Search for high-spin isomers near $N = 50$ shell closure

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Introduction

Isomeric states in nuclei with N or Z close to the magic numbers are of special interest, as relatively small number of valence particles and/or holes allows shell model calculations to be performed, thereby providing ideal candidate for testing the nuclear residual interactions. Isomers are also valuable tool in studying pairing correlation, shell evolution and shape coexistence. Several high-spin isomers with lifetime ranging from 10 ns to few μs have been systematically reported in nuclei near $N = 82$ [1, 2], $Z = 82$ and $N = 126$ [3] shell closures. In contrast, information on high-spin isomers in nuclei near $N = 50$ shell-closure is limited to $10\hbar$ states with the exception of ^{93}Mo [4]. The present work reports on an experiment performed to search for high-spin isomers in nuclei near $N = 50$ shell closure.

Experimental Details

Excited states in the nuclei of interest were populated using the heavy-ion fusion evaporation reaction ^{65}Cu(^{30}Si, xpxn). The 14UD TIFR-BARC Pelletron accelerator at Tata Institute of Fundamental Research provided the 137 MeV ^{30}Si beam. The target consisted of a 850 μg/cm^2 thick self-supporting foil of isotopically enriched ^{65}Cu. The recoiling residual nuclei were stopped in a separate Au stopper located 1 mm downstream from the target. The γ-ray coincidence events were measured with the Indian National Gamma Array (INGA) spectrometer consisting of 21 Compton-suppressed clover detectors [5]. To measure lifetime of excited states using fast timing technique, two $LaBr_3$ scintillators were used. Two- and higher-fold coincidence events were collected in a fast digital data acquisition (DDAQ) system based on Pixie-16 modules of XIA LLC [6]. The γ-ray energies and efficiencies were calibrated with standard ^{152}Eu and ^{133}Ba radioactive sources. For the offline analysis, the coincidence events were sorted into γ^2 matrices and γ^3 cubes. The software package RADWARE [7] was used for the data analysis.

Data Analysis and Results

The distance between target and stopper corresponds to ∼100 picoseconds, so that for longer lifetimes most isomeric transitions occurred in the stopper foil, hence, they were not Doppler shifted, whereas, all prompt decays took place in-flight and thus they were Doppler shifted. The recoil velocity v, at 137 MeV beam energy was observed to be $\sim$ 0.028c, as determined from the separation of corresponding Doppler shifted and unshifted lines. However, no Doppler correction was applied to the energies detected in detectors at various angles. Thus, when the ener-

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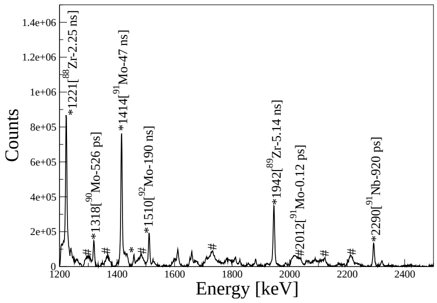

FIG. 1: Background subtracted γ-ray spectrum showing transitions from various nuclei produced in the ^{65}Cu(^{30}Si, xpxn) reaction. The peaks marked with asterisks denote transitions depopulating levels fed by delayed transitions. Hash marked peaks are the prompt decays. The identified peaks are labelled by the γ-ray energy, corresponding nuclei and lifetime of isomeric/prompt states [8].

gies from all the detectors were summed up, the delayed transitions were observed to be sharp peak, whereas, the prompt decays appeared as a broad structure, as shown in Fig 1. As a result, it was possible to distinguish between transitions depopulating levels fed by prompt transitions and those fed by delayed transitions by merely observing the spectrum. The decay path of the isomeric states was established by gating on the stopped peaks.

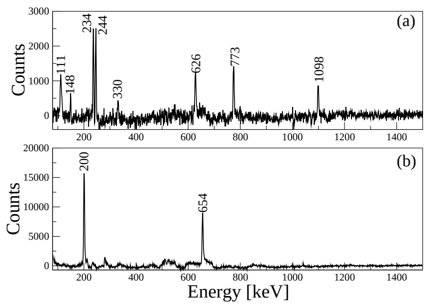

FIG. 2: Background subtracted γ-ray coincidence spectrum showing transitions depopulating the isomeric states in (a) ^{92}Mo and (b)^{91}Mo [8].

The validity of the technique for identification of isomeric states and their decay path was verified by gating on transitions depopulating known isomeric states. Figure 2 (a) shows the representative spectrum obtained by gating on 1510 keV transition of ^{92}Mo [8], where all the transitions depopulating the isomeric states at 11^- and 8^+ are clearly visible. Similarly, the 200 and 654 keV transitions depopulating the $21/2^+$ isomeric state in ^{91}Mo [8] are the only peaks in the spectrum generated by gating the 1414 keV transition as shown in Fig. 2 (b).

Our preliminary analysis suggests that the $13/2^-$ (2808 keV) state in ^{87}Y and $29/2^-$ (5407 keV) state in ^{89}Nb are long lived. Detailed analysis is in progress.

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