Study of Nuclear Structure around N=90

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Introduction

The present thesis comprises of experimental investigations of the low and moderately high spin structure of nuclei around N=90 in the mass $\sim$ 150-160 region using both heavy and light ion beams. This region around N=90 is interesting with respect to both λ=2 quadrupole and λ=3 octupole deformations. As one goes from N=88 to 90, a sudden increase in quadrupole collectivity is observed to take place in several nuclei (viz., Nd, Sm, Gd, Dy, Eb, Yb etc.) [1]. At Z=62, while going from ^{148}Sm to ^{154}Sm [2], transition from a vibrational to a rotational character has been observed experimentally. This shape changing phenomena continues upto Z=70 where another interesting observation regarding quadrupole deformation has also been observed. In these nuclei, an increase in Quadrupole collectivity [3, 4] with rotational frequency followed by another decrease have been observed for which no theoretical explanation does exist in the literature. Strong evidence of pear shaped λ=3 octupole deformation has also been observed experimentally in nuclei around N=90 namely, ^{151}Pm (Z=61), ^{149,150,151}Sm (Z=62) and ^{153,155}Eu (Z=63) [5–9]. There are theoretical predictions which suggest that the N=90 nuclei around Gadolinium (Z=64) and Ytterbium (Z=70), having both proton and neutron numbers close to the tetrahedral magic numbers [10, 11], are the most suitable candidates for the observation of the λ=3 nuclear tetrahedral deformation. Thus, it may be concluded that the region around N=90 is of substantial interest for understanding new shapes and excitations in the nucleus. Other than the variety of shapes and excitations, this region is also interesting with respect to the possible presence of long lived isomeric states [6].

In the framework of this thesis, spectroscopic investigations of two nuclei, i.e., ^{150}Sm (N=88) and ^{160}Yb (N=90) have been performed. The N=90 nuclei around A$\sim$160 which lie in the proton rich side of the N-Z plot can be accessed using the Heavy Ion (HI) beams. But it is difficult to populate the N=90 nuclei around A$\sim$150 using HI induced reactions for which the light ion induced reactions and/or the β decay could be quite useful. Prior to the study of nuclear structure of ^{150}Sm, an excitation function measurement for the ^{150}Nd(p,xn) reaction has also been performed as a part of this thesis which was of extreme importance in order to understand the relative population cross-sections of different residues. Also, an experiment on β decay end point energy measurement has been carried out in this thesis as a future perspective of studying the structure of the exotic nuclei in A$\sim$150 region where several long-lived beta decaying isomers are known to exist.

Experimental Details

The low and moderate spin states of ^{160}Yb nucleus were populated by using the HI fusion evaporation reaction ^{148}Sm(^{16}O,4n)^{160}Yb with E_{beam}=90 MeV from the 14UD Pelletron at TIFR using $\gamma-\gamma$ and $\gamma-\gamma-\gamma$ coincidence measurement. The 900 μg/cm^2 thick Sm_2O_3 target, 97% enriching and electro-deposited on a 3 mg/cm^2 Pb backing foil was used in this experiment. The INGA consisting of twenty compton suppressed clover detector at the time of experiment was used for detection of γ transitions.

In another experiment, the ^{150}Nd(p,xpyn) reaction was carried out using 7-15 MeV proton beams provided by K=130 AVF cyclotron

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at VECC. This work has facilitated the measurement of excitation function for p + ^{150}Nd reaction.

In the third experiment, the excited states of ^{150}Sm were populated by the ^{150}Nd(p,n)^{150}Pm reaction using 8 MeV proton beam provided by K=130 AVF cyclotron at VECC. The beam energy was choosen from the measured excitation function for the p + ^{150}Nd so as to have maximum cross-section for (p,n) channel. The irradiated targets were subsequently counted using different configuration of Ge detectors as per the requirements of decay spectroscopy measurement.

Results

A. Study of ^{160}Yb

The level scheme of ^{160}Yb has been significantly modified owing to the observation of doubles & triples coincidences & measurement of I_γ, R(θ), DCO & IPDCO ratios. Number of γ rays which could not be confirmed in the present work but were claimed to have been seen earlier is 82. Two non-yrast negative parity band structures have been studied which show strong E1 decays to the yrast band. From the comparison of reduced transition probability ratios with neighboring rare earth nuclei, it is conjectured that the even spin negative parity one might have a tetrahedral structure whereas the odd spin negative parity one can be associated with Y_{30} pear shape vibration. Also, limiting values of the branching intensities have been estimated for the unobserved transitions.

B. Study of Excitation Function

In the present work, the absolute cross-section for the reaction ^{150}Nd(p,xpyn) has been measured for the first time. The experimental results have been corroborated with statistical model calculations using different codes, viz., CASCADE, ALICE & EMPIRE3.1.

C. Study of ^{150}Sm

Using the results of the study of excitation function, decay spectroscopy of ^{150}Pm has been carried out to study the low lying levels in ^{150}Sm. The decay half lives followed by the observed transitions along with the $\gamma - \gamma$ coincidence information have been used for development of level scheme. New levels have been assigned to the decay scheme of ^{150}Pm with the placement of new transitions, confirming new transitions & also by changing earlier placement of few transitions. The logft analysis & angular correlation measurement has been utilized to assign the spin-parity of the excited levels of ^{150}Sm. The β-decay end point energies corresponding to the ^{150}Pm$\rightarrow^{150}$Sm decay is measured for the first time.

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