Study The Electric Quadrupole Transition Strengths $[M(E2)]^2$ In $_{18}$Ar And $_{20}$Ca Nuclei By Using Internal Conversion Coefficient.

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Abstract

The theoretical internal conversion coefficient values were used to study The reduced transition probability $B(E2)_{w.u.}\downarrow$ produced by pure electric quadrupole emission in even – even isotopes of $_{18}$Ar and $_{20}$Ca which have been calculated and plotted as a function for neutron number (N) by using life times of 2_1^+ first excited state and the γ_{0}- relative intensity. the $B(E2)_{w.u.}\downarrow$ values are converted to $[M(E2)]^2_{w.u}\downarrow$ values and then, the present $[M(E2)]^2_{w.u}\downarrow$ values are compared with previous study results.

Key words: Electric Quadrupole Transition (E2), Internal Conversion Coefficients(α_{tot}) ,Transition Strengths For Gamma-Ray.

دراسة قوى الانتقال لرباعي القطب الكهربائي$[M(E2)]^2$ في نويدات $_{18}$Ar و$_{20}$Ca بأستخدام معامل التحول الداخلي.

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الخلاصة

استخدم قيم معامل التحول الداخلي النظرية لدراسة احتمالية الانتقال المختزل $B(E2)_{W.U.}\downarrow$ لانتقالات كاما الناتجة عن أشعاع رباعي قطب كهربائي نقي للنظائر الزوجية- زوجية لكل من ^{36}Ar و ^{40}Ca كدالة إلى العدد النيوتروني. حيث حسبت احتمالية الانتقال $B(E2)_{W.U.}\downarrow$. ايضا بالاعتماد على معدل العمر للمستوي المتهيج الأول 2_1^+ والشدة النسبية لأشعة كاما المنبعثة من ذالك المستوي المحفز إلى المستوي الأرضي. قيم احتمالية الانتقال $B(E2)_{W.U.}\downarrow$ حولت الى $[M(E2;2^+\rightarrow0^+)]^2_{W.u.}\downarrow$ ومن ثم قورنت مع دراسة سابقة.

كلمات مفتاحية: أنتقال رباعي قطب كهربائي(E2), معاملات التحول الداخلي(α_{tot}), قوى الانتقال لاشعة كاما.

INTRODUCTION

The study of electromagnetic transition in nuclei has become widely used as a source of information about the nuclear structure. The best studies for electromagnetic transitions modes in nuclei are those involving electric quadrupole transition $|M(E2)|^2$, since the great amount of measured $|M(E2)|^2$ values for gamma transitions in even-even nuclei gives us a good knowledge of the energies, spins,parties and life times of the excited states in nuclei, besides in recent years the electric quadrupole transition E2 is used as a tool to understand the structure of magic nuclei.

MATERIALS AND METHODS

The WeissKopf single-particle transition probability B(EL,ML) is defined[1] as the ratio of the single-particle half-life time to the experimental half-life time for gamma transition

$$B(EL,ML)_{W.u}\downarrow=\frac{t^{\gamma}_{1/2}(EL,ML)_{SP}}{t^{\gamma}_{1/2}(EL,ML)_{\exp}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$t^{\gamma}_{\frac{1}{2}}(EL,ML)_{sp}=\frac{9.5235\times10^{6}}{E_{\gamma}^{5}A^{4/3}} \quad \ldots\ldots\ldots\ldots\ldots(2)$$

The experimental value of B(E2) is based on the traditional types of measurement [2], where B(E2)↑ values can be extracted from a level life time (τ) measurements(or vice versa), it is necessary to know the total internal conversion coefficient (α). The B(E2)↑ and(τ) values are related through;

$$\tau_m (1+\alpha) = \tau_0 = 10^{13} E^{\approx 5} [B(E2) \uparrow / e^2 b^2]^{\approx 1}$$

$$t^{\gamma}_{\frac{1}{2}}(EL,ML)_{Exp} = t_{\frac{1}{2}}(EL,ML)(1+\alpha) \quad \text{……..(3)}$$

Where L is the multipolarities L=1,2,3,………

L≠ 0 , $t_{\frac{1}{2}}$ is the half- life time of initial level in ps, E is in unit of keV, B (E2)↓ in e^2 b^2 and α is the the total internal conversion coefficient.

While the γ-ray transition strength $[M(EL,ML)]^2$ is defined as the ratio of gamma width to gamma width in Weisskopf unit (W.u.) [3]

$$[M(EL,ML)]^2_{W.u.}\downarrow = \frac{\Gamma(EL,ML)_{\exp}}{\Gamma(EL,ML)_{W.u.}} \quad \text{…………(4)}$$

Since $\Gamma_\gamma T \approx \hbar$ …………(5)

Where;

Γ_γ is the total width

$\Gamma_\gamma = \sum \Gamma_{\gamma l}$ …………(6)

$\Gamma_{\gamma l}$ is the partial gamma width

T is the mean life time of initial level

$$T = \frac{\tau_{1/2}}{\ln 2} \quad \text{…………..(7)}$$

$\hbar = \frac{h}{2\pi} = 0.65822 \times 10^{-15}$ eV.s , h is the Planck constant.

From eqs. (4, 5 and 6) , it can be concluded that:

$$B(EL,ML)_{W.u.}\downarrow = [M(EL,ML)]^2_{W.u.} \quad \text{...........(8)}$$

RESULTS AND DISCUSSION

The reduced electric quadrupole transition probability by Weisskopf unit, $B(E2)_{w.u.}\downarrow$ for the $2^+ \rightarrow 0^+_{g.s.}$ transition have been calculated as a function of neutron number (N) using eq. (1) with the aid of the internal conversion coefficients values for pure γ –transiton in ref. [4] and the experimental data reported in ref. [1] to even –even isotopes for; $_{18}$Ar (34≤A≤42) and $_{20}$Ca (40≤A ≤48) which have only one transition for γ is γ_0 with intensity (100%)E2.

The results of calculations are presented in table (1) for $_{18}$Ar nuclides and in table (2) for $_{20}$Ca nuclides. . The reduced transition probability B(E2)↓ are plotted as a function of neutron number (N) as shown in Fig. (1) and Fig. (2) for $_{18}$Ar and $_{20}$Ca respectively . For the sake of comparison, the $B(E2)_{w.u.}\downarrow$ values are converted to electric Quadrupole Transition Strengths $[M(E2)]^2_{w.u}\downarrow$ using eq. (8) and then, the present $[M(E2)]^2_{w.u}\downarrow$ values of γ_0 -transitions in $_{18}$Ar and $_{20}$Ca nuclides are compared with previous study as well as. This comparison are presented in tables (3 and 4) and shown in Figs. (3 and 4) respectively.

Table-1: Reduced transition probability $B(E2)_{w.u.}\downarrow$ of γ_0- transitions from $2_1^+ \rightarrow 0_1^+$ with internal conversion coefficient α of ref.[4] ,the experimental half-life time for gamma-ray $t_{1/2}^{\gamma}(E2)$, single particle half-life time for gamma-ray $t_{1/2}^{\gamma}(E2)_{SP}$ of $_{18}$Ar nuclei ,the experimental data [1]are used in the calculations.

A	N	E_i (keV)	$E_{\gamma 0}$ (keV)	$t_{1/2}$ (fs)	$t_{\frac{1}{2}}^{\gamma}(E2)$ (fs)	internal conversion coefficient $\alpha \times 10^{-5}$	$t_{\frac{1}{2}}^{\gamma}(E2)_{SP}$ (fs)	$B(E2)_{w.u.}\downarrow$
34	16	2090.9	2090.8	320±40	320.00424± 40.000531	1.328	2166.638	6.77 ± 0.84
36	18	1970.39	1970.33	320 ±30	320.00512± 30.00048	1.602	2701.1945	8.44 ± 0.79
38	20	2167.472	2167.405	470 ± 20	470.00585 ± 20.000249	1.245	1560.4225	3.32 ± 0.14
40	22	1460.859	1460.830	1120 ± 40	1120.0321 ± 40.001147	2.868	10477.129	9.35 ± 0.33
42	24	1208.2	1208.2	2600 ±600	2600.1125±600.02597	4.329	25368.463	9.75± 2.251

Table -2: Reduced transition probability $B(E2)_{w.u.}\downarrow$ of γ_0- transitions from $2_1^+ \rightarrow 0_1^+$ with internal conversion coefficient α of ref.[4] ,the experimental half-life time for gamma ray $t_{1/2}^{\gamma}(E2)$, single particle half-life time for gamma-ray $t_{1/2}^{\gamma}(E2)_{SP}$ of $_{20}$Ca nuclei ,the experimental data [1]are used in the calculations.

A	N	E_i (keV)	$E_{\gamma 0}$ (keV)	$t_{1/2}$ (fs)	$t_{\frac{1}{2}}^{\gamma}(E2)$ (fs)	internal conversion coefficient $\alpha \times 10^{-6}$	$t_{\frac{1}{2}}^{\gamma}(E2)_{SP}$ (fs)	$B(E2)_{w.u.}\downarrow$
40	20	3904.38	3904.17	34 ±2	34.000219 ±2.0000129	6.456	76.841725	2.26± 0.13
42	22	1524.73	1524.70	820 ±20	820.02929 ±20.000714	35.73	7926.2234	9.66 ± 0.23
44	24	1157.047	1157.031	2610±140	2610.1693 ±140.00908	64.9	29602.302	10.00 ± 0.06
46	26	1346.0	1346.0	3600 ±300	3600.1668 ±300.0139	46.36	13094.38	3.63 ± 0.30
48	28	3831.72	3832.2	41.8 ±2.6	41.800277 ± 2.6000172	6.638	66.134014	1.58 ±0.09

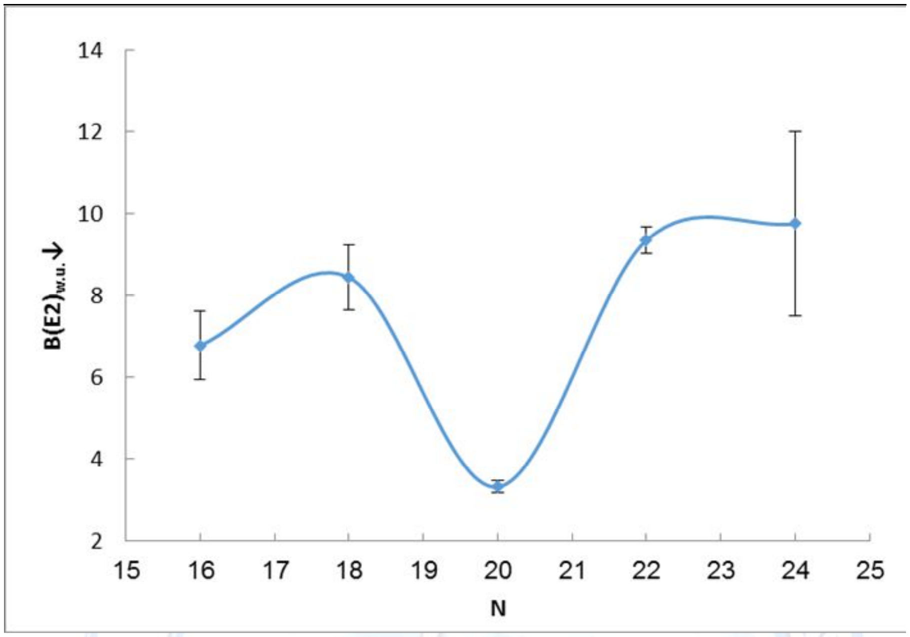

Figure -1: Reduced transition probability B(E2)$_{w.u.}$↓, for γ_0- transitions as a function of the neutron number in $_{18}$Ar nuclei.

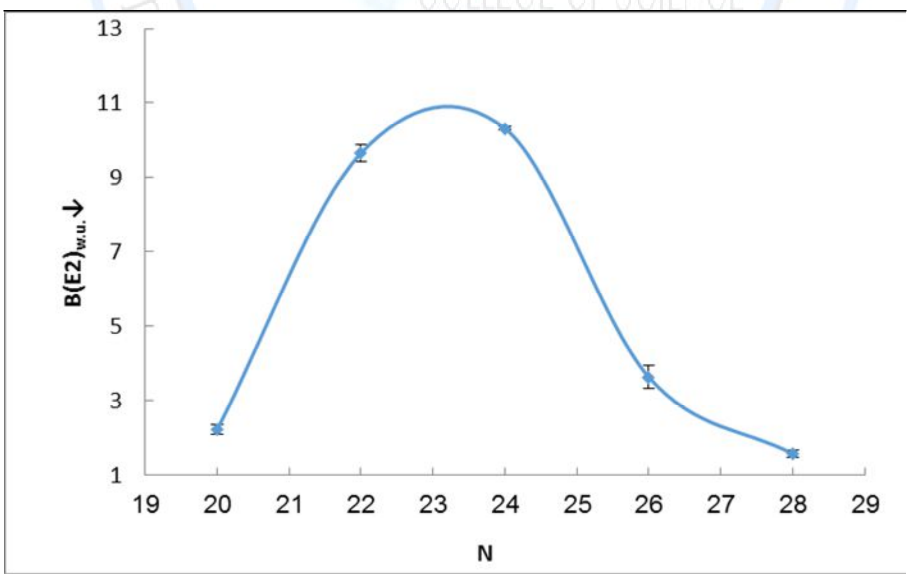

Figure -2: Reduced transition probability B(E2)$_{w.u.}$↓, for γ_0- transitions as a function of the neutron number in $_{20}$Ca nuclei.

the present $|M(E2)|^2_{W.u.}\downarrow$values of γ_0 -transitions in $_{18}$Ar and $_{20}$Ca nuclides are compared with the previous study values in ref.[5] as well as.This comparison are presented in tables (3&4) and shown in Figs. (3 &4) respectively.

Table -3: The electric quadrupole transition strengths $[M(E2)]^2_{W.u.}\downarrow$ values are compared with that reported in ref.[5] for $_{18}$Ar nuclides.

A	N	E_i (keV)	E_{γ_0} (keV)	internal conversion coefficient $\alpha\times 10^{-5}$	$\|M(E2)\|^2_{W.u.}\downarrow$	
					Present work	ref.[5]
34	16	2090.9	2090.8	1.328	6.77 ± 0.84	6.76 ± 0.84
36	18	1970.39	1970.33	1.602	8.44 ± 0.79	8.42 ± 0.79
38	20	2167.472	2167.405	1.245	3.32 ± 0.14	3.31 ± 0.14
40	22	1460.859	1460.830	2.868	9.35 ± 0.33	9.34 ± 0.33
42	24	1208.2	1208.2	4.329	9.75± 2.251	9.79± 2.240

Table -4: The electric quadrupole transition strengths $[M(E2)]^2_{W.u.}\downarrow$ values are compared with that reported in ref.[5] for $_{20}$Ca nuclides.

A	N	E_i (keV)	E_{γ_0} (keV)	internal conversion coefficient $\alpha\times 10^{-6}$	$\|M(E2)\|^2_{W.u.}\downarrow$	
					Present work	ref.[5]
40	20	3904.38	3904.17	6.456	2.26 ± 0.13	2.25 ± 0.13
42	22	1524.73	1524.70	35.73	9.66 ± 0.23	9.65 ± 0.23
44	24	1157.047	1157.031	64.9	10.00 ± 0.6	11.32 ± 0.06
46	26	1346.0	1346.0	46.36	3.63 ± 0.30	3.63 ± 0.30
48	28	3831.72	3832.2	6.638	1.58 ±0.09	1.58 ±0.09

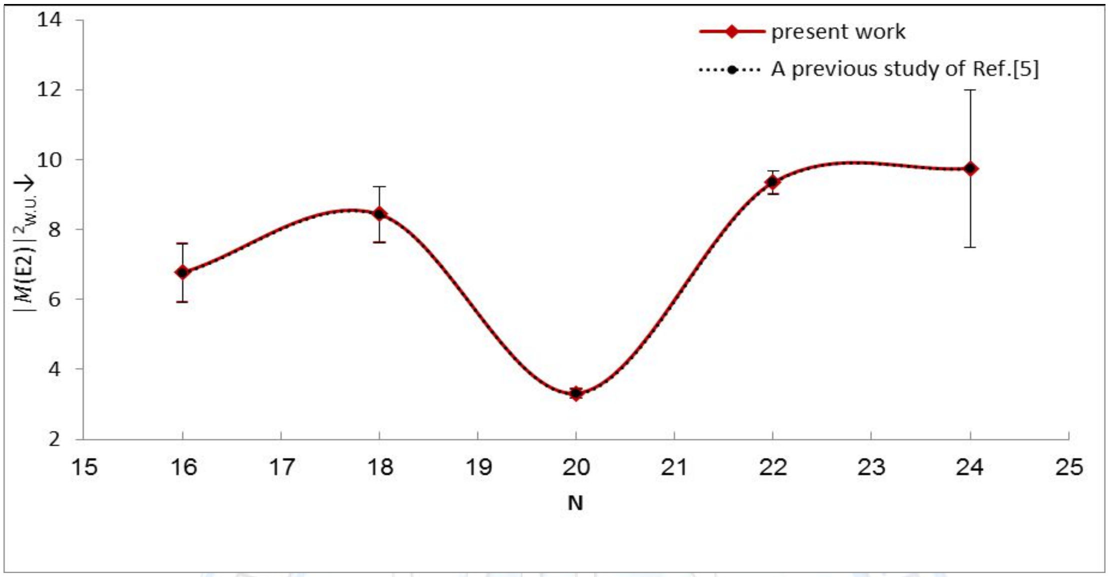

Figure -3: Comparison between the $[M(E2)]^2_{w.u.}\downarrow$ values of the present work for $_{18}$Ar nuclei with other study of ref.[5].

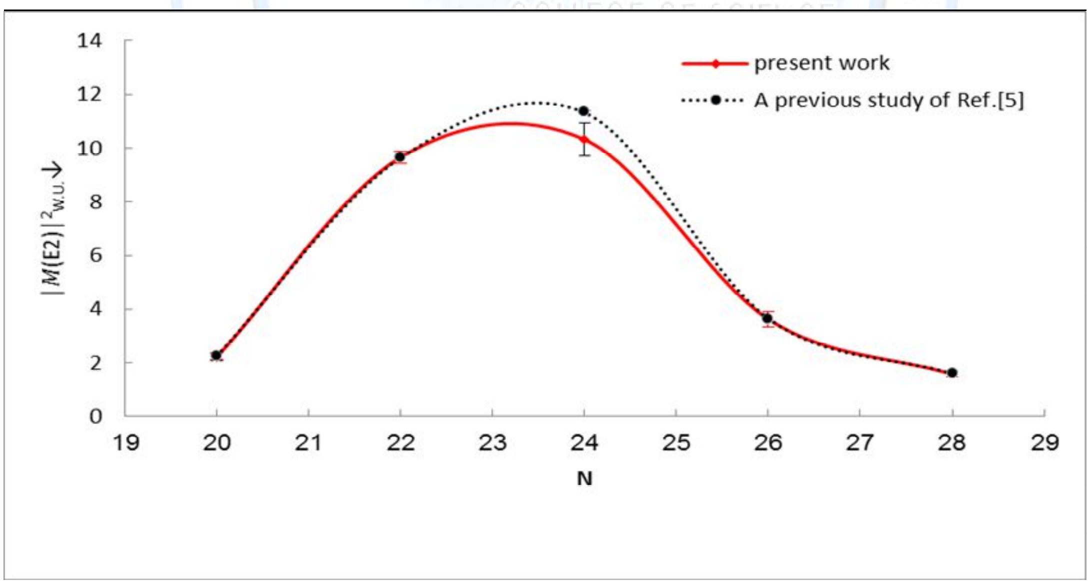

Figure -4: Comparison between the $[M(E2)]^2_{w.u.}\downarrow$ values of the present work for $_{20}$Ca nuclei with other study of ref.[5].

Magic and closed shell nuclei have very few excited states at low excitation energy, their low transition probabilities include low collective motion for nucleons and indicated the validity of single –particle shell model.

Therefore from tables (1&2) it is clear that the experimental values for half-life time for gamma-ray $t^{\gamma}_{\frac{1}{2}}(E2)$ to that estimated by Weisskopf unit $t^{\gamma}_{\frac{1}{2}}(E2)_{SP}$ have minimum values at nuclei with magic neutron number in isotopic chains.

From tables (1&2) are observed the Reduced electric qudrupole transition probability $B(E2)_{w.u.}\downarrow$ have minimum values at magic neutron number,N=20 in $_{18}$Ar and N=20,28 in $_{20}$Ca isotobic.

The $B(E2)_{w.u.}\downarrow$, is increasing gradually when the nucleon number deviated more and more from the magic nucleon number =20 as in fig.(1)

In Fig.(2); $_{20}$Ca $B(E2)w.u.\downarrow$ curve has minimum value at N=20,28.The comparison of the present values of $|M(E2)|^2_{W.u.}\downarrow$with those reported in ref.[5] can be explained by Figs(3,4)as that; the present $|M(E2)|^2_{W.u.}\downarrow$curves are in excellent agreement of that of ref.[5] and the $|M(E2)|^2_{W.u.}\downarrow$curves of ref.[5] have the same behaviore present work.

CONCLUSIONS

In the present work ,the internal conversion coefficients have been applied to calculate the pure electric transition strengths$|M(E2)|^2$. The good agreement of the present$|M(E2)|^2$ values with those reported in ref.[5]

The best study is concentrated on electronic quadruple transition E2 $2^+_1 \to 0^+_1$ Since several main features related to nuclei properties can be observed through the behavior of transition $|M(E2)|^2_{W.u}$ for γ_0-transition in even-even isotopic chains, as mentioned in the present work.

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