Angular Distributions and R_{DCO} Measurements for Dipole ($\Delta J = 0$) and Quadrupole ($\Delta J = 0$) Transitions.

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Abstract

Angular distributions and R_{DCO} measurements have been used to study the dipole ($\Delta J=0$) and quadrupole ($\Delta J=0$) transitions. Angular distribution of the dipole ($\Delta J=0$) is similar to the angular distribution of the quadrupole ($\Delta J=2$) whereas angular distribution of quadrupole ($\Delta J=0$) is different from quadrupole ($\Delta J=2$) transition. In order to distinguish above transitions we analyze the R_{DCO} ratios for two different angles (157^O vs. 90^O and 140^O vs 90^O). In addition to that the polarization asymmetry is obtained to distinguish $\Delta J=0$ electrical dipole and $\Delta J=0$ quadrupole transitions from the $\Delta J=2$ quadrupole transitions.

Introduction

Angular distributions and R_{DCO} measurements are used to study different multipole transitions. Since, the angular distribution coefficients A_2 and A_4 depends on the ΔJ, different ΔJ transitions can be distinguished from the study of their angular distribution coefficients [1].

Heavy ion fusion evaporation reaction has been used to form the compound nucleus, which decayed to the excited nuclei by the evaporation of particles like neutrons and protons. Then these excited nuclei dexcite by the emission of gamma-rays.

Angular Distribution of gamma-rays

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

$$W(\theta) = 1 + A_2P_2(\cos\theta) + A_4P_4(\cos\theta) \qquad \textbf{(1)}$$

Where, A_2 and A_4 are angular distribution coefficients.

Oriented nuclei have been populated by the heavy ion fusion evaporation reaction. Data of two different reactions have been analyzed. First reaction is $^{13}C+^{76}Ge$ @ 45 MeV [2] and the second reaction is $^{11}B+^{128}Te$ @ 50.5 MeV [3]. The angular distribution coefficients have been obtained for 1288-, 375-, 379-, 368-, 991- and 778 keV transitions. But, we concentrated on $\Delta J=0$ dipole 991 and 778 keV and $\Delta J=0$ quadrupole 375 and 379 keV transitions. The angular distribution of 1288 keV ($\Delta J=2$, quadrupole), 375 keV ($\Delta J=0$, quadrupole), 379 keV ($\Delta J=0$, quadrupole), 368 keV ($\Delta J=1$, dipole), 778 keV ($\Delta J=0$, dipole) and 991 keV ($\Delta J=0$, dipole), are shown in Figure I.

The angular distribution of 778 and 991 keV are similar to the angular distribution of 1288 keV. But the curves of 778 and 991 keV are slightly higher than the curve of 1288 keV. On the other hand the angular distribution of 375 and 379 keV are not similar to the angular distribution of 1288 keV as shown in Figure I. Thus using angular distribution we can distinguish $\Delta J=0$ dipole and $\Delta J=0$ quadrupole from $\Delta J=2$ quadrupole. The angular distribution coefficients of different ΔJ transitions are given in Table I.

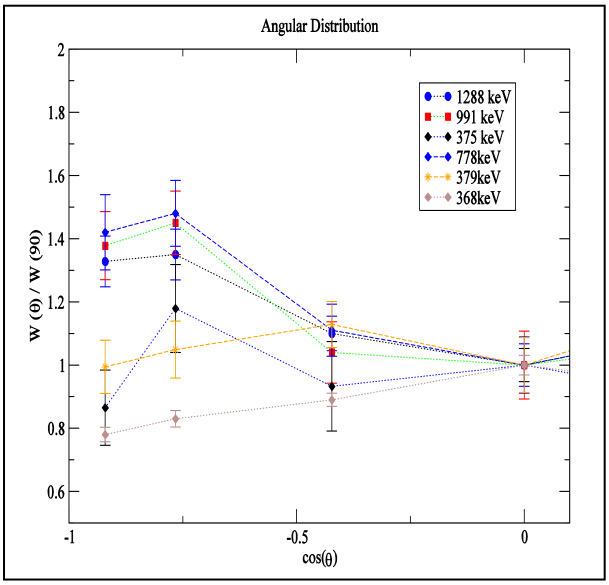

Figure I. Angular distribution of 1288 keV ($\Delta J=2$, Quad), 778 keV ($\Delta J=0$, Dipole), 778 keV ($\Delta J=0$, Dipole), 368 keV ($\Delta J=1$, Dipole), 375 keV ($\Delta J=0$, Quad), and 379 keV ($\Delta J=0$, Quad).

Table I. Angular Distribution Coefficients for different ΔJ transitions.

Energy (keV)	ΔJ	Multipolarity	A_2	A_4
1288	2	Quadrupole	0.36	-0.13
375	0	Quadrupole	0.14	-0.17
379	0	Quadrupole	0.16	-0.32
368	1	Dipole	-0.24	0.05
991	0	Dipole	0.49	-0.17
778	0	Dipole	0.48	-0.18

Directional Correlations

Experimentally R_{DCO}[4] is calculated by the eq. (**2**)

$$R_{DCO} = \frac{I_{\gamma_1}(\text{at } \theta_1, \gamma_2 \text{ gated at } \theta_2)}{I_{\gamma_2}(\text{at } \theta_2, \gamma_1 \text{ gated at } \theta_1)} \qquad (\mathbf{2})$$

The R_{DCO} values calculated for different ΔJ transitions are given in Table II. For 991 keV the R_{DCO} ratios changes at two different angles (157^O vs. 90^O and 140^O vs. 90^O) with respect to the gated transition (1111 keV or 368 keV), whereas for 375 and 379 keV it remains same.

Table II. R_{DCO} values at different multipole transitions.

Gated at 1111 keV (ΔJ=2) Quadrupole			Gated at 368 keV (ΔJ=1) Dipole			Polarization asymmetry
Energy (keV)	R_{DCO} (157^O)	R_{DCO} (140^O)	Energy (keV)	R_{DCO} (157^O)	R_{DCO} (140^O)	
368 (ΔJ=1) Dipole	0.51 ±0.03	0.62 ±0.04	444 (ΔJ=1) Dipole	1.10 ±0.08	1.04 ±0.09	-0.032 ±0.005
991 (ΔJ=0) Dipole	1.25 ±0.08	1.13 ±0.13	991 (ΔJ=0) Dipole	2.24 ±0.15	1.76 ±0.12	-0.075 ±0.007
1288 (ΔJ=2) Quad	0.98 ±0.05	0.92 ±0.06	1288 (ΔJ=2) Quad	1.90 ±0.15	1.74 ±0.08	0.078 ±0.006
Gated at 583 keV (ΔJ=2) Quadrupole			Gated at 360 keV (ΔJ=1) Dipole			
320 (ΔJ=1) Dipole	0.49 ±0.03	0.62 ±0.04	320 (ΔJ=1) Dipole	1.04 ±0.07	1.06 ±0.07	-0.06 ±0.02
375 (ΔJ=0) Quad	1.10 ±0.08	1.11 ±0.07	375 (ΔJ=0) Quad	1.94 ±0.17	1.79 ±0.21	0.18 ±0.02
379 (ΔJ=0) Quad	1.06 ±0.08	1.09 ±0.07	379 (ΔJ=0) Quad	1.89 ±0.17	1.79 ±0.21	0.19 ±0.02
592 (ΔJ=2) Quad	1.00 ±0.06	1.03 ±0.07	592 (ΔJ=2) Quad	2.04 ±0.17	1.73 ±0.20	0.09 ±0.01

The ^{86}Rb nucleus has already known transition of 778 keV (ΔJ=0 dipole). In the reaction $^{13}C+^{76}Ge$ @ 52 MeV, ^{86}Rb also has been populated as via product. The R_{DCO} value for this 778 keV transition is 1.12 in a quadrupole gate (1598 keV) and has polarization value equals to -0.052 ±0.012.

In addition to R_{DCO} measurements polarization measurements [5] can also be used to distinguish between ΔJ=0 dipole and ΔJ=0 quadrupole from ΔJ=2 quadrupole transitions. The polarization asymmetry values obtained for 991 keV (ΔJ=0, dipole), 1288 keV (ΔJ=2, quadrupole), 375 keV (ΔJ=0, quadrupole) and 379 keV (ΔJ=0, quadrupole) are -0.075±0.007, 0.078±0.006, 0.18±0.02 and 0.19±0.02 respectively.

Conclusions

Angular distribution of ΔJ=0 dipole is similar to the angular distribution of ΔJ=2 quadrupole transitions. The angular distribution of ΔJ=0 dipole is slightly higher than the angular distribution of ΔJ=2 quadrupole. This difference of angular distributions can help to analyze the R_{DCO} values at two different angles. This analysis results that for ΔJ=0 dipole transition the R_{DCO} values changes at two different angles whereas for ΔJ=0 quadrupole transition it remains same.

The polarization asymmetry value distinguish ΔJ=0 electrical dipole transition because of negative sign and ΔJ=0 quadrupole has positive value higher than the ΔJ=2 quadrupole. Thus, using Angular distributions, R_{DCO} and Polarization measurements different ΔJ transitions can be distinguished.

References

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