# Lifetime measurement for a dipole band in $^{142}$Eu

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### Introduction

The medium and/or high spin region of the weakly deformed nuclei near the shell closure show various interesting phenomena due to the interplay between the single particle and collective mode of excitations. Nuclei near mass $\sim$ 140 region, have been identified as the transition point at which the collective phenomena start to dominate as one goes away from shell closure. The $^{142}$Eu represents a perfect quantal system to investigate such a transition through the observation of the two extreme excitation mechanisms.
The previous work on the odd-odd $^{142}$Eu nucleus by M. Piiparinen et al. established a dipole band structure above $13^-$ state connecting the low-lying states via the E1 transitions [**?** ]. In order to get a clear picture about the intrinsic structure of this nucleus the determination of the electromagnetic transition rates is of utmost importance. The transition rates can be evaluated using the lifetime information of the nuclear states.

### Experimental Details

High spin states of $^{142}$Eu have been populated using the reaction $^{116}$Cd ($^{31}$P, 5n) at a beam energy of 148 MeV provided by the Pelletron Linac facility at TIFR, Mumbai. A 2.4 mg/cm$^2$ target of $^{116}$Cd is chosen on a 14.5 mg/cm$^2$ thick Pb backing in order to stop all the recoil nuclei produced. The deexciting $\gamma$-ray transitions were detected by the Indian National Gamma Array (INGA) which was consisted of nineteen Compton-suppressed clover detectors at the time of experiment.

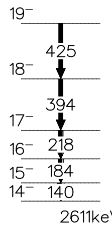


FIG. 1: The partial level scheme of $^{142}$Eu relevant for the present analysis.

### Experimental Results and Discussions

The sequence of dipole transitions having $J^{\pi}$=14$^-$ to $J^{\pi}$=19$^-$ form a rotational band-like structure in the proposed level scheme(fig.**??**). Measuring lifetimes (transition probabilities) of these excited states one can get required information about the possi-

TABLE I: The calculated lifetime for gate set on above ($\tau_{above}$) and below ($\tau_{below}$) for the state of interest in $^{142}Eu$ and also the corresponding B(M1) values as calculated.

| Spin ($J_i^\pi$)) | Energy(KeV) | $\tau_{above}$(ps) | $B(M1)_{above}(\mu_N^2)$ | $\tau_{below}$(ps) | $\tau_{sf}$(ps) | $B(M1)_{below}(\mu_N^2)$ |
|---|---|---|---|---|---|---|
| $15^-$ | 140.4 | $0.88^{+0.13}_{-0.10}$ | $12.3^{+1.82}_{-1.39}$ | $1.38^{+0.20}_{-0.16}$ | 0.0 | $7.83^{+1.13}_{-0.90}$ |
| $16^-$ | 184.5 | $0.42^{+0.08}_{-0.07}$ | $15.0^{+1.26}_{-1.10}$ | $0.95^{+0.14}_{-0.09}$ | 0.0 | $6.66^{+0.98}_{-0.63}$ |
| $17^-$ | 218.5 | $0.39^{+0.08}_{-0.05}$ | $11.7^{+0.99}_{-0.62}$ | $0.94^{+0.13}_{-0.11}$ | 0.0 | $4.87^{+0.67}_{-0.57}$ |
| $18^-$ | 394.4 | | | $0.85^{+0.12}_{-0.09}$ | 0.03±0.01 | $1.05^{+0.14}_{-0.11}$ |
| $19^-$ | 425.5 | | | $0.76^a$ | $0.44^a$ | $.88^b$ |

[a] denote upperlimit of level lifetime
[b] denote lowerlimit of B(M1)

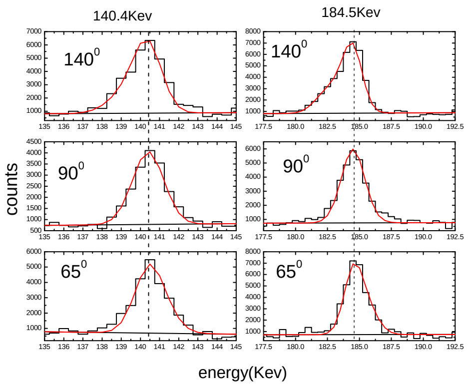


FIG. 2: A typical example showing the experimental spectra along with the calculated lineshapes for 140.4 and 184.5 keV transitions for 140 , 90 and 65 detectors, respectively with gate set on 394.4 keV transition. Desired line-shape of gamma transition, contaminant peaks and total line-shapes are represented by the blue, olive and red curves, respectively.

ble excitation modes of this band. Doppler-broadened lineshapes are observed for the transitions depopulating the $J^\pi = 15^-$ to $19^-$ states of the dipole structure in $^{142}$Eu, and the lifetimes of those states are determined in the present work using the DSAM technique.

The lifetime analysis in the present work is carried out using the LINESHAPE code [**?** ]. The extracted values of level lifetimes ($\tau$ ), sidefeeding lifetimes ($\tau_{sf}$ ) along with the transition rates are given in Table **??**. The experimental spectra at 65°, 90° and 140° are fitted for top and bottom gate simultaneously for the determination of the level lifetimes (fig.**??**). The sidefeeding contribution to these levels are measured by comparing the lifetimes obtained from both the top and bottom gated spectra as lifetimes obtained from the top gate are independent of the sidefeeding contribution. It is noteworthy that the $\chi^2$ minimization process shows zero sidefeeding contribution to the low lying states up to the $17^-$. It contradicts to the general concept of the sidefeeding time which decreases as the excitation energy increases.

However, the estimated high B(M1) transition rates (Table **??**) are indicative of the large transverse component of the magnetic dipole moment ($\mu_\perp$) which gives us an idea about the configuration to be assigned for this structure.

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**References**

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