Multipole Mixing Ratios of Gamma Transitions From Level ^{26}Mg Populated in ^{23}Na (α, pγ)^{26}Mg Reaction Using a_2 – Ratio Method.

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Abstract

The δ - mixing ratios of γ - transitions from levels of ^{26}Mg populated in ^{23}Na (α, pγ)^{26}Mg reaction are calculated using a_2 – ratio method for the first time in the case of two mixed γ - transitions from the same initial level. The results obtained have been compared with δ - values determined by other methods. The comparison shows that the agreement is excellent. This confirms the validity of this method in calculating the δ - values of such γ - transitions.

Introduction

The a_2 – ratio method has been successfully applied by Youhana et.al. (1,2) and by Youhana (3,4). In these studies, the method has been applied using the experimental a_2 – coefficients determined for at least two γ - transitions from the same initial state, one of which is a pure transition such as 1-0 or 2-0 transitions or it may be considered to be pure E1 transition such as 1^- - 2^+ , 2^- - 2^+ , 3^- - 2^+ , 3^- - 4^+ , 5^- - 4^+ , ...etc. or a pure E2 transition such as 4 – 2 , 5 – 3 , 6 – 4, ...etc.

In the present work, this method has been applied in the same manner and it has been applied for the first time, using the experimental a_2 – coefficients determined for two mixed γ - transitions whose δ - values have been determined. In such cases the δ - values of one transition are considered to be accurate and used to calculate the δ - values of the other γ - ray.

Data Reduction and Analysis

The a_2 – coefficients of γ - transitions from a certain initial level is related to the statistical tensor $\rho_2(ji)$, of the initial level by the following relationship [3 , 4].

$$a_2(J_i - J_f) = \rho_2(J_i)\frac{F_2(J_f L_1 L_1 J_i) + 2\delta F_2(J_f L_1 L_2 J_i) + \delta^2 F_2(J_f L_2 L_2 J_i)}{1+\delta^2} \text{ --------[1]}$$

where J_i and J_f are the angular momentum of the initial and final state respectively, L_1 and L_2 are angular momentum of γ - transition given by:

$$L_1 = |J_i - J_f| \text{ and } L_2 = L_1 + 1 \text{ ------[2]}$$

$L_1 \neq 0$

The F_2 – coefficients are tabulated in ref. [5].

For pure transitions, $\delta = 0$, and eq. (1) becomes:

$$a_2(J_i - J_f) = \rho_2(J_i) F_2(J_f L_1 L_1 J_i) \text{ --------[3]}$$

For γ - transitions from the same initial level, $\rho_2(ji)$, is the same, and hence, for two transitions from the same initial level, one of which is pure or considered to be pure:

$$\frac{a_2(J_i - J_{f1})}{a_2(J_i - J_{f2})} = \frac{F_2(J_{f1}L_1L_1J_i) + 2\delta F_2(J_{f1}L_1L_2J_i) + \delta^2 F_2(J_{f1}L_2L_2J_i)}{F_2(J_{f2}L_1'L_1'J_i)(1+\delta^2)} \text{ ----[4]}$$

Similarly, for two mixed γ - transitions from the same initial level:

$$\frac{a_2(J_i - J_{f1})}{a_2(J_i - J_{f2})} = \frac{[F_2(J_{f1}L_1L_1J_i) + 2\delta_1 F_2(J_{f1}L_1L_2J_i) + \delta_1^2 F_2(J_{f1}L_2L_2J_i)] / (1+\delta_1^2)}{[F_2(J_{f2}L_1'L_1'J_i) + 2\delta_2 F_2(J_{f1}L_1'L_2'J_i) + \delta_2^2 F_2(J_{f2}L_2'L_2'J_i)] / (1+\delta_2^2)} \text{ ----[5]}$$

The inverse of eq. (5) is also possible.

For the possible γ - transitions reported in the present work, eq. (4) becomes:

$$\frac{a_2(2-2)}{a_2(2-0)} = \frac{-0.41833 - 1.22476\delta + 0.12806\delta^2}{-0.59761(1+\delta^2)} \text{ -------[6]}$$

and eq. (5) becomes:

$$\frac{a_2(2^+-2^+)_2}{a_2(2^+-2^+)_1}=\frac{(-0.41833-1.22476\delta_2+0.12806\delta_2^2)/(1+\delta_2^2)}{(-0.41833-1.22476\delta_1+0.12806\delta_1^2)/(1+\delta_1^2)}\text{-------}[7]$$

$$\frac{a_2(2^+-2^+)_1}{a_2(2^+-2^+)_2}=\frac{(-0.41833-1.22476\delta_1+0.12806\delta_1^2)/(1+\delta_1^2)}{(-0.41833-1.22476\delta_2+0.12806\delta_2^2)/(1+\delta_2^2)}\text{-------}[8]$$

$$\frac{a_2(3^+-2^+)_2}{a_2(3^+-2^+)_1}=\frac{(0.34641-1.89738\delta_2-0.12372\delta_2^2)/(1+\delta_2^2)}{(0.34641-1.89738\delta_1-0.12372\delta_1^2)/(1+\delta_1^2)}\text{-------}[9]$$

and

$$\frac{a_2(3^+-2^+)_1}{a_2(3^+-2^+)_2}=\frac{(0.34641-1.89738\delta_1-0.12372\delta_1^2)/(1+\delta_1^2)}{(0.34641-1.89738\delta_2-0.12372\delta_2^2)/(1+\delta_2^2)}\text{-------}[10]$$

Results and Discussion

The energy levels of ^{26}Mg that have at least two. γ - transitions are presented in table (1) together with the experimental a_2 – coefficient reported in ref. (6) for each transition.

The δ - value calculated from eqs. (6-10) are also presented in table (1) and compared with those reported in ref. (6). In this table, the errors in the last digit or digits are given in parantheses unless specified. If the difference between (+ error) and (- error) is 0.01 for small | δ | values and is 0.1 for large | δ | values, the large error is taken into consideration.

It is clear from table (1) that the δ - value calculated in the present work are in excellent agreement with those reported in ref. (6). This indicates that the a_2 – ratio method in the case of two mixed transitions from the same initial level can be applied to calculated the δ - values of either transition taking into consideration the δ - values reported for the other transition. The weighted averages of δ - values are calculated and presented in table (1) as adopted values for each transition.

Conclusion

The δ - mixing ratios of γ - transitions from levels of ^{26}Mg populated in the reaction ^{23}Na (α, pγ) ^{26}Mg have been calculated using a_2 – ratio method. This method has been applied for the first time, taking into consideration two mixed transitions. The comparison of the δ - values calculated in the present work with those determined by other methods shows that the agreement is excellent for each γ - transitions. This confirms the validity of this method to calculated the δ - values of mixed γ - transitions from the same initial level.

References

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Table (1)Multiple mixing ratios of γ - transitions from energy levels of ^{26}Mg calculated by the a_2 – ratio method

Ei (Kev)	Eγ (Kev)	$J_i^\pi - J_f^\pi$	a_2 / a_4	δ - values: Ref. [6]	δ - values: a_2 - ratio	δ - values: a_2 - ratio	δ - values: Adopted
2938.4	2938.4	$2^+ - 0^+$	0.169 (18) -0.030 (23)	E2	E2	-	E2
	1129.7	$2^+ - 2^+$	0.076 (25) -0.014 (31)	-0.12 (7) $3.2^{+1.0}_{-0.7}$	-0.12 (7) $3.2^{+1.0}_{-0.7}$	-	-0.12 (5) 3.2 (6)
3940.8	2132.0	$3^+ - 2^+$	-0.173 (46) ?	0.02 (5) $-(4.4^{+1.2}_{-0.8})$	0.02 -4.4 }	0.02 (5) $-(4.4^{+1.1}_{-0.8})$	0.02 (4) -4.4 (7)
	1002.4	$3^+ - 2^+$	-0.244 (20) 0.003 (22)	-0.05 (4) -3.5 (5)	-0.05 (7) $-(3.3^{+1.0}_{-0.6})$	-0.05 -3.3 }	-0.05 (3) -3.3 (4)
4332.1	2523.4	$2^+ - 2^+$	0.163 (21) -0.011 (27)	$0.14^{+0.11}_{-0.09}$ 1.6 (4)	0.14 1.6 }	0.13 (10) 1.6 (4)	0.14 (7) 1.6 (3)
	1393.8	$2^+ - 2^+$	0.102 (11) -0.018 (14)	-0.05 (5) 2.6 (3)	-0.05 (5) 2.6 (4)	-0.05 2.6 }	-0.05 (4) 2.6 (2)
4350.5	2541.2	$3^+ - 2^+$	-0.298 (30) 0.110 (32)	-0.11 (5) -2.8 (4)	-0.11 -2.8 }	-0.11 (5) $-(2.7^{+0.5}_{-0.3})$	-0.11 (4) -2.8 (3)
	1411.6	$3^+ - 2^+$	-0.472 (56) 0.008 (53)	$-(0.32^{+0.16}_{-0.11})$ -1.6 (5)	$-(0.32^{+0.14}_{-0.10})$ -1.6 (4)	-0.32 -1.6 }	-0.32 (9) -1.6 (3)

نسبة خلط متعدد الاقطاب لاشعة كاما المنبعثة عن مستويات في ^{26}Mg متولدة من التفاعل $^{23}Na (\alpha, p\gamma)^{26} Mg$ باستخدام طريقة نسبة a_2

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الخلاصة

حســبت نسب الاختلاط (δ) لانتقالات كامية منبعثة عن مستويات في ^{26}Mg متولدة من التفاعل $^{23}Na (\alpha, p\gamma)^{26} Mg$ باستخدام طريقة نسبة a_2 والتي استخدمت لاول مرة في حالة انتقالين مختلطين من المستوى الابتدائي نفسه وقيم δ التي تم الحصول عليها تمت مقارنتها مع قيم δ مقاسة بطرائق اخرى وقد وجد ان الاتفاق كان ممتازاً. وهذا يثبت ان الطريقة الحالية قد استخدمت بنجاح في حساب قيم δ لمثل هذه الانتقالات المختلطة.