Correlating yrast isomers and shape co-existence in ^{152}Dy

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Introduction

The even-even nucleus ^{152}Dy has been studied widely [1,2] due to variety in its structure. This nucleus exhibits different nuclear shapes with change in spin, as well as shape coexistence effect. At low spin the nucleus is found to be near spherical oblate in shape and collective prolate shape is dominant at higher spin.

Recently it has been demonstrated [3] for ^{153}Ho that the study of yrast isomers can be useful to follow the evolution of the structure of a nucleus with increasing excitation energy and spin. In the excitation pattern several twists and turns were observed as a function of spin, which indicated several changes in structure. Interestingly most of the bends are associated with isomers. In this work [3], it has been also demonstrated that the excitation pattern of ^{153}Ho follows the core nucleus ^{152}Dy.

Several yrast isomers are also reported in ^{152}Dy [1]. Superdeformed band was first observed in ^{152}Dy [2]. However, most of these work on ^{152}Dy, especially the lower spin data have been collected from experiments done in late seventies or early eighties. In many cases, the placement of levels and assignment of spin-parities are to be re-validated as they are not certain as indicated in [4].

The motivation of the present work is to revisit the structural data of ^{152}Dy to re-validate the isomer lifetimes in this nucleus, correlate the isomers with the structural changes in a phenomenological way, theoretically interpret the low spin data within shell model and test whether the shape coexistence phenomena can be theoretically established within restricted basis calculations.

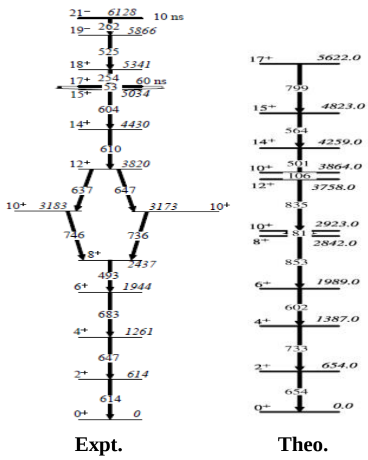

Fig. 1: Relevant portion of the experimental and theoretical level scheme of ^{152}Dy.

Experimental Details and Results

The high spin states of ^{152}Dy are populated by ^{139}La(^{20}Ne, 1p6n) reaction at a projectile energy of 139 MeV. The gamma-gamma coincidence measurements have been performed using the multi-detector array of eight Compton suppressed Clover detectors (Indian National Gamma Array, INGA set up) at Variable Energy Cyclotron Centre (VECC), Kolkata. The relevant details of the experiment have been discussed in Ref. [3]. Delayed and prompt gamma – gamma correlation matrices have been generated by putting gates at different parts of RF-gamma time difference spectra (200 ns range) as well as on the gamma-gamma time difference spectra (800 ns range) to distinguish the isomers.

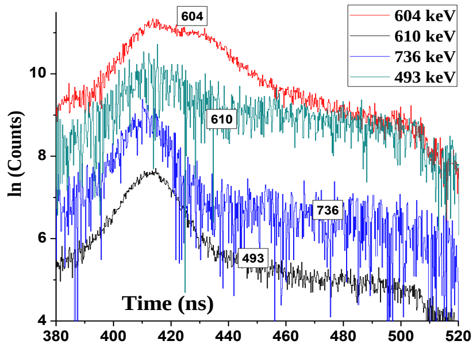

Fig. 2: The time spectra (TAC) in ^{152}Dy are shown for comparison.

The half –lives of the isomers at 5034 (17^+) and 6128 (21^-) keV levels (Fig. 1) have been re-measured. Fig. 2 shows the time spectra corresponding to the gamma rays emitted from levels below the 17^+ isomeric state. The spectra are generated from gamma – gamma time difference matrix. The delayed components in the TAC (time to amplitude converted) spectra of 604 and 610 keV give a definite evidence for the presence of the long-lived isomeric state. The delayed components are diminishing in case of 736 and 493 keV transitions and they behave like the prompt transitions.

The half-life of the 21^- isomeric state has been determined (Fig. 3(a)) from the TAC spectra of 525 keV transition generated from gamma - gamma time difference matrix. The half-life of yrast 21^- state comes out to be 7.9(2) ns, which is close to the earlier measurement [1]. Fig. 3(b) shows the TAC spectrum corresponding to 604 keV transition, decaying from the 15^+ state. The preliminary estimation of the half-life of 17^+ isomeric state comes out to be 47 (4) ns, which is lower than the adopted value ~60 ns, but agrees well with one of the earlier measurements (second in Ref. [1]).

Shell Model Calculation

Shell model (SM) calculation has been performed in the π (*gdsh*)$\oplus\nu$(*hfpi*) valence space above the ^{132}Sn core. However due to computational limitation with the large basis space, a truncated calculation has been performed by fixing 8 and 6 protons in $1g_{7/2}$ and $2d_{5/2}$ orbitals respectively. The low-lying yrast states are reasonably predicted as shown in Fig.1. The half-lives of yrast isomeric states and wave function structures have been obtained and will be presented in the Symposium.

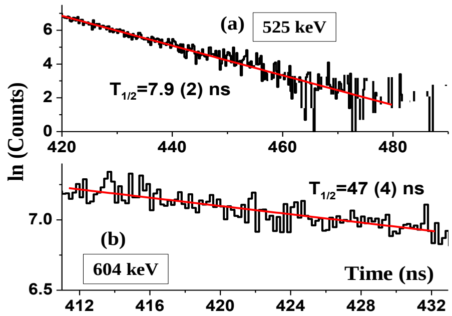

Fig. 3: The decay curves (a) for 525 keV transition, decaying from 19^- state and (b) for 604 keV transition, decaying from 15^+ state.

Conclusion

We have re-measured half-lives of two isomers. Half-life of yrast 21^- state comes out to be 7.9(2) ns, which is close to the earlier measurement but from our preliminary analysis the half-life of 17^+ yrast state comes out to be 47 (4) ns in contrast to the adopted value. A truncated space SM calculation show reasonable results which could be improved further.

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