Competing collectivity and multiplet structure in ^{154}Ho

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Neutron deficient rare-earth isotopes close to ^{146}Gd are interesting due to their novel structural features [1]. Interplay between single particle excitations and collective ones are observed in most of these nuclei. For nuclei having neutron number less than 88, single particle mode of excitations is seen at low spins. For neutron numbers above N=88, collectivity sets in even at low excitation energies.

We have been studying a few Ho isotopes spanning neutron numbers from 84 to 87. ^{154}Ho is extremely significant in studying the changeover from single particle modes to collectivity. But even in the latest compilation, there are uncertainties in the spin and parity assignments of the excited levels in these nuclei. We have already studied ^{153}Ho [2]. We found that there is a possibility of shape coexistence in this nucleus even at lower spins. Experimental data on $^{151-154}$Ho obtained from INGA campaign at Variable Energy Cyclotron Centre (VECC) have been analysed to confirm the existing level schemes as well as assign new levels. The evolution of structural features in these Ho isotopes with increasing neutron numbers and increasing spin has been studied theoretically using shell model as well as Total Routhian Surface (TRS) calculations [3].

In the earlier experiment during VECC campaign, ^{154}Ho was not populated strongly. In the present work we report the results of the data on this nucleus obtained during a recent experiment. High spin states in odd-odd ^{154}Ho have been populated by ^{141}Pr(^{16}O, 3n) reaction at a projectile energy of 82 MeV from 14-UD Pelletron accelerator at Tata Institute of Fundamental Research (TIFR), Mumbai. The target was prepared with black powder of Praseodymium Oxide (Pr_6O_{11}) of 3mg/cm^2 thickness at the target laboratory of (VECC) by centrifuge on a backing of 11.15mg/cm^2 gold.

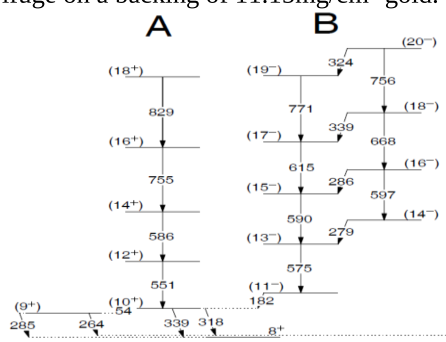

Fig. 1 Partial level scheme of ^{154}Ho

Gamma-gamma coincidence measurement has been done using the multi detector array of nineteen Compton suppressed Clover detectors (Indian National Gamma Array: INGA setup) [4]. The detectors are placed at the following angles: three Clovers each at ±40 degree and ± 65 degree, four Clovers at 90 degree and three at -23 degree. 2×10^9 two-fold events have been collected.

All the gamma rays observed in the earlier study [5] of ^{154}Ho till I=26ħ are observed. In the previously published level scheme (Fig.1) of ^{154}Ho, no connecting gammas between the two bands (A and B) were detected. In the present data, after preliminary analysis, a few transitions have been found to connect them. In 551 keV (band A) gated spectrum (Fig.2), 586, 755, 829 keV gammas are seen as expected. The spectrum also shows 575, 279, 597, 615, 668, and 756 keV transitions of band B as well. This observation indicates that these two bands must have connecting transitions. However, the 590, 771 keV in this band could not be seen in the spectrum (Fig.2). Moreover, according to the existing scheme, presence of the 575 keV peak in the 551 keV-gated spectrum is also not expected. This clearly indicates that the level scheme also needs modification.

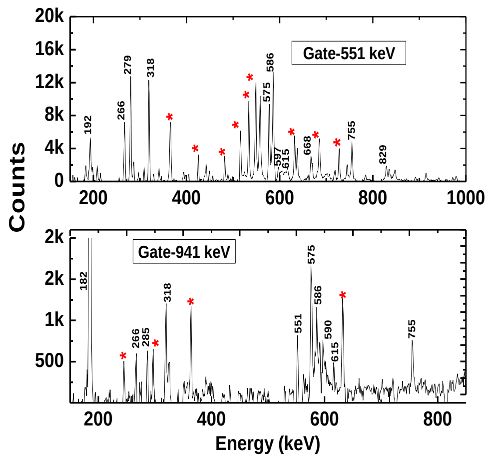

Fig.2 Gated spectra with red stars indicating new transitions.

A new transition 941 keV has been identified which probably connects the two bands (Fig.2). 941 keV is in coincidence with 551, 755, 586, 615, 590, 575 keV transitions but not with 829 and 771 keV. Another new transition 744 keV is correlated with 551 and 575 keV transitions, but it is not in coincidence with 829, 755, 586, 771, 615, 590 keV transitions. Detailed analysis is in progress to build up the level scheme incorporating the DCO and polarization data.

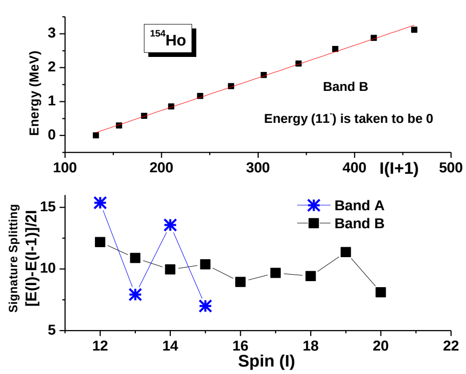

Fig.3 Characteristics of the two bands

The level scheme [5] of ^{154}Ho consists of a well-developed negative parity band (band B). It has been identified as a signature-split band till I=20ħ. We have plotted (Fig. 3) the excitation energies of different levels in this band as a function of I(I+1). The band B (ΔI=1) in ^{154}Ho shows linear relationship with I(I+1) unlike that in ^{152}Tb [1]. Weak signature splitting for this band is shown in fig. 3. These observations indicate a stable deformed shape of the nucleus having almost constant moment of inertia till I=20ħ. However, the intensity patterns of the emitted gammas as shown qualitatively in Ref. [5] do not provide any definite pattern expected from a strongly deformed nucleus.

On the other hand, the positive parity band (band A) shows substantial splitting indicating a weakly deformed structure. In our earlier work [3], we have shown that the splitting in band A could be reproduced reasonably well within simple shell model calculations with 1 neutron- 1 proton multiplet structure.

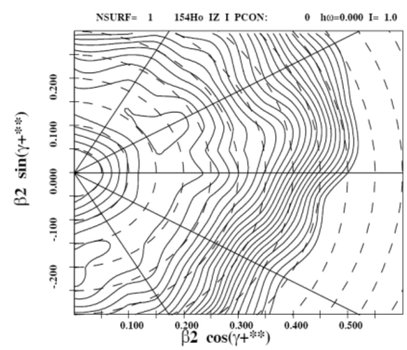

Fig.4 TRS results for low spins in ^{154}Ho. The axes are defined with respect to (γ+30^o).

TRS calculations (Fig. 4) support a deformed character for this nucleus along with a secondary minimum for an oblate structure. More conclusive evidences from experimental data will be presented to strengthen the characterisation of these bands.

References

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