + b_2\hat{Q}^2 \qquad \ldots.(6)$$

for chain (III) :

$$H^{(III)} = b_0(\hat{P}^\dagger.\hat{P}) + b_1\hat{L}^2 + b_3\hat{T}_3^2 \quad ..(7)$$

The electric transition operator, which is associated with collective states can be written as [4]:

$$\hat{T}(E2) = \delta_0[\hat{d}^\dagger\times\hat{\tilde{s}} + \hat{s}^\dagger\times\hat{\tilde{d}}]^{(2)} + \delta_1[\hat{d}^\dagger\times\hat{\tilde{d}}]^{(2)} \quad —(8)$$

This operator has two parts $[\hat{d}^\dagger\times\hat{\tilde{s}} + \hat{s}^\dagger\times\hat{\tilde{d}}]$ which satisfies the selection rule Δnd= ±1, and the term $[\hat{d}^\dagger\times\hat{\tilde{d}}]$ which satisfies the Δnd= 0 selection rule .

The parameters δ0 and δ1 depend on the limit involved or the appropriate intermediate structure .

The electric transition operator T(E2) in equation (8) can be written down as[3] :

$$\hat{T}(E2) = e_B[(\hat{d}^\dagger\times\hat{\tilde{s}} + \hat{s}^\dagger\times\hat{\tilde{d}}) + \chi\ (\hat{d}^\dagger\times\hat{\tilde{d}})]^{(2)} = e_B Q \quad \ldots(9)$$

Where eβ is a boson effective charge ,χ is any parameter.

The electric transition probability B(E2) determined from the following reduced matrix element [4]:

$$< LM_L \,\|\, \hat{T}_K^{(K)} \,\|\, L`M`_L >= (-1)^{L-M}) \begin{pmatrix} L & K & L` \\ -M_L & K & M`_L \end{pmatrix} < L \mid \hat{T}^{(K)} \mid L`> \ldots(10)$$

The calculation of electric quadrupole moments for three chains depended on selected rules as shown in table (1), and can be written as:

$$Q_L = 0.676\begin{pmatrix} L & 2 & L \\ -L & 0 & L \end{pmatrix} < L_f \,\|\, \hat{T}^{(E2)} \,\|\, L_i > \ldots(11)$$

While the electric transition probability B(E2) can be written as:

$$B(E2;L_i \rightarrow L_f)=\frac{1}{(2L+1)} |< L_f \| \hat{T}^{(E2)} \| L_i >|^2 \quad ....(12)$$

Results and Discussions:

<u>1-The energy levels , and Their</u> Transitions:

In order to calculate the nuclear structure of even-even ${}^{70}_{32}Ge_{38}$ deformed nucleus, we must find the dynamical symmetry of this nucleus. The dynamical symmetry for any nucleus was determined according to the following[4]:

1-Energy ratios as shown in table(2).

2-Experimential energy spectrum see references [3,4].

3-Energy band arrangement(g,β,γ)

Table (2) listed the calculated energy ratios (pw) in comparison with experimental [12,13] and ideal [3] values . This table shows the nucleus under study lying in the transitional region SU(5)-SU(3), also this table gives very reasonable description of the behavior ${}^{70}_{32}Ge_{38}$ nucleus.

The parameters of Hamiltonian equation (4) for ${}^{70}_{32}Ge_{38}$ nucleus are shown in table (3).

These parameters have been obtained by fits them with experimental energy levels values for low spin and used to calculate the energy levels and their transitions as in table(4)

Table(4) shows a good comparison between calculated energy levels and available experimental values ,specially at low-lying of the ground states ($0_1^+,2_1^+,4_1^+,6_1^+,8_1^+$),and in other states ($2_3^+,0_3^+,2_4^+,4_2^+,2_5^+,4_3^+,4_4^+,4_5^+,2_7^+,4_7^+$) while at high angular momentum, some theoretical values are somehow larger than experimental because:

1-These values need large time to be measured.

2-The IBM-1 does not distinguish between neutrons and protons bosons.

3-The fitted of equation (4) was very difficult to get same values as experimental data for all energy levels.

2-The electric Transitions Probability B(E2):

In this work, the equations (10,12) are used to calculate the electric transition probability and their reduced matrix element for this deformed nucleus .The parameters for these equations are (δ0=0.10498(eb), and δ1=0.068(eb)). These parameters have been obtained by fitting them with experimental values of B(E2).

The calculated results are listed in table (4). This table contain the comparison between calculated B(E2) and available experimental data. The comparison shows an acceptable agreement, specially at transitions ($2_1^+ \rightarrow 0_1^+$),($4_1^+ \rightarrow 2_1^+$),($4_2^+ \rightarrow 2_2^+$), ($4_3^+ \rightarrow 2_1^+$),and($6_1^+ \rightarrow 4_1^+$).

Figure (1) shows the relation between the electric transitions probability B(E2) for the transitions ($2_1^+ \rightarrow 0_1^+$) , ($4_1^+ \rightarrow 2_1^+$),($6_1^+ \rightarrow 4_1^+$),($8_1^+ \rightarrow 6_1^+$) as a function of angular momentum L+2→L. It is noticed in this figure that the highest probability happened at transition ($6_1^+ \rightarrow 4_1^+$). This means that the strong B(E2) happened at this transition ,also this figure shows very good agreement between present work and experimental data .

3-<u>The electric quadrupole moments:</u>

The electric quadrupole moments can be calculated from equation (8)by using the same parameters (δ0 and δ1)of B(E2). The calculated values of (QL)show that these values are depending on δ1 – value more than(δ0) and both of them depends on total number of bosons(N).

Table (5) shows the values of QLi where L=2 to 6 ,i=1 to 10.

These values have been compared with experimental data and gives very perfect agreement of the first excited state

(2_1^+) and somehow small in second excited state (2_2^+).

Figure (2) explain the shape deformation of angular momentum $2_1^+ \rightarrow 2_{10}^+$ for nucleus understudy, which has a prolete type of deformation at state (2_1^+, 2_3^+, 2_5^+, 2_7^+, 2_8^+, and 2_9^+), This is agreeing with experimental shape and value in the state (2_1^+), while it has an oblate type at states (2_2^+, 2_4^+, 2_6^+, and 2_{10}^+).

Figure (3) same as in figure (2) but for L= $3_1^+ \rightarrow 3_{10}^+$. This figure shows the nucleus has an oblate type in (3_1^+, 3_2^+, 3_3^+)states, but the(3_4^+)state has prolate type, and has QL=0 in other states. While in the figure (4) has prolate type in states (4_1^+, 4_3^+, 4_6^+, 4_7^+, 4_8^+, and 4_9^+) and an oblate type in another state .

Figure (5)shows that it has prolete type in states (5_1^+, 5_4^+, 5_5^+) ,while it has an oblate type in state (5_2^+, 5_3^+).

Figure (6) shows the nucleus has an oblate type in all states except has an oblate type in (6_3^+) state.

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Table(1):Selection rules and quadrupole moments in different dynamical symmetries[23]

Chain	operators	selection rule	Quadrupole moments
SU(5)	$[\hat{d}^\dagger \times \hat{\tilde{s}} + \hat{s}^\dagger \times \hat{\tilde{d}}]^{(2)}$ $[\hat{d}^\dagger \times \hat{\tilde{d}}]^{(2)}$	$\Delta n_d = \pm1, \Delta\upsilon = \pm1$ $\Delta n_d = 0, \Delta\upsilon = 0, \pm2$	$Q_L = 0.676\delta_1\sqrt{L/14}$
SU(3)	$[\hat{d}^\dagger \times \hat{\tilde{s}} + \hat{s}^\dagger \times \hat{\tilde{d}}]^{(2)}$ $[\hat{d}^\dagger \times \hat{\tilde{d}}]^{(2)}$	$\Delta\sigma = \pm1, \Delta\tau = \pm1$ $\Delta\sigma = 0, \Delta\tau = 0, \pm2$	$Q_L = -1.121\delta_o$ (L /2L+3)(4N+3)
O(6)	$[\hat{d}^\dagger \times \hat{\tilde{s}} + \hat{s}^\dagger \times \hat{\tilde{d}}]^{(2)}$ $[\hat{d}^\dagger \times \hat{\tilde{d}}]^{(2)}$	$\Delta\lambda = \Delta\mu = 0$ $\Delta\lambda = \Delta\mu = 0$ or $\Delta\lambda = \pm4, \Delta\mu = \pm4$	$Q_L = 0$

Table(2):Ideal energy ratios of three chains[3] compared with experimental[12,13] and theoretical values .

Valeus	$E(4_1^+)/E(2_1^+)$	$E(6_1^+)/E(2_1^+)$	$E(8_1^+)/E(2_1^+)$
SU(5)	2	3	4
SU(3)	3.33	7	12
O(6)	2.5	4.5	7
Exp..[12,13]	2.0721	3.1735	4,0459
Present work(pw)	2.0072	3.0234	4.0501

Table (3): The parameters of Hamiltonian operators for $^{70}_{32}Ge_{38}$ nucleus.

The Parameters	N_π	N_υ	N	ε (MeV)	$\hat{P}^\dagger.\hat{P}$ (MeV)	$\hat{L}^2$ (MeV)	$\hat{Q}^2$ (MeV)	$\hat{T}_3^2$ (MeV)	$\hat{T}_4^2$ (MeV)	χ (MeV)
Values	2	5	7	0.9740	0.0000	0.0090	0.0200	0.0500	-0.1000	0.8200

Table (4): Theoretical energy levels, transition energy, reduced matrix element $\left\langle L_f \parallel \hat{T}^{(E2)} \parallel L_i \right\rangle$, and probabilities of electric transitions B(E2) compared with available experimental data

L_i^+	Energy level E(L) (MeV)		Spin sequence $L_i^+ - L_f^+$	Transition energy E_γ(MeV)		$\left\langle L_f \parallel \hat{T}^{(E2)} \parallel L_i \right\rangle$ (eb)	B(E2) $(eb)^2$	
	Exp.[12]	IBM-1		Exp.[12]	IBM-1		Exp.[12]	IBM-1
0_1^+	0.00	0.00	-	-	-	-	-	-
2_1^+	1.0392	1.0536	$2_1^+ \to 0_1^+$	1.0392	1.0536	0.5130	0.0525	0.0526
0_2^+	1.2154	1,4608	$0_2^+ \to 2_1^+$	0.1762	0.4072	0.2825	0.1200	0.0798
			$0_2^+ \to 0_1^+$	1,2154	1.4608	0.0000	0.0000	0.0000
2_2^+	1.7079	1.9443	$2_2^+ \to 0_2^+$	o.4925	0.4835	-o.1470	o.0625	0.0043
			$2_2^+ \to 2_1^+$	0.6687	0.8907	0.4915	0.2775	0.o482
			$2_2^+ \to 0_1^+$	1.7079	1.9443	-0.0133	0.0025	0.0003
4_1^+	2.1534	2.1148	$4_1^+ \to 2_2^+$	0.4455	0.1705	-0.1279	-	o.0018
			$4_1^+ \to 2_1^+$	1.1142	1.0612	0.8512	0.0600	0.0665
2_3^+	2.1574	2.1949	$2_3^+ \to 2_2^+$	0.4495	0.2506	0.1974	-	0.0078
			$2_3^+ \to 0_2^+$	0.9470	0.7341	-0.2574	-	0.0132
			$2_3^+ \to 2_1^+$	1.1182	1.1413	-0.4306	-	0.0371
			$2_3^+ \to 0_1^+$	2.1574	2.1949	-0.0298	-	0.0002
0_3^+	2,3069	2.2099	$0_3^+ \to 2_2^+$	0.5990	0.2656	o.1268	0.1200	0.0161
			$0_3^+ \to 0_2^+$	1.0915	o.7491	0.0000	0.0000	0.0000
			$0_3^+ \to 2_1^+$	1.2677	1.1563	-0.0662	0.0350	0.0044
			$0_3^+ \to 0_1^+$	2.3063	2.2099	0.0000	-	0.0000
3_1^+	2.4515	2.8507	$3_1^+ \to 2_3^+$	0.2941	0.6558	-0.0551	-	0.0040
			$3_1^+ \to 4_1^+$	0.2981	0.7359	-0.3289	-	0.0154
			$3_1^+ \to 2_2^+$	0.7436	0.9064	0.5607	-	0.5449
			$3_1^+ \to 2_1^+$	1.4123	1.7971	-0.0006	-	0.5E-6
2_4^+	2.5356	2.4970	$2_4^+ \to 2_2^+$	0.8277	0.5527	0.1835	-	0.0067
			$2_4^+ \to 0_2^+$	1.3202	1.0362	0.3433	-	0.0236
			$2_4^+ \to 2_1^+$	1.4964	1.4434	0.0355	-	0.0002
4_2^+	2,8067	2.8099	$4_2^+ \to 4_1^+$	0.6533	0.6951	-0.2185	-	0.0053
			$4_2^+ \to 2_2^+$	1.0988	0.8656	-0.3693	0.0725	0.0152

Table(4):To be continued(2/3):

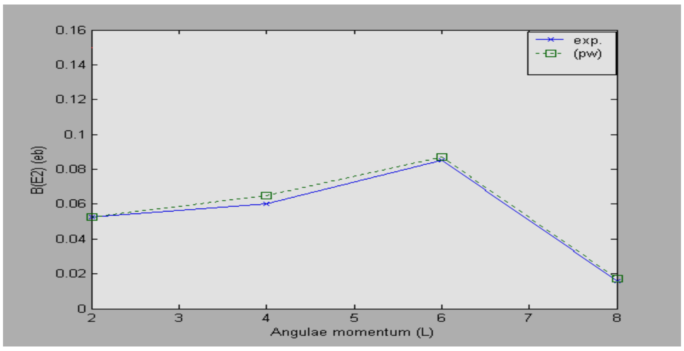
L_i^+	Energy level E(L) (MeV)		Spin sequence $L_i^+ - L_f^+$	Transition energy E_γ(MeV)		$\langle L_f \parallel \hat{T}^{(E2)} \parallel L_i \rangle$ (eb)	B(E2) $(eb)^2$	
	Exp.[12]	IBM-1		Exp.[12]	IBM-1		Exp.[12]	IBM-1
2_5^+	2.8877	2.8566	$2_5^+ \to 2_3^+$	0.7303	0.6617	0.0560	-	0.0006
2_6^+	2,9452	2.8734	$2_6^+ \to 2_2^+$	1.2373	o.9291	0.0999	-	0.0020
3_2^+	3.0468	3.2326	$3_2^+ \to 4_2^+$	0.2401	0.4227	-0.4120	-	0.0242
			$3_2^+ \to 3_1^+$	0.5953	0.3819	0.008E-6	-	0.7E-8
			$3_2^+ \to 2_3^+$	0.8894	1.0377	-0.4748	-	0.0322
			$3_2^+ \to 4_1^+$	0.8934	1.1178	-0.3028	-	0.0131
			$3_2^+ \to 2_2^+$	1.3389	1.2883	0.2839	-	0.0115
			$3_2^+ \to 2_1^+$	2.0076	2.1790	-0.0028	-	0.0E-4
4_3^+	3.0588	3.0133	$4_3^+ \to 4_2^+$	0.2521	0.2034	0.0306	-	0.0001
			$4_3^+ \to 2_3^+$	0.9014	0.8184	-0.6178	-	0.0024
			$4_3^+ \to 4_1^+$	0.9054	0.8985	0.4959	-	0.0273
			$4_3^+ \to 2_1^+$	2.0196	1.9527	0.0207	0.0050	0.0048
0_4^+	3.1070	2.6974	$0_4^+ \to 2_2^+$	1.3991	0.7531	0.0662	-	0.0043
			$0_4^+ \to 2_1^+$	2.0678	1.6438	-0.0259	-	0.0007
4_4^+	3.1942	3.2604	$4_4^+ \to 2_1^+$	2.1550	2.2068	-0.0815	-	0.0007
6_1^+	3.2979	3.1855	$6_1^+ \to 4_1^+$	1.1445	1.0707	0.7008	0.0850	0.0878
4_5^+	3,3730	3.3856	$4_5^+ \to 4_1^+$	1.2183	2.3320	0.2703	-	0.0081
			$4_5^+ \to 2_1^+$	2.3334	2.3320	-0.0081	-	0.07E-5
2_7^+	3.4230	3.4840	$2_7^+ \to 2_1^+$	2.3838	2.4304	0.0289	-	0.0002
5_1^+	3.4560	3.7978	$5_1^+ \to 4_1^+$	1.3026	1,6830	-0.0551	-	0.0003
3_3^+	3.4824	3.7152	$3_3^+ \to 2_4^+$	0.9538	1.2182	0.0280	-	0.0001
			$3_3^+ \to 2_3^+$	1.3320	1.5203	0.0800	-	0.0009
			$3_3^+ \to 4_1^+$	1.3360	1.6004	0.0690	-	0.0007
			$3_3^+ \to 2_2^+$	1.7815	1.7709	-0.0676	-	0.0006
			$3_3^+ \to 2_1^+$	2.4502	2.6616	0.0027	-	0.01E-4
6_2^+	3.6670	3.5401	$6_2^+ \to 4_1^+$	1.5136	1.4253	0.7662	-	0.0451

Table(4):To be continued(3/3):

L_i^+	Energy level E(L) (MeV)		Spin sequence	Transition energy E_γ(MeV)		$\langle L_f \parallel \hat{T}^{(E2)} \parallel L_i \rangle$	B(E2) $(eb)^2$	
	Exp.[12]	IBM-1	$L_i^+ - L_f^+$	Exp.[12]	IBM-1	(eb)	Exp.[12]	IBM-1
4_6^+	3.6775	3.7196	$4_6^+ \to 4_1^+$	1.5241	1.6048	0.0845	-	0.0008
			$4_6^+ \to 2_1^+$	2.6383	2.6660	0.0122	-	0.16E-4
6_3^+	3.7534	3.8467	$6_3^+ \to 4_2^+$	0.9467	1.0368	-0.3460	0.0675	0.0092
4_7^+	3.9280	3.9266	$4_7^+ \to 2_1^+$	2.8888	2.8730	-0.0152	-	0.25E-4
8_1^+	4.2045	4.2672	$8_1^+ \to 6_1^+$	0.9066	1.0817	0.5417	0.0162	0.0173
7_1^+	4.2991	4.6746	$7_1^+ \to 6_1^+$	1.0012	1,4891	0.3881	0.0002	0.0100
8_2^+	4.4316	4.6186	$8_2^+ \to 6_1^+$	1.1337	1.4331	0.1939	0.1075	0.0022
8_3^+	4.8521	4.9204	$8_3^+ \to 8_1^+$	0.6476	0.6532	-0.3870	-	0.0088
8_4^+	5.2994	5.3211	$8_4^+ \to 8_2^+$	0.8678	0.7025	-0.7157	-	0.0301
10_1^+	5.5399	5.3281	$10_1^+ \to 8_2^+$	0.1083	0.7095	0.1386	-	0.0009

Table (5):The calculated and experimental values of electric quadrupole moments.

Q_L	Value(eb)	Q_L	value(eb)	Q_L	value(eb)	Q_L	value(eb)	Q_L	value(eb)
Q_{2_1}	**0.0373 +0.03**[11]	Q_{3_1}	**-0,18x10^{-8}**	Q_{4_1}	**0.1336**	Q_{5_1}	**0.1023**	Q_{6_1}	**0.7407**
Q_{2_2}	**-0.0472**	Q_{3_2}	**-0.07x10^{-8}**	Q_{4_2}	**-0.0927**	Q_{5_2}	**-0.0351**	Q_{6_2}	**0.1485**
Q_{2_3}	**0.3996**	Q_{3_3}	**0.10x10^{-7} -**	Q_{4_3}	**0.3032**	Q_{5_3}	**-0.1754**	Q_{6_3}	**-0.4613**
Q_{2_4}	**-0.1975**	Q_{3_4}	**0.26x10^{-8}**	Q_{4_4}	**-0.0953**	Q_{5_4}	**0.2764**	Q_{6_4}	**0.3578**
Q_{2_5}	**0.4186**	Q_{3_5}	…..	Q_{4_5}	**-0.1555**	Q_{5_5}	**0.2165**	Q_{6_5}	**0.5516**
Q_{2_6}	**-0.6701**	Q_{3_6}	…..	Q_{4_6}	**0.2102**	Q_{5_6}	…..	Q_{6_6}	**0.1100**
Q_{2_7}	**0.4438**	Q_{3_7}	…..	Q_{4_7}	**0.0226**	Q_{5_7}	…..	Q_{6_7}	**0.6991**
Q_{2_8}	**0.3640**	Q_{3_8}	……	Q_{4_8}	**0.3106**	Q_{5_8}	…..	Q_{6_8}	**0.1271**
Q_{2_9}	**0.0157**	Q_{3_9}	……	Q_{4_9}	**0.9742**	Q_{5_9}	…..	Q_{6_9}	**0.4360**
$Q_{2_{10}}$	**-0.1385**	$Q_{3_{10}}$	……	$Q_{4_{10}}$	**-0.0282**	$Q_{5_{10}}$	…..	$Q_{6_{10}}$	**0.5491**



Figure(1):Electric transition probability B(E2) with angular momentum

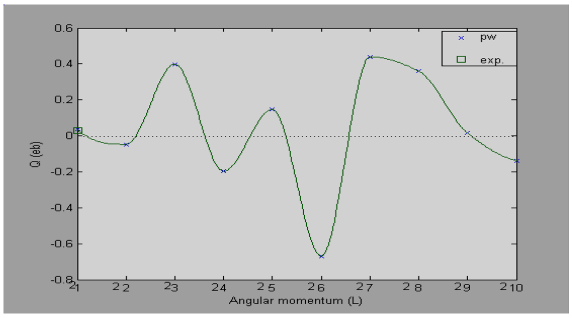


Figure (2): The electric quadrupole moment as a function of angular momentum L=2_1 to 2_{10}.

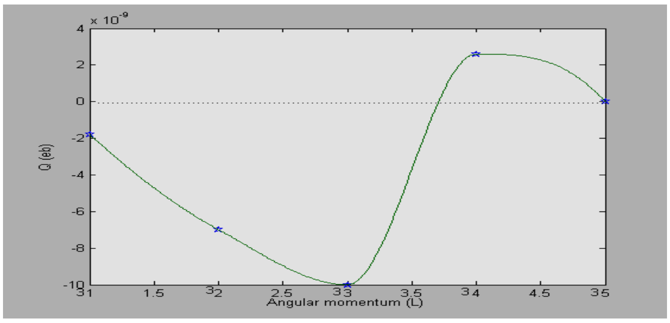
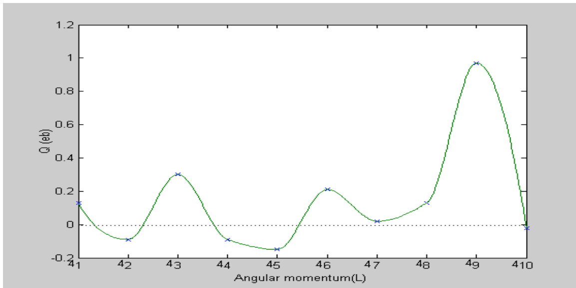
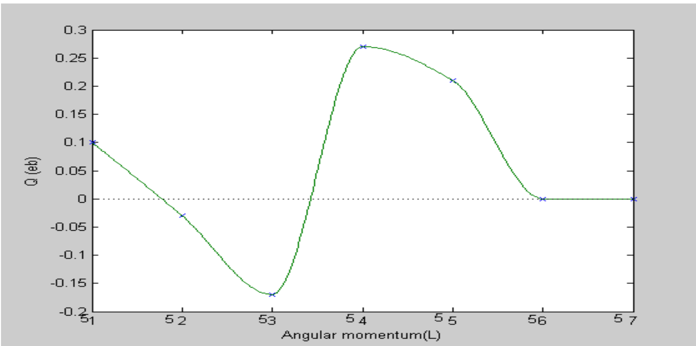


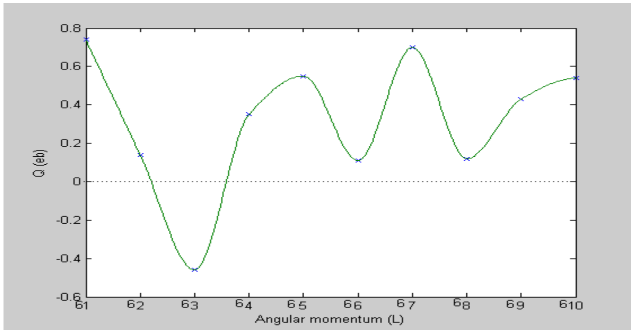
Figure (3): Same as in fig. (2) but for L=3_1 to 3_5.



Figure(4):The electric quadrupole moment as a function of angular momentum L=4_1 to4_{10}



Figure(5):The electric quadrupole moment as a function of angular momentum L=5_1 to5_7



Figure(6):The electric quadrupole moment as a function of angular momentum L=6_1 to6_{10}

دراسة التركيب النووي لنواة الجرمانيوم $^{70}_{32}Ge_{38}$ الزوجية–الزوجية المشوهة

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الخلاصة

في البحث الحالي تم استخدام نموذج البوزونات المتفاعله الاول (IBM-1) لحساب مستويات الطاقة الموجبة التناظر وانتقالاتها الكامية كداله للزخم الزاوي والعزوم الكهربائية رباعية القطب واحتمالية الانتقالات الكهربائية رباعية القطب التي تعتمد على عناصر المصفوفة المختزلة لنواة الجرمانيوم الزوجية - الزوجية التي تنتمي الى التناظر الديناميكي SU(5)-SU(3) لقد تم مقارنة هذه النتائج مع النتائج العملية المتوفرة وكانت النتائج متوافقة بشكل جيد.