ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: https://doi.org/10.29121/granthaalayah.v7.i8.2019.637

INTERNATIONAL JOURNAL OF RESEARCH – GRANTHAALAYAH
A knowledge Repository

Science

CALCULATION OF MULTIPLE MIXING RATIOS OF GAMMA RAYS FROM $^{142-150}_{60}Nd(n,n')^{142-150}_{60}Nd$ INTERACTION

Taghreed Abdull-jabbar Younis [1], Adel Kamel Shbeeb [1]
[1] Department of Physics, College of Education, Ibn Al-Haitham, Iraq

Abstract

In the current research, multiple mixing ratios of gamma -transitions of the energy levels $^{142-150}_{60}Nd$ isotopes populated in $^{142-150}_{60}Nd(n,n')^{142-150}_{60}Nd$ interaction are calculated using the constant statistical tensor (CST) method. The results obtained are, in general, in good agreement or consistent, within the experimental error, with the results published in the previously researches. Existing discrepancies result from inaccuracies in the experimental results of previous works. The current results confirm the validity of the constant statistical tenser method of calculating the values of mixing ratios and its predictability of errors in experimental results.

Keywords: Multiple Mixing Ratios, The Constant Statistical Tensor (CST) Method, Electric Quadra Pole E_2, Magnetic Dipole M_2,, $^{142-150}_{60}Nd$, Gamma –Transition, δ,.

Cite This Article: Taghreed Abdull-jabbar Younis, and Adel Kamel Shbeeb. (2019). "CALCULATION OF MULTIPLE MIXING RATIOS OF GAMMA RAYS FROM $^{142-150}_{60}Nd(n,n')^{142-150}_{60}Nd$ INTERACTION." *International Journal of Research - Granthaalayah*, 7(8), 39-50. https://doi.org/10.29121/granthaalayah.v7.i8.2019.637.

1. Introduction

The mixing ratios (δ) are defined as the ratio between the matrix elements for electric Quadra pole E_2 and the magnetic dipole M_2 for the transition of gamma from the elementary to final level. The angular distribution measurements of gamma radiation are sensitive to interference between matrix elements for E_2 and M_2.There are different terms in the literature because of the different formulas proposed for the interpretation of angular distribution [1].Therefore, the definition used for the mixing ratio should be determined in the angular distribution measurements. The definition of the user in the current research is the definition of Steffen and Alder [2]

$$\delta = \frac{\langle J_f|E_2|J_i\rangle}{\langle J_f|M_1|J_I\rangle} \dots \dots \dots. \quad (1)$$

Youhana [3] noted that the statistical tenser $\rho_2(J_i)$ that is associated with $P(M_i)$ of the relationship:

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

$$\rho_2(J_i\ ) = \sum_{\substack{M_i=0 \\ or \\ M_i=\frac{1}{2}}}^{M_i=J_i} \rho_2\,(J_i, M_i)P(M_i) \dots \dots \quad (2)$$

It must be constant for levels with the same spin as long as the coefficients of the statistical tenser $\rho_2\ (J_i, M_i)$ are not dependent on the energy of the level but only on $J_i and\ M_i$, Youhana therefore proposed the method of constant statistical tenser (CST) and applied it successfully in the calculation of $\delta -$values of mixed transitions from excited levels in interactions $^{90,92,94}Zr(\,n, n^{'}\gamma\,)^{90,92,94}Zr$ [3],[4]and $^{150}Nd(\,n, n^{'}\gamma\,)^{150}Nd$ reaction [5].This method proved to be a good way, such as the international program (CINDY) for the calculated of mixed gamma transitions, as well as its predictability of any error or inaccuracy in experimental results because the method is based on experimental results and does not depend on any nuclear model, to do all the necessary calculations.

In the current research, the transitions ($2^+ - 2^+$) in $^{142,144,146,158,150}Nd$ isotopes were studied and their mixing ratios were calculated due to their importance in examining the nuclear models. Berthier and Berthoumieux [6] mention In their research, that many nuclear models were developed within thirty years for the purpose of describing the nucleus, but so far no nuclear model has been developed to do so due to the lack of empirical data, especially the mixing ratios of gamma transitions ($2^+ - 2^+$) or the discrepancy of measured values in different research .

Demidov and others [7] studied the excited levels of $^{142,148,150}_{60}Nd(n, n^{'})$ interactions and Govor and others [8]studied the isotope $^{142,}_{60}Nd$ from the inflexable scattering reaction of the fast reactor neutrons. They measured the angular distribution of gamma rays emitted from $^{142,}_{60}Nd$ levels. Al-Janabi and others [9],[10].also studied the angular distribution of gamma rays from the energy levels of the two isotopes $^{144,}_{60}Nd$, $^{146,}_{60}Nd$ respectively. Youhana [5] studied the angular distribution of gamma rays from the energy levels of the $^{150,}_{60}Nd$ based on the results of the reference [7] and the results [11].

2. Data Reduction and Analysis

For pure transitions and transitions that can be counted as pure, the constant statistical tenser $\rho_2\ (J_i)$ can be calculated for the following relationship:

$$a_2(J_i - J_f) = \rho_2(J_i\ )F_2(J_i\, J_f\ \delta) \dots\dots\ [12] \quad (3)$$

Where $\rho_2(J_i\ )$ =constant statistical tenser for primary level J_i
$F_k(J_i J_f \delta)$ =Coefficients which contain the information on angular momentum changes and the multipole mixing

$$F_k(J_i J_f \delta) = \frac{F_k(J_f L_1 L_1 J_i) + 2\delta\, F_k(J_f L_1 L_2 J_i) + \delta^2 F_k(J_f L_2 L_2 J_i)}{(1+\delta^2)} \dots \dots\ [13] \quad (4)$$

$$L_1 = |J_i - J_f| \neq 0 \dots \dots \dots \quad (5)$$

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

$L_2 = L_1 + 1 \dots \dots$ (6)

$L = l + s \neq 0 \dots \dots \dots.$ (7)

$L = Angular\ momentum\ of\ gamma\ Ray \neq 0\ \ because\ the\ following$
$l = \ \ Angular\ orbit\ momentum = 0, 1, 2, 3, 4 \dots$
$s\ =\ spin = 1$

If the transition is pure, then $\delta = 0$ the equation (4) becomes:

$F_k(J_i J_f \delta) = F_k(J_f L_1 L_1 J_i) \dots \dots ..$ (8)

Reparation of equation (8) in (3) Produce:

$a_2(J_i - J_f) = \rho_2(J_i) F_k(J_f L_1 L_1 J_i) \dots \dots.$ (9)

From equation (9) we get on $\rho_2(J_i)$

$\rho_2(J_i) = a_2(J_i - J_f)/F_k(J_f L_1 L_1 J_i) \dots\dots\dots$ (10)

The values of $F_k(J_f L_1 L_1 J_i)$, ,$J_i and\ J_f$ are listed in the Appendix (A)

And taking the pure probability $(2^+ - 0^+)$ of $^{142-150}_{60}Nd$ isotopes

$\rho_2(2) = \frac{a_2(2-0)}{F_2(0222)} = -\frac{a_2(2-0)}{59761} \dots \dots \dots ..$ (11)

$\rho_2(2)$ Values can be found for the mixed transition ($2^+ - 2^+$) of $^{142-150}_{60}Nd$ isotopes by Reparation of equation (4) in (3) Produce:

$a_2(J_i - J_f) = \rho_2(J_i) \frac{F_k(J_f L_1 L_1 J_i) + 2\delta\, F_k(J_f L_1 L_2 J_i) + \delta^2 F_k(J_f L_2 L_2 J_i)}{(1+\delta^2)} \dots ..$ (12)

$a_2(2-2) = \rho_2(2) \frac{F_2(J_2 L_1 L_1 J_2) + 2\delta\, F_2(J_2 L_1 L_2 J_2) + \delta^2 F_2(J_2 L_2 L_2 J_2)}{(1+\delta^2)} \dots \dots ..$ (13)

$a_2(2-2) = \rho_2(2) \frac{-0.41833 - 1.22476\,\delta + 0.12806\delta^2}{(1+\delta^2)} \dots \dots \dots \dots \dots \dots \dots.$ (14)

The transition is pure or can be considered pure if the following condition is met:

$|J_i - J_f| \leq L \leq (J_i + J_f)$

$|2 - 0| \leq L \leq (2 + 0) \rightarrow\ 2 \leq L \leq 2 \rightarrow L = 2\ only$

$\pi_i . \pi_f = (-1)^L$ (The change in the parity of the electrical radiation (EL))

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

π_i = the parity of initial level= (+)
π_f== the parity of final level= (+)
$(+)\times(+) = (-1)^L \rightarrow L = even\ numbers = 2,4,6,\ldots..,k \ \rightarrow$
$E = E2 \quad because\ \ L = 2\ only$
$\pi_i.\pi_f = (-1)^{L+1}$ (The change in the parity of the magnetice radiation (ML))
$(+)\times(+) = (-1)^{L+1} \rightarrow L = odd\ numbers = 1,2,3,5,\ldots\ldots,k \ \rightarrow \ ML = M1, M3, M5, \ldots$
$\rightarrow ML\ is\ not\ found\ \ because\ \ L = 2\ only$

Therefore pure $E2$ transitions represent transitions $(2^+ - 0)$
While the transition $(2^+ \ - \ 2^+)$ is a mixed transition due to the following:

$|J_i - J_f| \leq L \leq (J_i + J_f)$
$|2-2| \leq L \leq (2+2) \rightarrow \ 0 \leq L \leq 4 \rightarrow L = 0,1,2,3,4$

For the electrical radiation
$(+)\times(+) = (-1)^L \rightarrow \ \ L = even\ numbers \ \rightarrow EL = \ E2\ , E4 \quad but\ EL \neq E0\ because\ L \neq 0$
$EL = E2\ only\ because\ \ E2 > E3 > \ E4 \rightarrow E2 \ >> \ E4$

For the magnetice radiation
$(+)\times(+) = (-1)^{L+1} \rightarrow \ L = odd\ numbers, ML = M1, M3$
$ML = M1\ because\ M1 > M2 > M3 \rightarrow \ M1 >> M3$

Therefore the transition $(2^+ \ - \ 2^+)$ is mix transition $(E2 + \ M1)$

The $\rho_2(J_i)$ of pure gamma transitions in addition to the mixed gamma transitions were calculated using the equation (4) and the values of $a_2(J_i - J_f)$ and δ −values measured experimentally for such transitions were considered. If there is more than one value for constant statistical tenser, the weighted average is taken as in relation:

$$\rho_2(J_i) = \frac{\sum \frac{\rho_2(J_i)}{\Delta\rho_2(J_i)_i^2}}{\sum \frac{1}{\Delta\rho_2(J_i)_i^2}} \ldots\ldots\ldots.. \qquad (15)$$

$$\rho_2(J_i) = \frac{1}{\sqrt{\frac{1}{\Delta\rho_2(J_i)_i^2}}} \ldots\ldots\ldots \qquad (16)$$

Where $\Delta\,\rho_2(J_i)$ = The amount of error in constant statistical tenser

3. Results and Discussion

Tables (1), (2),(3),(4),(5) show the energy levels and the gamma- transitions $(2^+ - 0^+)$ used to calculate $\rho_2(2^+)$ for the levels $J_i^\pi = 2^+$ in ${}^{142}_{60}Nd\,{}^{144}_{60}Nd$, ${}^{146}_{60}Nd$, ${}^{148}_{60}Nd$, ${}^{150}_{60}Nd$ respectively. While the table (6) shows the weighted average for $\rho_2(2^+)$ values of the isotopes themselves.

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

Table 1: the energy levels and gamma transitions $(2^+ - 0^+)$ $in\ {}^{142}_{60}Nd$ used in the calculation $\rho_2(2^+)$

$E_i(KeV)$	$E_\gamma(KeV)$	a_2 [8]	$\rho_2(2^+)$
1575.8	1575.8	0.223(17)	-0.37315 ± 0.02845
2384.3	2384.3	0.297(17)	-0.49698 ± 0.02845
2845.9	2845.8	0.325(25)	-0.54383 ± 0.04183
3045.1	3045.1	0.250(19)	-0.41833 ± 0.03179
3128.0	3128.0	0.210(30)	-0.35140 ± 0.06693
3358.7	3358.6	0.210(80)	-0.35140 ± 0.13387
3470.2	3470.3	0.260(60)	-0.43507 ± 0.10040
3579.8	3579.8	0.380(50)	-0.63587 ± 0.08367

Table 2: the energy levels and gamma transitions $(2^+ - 0^+)$ $in\ {}^{144}_{60}Nd$ used in the calculation $\rho_2(2^+)$

$E_i(KeV)$	$E_\gamma(KeV)$	a_2 [9]	$\rho_2(2^+)$
696.3	696.3	0.223(18)	-0.37315 ± 0.03012
1560.3	1560.3	0.361(67)	-0.60407 ± 0.11211
2072.2	2072.1	0.417(52)	-0.69778 ± 0.08701
2270.0	2270.0	0.180(81)	-0.30120 ± 0.13554
2526.7	2526.5	0.466(52)	-0.77977 ± 0.08701

Table 3: the energy levels and gamma transitions $(2^+ - 0^+)$ in ${}^{146}_{60}$Nd used in the calculation $\rho_2(2^+)$

$E_i(KeV)$	$E_\gamma(KeV)$	a_2 [10]	$\rho_2(2^+)$
453.9	453.9	0.231(24)	-0.38654 ∓ 0.04016
1470.4	1470.4	0.312(34)	-0.52208 ± 0.05689
1787.1	1787.2	0.281(35)	-0.47021 ± 0.05857
1977.8	1977.4	0.322(50)	-0.53881 ± 0.08367
2119.5	2119.4	0.305(87)	-0.51037 ± 0.14558
2208.4	2208.4	0.310(25)	-0.51873 ± 0.04183

Table 4: the energy levels and gamma transitions $(2^+ - 0^+)$ in ${}^{148}_{60}$Nd used in the calculation $\rho_2(2^+)$

$E_i(KeV)$	$E_\gamma(KeV)$	a_2 [7]	$\rho_2(2^+)$
301.6	301.6	0.24(3)	-0.40160 ± 0.05020
1171.0	1171.0	0.36(6)	-0.60240 ± 0.10040
1248.8	1248.9	0.35(3)	-0.58567 ± 0.05020

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

Table 5: the energy levels and gamma transitions $(2^+ - 0^+)$ in ${}^{150}_{60}Nd$ used in the calculation $\rho_2(2^+)$

$E_i(KeV)$	$E_\gamma(KeV)$	a_2 [5]	$\rho_2(2^+)$
130.1	130.1	0.185(25)	-0.30957 ± 0.04183
1061.6	1061.7	0.277(12)	-0.46351 ± 0.02008
2260.4	1584.0	0.305(79)	-0.51037 ± 0.13219

Table 6: Average weighted for values $\rho_2(2^+)$

Isotope	$\rho_2(2^+)$
${}^{142}_{60}Nd$	-0.44625 ± 0.01482
${}^{144}_{60}Nd$	-0.44716 ± 0.02582
${}^{146}_{60}Nd$	-0.47201 ± 0.02246
${}^{148}_{60}Nd$	-0.50572 ± 0.03347
${}^{150}_{60}Nd$	-0.43607 ± 0.01793

These values are constant for all levels $J_i^\pi = 2^+$ and used in the calculation of δ values of transitions $(2^+ - 2^+)$ in even neodymium isotopes. The obtained results are shown in the tables (7,8,9,10,11) for isotopes, ${}^{142}_{60}Nd{}^{144}_{60}Nd$, ${}^{146}_{60}Nd$, ${}^{148}_{60}Nd$, ${}^{150}_{60}Nd$ respectively. In each table, the current results were compared with the previously measured results.

Table 7: Mixing ratios for gamma transitions $(2^+ - 2^+)$ in ${}^{142}Na$ by using constant statistical tenser (CST) method

$E_i(KeV)$	$E_\gamma(KeV)$	$\frac{a_2}{a_4}$[8]	$\delta - values$		
			Ref. [8]	Ref. [14]	Present work
2384.3	808.6	0.329(37) 0.078(50)	0.16(6) ……..	0.20(5) 1.3(2)	$(0.34^{+?}_{-0.12})$ $(1.1^{+0.3}_{-?})$
2583.1	1007.3	0.030(22) 0.020(30)	-0.28(3) ……	-0.28(2) $(6.5^{+1.3}_{-0.9})$	$-(0.27^{+0.05}_{-0.03})$ $(6.5^{+2.2}_{-1.3})$
2845.9	1270.0	-0.220(90) -0.160(130)	-0.60(30) $-(0.60^{+29}_{-3})$	-0.82(8) -3.7(7)	$-(1.1^{+?}_{-0.5})$ $-(2.2^{+4.7}_{-?})$
3045.1	1469.5	0.290(60) -0.030(80)	$0.1 < \delta < 1.5$	0.20(9) 1.4(3)	$(0.22^{+0.23}_{-0.14})$ 1.4(5)
3128.0	1552.2	-0.120(24) -0.030(50)	-0.69(9) $-(5.1^{+2.2}_{-1.4})$	-0.61(4) -5.8(14)	$-(0.60^{+0.08}_{-0.06})$ $-(8.1^{+5.6}_{-2.8})$
3358.7	1782.9	-0.200(40) 0.020(50)	$-5 < \delta$ < -0.7	$-(0.84^{+0.20}_{-0.10})$ $-(3.4^{+1.3}_{-0.9})$	$-(0.94^{+?}_{-0.21})$ $-(2.9^{+1.7}_{-?})$

Table 8: Mixing ratios for gamma transitions $(2^+ - 2^+)$ in ${}^{144}Na$ by using constant statistical tenser (CST) method

$E_i(KeV)$	$E_\gamma(KeV)$	$\frac{a_2}{a_4}$[9]	$\delta - values$		
			Ref. [9]	Ref. [14]	Present work
1560.5	864.2	-0.165(30) 0.088(43)	$-0.73(8)$ ….	-0.70(6) $-(4.6^{+1.5}_{-0.9})$	$-(0.75^{+0.16}_{-0.11})$ $-(4.3^{+2.2}_{-1.3})$

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

2072.2	1375.9	0.309(38) -0.005(56)	0.13(7) 1.7(3)	0.12(4) 1.5(2)	$(0.27^{+0.18}_{=0.11})$ 1.2(3)
2084.4	1387.9	-0.185(50) -0.040(61)	$-(0.70^{+0.20}_{-0.12})$ $-(5.1^{+4.8}_{-2.0})$	$-(0.77^{+0.18}_{-0.08})$ $-(3.9^{+2}_{-1.1})$	$-(0.85^{+?}_{-0.21})$ $-(3.4^{+3.1}_{-?})$
2367.8	1671.7	0.288(36) 0.016(43)	$0.15^{+0.09}_{-0.06}$ 1.6(3)	0.18(6) 1.5(2)	$(0.21^{+0.13}_{-0.09})$ 1.4(3)
2526.7	1830.5	0.393(59) -0.048(84)	0.50(25) … …	Imaginary roots	Imaginary roots
2591.6	1895.2	0.289(51) 0.067(94)	0.15(10) …….	0.18(7) 1.4(3)	$(0.22^{+0.18}_{-0.13})$ 1.4(4)
2828.2	1267.6	0.221(92) -0.106(113)	0.02(15) $(2.2^{+1.2}_{-0.8})$	$(0.06^{+0.22}_{-0.16})$ $(1.9^{+1.2}_{-0.7})$	$(0.06^{+0.24}_{-0.16})$ $(1.9^{+1.2}_{-0.7})$
2900.5	1339.9	0.293(47) 0.087(87)	$(0.15^{+0.17}_{-0.13})$ 1.6(6)	0.20(8) 1.4(3)	$(0.23^{+0.17}_{-0.12})$ 1.3(4)

Table 9: Mixing ratios for gamma transitions $(2^+ - 2^+)$ in ^{146}Na by using constant statistical tenser (CST) method

$E_i(KeV)$	$E_\gamma(KeV)$	$\frac{a_2}{a_4}$[10]	$\delta - values$		
			Ref. [10]	**Ref. [14]**	**Present work**
1470.4	1016.5	0.05(250) -0.020(31)	-0.24(5) $(5.4^{+3}_{-2.3})$	-0.24(2) $(5.6^{+0.8}_{-0.6})$	-0.24(5) $(5.5^{+1.6}_{1.1})$
1787.1	1333.2	-0.111(37) 0.000(47)	-0.64(11) $-(10^{+70}_{-4})$	$-(0.56^{+0.06}_{-0.04})$ $-(11^{+18}_{-2})$	$-(0.56^{+0.11}_{-0.09})$ $-(11^{+32}_{-5})$
1905.4	1451.6	-0.058(33) -0.025(50)	-0.45(7) ……	-0.44(4) …..	-0.44(7) only
1977.8	1523.7	0.177(29) -0.001(38)	-0.07(4) 2.8(4)	-0.05(2) 2.6(2)	-0.03(5) 2,5(4)
2143.1	1689.4	-0.074(12) -0.012(15)	-0.48(3) ……	-0.48(2) ………	-0.47(3) Only
2197.4	1743.5	0.165(26) -0.052(32)	…… 2.9(4)	……. 2.7(2)	-0.05(5) 2.6(4)
2265.9	1812.0	0.374(48) -0.006(59)	$(0.40^{+?}_{-0.16})$ $(0.95^{+0.35}_{-?})$	0.45(11) 0.87(20)	$(0.47^{+?}_{-0.21})$ $(0.86^{+0.39}_{-?})$
2286.0	1831.7	0.083(14) -0.003(17)	-0.19(3) 4.4(5)	-0.19(2) 4.2(3)	-0.19(2) 4.2(5)
2436.8	1982.5	0.089(14) 0.008(17)	-0.18(2) ……	-0.18(1) …..	-0.18(2) 4.0(5)
2457.2	2002.9	0.280(80) 0.042(92)	$(0.14^{+0.20}_{-0.14})$ 1.6(5)	0.16(9) 1.6(4)	$(0.16^{+0.24}_{-0.16})$ $(1.5^{+0.7}_{-0.5})$
2491.1	2037.2	-0.206(78) 0.111(165)	$-(0.85^{+?}_{-0.47})$ …….	-0.90(20) ……….	$-(0.90^{+?}_{-0.30})$ $-(3.1^{+4.9}_{-?})$

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

Table 10: Mixing ratios for gamma transitions $(2^+ - 2^+)$ in ^{148}Na by using constant statistical tenser (CST) method

$E_i(KeV)$	$E_\gamma(KeV)$	$\frac{a_2}{a_4}$[7]	$\delta - values$	
			Ref.[7]	**Present work**
1171.0	869.2	0.01(4) 0.02(5)	…… $(8.3^{+11.7}_{-2.4})$	-0.31(7) $(8.6^{+9.6}_{-3})$
1248.8	947.1	-0.06(4) 0.01(4)	-33(17) …..	-0.44(8) only
1645.4	1343.8	0.09(6) 0.04(7)	-0.18(10) $(4.2^{+3.4}_{-1.3})$	-0.19(9) $(4.2^{+2.6}_{-1.2})$
1659.6	1358.0	0.22(6) 0.00(7)	0.02(8) 2.2(5)	$(0.01^{+0.11}_{-0.09})$ 2.2(6)

Table 11: Mixing ratios for gamma transitions $(2^+ - 2^+)$ in ^{150}Na by using constant statistical tenser (CST) method

$E_i(KeV)$	$E_\gamma(KeV)$	$\frac{a_2}{a_4}$[5]	$\delta - values$		
			Ref. [5]	**Ref. [11]**	**Present work**
1061.6	931.6	-0144(29) 0.006(35)	$-(0.68^{+0.12}_{-0.09})$ $-(5.5^{+3.2}_{-1.7})$	-0.75(10) …….	$-(0.69^{+0.12}_{-0.10})$ $-(5.4^{+3.1}_{-1.7})$
1391.2	329.7	-0.178(15) -0.017(19)	$-(0.82^{+0.1}_{-0.07})$ $-(3.6^{+0.8}_{-00.6})$	-0.92(10) $-(3.1^{+0.7}_{-0.5})$	$-(0.83^{+0.10}_{-0.07})$ $-(3.5^{+0.8}_{-0.6})$
1434.6	373.3	0.196(36) -0.016(44)	0.02(8) 2.1(4)	0.05(8) …..	0.03(7) 2.1(4)
	234.2	-0.089(46) 0.017(55)	$-(0.52^{+0.13}_{-0.10})$ ….	-0.7(2) ……	$-(0.53^{+0.13}_{-0.11})$ only
1545.2	1414.6	0.103(8) -0.016(10)	-0.14(2) 3.5(2)	-0.13(2) 3.4(2)	-0.14(2) 3.5(2)
1579.4	1449. 7	0.054(30) -0.036(37)	-0.23(6) $(5.1^{+1.9}_{-1.1})$	-0.23(6) 5.0(11)	-0.23(5) $(5.1^{+1.9}_{-1.1})$
71986.7	925.2	-0.211(42) -0.095(49)	$-(1.1^{+?}_{-0.3})$ $-(2.4^{+1.7}_{-?})$	$-(1.1^{+?}_{-0.3})$ …….	$-(1.1^{+?}_{-0.3})$ $-(2.4^{+1.6}_{-?})$
2243.0	1181.1	0.140(26) -0.018(31)	-0.08(5) 2.8(5)	-0.08(5) 2.8(5)	-0.08(5) 2.8(5)
2260.4	1198.5	-0.228(38) -0.051(46)	$-(1.3^{+?}_{-0.4})$ $-(1.8^{+1.4}_{-?})$	$-(1.6^{+?}_{-0.4})$ ……	$-(1.4^{+?}_{-0.5})$ $-(1.7^{+1.4}_{-?})$
2532.3	1140.8	0.190(39) 0.034(45)	0.01(8) 2.2(5)	0.00(7) 2.2(5)	0.01(8) 2.2(5)
2580.1	1518.5	0.108(8) -0.009(10)	-0.14(2) 3.4(2)	-0.14(2) …..	-0.14(2) 3.4(2)

From the table (7), we observe that the calculated δ values for the transition 1007.3 KeV from the level 2583.1 KeV are very agreement with the δ values published in the two references [8,14]. As well as the calculated δ values for the transition 1552.2 KeV from the level 3128.0 and the

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

calculated δ values for the two transitions 1469.5 KeV and 1782.9 KeV of the two levels 3045.1 KeV and 3358.7 KeV respectively agreement with the reference [14],and within the range in reference [8] to each of these two transitions. As for the two transitions 808.6 and 1270.0 KeV respectively, from the levels 2384.3 and 2845.9 KeV there is a difference in δ values. This indicates the inaccuracy of the Coefficients $a_2 and\ a_4$ measured in the reference [8]. This is clear from the value of a_4 −coefficient of the first transition, which should have been negative signal within the experimental error. As for the second transition, it is clear from the relatively large error associated with each of $a_2 and\ a_4$ for this transition.

Note from Table (8) that the δ values calculated in the current search using the CST method are consistent with δ values within the experimental error limits published in the references [9,14], for all transitions except for the transition 1830.5 KeV from the level 2526.7 KeV. The imaginary roots obtained in the present research and in the reference [14] indicate inaccuracy $a_2 and\ a_4$ published in the reference [9] for this transition.

Note from the table (9) that the values calculated in the current search in agreement with the published δ values in the references [10, 14] for all transitions.

The table (10) shows that the current δ values are fully consistent with the reference values [7] for all transitions except the transition 947.1 KeV from the level 1248.8 KeV where we observe a clear contradiction. This indicates that the published δ value in the reference [7] is incorrect. In this reference, the authors did not mention why they ignored the value of δ small.

The table (11) shows that the δ values calculated in the current search are fully consistent or within the experimental error limits with references δ values [5, 11]. This indicates that the measured $a_2 and\ a_4$ values in the reference [11] for these transitions are correct.

4. Conclusions

It was ascertained that the constant statistical tenser (CST) method of calculating the values of the mixing ratios as well as its ability to predict the existence of any error of the experimental results.

APPENDIX A

J_i	L_1	L_2	J_f	F_2	F_4
1	1	1	0	0.70711	0
1	1	1	1	-0.35355	0
1	1	2	1	-1.06067	0
1	2	2	1	-0.35355	0
1	1	1	2	0.07071	0
1	1	2	2	0.47434	0
1	2	2	2	0.35355	0
1	2	2	3	-0.10101	0
1	2	3	3	0.37796	0
1	3	3	3	0.53034	0
1	3	3	4	-0.17678	0
2	2	2	0	-0.59761	-1.06904

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

2	1	1	1	0.41833	0
2	1	2	1	-0.93542	0
2	2	2	1	-0.29881	0.71269
2	1	1	2	-0.41833	0
2	1	2	2	-0.61238	0
2	2	2	2	0.12806	-0.30544
2	1	1	3	0.11952	0
2	1	2	3	0.65466	0
2	2	2	3	0.34149	0.07636
2	2	2	4	-0.17075	-0.00848
2	2	3	4	0.50507	-0.06274
2	3	3	4	0.44822	-0.02970
2	3	3	5	-0.29881	0.00405
3	3	3	0	-0.86603	0.21320
3	2	2	1	-0.49487	-0.44670
3	2	3	1	-0.46290	1.04463
3	3	3	1	-0.64953	0.03553
3	1	1	2	0.34641	0
3	1	2	2	-0.94869	0
3	2	2	2	-0.12372	0.67006
3	1	1	3	-0.43301	0
3	1	2	3	-0.43301	0
3	2	2	3	0.22682	-0.44670
3	1	1	4	0.14434	0
3	1	2	4	0.72169	0
3	2	2	4	0.30929	0.14890
3	2	2	5	-0.20620	-0.02030
3	2	3	5	0.54554	-0.13430
3	3	3	5	0.36085	-0.05492
3	3	3	6	-0.36085	0.00969
4	3	3	1	-0.78349	0.14527
4	2	2	2	-0.44770	-0.30438
4	2	3	2	-0.52972	0.90036
4	3	3	2	-0.47009	-0.04842
4	1	1	3	0.31339	0
4	1	2	3	-0.94018	0
4	2	2	3	-0.04477	0.60876
4	1	1	4	-0.43875	0
4	1	2	4	-0.33541	0
4	2	2	4	0.26455	-0.49807
4	1	1	5	0.15955	0
4	1	2	5	0.75679	0
4	2	2	5	0.28490	0.19370
4	2	2	6	-0.22792	-0.02980
4	2	3	6	0.56407	-0.184337

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

4	3	3	6	0.29915	-0.06874
4	3	3	7	-0.39887	0.01422
5	3	3	2	-0.73599	0.11589
5	2	2	3	-0.42056	-0.24281
5	2	3	3	-0.55634	0.80301
5	3	3	3	-0.36799	-0.07726
5	1	1	4	0.29439	0
5	1	2	4	-0.93095	0
5	2	2	4	0	0.56556
5	1	1	5	-0.44159	0
5	1	2	5	-0.27386	0
5	2	2	5	0.28307	-0.52297
5	1	1	6	0.16984	0
5	1	2	6	0.77832	0
5	2	2	6	0.26689	0.22413
5	2	2	7	-0.24263	-0.03736
5	2	3	7	0.57416	-0.22100
5	3	3	7	0.25476	-0.07726
5	3	3	8	-0.42461	0.01783
6	3	3	3	-0.70510	0.09967
6	2	2	4	-0.40291	-0.20883
6	2	3	4	-0.56980	0.73833
6	3	3	4	-0.30219	-0.09018
6	1	1	5	0.28204	0
6	1	2	5	-0.92319	0
6	2	2	5	0.02878	0.53699
6	1	1	6	-0.44320	0
6	1	2	6	-0.23146	0
6	2	2	6	0.29355	-0.53699
6	1	1	7	0.17728	0
6	1	2	7	0.79283	0
6	2	2	7	0.25326	0.24613
6	2	2	8	-0.25326	-0.04343
6	2	3	8	0.58028	0.24879
6	3	3	8	0.22160	-0.08292
6	3	3	9	-0.44321	0.02073

References

[1] Krane K.S., Phys. Rev. C8, 1494 (1973).
[2] Krane K.S., Atomic Data Nucl. Data Tables, 16, 383 (1975)
[3] Youhana H.M.; Ibn Al-Haitham J. for Pure and Appl. Sci. 15 No 4, 33 (2002)
[4] Youhana H.M.; Ibn Al-Haitham J. for Pure and Appl. Sci. 15 No 46, 14 (2002)
[5] Youhana H.M.; Math. And Phys. J. 17 No 2, 52 (2002)
[6] Berthier B. and Berthoumieux E.; Nucl. Instr. Meth. Phys. Research Sec. B. Beam Interaction with materials and atoms, 130, 224 (1997)

 ISSN- 2350-0530(O), ISSN- 2394-3629(P)
DOI: 10.5281/zenodo.3379723

[7] Demidov A.M., Goror L.I., Cherepontsev Y.K., Al-Janabi J.J., Matti H. Mahmood K. and Youhana H.M.; IAE-3457/2 Moscow (1981)
[8] Goror L.I., Demidov A.M. and Kurkin V.A.; Phys. Atomic Nuclei 59 No 10, 1675 (1996)
[9] Al-Janabi T.J.; Jafar T.D.; Mahmood K.M., Youhana H.M., Demidov A.M. and Govor L.I.; Nucl. Phys. A402, 247 (1983)
[10] Al-Janabi T.J., Jafar J.D., Youhana H.M., Demidov A.M. and Govor L.J.; J. Phys. G.: Nucl. Phys. 9, 779 (1983)
[11] Al-Obeidi Al-Obeidi S.R.; M.Sc. Thesis, University of Baghdad (1982)
[12] Poletti A.R. and Warburton E.K.; Phy s. Rev. 137 B:595, (1965)
[13] Yamazaki T.; Nucl. Data, section A3:1. (1967)
[14] Rashid M.M.A.H.; M.Sc. Thesis, University of Salahaddin, Erbil (2003).

*Corresponding author.
E-mail address: tagh2011reed@ gmail.com