High Spin Spectroscopy of odd-odd ^{140}Pr

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Introduction

The detailed studies on doubly odd Pr nuclei, below N = 82 shell closure, have been performed in recent years using heavy ion fusion evaporation reactions [1,2]. Well developed band structures have been observed in these nuclei with the excitation of the odd particles to the high-j $h_{11/2}$ orbitals. The ^{140}Pr is the last candidate in the series having one neutron hole in N=82 shell closure. In this nucleus, the core excitation of proton particles above Z=64 sub-shell is important to produce high spin states. Besides, high spin yrast isomers are expected due to the presence of high-j intruder orbital that makes complete spectroscopy extremely challenging. It is, therefore, important to identify first the isomers and to measure their lifetimes in order to arrive at a consistent level scheme. Till date, the level scheme of ^{140}Pr is largely incomplete as there is hardly any data using HI reaction, except the only report by Yu et al.[3]. In this work, we report the high spin spectroscopy of ^{140}Pr, done using the Indian National Gamma Array (INGA).

Experiment

The high spin states in ^{140}Pr was produced by ^{130}Te (^{14}N, 4n) ^{140}Pr HI reaction using 75 MeV pulsed ^{14}N beam, delivered by the 15UD Pelletron accelerator at IUAC, New Delhi. The target was 1.0 mg/cm^2 enriched ^{130}Te, evaporated on a 4.8 mg/cm^2 Au backing. The beam energy was optimized for the study of neighboring ^{139}Pr nucleus, reported earlier [4]. The de-excited gamma transitions were recorded using the INGA setup, consisting of thirteen Compton suppressed Clover detectors that were arranged on rings, placed at five different angles with respect to the beam axis. The data were taken both during beam on and beam off periods in order to identify the delayed γ-rays.

Data Analysis

The data has been sorted offline and each Clover segment has been looked for the gain drifts during the experiment. 4K X 4K γ–γ matrix and γ–γ–γ cube were generated from the add-back Clover data. For this purpose, a gate of 108 ns has been put in the prompt γ–γ TAC spectrum. Several new transitions have been identified and have been placed in the revised level scheme. A preliminary Time-γ matrix has been generated for a limited number of detectors for which the prompt RF-γ TAC centroids of individual segments have been gain matched. TAC spectra corresponding to different gamma transitions have been projected for the extraction of level lifetime.

Results

The reported level scheme of ^{140}Pr [3] has been shown in Fig. 1. In the present work, several new gamma rays have been found to be placed in the level scheme from the rigorous γ–γ matrix and γ–γ–γ cube analysis. In Fig. 2, two representative added γ–γ gates have been shown, corresponding to a few strong transitions. The new transitions, observed in the gated spectrum, have been indicated with '*'. The level scheme is being modified on the basis of obtained double and triple gamma coincidence information. The spin

parities for many of the levels are tentatively assigned in the previous work. The DCO and

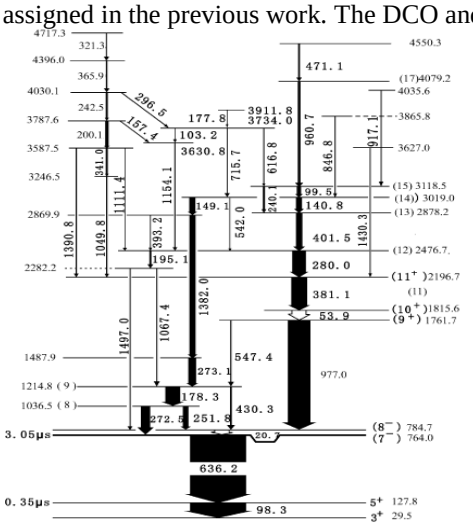

Fig. 1 Level scheme of ^{140}Pr [3]

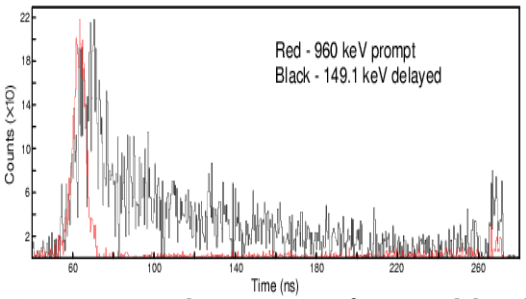

Fig. 2 Projected RF-γ TAC for one delayed (149.1 keV) with respect to the same for a prompt (960.7 keV) transition.

Acknowledgement

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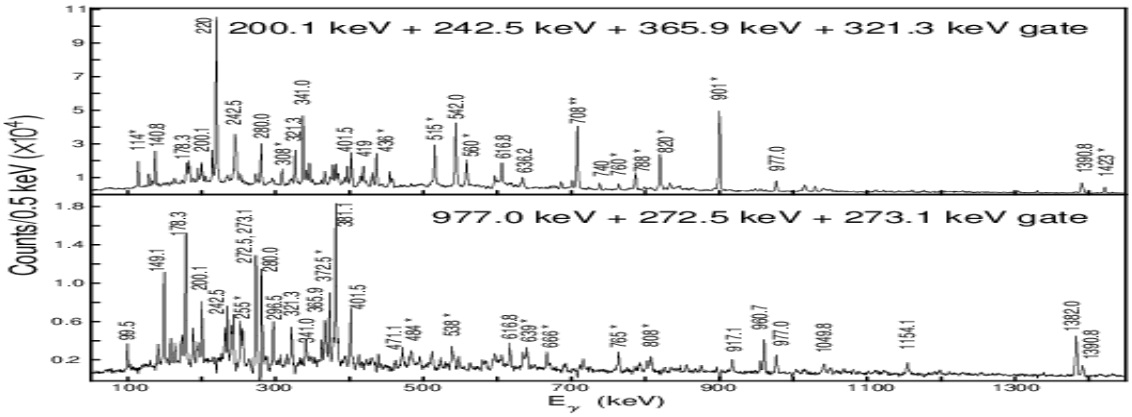

Fig. 2 Added spectra obtained from the prompt time gated γ–γ matrix. The lower panel shows the added gates of the transitions from the low lying levels and the upper panel shows the added gates corresponding to the high spin band structure developing on 3587.5 keV. The '*' indicates the gamma rays which are not placed in the level scheme but in coincidence. The '**' corresponds to g-rays de-excited from the long-lived isomeric levels in the neighboring nuclei.

Polarization analysis is in progress for the assignment of definite spin and parity to the excited levels of the nucleus. From the projection of time-γ matrix, lifetimes are indicated for a few excited levels. A representative spectrum has been shown in Fig. 3 where the TAC projection corresponding to 149.1 keV is given. The long tail is indicative of lifetime for the 3018.9 keV level of ^{140}Pr. The detailed analysis is in progress and complete level scheme will be presented.

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