Measurement of lifetime and transition moments near doubly closed ^{146}Gd

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Introduction

The doubly closed ^{146}Gd has been a good test ground to explore the various aspects of shell structures in nuclei since long, as evidenced by a good number of experimental and theoretical investigations. Single nucleon transfer reaction studies on neighboring nuclei have been undertaken, wherever possible, in order to identify the involved single particle orbits, their strength and mixing as one departs from the shell closure. In that context, measurement of the quadrupole and magnetic moment of the ground and the excited states of nuclei around ^{146}Gd is very important as it provides complimentary information on the underlying single particle configurations. The odd-odd ^{146}Eu nucleus with one proton hole and one neutron particle relative to ^{146}Gd, is one such interesting nucleus where the ground state transition moments have been measured. Though the level scheme of ^{146}Eu has been known reasonably well from decay studies, the lifetimes of the low-lying states are either very short or not known precisely. Only for a few states, limits on measured lifetimes are available from the literature and there is no information on the transition moments of excited states. In this work, the measurement of lifetimes and the transition moments of the low lying states of ^{146}Eu, have been undertaken following the electron capture decay of ^{146}Gd.

Experiment

The ^{146}Gd nucleus has been produced by the ^{144}Sm (^{4}He, 2n) ^{146}Gd reaction using the 35 MeV ^{4}He beam from K =130 cyclotron at VECC, Kolkata. The level scheme of ^{146}Eu has been studied from the EC decay of the 48.8 d ground state of ^{146}Gd, by using the recoil implantation technique. The level scheme of ^{146}Eu has been shown in Fig. 1. The recoils have been implanted

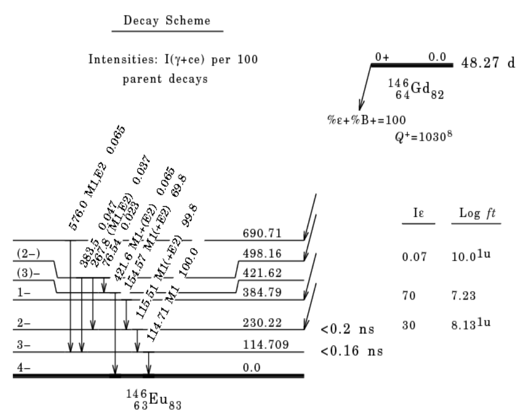

Fig. 1 Level Scheme of ^{146}Eu

on Al catcher foil and both the catcher and the target have been counted offline for the measurement of the lifetimes by using the centroid-shift [2] as well as the prompt time de-convolution method [3]. The offline data has been taken with two different experimental set-ups. In one setup, four BaF_2 detectors, each having 20 mm thickness and a 5 mm long conical face, were used. In the other setup, two thin detectors with 6 mm and 12 mm thickness, were placed along with the above mentioned 20mm thick detector and a planar segmented Ge-LEPS detector. The later detector was used for monitoring purpose. In both the setups, the detectors were arranged in closed geometry, separated by 90^o in their angular position. The TAC spectra were generated between different detector combinations in order to obtain the timing information from all possible sets. During analysis, the TAC spectra were projected by selecting the transitions deexciting the level of interest. The reference prompt time spectrum has been generated with a ^{106}Ru source having two prompt gamma transitions of 511.86 and 621.93 keV. The Integrated Perturbed Angular Correlation (IPAC) technique [4] has been employed for the measurement of the quadrupole moments by separating the Gd ions radiochemically from the Al matrix. The ions were then doped into rutile TiO_2 matrix by co precipitation technique. Magnetic interaction for the present probe (Eu^{3+}) can be studied into the cubic structure of Al catcher itself. Offline counting with the setup of one segmented Ge LEPS and one single HPGe detector as well as with the first timing setup with BaF_2 is in progress for the measurement of transition moments.

Data Analysis and Results

The time spectra between two BaF_2 detectors in the first setup have been shown in Fig. 2. The solid curve indicates the TAC projection from the ^{146}Eu data which has been obtained by putting a gate on 115.51 keV transition in one detector and 154.57 keV transition in the other. The dashed curve is for ^{106}Ru, when gates were put on same energy Compton background. The presence of lifetime in the 2^-, 230.33 keV level is apparent from the shift in centroid and the right side tail of the ^{146}Eu TAC peak. For the measurement of lifetime by centroid shift method, prompt time curves have been generated from the ^{106}Ru data, by plotting the centroid of the TAC peak projected with the selection of different energy gates in respective detectors. Fig. 3 shows three different prompt curves, obtained when gated on different energy bins of the Compton profile in the STOP detector while in the START detector, 511.86 keV photopeak, 621.93 keV photopeak and same energy Compton bins have been selected respectively. All the profiles estimate similar prompt time centroids, beyond ~ 300 keV. Below 300 keV, the profile looks different when generated from photopeak-Compton coincidence and Compton-Compton coincidences. In the same figure, the centroids obtained for different gamma transitions decaying from respective levels have been plotted. The time centroids have been generated by putting a gate on Eu X-ray, arising due to the EC decay, in the START detector and putting the gamma energy gate in the STOP detector. The events have been validated with a genuine coincidence by selecting a third gamma ray in one of the remaining detectors. The difference in the centroid with respect to the prompt has been used in order to determine the lifetimes of the levels. The evaluation of lifetime by the other method is in progress.

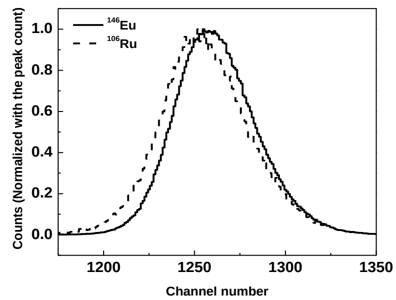

Fig. 2 Energy gated TAC peaks from the ^{146}Eu and ^{106}Ru.

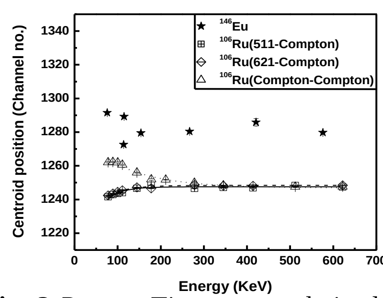

Fig. 3 Prompt Time curves derived from ^{106}Ru source data and the TAC peak centroids obtained by gating on ^{146}Eu γ rays.

Acknowledgement

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References

[1] F.G. Vandenberg, W. Vanrijswijk and W.J. Huiskamp, Physica **133B**, 138 (1985).

[2] W. Andrejtscheff, M. Senba, N. Tsoupas and Z.Z. Ding, NIM **204**, 123 (1982).

[3] H. Mach, R.L. Gill and M. Moszyiski, Nucl. Inst. & Meth. **A280**, 49 (1989).

[4] H. Laurent *et al.*, Nucl. Phys. **A284**, 501 (1977).