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Study the transition strengths $|M(E2)|^2$ and transition probability B(E2) in $_{52}$Te & $_{34}$Se nuclei

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Abstract
Have been calculated the values of the transition strengths $|M(E2)|^2$ for the isotopes with even mass number $_{52}$Te ($120 \leq A \leq 136$) and $_{34}$Se ($68 \leq A \leq 86$) of even–even nuclides.
The values of ($|M(E2)|^2$) have been calculated by dependence on value of The total gamma width (Γ_{γ}) and the partial gamma widths of electric quadruple Γw.u (E2). Have been plotted the change of the values of $|M(E2)|^2$ with number of neutrons (N)
Have been calculated the values of B(E2) for a number for the isotopes with even mass number $_{52}$Te ($120 \leq A \leq 136$) and $_{34}$Se ($68 \leq A \leq 86$) of even–even nuclides. For comparison purpose with theoretic values that contain: ("SSANM, Adopted values, Global Best fit, and FRDM") have been plotted the change of the values of B(E2) with number of neutrons (N).

Keywords: Transition probability B(E2), Mean lifetime, Transition strengths $|M(E2)|^2$, Gamma Width

Introduction
An atom contains an atomic nucleus and is the, central portion of an atom and be small and thick. It contains two collections of protons and neutrons is distributed on certain energy states, and their mutual interactions very complex holds them together [1].
Used the electromagnetic transition to knowing the structure of nuclei and is one of the chief goals of the nuclear physics. In (Even-even) nuclei the transition strength for gamma transition is significant factor and use to decide the comparative significance of the collective and single-particle influence to define transitions styles and construction of the nucleus, and provides a decent information of spins, the energie and life times of the excited states in nuclei [1].
The transition probability B(E2) denote elementary nuclear data of the energies of low levels in these nuclides. Commonly, the values of B(E2) confirm the wide happening of quadruple deformations in nuclides [2].

Theory
Transition Strengths $|M(E2)|^2$
The total gamma width (Γ_{γ}) of a definite mean lifetime (τ_m) were defined by the following [3]:

$$\Gamma_{\gamma} = \frac{\hbar}{\tau_m} \tag{1}$$

Where:
ħ: the Dirac constant which equal ($0.658212 * 10^{-15}$ eV.s).

$$\tau_m = \frac{t_{1/2}}{ln2} \tag{2}$$

Where: $t_{1/2}$: Lifetime of level
"The partial gamma width ($\Gamma_{\gamma i}$), If two or more gamma-rays de-excited from the similar state" shown in eq. (3):

$$\Gamma_{\gamma i} = \Gamma_{\gamma}\ B.R\ (\gamma i) \quad (3)$$

Where:

$$B.R(\gamma i) = \frac{I_{\gamma i}}{I_{tot}} \times 100\% \quad (4)$$

Where:
$I_{\gamma i}$: the intensity of ith gamma -transition.
I_{tot}: the entire intensity, were defined by the following:

$$I_{tot} = \Sigma\ I_{\gamma i} \quad (5)$$

The transition strengths of E2 determine by the total gamma width (Γ_{γ}) by by equation (6) [3]:

$$|M(E,M(L))|^2 = \frac{\Gamma(E,M(L))}{\Gamma w.u\ (E,M(L))} \quad (6)$$

Where:
Γ(E,M(L)): is the partial gamma width of magnetic transfer, electric transfer.
$\Gamma_{w.u}$ (E,M(L)): is the partial gamma width of magnetic transfer, electric transfer, (in Weisskopf units).
L: are manifold orders.
"For mixed (M1+E2) gamma -ray transition, the Γ(E2) and Γ(M1) components", which is calculated by equations (7&8) [4].

$$\delta^2 = \frac{\Gamma(E2)}{\Gamma(M1)} \quad (7)$$

$$\Gamma(E2) + \Gamma(M1) = \Gamma_{\gamma} \quad (8)$$

Where δ = 0 For pure E2 transitions [1],

$$\Gamma(E2) = \Gamma_{\gamma} \quad (9)$$

The $|M(E2)|^2$ of the γ-ray which is calculated by equation (10) [4]:

$$|M(E2)|^2 = \frac{\Gamma(E2)}{\Gamma w.u\ (E2)} \quad (10)$$

Γw.u (E2): the partial gamma width calculated by equation below [4]:

$$\Gamma_{w.u}\ (E2) = 4.7925 * 10^{-23}\ A^{4/3}\ E_{\gamma}^{5} \quad (11)$$

Where
A: the mass number
Eγ: "the energy of the gamma -transitions" in (keV units).

2-Transition Probability B (E2)
"The reduced electric quadruple transition probability B(E2) for (E2-transition $0^+ \rightarrow 2^+$)" of even–even nuclides which is calculated from equation below [2]:

$$B(E2)\uparrow = \frac{2.6 * Z^2}{E_{\gamma_0} * A^{\frac{2}{3}}} \quad (12)$$

Result and Dissection
1-Gamma Width and Transition Strengths $|M(E2)|^2$
The mean lifetime have been calculated using Equation (2), whose life times have been informed previously [5] and used to compute the total gamma width (Γ_{γ}) using Equation (1).
The partial gamma widths Γwu (E2) have been calculated in W.u units; for γ-transitions using Equation (11) and the $M(E2)|^2$ calculating done using Equation (10) for the isotopes with even mass number $_{52}$Te (120≤ A ≤136) and $_{34}$Se (68≤ A ≤ 86) of even–even nuclides of some γ-transitions.
The results of the $M(E2)|^2$ for $_{52}$Te (120≤ A ≤136) and $_{34}$Se (68≤ A ≤ 86) nuclides are presented in table (1 &2) respectively. The $M(E2)|^2$ for $_{52}$Te (120≤ A ≤136) and $_{34}$Se (68≤ A ≤ 86) nuclides have been plotted as a function of neutrons number using excel program (version 2016) which are clarified in Figures (1, 2) respectively.

Table 1: Mass number (A), Neutrons number (N), lifetime of level $t_{1/2}$, Mean life time (τ_m), Total gamma width (Γ_{γ}), The partial gamma widths Γ(E2)w.u.x and The transition strengths $M(E2)|^2$W.U.↓for even–even nuclides $_{52}$Te (120≤ A ≤136).

A	N	The energy of the γ-transitions (keV) E_i [5]	The energy of the γ-transitions (keV) E_γ [5]	lifetime of level $t_{1/2}$ (ps) [5]	mean lifetime τ_m (ps)	The total gamma width (Γ_{γ}) Γtot x 10^{-6} (eV)	The partial gamma widths Γ(E2)w.u. x 10^{-6} (eV)	The transition strengths $M(E2)|^2$W.U.↓
120	68	560.438	560.44	9.3	0.134	0.490	1.57	31.279
122	70	564.117	564.119	7.4	0.106	0.616	1.66	37.216
124	72	602.732	602.730	6.2	8.944	0.735	2.36	31.216
126	74	666.338	666.331	4.52	6.520	100.938	3.98	25.381
128	76	743.219	743.22	3.32	4.789	137.421	7.01	19.601
130	78	839.494	839.49	2.30	3.318	198.364	0.132	15.073
132	80	973.90	973.9	1.83	2.640	249.31	0.282	8.834
134	82	1279.7	1279.1	0.64	92.332	712.872	0.0113	6.320
136	84	605.91	605.91	21.6	0.311	0.211	2.74	7.716

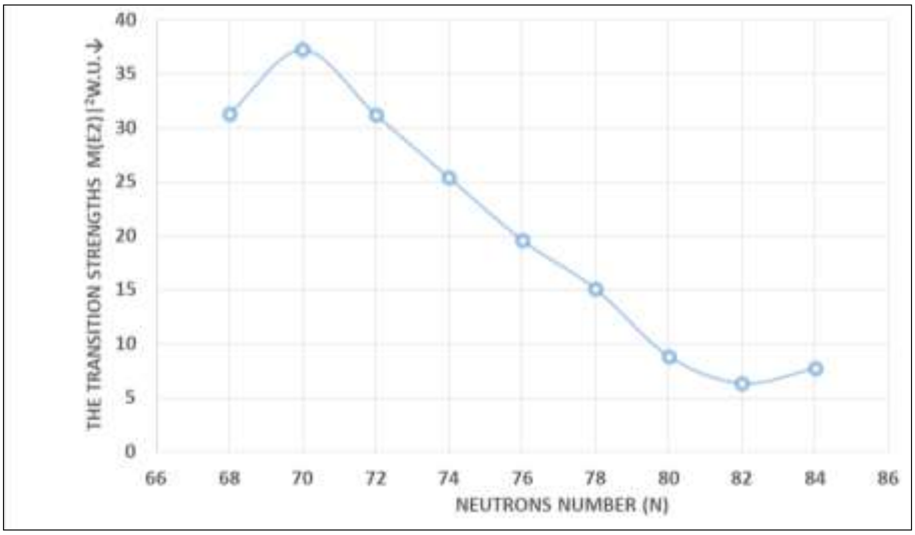

Fig 1: The M(E2)|²W.U.↓ as a function of (N) for even–even nuclides $_{52}$Te (120≤ A ≤136).

Table 2: Mass number (A), Neutrons number (N), lifetime of level $t_{1/2}$, Mean life time (τ_m), Total gamma width (Γ_γ), The partial gamma widths Γ(E2)w.u.x and The transition strengths M(E2)|²W.U.↓for even–even nuclides $_{34}$Se (68≤ A ≤ 86).

A	N	The energy of the γ-transitions (keV) E_i [5]	The energy of the γ-transitions (keV) E_γ [5]	Lifetime of level $t_{1/2}$(ps) [5]	Mean lifetime τ_m (ps)	The total gamma width (Γ_γ) Γtot x 10^{-6} (eV)	The partial gamma widths Γ(E2)w.u.x x 10^{-6} (eV)	The transition strengths M(E2)|²W.U.↓
68	34	853.75	853.71	2.8	4.03955	162.942	6.03338	27.006
70	36	944.6	944.6	2.23	3.21721	204.591	10.3976	19.676
72	38	862.08	862.03	2.82	4.0684	161.786	6.83508	23.670
74	40	634.76	634.78	7.08	0.102143	64.4404	1.53433	41.999
76	42	559.101	559.101	12.3	0.177451	37.0925	0.842878	44.006
78	44	613.727	613.725	9.79	0.14124	46.6024	1.39069	33.510
80	46	666.16	666.14	8.52	0.122918	53.549	2.16725	24.708
82	48	654.69	654.6	12.8	0.184665	35.6436	2.05349	17.357
84	50	1455.11	1455.1	0.42	60.5932	1086.28	115.013	9.444
86	52	704.30	704.30	7.5	0.108202	60.8317	3.15269	19.295

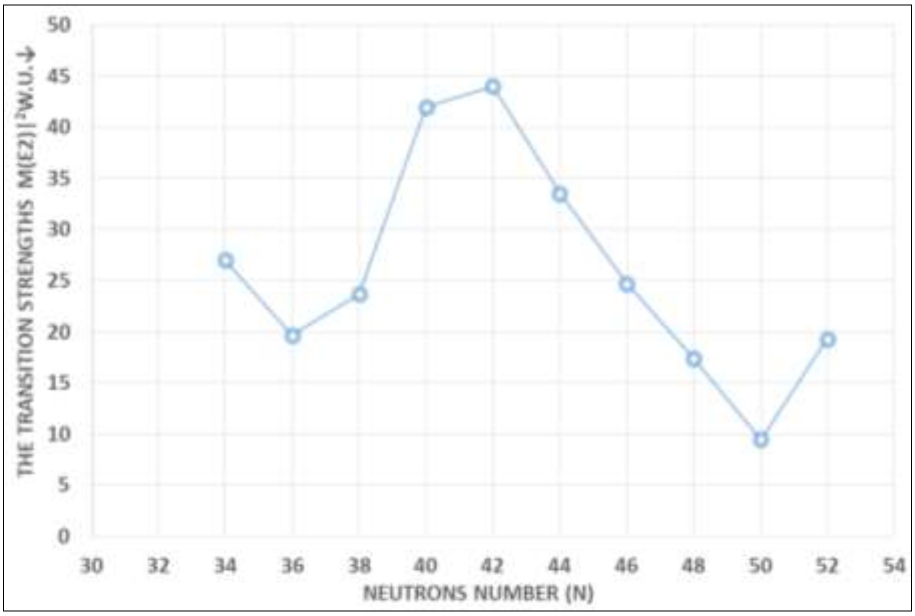

Fig 2: The M(E2)|²W.U.↓ as a function of (N) for even–even nuclides$_{34}$Se (68≤ A ≤ 86).

2. Transition Probability B(E2)

The B(E2) calculating done using Equation (12), for even–even nuclides $_{52}$Te (120≤ A ≤136) and $_{34}$Se (68≤ A ≤ 86), The results of the B(E2) for even–even nuclides $_{52}$Te (120≤ A ≤136) and $_{34}$Se (68≤ A ≤ 86) are presented in table (3 &4) respectively.

For comparison purpose The B(E2) for even–even nuclides $_{52}$Te (120≤ A ≤136) and $_{34}$Se (68≤ A ≤ 86) have been plotted as a function of neutrons number using excel program (version 2016) which are clarified in Figures (3, 4) respectively.

Table 3: Mass number (A), Neutrons number (N), The energy of the γ-transitions (E_{γ}), Values of reduced transition probabilities B(E2) e^2 b^2 ↑ for even–even nuclides $_{52}$Te (120 ≤ A ≤ 136)

A	N	E_{γ}(keV)	B(E2; 21+ →01+) e^2 b^2				
			Present work values	Theoretical values [[2]]			
				Adopted values	Global Best fit	SSANM	FRDM
120	68	560.44	0.515622227	0.77	0.51	0.934	0.418
122	70	564.119	0.506645622	0.660	0.50	0.911	0.336
124	72	602.730	0.469073965	0.568	0.46	0.782	0.227
126	74	666.331	0.419796124	0.475	0.41	0.612	0.198
128	76	743.22	0.372440229	0.383	0.376	0.458	*
130	78	839.49	0.326337416	0.295	0.32	0.328	*
132	80	973.9	0.278451598	*	0.275	0.220	*
134	82	1279.1	0.209798317	*	0.207	0.112	*
136	84	605.91	0.438745467	*	0.43	0.346	*

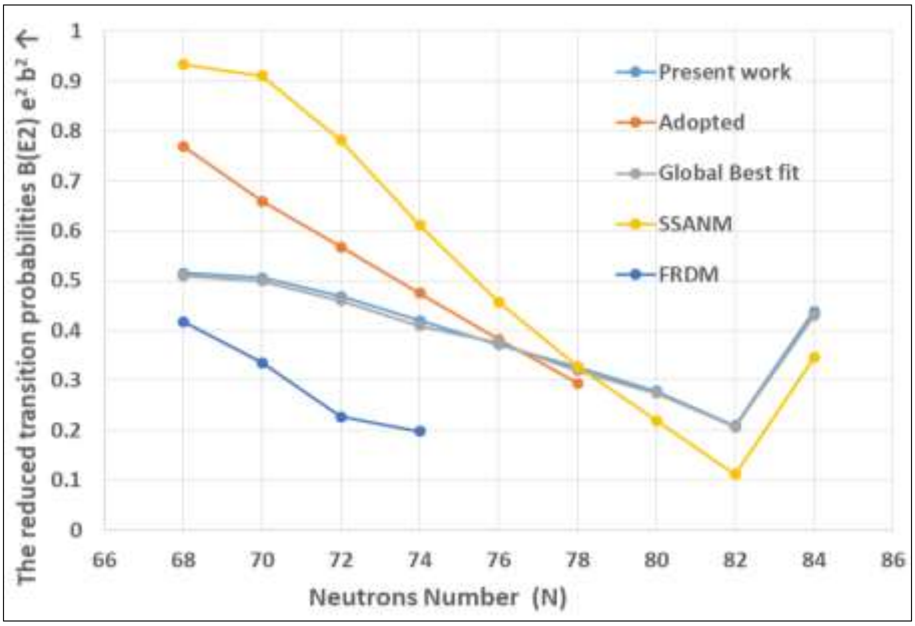

Fig 3: The B(E2) e^2 b^2 ↑ as a function of (N) for even–even nuclides $_{52}$Te (120≤ A ≤136).

Table 4: Mass number (A), Neutrons number (N), The energy of the γ-transitions (E_{γ}), Values of reduced transition probabilities B(E2) e^2 b^2 ↑for even–even nuclides $_{34}$Se (68≤ A ≤ 86).

A	N	E_{γ} (keV)	B(E2; 21+ →01+) e2 b2				
			Present Work values	Theoretical values [2]			
				Adopted Values	Global Best fit	SSANM	FRDM
68	34	853.71	0.211313799		0.208	0.419	0.218
70	36	944.6	0.18733455	0.38	0.185	0.462	0.302
72	38	862.03	0.201447531	0.207	0.199	0.494	0.258
74	40	634.78	0.268637818	0.387	0.265	0.510	0.206
76	42	559.101	0.299616126	0.420	0.30	0.455	0.195
78	44	613.725	0.268262242	0.335	0.265	0.373	0.100
80	46	666.14	0.243011022	0.253	0.240	0.296	0.118
82	48	654.6	0.243231363	0.182	0.240	0.229	0.118
84	50	1455.1	0.107691766	*	0.106	0.146	0.014
86	52	704.30	0.219032147	*	0.216	0.309	0.090

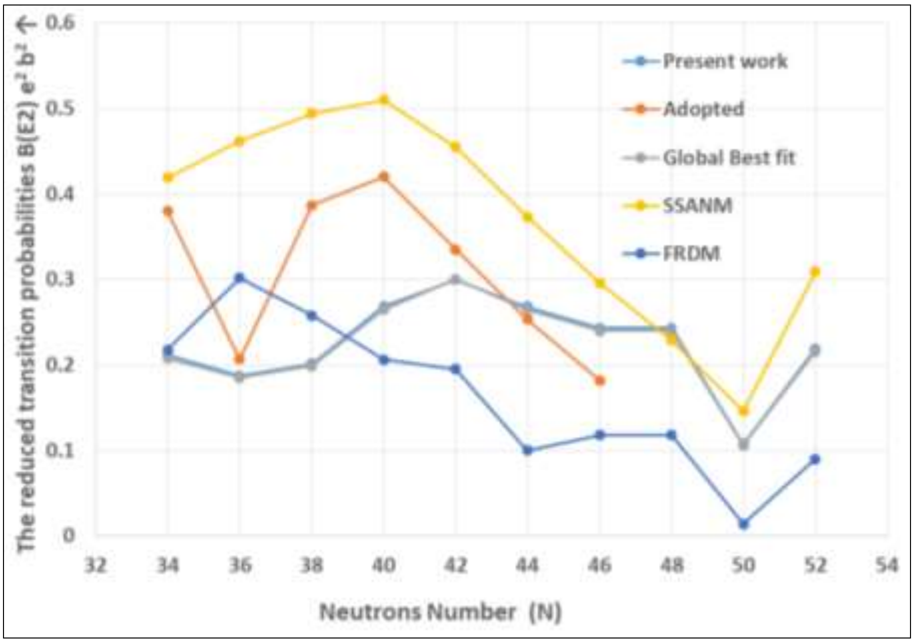

Fig 4: The B(E2) e^2 b^2 ↑ as a function of (N) for even–even nuclides $_{34}$Se (68≤ A ≤ 86).

This work concentrated on the calculation of $|M\ (E2)|^2$ and B(E2) e^2 b^2 ↑ for the isotopes with even mass number $_{52}$Te (120≤ A ≤136) and $_{34}$Se (68≤ A ≤ 86) of even–even nuclides, as some of these nucleus have magic number of Neutrons such as N= (82) for ($_{52}$Te) nuclide and Z= 50 for ($_{34}$Se) nuclide.

From the table 1 & 2 we can notice the values of "total gamma width (Γ_γ)" are bigger than "partial gamma widths Γ(E2) w.u.x" particularly when the number of neutrons closer from the magic number.

As is clear in Figures 1 & 2 the $|M\ (E2)|^2$ values decreased with increased number of neutrons, the $|M\ (E2)|^2$ have the minimum value when number of neutrons nearer to the magic number, As is clear in figure (1) for even–even nuclides $_{52}$Te (120≤ A ≤136), when neutrons number (N=82), the $|M\ (E2)|^2$ have minimum value (6.320). While figure (2) for even–even nuclides $_{34}$Se (68≤ A ≤ 86), when neutrons number (N=50), the $|M\ (E2)|^2$ have minimum value (9.444).

Have been compared our calculations for B(E2) e^2 b^2 ↑ for the isotopes with even mass number $_{52}$Te (120≤ A ≤136) and $_{34}$Se (68≤ A ≤ 86) of even–even nuclides with theoretic values that contain: ("SSANM, Adopted values, Global Best fit, and FRDM").

As is clear in Figures 3 & 4 the values of present work of B(E2) e^2 b^2 ↑ are closely with Global Best fit, and have the minimum value when number of neutrons nearer to the magic number, As is clear in figure (1) for even–even nuclides $_{52}$Te (120≤ A ≤136), when neutrons number (N=82), the B(E2) e^2 b^2 ↑ have minimum value (0.209798317). While figure (2) for even–even nuclides $_{34}$Se (68≤ A ≤ 86), when neutrons number (N=50), the B(E2) e^2 b^2 ↑ have minimum value (0.107691766).

Conclusions

The value of $|M\ (E2)|^2$ depends on the (total gamma width (Γ_γ)) and the partial gamma widths Γwu (E2)"), while B(E2) e^2 b^2 ↑ depends on the " The energy of the γ-transitions E_γ and Mass number (A) " of the nucleus.

We can notice decrease values of $|M\ (E2)|^2$ more when the neutrons number of the nuclide near to "magic number" (82 & 50) for ($_{52}$Te) and ($_{34}$Se) nuclides that denotes to the stability of the nuclide.

It is clear from values of present work of B(E2) e^2 b^2 ↑ almost equal with values of the "Global Best fit" for ($_{52}$Te) and ($_{34}$Se) nuclides respectively.

References

1. Hadi RS. Study of excited structure for even-even nuclides of Z = 50, 48, 46 in the first excited state A. Baghdad; c2015.
2. Raman S, Nestor CW, Tikkanen P. Transition probability from the ground to the first-excited 2^+ state of even–even nuclides. At. Data Nucl. Data Tables. 2001 May;78(1):121-128.
3. Jarallah NT. Calculation of the transition strengths $|M(E2)|^2$ and transition probability B(E2) in ^{38}Sr and ^{58}Ce nuclei. J. Coll. Educ., 2015, 1.
4. Son NA, Khang PD, Hoa ND, Hai NX, Lanh D. Determination of gamma width and transition strength of gamma rays from ^{48}Ti (*n,*2 gamma) ^{49}Ti reaction. Int. J. Comput. Eng. Res. 2013;3:33-37.
5. Stone F, V.S. Table of isotopes. 8th ed. New York: John Wiley and Sons; c1999.