Spectroscopy of ^{160,161}Ho

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Introduction

Nuclei in A ~150 region exhibit varieties of structure. $^{152\text{-}154}$ Ho have been studied [1] by our group in an earlier experiment during the previous Indian National Gamma Array (INGA) campaign. Shape-coexistence in ^{153}Ho has been demonstrated from our experimental data [1].

In the present work, our plan is to extend our study of shape evolution in Ho isotopes to relatively heavier ones (A>159), which are difficult to populate with heavy ions [2, 3]. $^{160\text{-}161}$Ho nuclei were populated via fusion evaporation reaction using alpha beam. The data from the most recent studies [3] on $^{160\text{-}162}$Ho also have limitations and have reported several issues to be resolved. There is an unknown band (X) [3] yet to be placed in either ^{160}Ho or ^{161}Ho though it was conjectured in ref [3] that the band belongs to ^{161}Ho because of higher population. A few spin-parities are to be confirmed also. We can also remeasure the life-time of some isomeric levels of ^{160}Ho to study the evolution of the nuclear structure.

Experimental details and analysis

The experiment was performed at VECC, Kolkata in 2018 using K-130 cyclotron. Self-supporting foil of ^{159}Tb (6.59 mg/cm^2) was bombarded with alpha beam of 35 MeV. The ^{160}Ho (3n channel) and ^{161}Ho (2n channel) were primarily populated in this reaction (Fig.1). There were 8 detectors (7 Compton suppressed Clover: 40°(1), 90° (4) and 125° (2) and one LEPS at 40°) in the recent campaign of INGA at VECC.

Data were acquired using PIXIE-16 module both in singles and coincidence modes. The calibration and efficiency measurement were done using ^{152}Eu and ^{133}Ba data taken in singles mode. Data were sorted using IUCPIX programs [4] and we have used INGASORT [5] to analyse the matrix formed with sorted data.

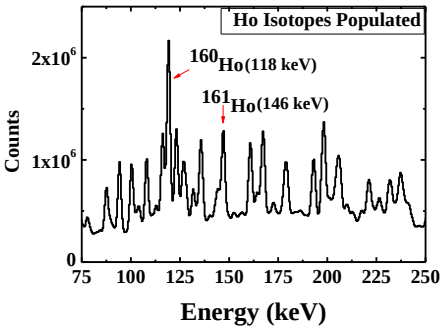

Fig.1 Strongly populated Ho isotopes.

Results and discussions

When we set the gate on 248 keV gamma of the X band, almost all the strong transitions of the 7/2$^-$ [523] band of ^{161}Ho are clearly seen (Fig.2).

This gated spectrum shows that X band belongs to ^{161}Ho because 248 keV gamma of the X band is found in coincidence with a cascade in

^{161}Ho. We are still to place the X band in the cascade of ^{161}Ho.

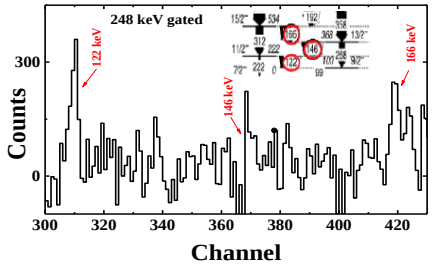

Fig.2 Some transitions indicated in red (inset) are shown in the 248 keV gated spectrum.

There are also some new connecting transitions in ^{161}Ho indicated in red in Fig.3.

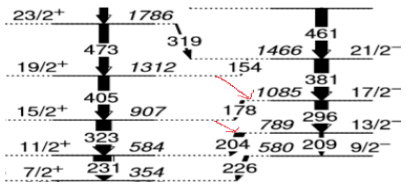

Fig.3 Partial level scheme of ^{161}Ho.

From the gated spectra of 473 keV and 405 keV gammas as shown in Fig.4, two new gammas of 227 keV and 118 keV energy are seen and they are indicated as connecting transitions in Fig.3 as there were no connections reported previously between 473 keV and 296 keV, 226 keV, 209 keV gammas and also between 405 keV and 209 keV, 226 keV gammas.

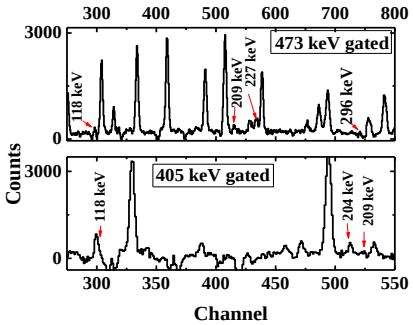

Fig.4 New gammas along with existing ones indicated in the gated spectra.

Spin-parity measurement of the new gammas and a few existing ones (not confirmed) is being done for both the nuclei ^{160,161}Ho.

Life-time measurement of a few isomeric levels of ^{160}Ho is yet to be done.

Large Basis Shell Model [LBSM] calculation using the OXBASH code [6] with some judicious truncation, gives energy eigenvalues of a few low-lying states those compare reasonably well (Fig.5) with the experimental values [7]. We have used z50n82 (single particle model space) and cw5082 (interaction file).

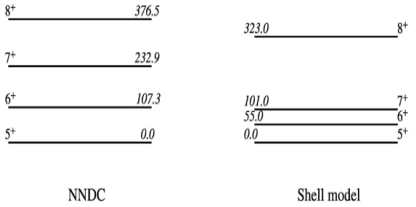

Fig.5 Comparison of few levels of ^{160}Ho.

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