# Mixing ratio of gamma-rays in $^{85}$Sr nucleus from the $R_{DCO}$ and Polarization Asymmetry measurements

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## Introduction

In nuclear structure, the excited states decay through the emission of gamma-ray transitions [1]. These gamma-rays transitions have multipole character such as E1, M1, M1+E2, E2 etc. The angular distribution, $R_{DCO}$ and polarization asymmetry measurements help us to know their multipole character. In fact, the values of angular distribution coefficients, $R_{DCO}$ and polarization asymmetry for the mixed gamma-ray transitions depend on the value of mixing ratio.

In the present work, the mixing ratio of the gamma-ray transitions having mixed character is calculated from the values of angular distribution coefficients, $R_{DCO}$ and polarization asymmetry values for the $^{85}$Sr nucleus [2].

## Theoretical background

Angular distributions of gamma-rays at an angle θ is given by the eq. (1)

$$W(\theta) = 1 + A_2P_2(\cos\theta) + A_4P_4(\cos\theta) \quad (1)$$

where, $A_2$ and $A_4$ are angular distribution coefficients. They can be calculated theoretically by using the relation

$$A_2 = \alpha_2 A_2^{max} \text{ and } A_4 = \alpha_4 A_4^{max} \quad (2)$$

where, $\alpha_2$ and $\alpha_4$ are attenuation coefficients and $A_2^{max}$ and $A_4^{max}$ are angular distribution coefficients for completely aligned nuclei and given by the relation

$$A_2^{max} = \frac{1}{(1+\delta^2)}[F2(L1L1) + 2\delta F2(L1L2) + \delta^2 F2(L2L2)] \quad (3)$$

$$A_4^{max} = \frac{1}{(1+\delta^2)}[F4(L1L1) + 2\delta F4(L1L2) + \delta^2 F4(L2L2)] \quad (4)$$

where, $\delta$ is the mixing ratio and $F_2(L_mL_n)$ and $F_4(L_mL_n)$coefficients have been taken from reference [3].

Directional correlation from oriented sates ($R_{DCO}$) [4] is calculated using the relation

$$R_{DCO} = \frac{W(\gamma_1,\theta_1)W(\gamma_2,\theta_2)}{W(\gamma_1,\theta_2)W(\gamma_2,\theta_1)} \quad (5)$$

The polarization asymmetry [5] is defined as

$$\Delta = P(\theta)Q \quad (6)$$

where, P(θ) is degree of polarization. Degree of polarization at $90^0$ is given by the relation

$$P_{cal}(90^0) = \pm\frac{3A_2H_2 - 7.5A_4H_4}{2 - A_2 + 0.75A_4} \quad (7)$$

Where, $H_2 = 1$ and $H_4 = -1/6$ for pure transition and for mixed transitions

$$H_2 = \frac{F2(L1L1) - 0.667\delta F2(L1L2) + \delta^2 F2(L2L2)}{F2(L1L1) - 2\delta F2(L1L2) + \delta^2 F2(L2L2)};\ H_4 = -\frac{1}{6} \quad (8)$$

Polarization sensitivity Q is given by

$$Q(E_\gamma) = (CE_\gamma + D)Q_0(E_\gamma) \quad (9)$$

$$Q_0(E_\gamma) = \frac{\alpha+1}{\alpha^2+\alpha+1};\ \alpha = \frac{E_\gamma}{m_ec^2} \quad (10)$$

## Calculations and Results

In the present work data of $^{13}$C+$^{76}$Ge @ 45 MeV [2] have been analyzed. The angular distribution, $R_{DCO}$ and polarization asymmetry have been calculated for few transitions as shown in table 1.

**Table 1:** $R_{DCO}$ (Dipole gate) and polarization asymmetry values for different transitions.

| Energy (keV) | Multipolarity | $R_{DCO}$ | Polarization Asymmetry |
|---|---|---|---|
| 990.5 | E1(ΔJ = 0) | 2.24 ±0.15 | -0.075 ± 0.007 |
| 906.3 | M1+E2 | 1.11 ±0.12 | -0.084 ± 0.013 |
| 964.6 | M1+E2 | 0.85 ±0.06 | -0.037 ± 0.008 |
| 1288 | E2 | 1.90 ±0.15 | 0.078 ± 0.006 |

Using the equations (1- 10) a contour plot between polarization asymmetry and $R_{DCO}$ have been obtained as shown in Figs. 1-3. Then from the values of $R_{DCO}$ and polarization asymmetry, mixing ratio of the gamma-ray transitions have been calculated.

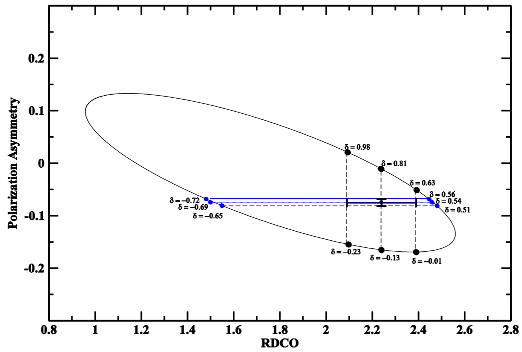


**Fig. 1** Polarization asymmetry vs. $R_{DCO}$ for 990.5 keV gamma-ray transition

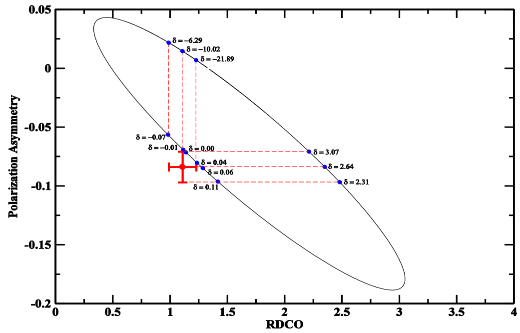


**Fig. 2** Polarization asymmetry vs. $R_{DCO}$ for 906.3 keV gamma-ray transition

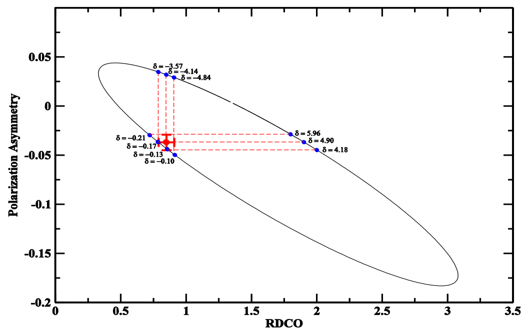


**Fig. 3** Polarization asymmetry vs. $R_{DCO}$ for 964.3 keV gamma-ray transition

The values of mixing ratio obtained are shown in table 2.

**Table 2:** Mixing ratio different transitions.

| Energy (keV) | Mixing Ratio from Polarization Asymmetry | Mixing Ratio from $R_{DCO}$ | Mixing Ratio |
|---|---|---|---|
| 990.5 | 0.54 ± 0.03 | 0.81 ± 0.18 | 0.55 ±0.02 |
| 906.3 | 0.00 ± 0.11 | -0.01 ± 0.12 | 0.00 ±0.01 |
| 964.6 | -0.17 ± 0.04 | -0.13 ± 0.04 | -0.15 ±0.03 |

## Conclusions

Mixing ratio of 991-, 906- and 964 keV transition have been obtained by using Chi-square minimization in the theoretically calculated and experimentally obtained $R_{DCO}$ and polarization asymmetry values.

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## References

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