In-beam $\gamma-$ray spectroscopy of transitional nuclei

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Introduction

In-beam $\gamma-$ray spectroscopy serves as an efficient tool to investigate structural properties of nuclei. The present thesis entitled as **"In-beam $\gamma-$ray spectroscopy of transitional nuclei"**, provides a γ-ray spectroscopic investigation of band structures of transitional nuclei near proton Shell closure (Z = 50) and also near neutron shell closure (N = 82). Investigation of these nuclei draws great attention over last few decades due to the abundance of versatile structural phenomena and made a very good laboratory to test different theoretical models. The process helps to understand the various underlying physical processes for the shape evolution and phase transition processes in a many-body quantum system.

Motivation

The transitional nuclei lying near the Z = 50 and N = 82 shell closure are subject of immense interest because of shape transitions and evolution, which leads to a variety of structural phenomena in these nuclei. In the mass $A \sim 130$ region, proton (neutron) Fermi surface lies near the lower-side (higher-side) of the $h_{11/2}$ sub-shell and which gives rise opposite shape driving effects and drive the nuclei towards the $\gamma-$soft triaxial shape. Due to induced triaxiality, various types of band structures are expected. The Potential Energy Surface (PES) calculations also predicted a very small energy difference between prolate and oblate shapes and hence, these nuclei possess soft towards triaxial deformation (γ). Therefore, investigation of band structures of ^{124,126}Te (near Z = 50 shell closure) and ^{139}Pm (near N = 82 shell closure) nuclei have been carried with aims to understand the behaviour of triaxialilty and associated band structures.

Experimental set-up

The experimental data, obtained from two different fusion evaporation reactions, have been used to fulfill the purpose of present thesis. The experiments have been carried out using Indian National Gamma Array (INGA) facility at Inter-University Accelerator Centre, New Delhi. The 15 UD pelletron accelerator facility have been used to accelerate the heavy-ions used during the experiments.

Results and Discussions

The influence of high-j quasi-particles on collective excitation have been investigated, near the proton (Z = 50) and neutron (N = 82) shell closure. The high-j quasi-particles significantly polarized the nuclear shape and induces various shape evolution in nuclei.

The level scheme of ^{124}Te and ^{126}Te has been updated from ^{122}Sn(^{9}Be,α3n)^{124}Te and ^{124}Sn(^{7}Li,p4n)^{126}Te fusion evaporation reactions, respectively. In ^{124}Te 7 new band structures with 29 new $\gamma-$transitions have been established. The spin and parity of excited states have been confirmed on the basis of results of angular correlation (R_{DCO}) and linear polarization asymmetry measurements. States of quasi-γ bands have been identified in ^{124}Te upto 10^{+} state and upto 8^{+} state in ^{126}Te. The structures of these bands have also been discussed under the framework of Triaxial projected shell model (TPSM) calculations. The TPSM calculations fairly supported the interpretation of quasi-γ bands in ^{124}Te and ^{126}Te. In addition, the staggering pattern of between odd-even spin states of the quasi-γ band suggests the γ-soft behaviour (in contrast to spherical vibrational character) for ^{124}Te. The typical values of staggering factors indicates the presence of *E(5)*-critical point symmetry in ^{124}Te.

The population of high spin states of ^{139}Pm have been carried out via ^{127}I(^{16}O, 4n)^{139}Pm fusion evaporation reaction. The spin and parity of excited states have been confirmed on the basis of results of angular correlation (R_{DCO}), angular distribution and linear polarization measurements. A new $\Delta I = 2$ band has been observed and suggested to be associated with proton $g_{7/2}$ orbital. The configuration is also supported by TPRM-calculation, with $\beta \sim 0.18$ quadrupole deformation and $\gamma \sim 28^0$ triaxial deformation. Observation of this single quasi-particle band will help in understanding the structures of the positive parity bands of ^{139}Pm at higher angular momentum. However, the structure $\pi g_{7/2}$ band did not supported the previously assigned configurations for positive parity quadrupole bands (band 4 and band 5). The parity of a dipole sequence has been confirmed and established as a strongly coupled dipole band at $I^\pi = 17/2^+$. Such sequence is very rare in this mass region and hence, will extend the systematic of such band. A new quadrupole decoupled band structure has also been established at 2799 keV and extended upto 6312 keV state.

In the present investigation, search for the states associated with the wobbling excitation, in ^{139}Pm, has also been carried out. The yrast states, with $I^\pi = 13/2^-$, $17/2^-$, $21/2^-$ and $25/2^-$, has shown an evidence to be associated with one phonon wobbling mode excitation. As, evident from the present results of angular correlation (R_{DCO}), angular distribution and linear polarization measurements, which showed $\Delta I = 1$, E2-character for the 597, 721, 785 and 805 keV transitions decaying from these states. Earlier these states were interpreted to be associated with unfavoured signature partner of $\pi h_{11//2}$band. In this work, a soft indication of second phonon transverse wobbler band has also been found in ^{139}Pm. The decreasing trend of wobbling energy with spin confirm the transverse nature for both wobbling bands.

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