crisis and the crisis of social relations); shows the influence of these processes on reforming the system of higher pedagogical education; described components of the system of higher pedagogical education in Poland in the late twentieth century; emphasises the formation of a radically different approach to solving the problem of teacher training in the period of transformation of the social structure, globalisation and integration processes in the world.

Keywords: *higher pedagogical education, system transformation, reforming the education system, teacher training, integration and globalization of educational processes.*

УДК 378:53

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THE CALCULATION OF ENERGY LEVELS AND ELECTROMAGNETIC TRANSITION E0, M1,E2 FOR CE AND W ISOTOPES BY IBM-2

We have employed the most convenient Hamiltonian that is needed for present calculations of nuclei Ce(A=130-138) and W(A=180-186) regain by the using of Interacting Boson Model-2 (IBM-2). After obtaining the best Hamiltonian parameters, level energies, B(E2), B(M1). B(E0) probabilities and the δ, X ratios of these nuclei were estimated. Results are compared with previous experimental and theoretical data and it is observed that they are in good agreement.

Introduction

The (IBM-2) is one of those models that has been successful in describing the low-lying nuclear collective motion in medium and heavy even-even nuclei [1, 2]. The IBM can describe transitional nuclei [3], as well as spherical and well deformed nuclei [4]. In the IBM, the original version [4] does not distinguish between the proton and neutron degrees of freedom, this is called IBM-1 is obtained as the totally symmetric subspace of the IBM-2. The IBM-2 has mixed symmetry states with respect to the proton and neutron degrees of freedom because of the distinction of proton bosons and neutron bosons.

The strength of electric monopole transitions $\rho^2(E0)$ can be used as a criterion for shape coexistence and mixing of configurations with different deformations. For instance in the neutron rich Sr, Zr, and Mo nuclei of mass closed to A=100, large *E*0 strengths have been found in $(0_2^+ \rightarrow 0_1^+)$ transitions suggesting that we interpret these states as due to a strong mixing of spherical and deformed configurations [5,6]. The highly deformed bands in the A=130 mass region are also candidates for such strong *E*0 transitions. In the decay out of ^{130}Ce highly deformed band, conversion-electron-CE spectroscopy measurements have shown an excess of electrons with respect to the yield expected from converted g transitions [7].

The aim of this study is to carry out some even-even nuclei, which are around the mass regions 130, 180 and to provide a clear description of their structure in the dynamic symmetry limits of IBM. Therefore, we have carried out a microscopic study of the energy levels and some selected transition probabilities, the ratios and branch ratios.

The model

We adopted the usual Hamiltonian in the following form[2]:

$$H = E_o + \varepsilon_d(\hat{n}_{d_\pi} + \hat{n}_{d_\upsilon}) + \kappa_{\pi,\upsilon}(\hat{Q}_\pi . \hat{Q}_\upsilon) + \hat{M}_{\pi\upsilon} + \hat{V}_{\pi\pi} + \hat{V}_{\upsilon\upsilon} \quad (1)$$

Where the indexes υ and π refer to neutron and proton bosons, respectively, and E_o is a constant which contributes to the total binding energy only. Moreover

$$\hat{n}_{d_\rho} = (d_\rho^\dagger . \tilde{d}_\rho) \qquad (2)$$

$$\hat{Q}_\rho = [a_\rho^\dagger \times \tilde{s}_\rho + s_\rho^\dagger \times \tilde{d}_\rho]^{(2)} + \chi_\rho [d_\rho^\dagger \times \tilde{d}_\rho]^{(2)} \qquad (3)$$

$$\hat{M}_{\pi\upsilon} = \frac{1}{2}\xi_2 [s_\upsilon^\dagger \times d_\pi^\dagger - s_\pi^\dagger \times d_\upsilon^\dagger]^{(2)} . [\tilde{s}_\upsilon \times \tilde{d}_\pi - \tilde{s}_\pi \times \tilde{d}_\upsilon]^{(2)} - \sum_{k=1,3} \xi_k [d_\upsilon^\dagger \times d_\pi^\dagger]^{(k)} . [\tilde{d}_\pi \times \tilde{d}_\upsilon]^{(k)}$$

The Majorana term $\hat{M}_{\pi\upsilon}$ is responsible for the location of mixed symmetry states with respect to fully symmetric ones. The term ($\hat{V}_{\rho\rho}$) shows from microscopic considerations represents the interaction between same bosons, it given following form:

$$\hat{V}_{\rho\rho} = \frac{1}{2}\sum_{(L=0,2,4)} c_{L\rho} [d_\rho^\dagger \times d_\rho^\dagger]^{(L)} . [\tilde{d}_\rho \times \tilde{d}_\rho]^{(L)} \qquad (5)$$

For the calculation of reduced transition probability and moments the following one-body electromagnetic operators were considered:

$$\hat{T}(E2) = e_\pi \hat{Q}_\pi + e_\upsilon \hat{Q}_\upsilon \qquad (6)$$

$$\hat{T}(M1) = \left[\frac{3}{4\pi}\right]^{1/2} (g_\pi \hat{L}_\pi + g_\upsilon \hat{L}_\upsilon) \quad \text{where:} \quad \hat{L}_\rho = \sqrt{10}[d_\rho^\dagger \times \tilde{d}_\rho]^{(1)} \qquad (7)$$

Where (e_π) and (e_υ) are boson effective charges depend on boson number and (g_π), (g_υ) are (g - factor) for the proton and neutron boson respectively. The Hamiltonian in eq.(1) is not F scalar because of the quadrupole-quadrupole interaction, whose strength is driven by $\kappa_{\pi,\upsilon}$, χ_ν, and χ_π . They determine a sharing of different F-spin components into excited states originally belonging to full- and mixed-symmetry bands. Diagonal matrix elements of operators in eq.(6) and (7) give, apart from usual numerical factors, electric quadrupole and magnetic dipole moments, respectively. Off-diagonal matrix elements of eq. (7) are very sensitive to mixed-symmetry components in the wave function. As a consequence, the mixing ratio δ(E2/M1) is also very sensitive to the presence of different F-spin components.

The M1 strength of gamma transition may be expressed in terms of the multipole mixing ratio which can be written as: [8]

$$\delta\left(\frac{E2}{M1}\right) = 0.835\ E_\gamma\ \Delta\left(\frac{eb}{\mu_N}\right) \quad \text{where} \quad \Delta = \frac{\langle I_f | T^{E2} | I_i \rangle}{\langle I_f | T^{M1} | I_i \rangle} \qquad (8)$$

Monopole transitions (E0) are known to be pure penetration effect, where the transition is caused by an electromagnetic interaction between the nuclear charge and the atomic electron penetrating the nucleus. An E0 transition occurs between two states of the same spin and parity by transferring the energy and zero unit of angular momentum. Thus E0 has no competing gamma ray. These transitions are different from zero only in the case where the transition is accompanied by the nucleus surface change. For example in the nuclear models where the surface is assumed to be fixed E0 transitions are strictly forbidden. Electric monopole transitions can occur not only in $0_i^+ \to 0_f^+$ transition but also, in competition with gamma multipole transition and depending on transition selection rules may compete in any ΔI=0 decay such as a $2_i^+ \to 2_f^+$. At transitions energies greater than $2m_0c^2$, monopole pair production is also possible. The E0 reduced transitions probability written as: [9]

$$B(E0;I_i \rightarrow I_f) = e^2 R^4 \rho^2(E0), \text{ where: } R = 1.2A^{1/3} \quad f.m \quad (9)$$

where e in the electronic effective charge, R is the nuclear radius and ρ(E0) is the transition matrix element. However, there are only limited cases where ρ(E0) can be measured directly. In most cases we have to determine the intensity ratio of E0 to the competing E2 transition calling this as X(E0/E2) value [10] which can be written as:

$$X\left(\frac{E0}{E2}\right) = \frac{B(E0;I_i \rightarrow I_f)}{B(E2;I_i \rightarrow I_{f'})} \quad (10)$$

where $I_f = I_{f'}$ for $I_i \neq 0$, and $I_f = 0$, $I_{f'} = 2$, for $I_i = 0$.

The $T^{(E0)}$ operator may be found by setting $l = 0$ on the IBM- 2 operator [11]:

$$\rho_{if}(E0) = \frac{Z}{R_0^2} \sum \tilde{\beta}_{0\rho} \langle f | d_\rho^\dagger \times d_\rho | i \rangle \quad (11)$$

ρ(E0) is a dimensionless quantity. The two parameter $\tilde{\beta}_{0\pi}$, $\tilde{\beta}_{0\nu}$ in eq.(11) may be estimated by fitting in isotope shift.

Calculation and Results

The parameters using in the NPBOS cade [12], to obtain the best fitting are given in tables (1,2) to calculated the energies levels for all isotopes. we found the energy as well obtain to the transition probability B(E2), B(M1), B(E0) and calculated the ratios δ(M1/E2), X(E0/E2).

Table 1

The parameters of the IBM-2 Hamiltonian. $x_\nu = -x_\pi = 0.9$, $C_{0\nu} = C_{2\nu} = C_{4\nu} = 0$ ***have been chosen for*** $^{130-138}$***Ce isotopes, all parameters are in MeV unit except*** x_ν ***and*** x_π ***which are dimensionless***

A	N_ν	N_π	ε_d	κ	ξ_1	ξ_2	ξ_3	$C_{0\pi}$	$C_{2\pi}$	$C_{4\pi}$
130	5	4	0.35	-0.230	0.300	0.300	-0.100	-0.300	0.300	0.300
132	4	4	0.45	-0.230	0.300	0.010	-0.100	-0.300	0.300	0.300
134	3	4	0.65	-0.190	0.300	0.170	-0.100	-0.300	0.300	0.300
136	2	4	0.85	-0.160	0.300	0.250	-0.100	-0.300	-0.300	0.300
138	1	4	0.90	-0.100	0.300	0.600	-0.050	-0.300	-0.300	0.300

Table 2

The parameters of the IBM-2 Hamiltonian. $x_\nu = x_\pi = \frac{\sqrt{7}}{2}$, $\xi_1 = 0.24$ ***have been chosen for*** $^{180-186}$***W isotopes, all parameters are in MeV unit except*** x_ν ***and*** x_π ***which are dimensionless***

A	N_ν	N_π	ε_d	κ	$C_{0\nu} = C_{0\pi}$	$C_{2\nu} = C_{2\pi}$	$C_{4\nu} = C_{4\pi}$	ξ_2	ξ_3
180	10	4	0.28	-0.062	0.05	-0.10	0.13	0.10	0.10
182	9	4	0.28	-0.062	0.05	-0.10	0.13	0.10	0.10
184	8	4	0.30	-0.062	0.10	-0.10	0.15	0.04	0.04
186	7	4	0.33	-0.060	0.10	-0.20	0.20	0.04	0.04

Table 3

The values using for e_ν, e_π in unit (e.b.), g_ν, g_π in unit (μ_N), β_ν, β_π in unit (b.) for the IBM-2 calculation

Nuclei	e_ν	e_π	g_ν	g_π	β_ν	β_π
$^{130-138}_{58}Ce$	0.15	0.10	0.0	1.0	0.59	1.05
$^{180-186}_{74}W$	0.14	0.12	0.15	0. 75	0.06	0.12

The calculated energy values are compared with the experimental data [13], and listed in table 2. We showed the agreement between the predictions of the model and the experimental data.

Table 4

The calculated energy values with the experimental data for the Ce isotopes

Spin Parity	^{130}Ce		^{132}Ce		^{134}Ce		^{136}Ce		^{138}Ce	
	E(exp)	E(IBM)	E(exp)	E(IBM)	E(exp)	E(IBM)	E(exp)	E(IBM)	E(exp)	E(IBM)
2_1^+	0.253	0.269	0.325	0.317	0.409	0.405	0.552	0.559	0.788	0.759
2_2^+	0.834	0.571	0.822	0.677	0.965	0.923	1.092	1.085	1.510	1.399
4_1^+	0.710	0.709	0.858	0.842	1.048	1.052	1.314	1.416	1.826	1.786
0_2^+	1.025	0.823	1.158	0.989	1.533	1.458	1.076	1.387	1.479	1.484
3_1^+	1.199	1.010	1.199	1.156	1.382	1.556	1.553	1.787	2.177	2.216
4_2^+	1.322	1.108	1.384	1.285	1.643	1.706		2.006	2.136	2.432
6_1^+	1.324	1.334	1.542	1.576	1.863	1.945	2.214	2.560	2.293	3.077
2_3^+	1.177	1.292	1.497	1.475	1.964	1.960	2.067	2.036	2.236	2.340
4_3^+		1.504	1.931	1.683	1.812	2.222		2.546	2.471	3.094
0_3^+		1.782		1.691		1.626		1.610		1.881
2_4^+	1.671	1.635	1.734	1.782		2.116	2.155	2.127	2.443	2.594
5_1^+	1.814	1.597	1.814	1.799	2.050	2.322		2.743	2.748	3.298
6_2^+	1.897	1.791	2.023	2.060		2.715		3.145	2.733	3.656
2_5^+	2.115	1.987	1.808	1.952		2.331	2.451	2.426	2.642	2.725
8_1^+	2.053	2.128	2.329	2.529	2.811	3.095		3.990	3.108	4.639
3_2^+		1.925		2.064		2.367		2.361		2.706
1_1^+		2.633		2.611		2.721	2.794	2.723	2.903	3.050
1_2^+		2.925		2.745		3.008	2.932	2.996		3.281

Table 5

The calculated energy values with the experimental data for the W isotopes

Spin Parity	^{180}W		^{182}W		^{184}W		^{186}W	
	E(exp)	E(IBM)	E(exp)	E(IBM)	E(exp)	E(IBM)	E(exp)	E(IBM)
2_1^+	0.103	0.104	0.100	0.101	0.111	0.102	0.122	0.110

Spin Parity	^{180}W		^{182}W		^{184}W		^{186}W	
	E(exp)	E(IBM)	E(exp)	E(IBM)	E(exp)	E(IBM)	E(exp)	E(IBM)
2_2^+	1.117	0.942	1.221	0.927	0.903	0.886	0.737	0.778
4_1^+	0.337	0.343	0.329	0.335	0.364	0.339	0.396	0.375
0_2^+	1.516	1.240	1.135	1.166	1.022	1.011	0.883	0.822
3_1^+	1.232	1.119	1.331	1.092	1.005	1.038	0.862	0.919
4_2^+	1.360	1.201	1.442	1.182	1.133	1.150	1.006	1.056
6_1^+	0.688	0.744	0.680	0.727	0.745	0.735	0.809	0.809
2_3^+	1.322	1.349	1.257	1.279	1.121	1.148	1.030	0.972
4_3^+	1.784	1.717		1.637	1.298	1.493	1.298	1.362
0_3^+	1.695	1.689		1.651	1.322	1.359	1.150	1.142
2_4^+	1.814	1.844		1.766	1386	1.408	1.285	1.226
5_1^+	1.535	1.388	1.623	1.365	1.294	1.346	1.197	1.263
6_2^+		1.724	1.756	1.681	1.470	1.640		1.563
2_5^+		1.989		1.890	1.431	1.441	1.322	1.254
8_1^+	1.138	1.324	1.114	1.293	1.252	1.310	1.249	1.449
3_2^+		2.073		1.992	1.425	1.542		1.360
1_1^+		2.130		2.024	1.613	1.612	1.563	1.513
1_2^+		2.877		2.738		2.243		1.961

For using eq. (8, 10, 11), we can the calculated the ratios δ, X and ρ(E0) for all nuclei in this paper, the results are given the following tables:

Table 6

The calculated values δ, X and ρ(E0) and experimental data for Ce isotopes

Nuclei	Quantity	$0_2 \to 0_1$	$0_3 \to 0_1$	$2_2 \to 2_1$	$2_3 \to 2_1$	$2_4 \to 2_1$	$2_5 \to 2_1$	$2_6 \to 2_1$
$^{130}_{58}Ce$	$\delta(E2/M1)$			- 0.84	0.08	- 0.03	0.11	0.18
	X(E0/E2)	0.0148	11.4132	0.0002	8.2	334.285	84.4814	98.1086
	$\rho(E0)$	0.0634	0.7180	0.0308	0.0547	0.1308	0.4086	0.5748
$^{132}_{58}Ce$	$\delta(E2/M1)$			- 0.76	0.15	0.16	0.11	0.06
	X(E0/E2)	0.5010	8.3709	0.0012	1.9767	136.933	26	61.6538
	$\rho(E0)$	0.1170	0.8157	0.0580	0.0780	0.3838	0.3231	0.4795
$^{134}_{58}Ce$	$\delta(E2/M1)$			- 1.21	0.02	0.07	0.006	0.18
	X(E0/E2)	2198.57	6.2406	0.0016	0.0021	772.5	740	145
	$\rho(E0)$	0.4652	0.0311	0.0586	0.3098	0.8073	0.1249	0.3497
$^{136}_{58}Ce$	$\delta(E2/M1)$			1.33	- 0.12	0.09	- 0.29	0.31
	X(E0/E2)	1.7458	2.28	0.0064	6.6158	233.208	7.8	1.8652
	$\rho(E0)$	0.6578	0.5500	0.0928	0.2734	0.6211	0.2643	0.1346
$^{138}_{58}Ce$	$\delta(E2/M1)$			- 3.54	- 0.15	- 0.25	- 0.20	0.14

Nuclei	Quantity	$0_2 \to 0_1$	$0_3 \to 0_1$	$2_2 \to 2_1$	$2_3 \to 2_1$	$2_4 \to 2_1$	$2_5 \to 2_1$	$2_6 \to 2_1$
	X(E0/E2)	0.2352	1.4528	0.0007	45.1025	1.4361	0.1411	7.8
	$\rho(E0)$	0.3400	0.0642	0.0246	0.3448	0.2007	0.0284	0.0513

Table 7

The calculated values δ, X and ρ(E0) and experimental data for W isotopes

Nuclei	Quantity	$0_2 \to 0_1$	$0_3 \to 0_1$	$2_2 \to 2_1$	$2_3 \to 2_1$	$2_4 \to 2_1$	$2_5 \to 2_1$	$2_6 \to 2_1$
$^{180}_{74}W$	$\delta(E2/M1)$			- 13.79	1.515	3.034	0.077	0.152
	X(E0/E2)	0.0877	6.5	0.0	0.8133	0.0100	2.3043	0.0493
	$\rho(E0)$	0.0797	0.0248	0.0	0.0763	0.0182	0.0501	0.0043
$^{182}_{74}W$	$\delta(E2/M1)$			- 12.63	1.559	2.588	0.109	- 0.370
	X(E0/E2)	0.0983	2.2	0.0	0.7243	0.0072	0.7419	9.4
	$\rho(E0)$	0.0826	0.0226	0.0	0.0791	0.0136	0.0327	0.0468
$^{184}_{74}W$	$\delta(E2/M1)$			- 5.718	0.810	0.084	- 0.132	1.851
	X(E0/E2)	0.0594	0.5303	0.0001	0.3137	1.8979	0.0101	0.0517
	$\rho(E0)$	0.0828	0.0567	0.0030	0.0752	0.0654	0.0021	0.0332
$^{186}_{74}W$	$\delta(E2/M1)$			- 14.209	0.832	0.090	0.007	2.374
	X(E0/E2)	0.0726	101.25	0.0	0.4186	6	256.66	0.0281
	$\rho(E0)$	0.0825	0.0606	0.0	0.0756	0.0330	0.0591	0.0260

From the table 4, we note in the $^{130-138}$Ce nuclei, the (2_3) state is ($2_{1,ms}$), while in the $^{132-134-136}$Ce nuclei as illustrated from the (δ) values in the table 6. The table 5 demonstrates mixed symmetry in the W isotopes where the (2_5) state in ^{180}W, the (2_6) state in ^{182}W, and the (2_4) state in $^{184-186}$W are the first mixed symmetry state. As well as we note the contrast in the X values because the difference in the E0, E2 values from the nuclei to other.

We can the calculated B(E2) ratios from the following relatives and compare with the experimental data of dynamic symmetry limits U(5), SU(3), and O(6):[14]

$$R_1 = \frac{B(E2;4_1\to2_1)}{B(E2;2_1\to0_1)} \quad R_2 = \frac{B(E2;2_2\to2_1)}{B(E2;2_1\to0_1)} \quad R_3 = \frac{B(E2;0_2\to2_1)}{B(E2;2_1\to0_1)} \quad R_4 = \frac{B(E2;2_2\to0_1)}{B(E2;2_2\to2_1)}$$

$$R_5 = \frac{B(E2;3_1\to2_1)}{B(E2;3_1\to4_1)} \quad R_6 = \frac{B(E2;4_2\to4_1)}{B(E2;4_2\to2_2)} \quad R_7 = \frac{B(E2;4_1\to2_1)}{B(E2;2_2\to2_1)}$$

Table 8

The calculated values of B(E2) ratios with the experimental data from ref. [13]

Nuclei	R_1	R_2	R_3	R_4	R_5	R_6	R_7
U(5)[13]	2	2	2	0.011	0.06	0.72	1.0
SU(3)	1.60	0.02	0.0	0.70	2.50	0.03	6.93

Nuclei	R_1	R_2	R_3	R_4	R_5	R_6	R_7
O(6)[13]	1.60	0.79	0.0	0.07	0.12	0.75	1.84
^{130}Ce	1.37	1.21	0.09	0.007	0.04	0.80	1.13
^{132}Ce	1.35	1.25	0.06	0.005	0.02	0.83	1.08
^{134}Ce	1.35	1.37	0.00004	0.00006	0.00007	0.92	1.01
^{136}Ce	1.40	1.45	0.27	0.0001	0.01	0.83	0.96
^{138}Ce	1.84	1.51	0.97	0.0	0.001	0.80	0.97
^{180}W	1.39	0.01	0.01	1.34	2.14	0.09	93.88
^{182}W	1.38	0.01	0.01	1.27	2.23	0.08	99.78
^{184}W	1.39	0.01	0.03	1.06	2.42	0.08	85.41
^{186}W	1.38	0.01	0.03	1.22	5.14	0.05	111.97

The calculated values for B(E2) ratios are explains the shape transition in theses nuclei from the γ-soft to vibration in Ce isotopes, while W isotopes are rotational limit through a slow change of the values.

We note from the table 8 the R values is vary with the shape transition in the isotopes on based the values for ($2_1^+ \rightarrow 0_1^+$) and ($2_2^+ \rightarrow 2_1^+$) transitions where the decrease with increase (A) in the Ce and W isotopes. The figure 1 is shows relation between E(MeV) and B(E0) for ($2_2^+ \rightarrow 2_1^+$) transition where notes the decline in B(E0) values with the increase E(2_2) value this corresponds to with the shape transition from O(6) to U(5) in Ce isotopes. In these isotopes there is an increase in B(E0) with energy because it was the O(6) limit except ^{138}Ce isotope, the nuclei is U(5) limit where E0 transition be very small, W isotopes be the transition probability roughly constant and small because it was the SU(3) limit and the energy of (2_2) and (2_1) are slowly changing, while B(E2) values are fairly large for same transition.

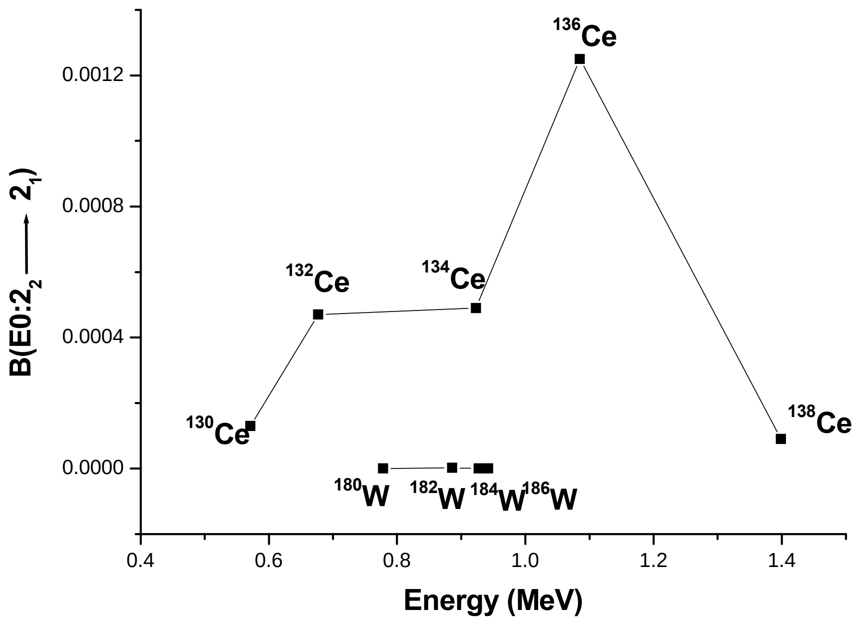

Figure 1. The relation between the energy of (2_2) and B(E0:$2_2 \rightarrow 2_1$)

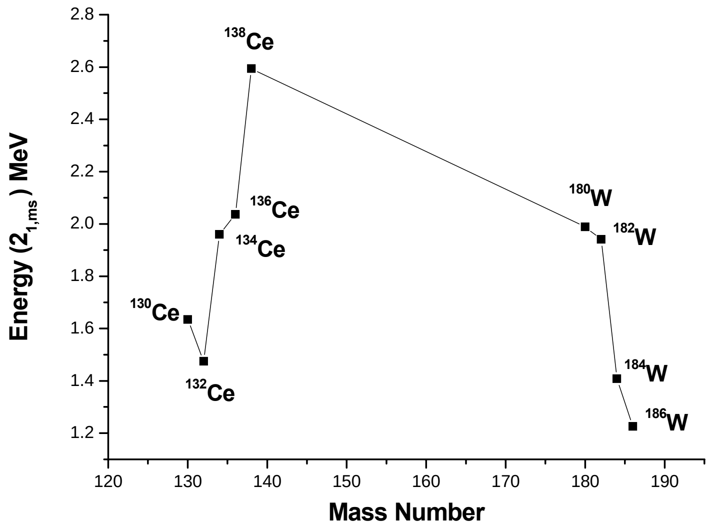

Figure 2. The relation between the energy of ($2_{1,ms}$) and mass number A

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Алі Махді Аль-Гарпауі, Хусам Абдул-Амір Аль-Шаммарі. Розрахунок енергетичних рівнів електромагнітних переходів CE і W з використанням IBM-2.

Використано найбільш зручний Гамільтоніан необхідний для сучасних розрахунків ядер Ce (A=130-138)Та W(A=180-186), отриманих з використанням моделі взаємодіючих бозонів (IBM-2) після отримання найкращих параметрів Гамільтоніана енергетичних рівнів B(E2), B(M1), B(E0) імовірностей та δ, х співвідношень ядер.

Отримані результати добре співпадають з отриманими раніше експериментальними та теоретичними даними.

Али Махди Аль-Гарпауи, Хусам Абдул-Амир Аль-Шаммари. Расчет энергетических уровней электромагнитных переходов CE и W с использованием IBM-2.

Использован наиболее удобный Гамільтоніан необходимый для современных расчетов ядер Ce (A=130-138) Та W(A=180-186), полученных с использованием модели взаимодействующих бозонов (IBM-2) по получении наилучших параметров Гамільтоніана энергетических уровней B(E2), B(M1), B(E0) вероятностей и δ, х соотношений ядер.

Полученные результаты хорошо совпадают с полученными ранее экспериментальными и теоретическими данными.