Collective and Non-collective States in Transitional Nuclei

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Introduction

Generation of angular momentum in an atomic nucleus can takes place either through collective rotations / vibrations or via non-collective excitations. While vibrations or non-collective excitations are mainly observed in spherical / weakly deformed nuclei, rotational motions are mainly realized in deformed nuclei. Transitional nuclei are lying in between spherical and well deformed region and therefore, become a very good laboratory to study the both collective and non-collective excitations and their interplay.

The nuclei in $A \approx 130$ (200) region, having $Z \gtrapprox 50$ ($Z \lessapprox 82$) and $N \lessapprox 82$ ($N \lessapprox 126$), have drawn a great interest in contemporary nuclear physics because of their transitional nature. The present thesis explores several collective and non-collective modes of excitations in nuclei and the role of negative parity $h_{11/2}$ orbital on their band structure.

Experiments

Excited states in four nuclei, *viz.* ^{127}Xe, ^{125}Te, ^{127}I and ^{198}Hg, were populated via ^{9}Be / ^{7}Li induced fusion-evaporation reactions. Energetic projectiles were delivered by the pelletron accelerator of Inter-University Accelerator Centre (IUAC), New Delhi. De-exciting γ rays were detected by the HPGe clover detectors of Indian National Gamma Array (INGA). Details of the experiments were given in Table I. Offline data analysis were carried out using INGAsort and RadWare analysis packages.

TABLE I: Details of the experiments.

Target	Beam	E_{beam}	No. of Det.	x$pyn\gamma$	Nucl.	Ref.
^{122}Sn	^{9}Be	48 MeV	14	$4n$	^{127}Xe	[1–4]
^{122}Sn	^{9}Be	48 MeV	14	$\alpha 2n$	^{125}Te	[5]
^{124}Sn	^{7}Li	33 MeV	15	$4n$	^{127}I	[6]
^{197}Au	^{7}Li	33 MeV	15	$\alpha 2n$	^{198}Hg	[7]

Results and Summary

^{127}Xe: The level scheme of ^{127}Xe has been updated significantly by placing $\approx$ 80 new γ rays and also by assigning spin/parity of several excited levels. Three positive parity one-quasineutron bands, based on $s_{1/2}$, $d_{3/2}$, and $g_{7/2}$ orbitals, have been extended up to high spin. Large signature splitting has been observed in low-Ω $s_{1/2}$ and $d_{3/2}$ bands in contrast to the low and inverted at the higher spin signature splitting of $g_{7/2}$ band [8]. Spin and parity of the yrast negative parity band have been assigned up to $\frac{47}{2}\hbar$. Signature partner of the negative parity yrast band has been observed. The high spin states of this band have been explained in terms of two-neutron alignment [1]. Competing alignment of proton-pair has also been identified. The half-life of a previously reported K-isomer has been revised and a rotational band above the isomer has also been established [3]. A three-quasineutron configuration has been proposed for the isomer. Systematic behaviour of the *reduced hindrance factor per degree of K-forbiddenness* has been discussed in the light of $A \approx 180$ region. A $\Delta I = 2$ band has been established above $19/2^+$ state at 2307 keV [2]. The experimental dynamic moment of inertia of this band found low and also constant as a function of spin. Semiclassical particle rotor model calculation shows a very low $B(E2)$ value for this band indicating the existence of antimagnetic rotation, observed for the first time in this mass region [9]. Apart from these, two more negative parity bands have been observed at lower angular momentum. Experimental signatures indicates the wobbling nature of these two bands. Another positive parity quadrupole band has been observed to decay only in the yrast negative parity band via $E1$ transitions. Parity of a three-quasiparticle band has been assigned on the basis of linear polarization measurement. A cluster of non collective states has also been observed in the present work.

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^{125}**Te:** Excited states in ^{125}Te has been studied to search for the expected K-isomer, observed systematically in $N = 73$ Xe-Ba isotones. Spin and parity of the states belonging to $h_{11/2}$ and $d_{3/2}$ bands have been confirmed unambiguously [5]. Spin and parity of a state at have been assigned as $I^{\pi} = 21/2^{-}$, which is a candidate of expected K-isomer. Systematics of the K-isomer observed in $N = 73$, 79 has been discussed.

^{127}**I:** Level scheme of ^{127}I has been revised significantly. Apart from the strongly populated $\pi(d_{5/2}/g_{7/2})$ and $\pi h_{11/2}$ bands, weakly populated bands have been critically investigated. Parity of the kev levels have been changed on the basis of present polarization measurement [6]. Few states, previously suggested as non-collective in nature, are found to form a negative parity three-quasiproton band [6]. This leads to the first observation of such negative parity three-quasiproton band in an iodine isotope. Few feebly populated have been identified to decay in to the $\pi h_{11/2}$ band. Excitation energy of this states is matching nicely with the γ-vibrational states of the ^{126}Te core. Therefore, it is predicted that these states might be originated due to the coupling of γ-vibration with an odd $h_{11/2}$ proton.

^{198}**Hg:** Low-lying states in ^{198}Hg have been investigated via in-beam γ-ray spectroscopy and both the favoured and unfavoured partners of the γ-vibrational band have been identified [7]. A state with $I^{\pi} = 4^{+}$ has been predicted as the band-head of the two-phonon γ-vibrational band. Properties of the observed γ-band has been compared with the γ-bands observed in other nuclei in this mass region.

Acknowledgement

I am grateful to my Ph.D. supervisor Prof. H. P. Sharma for his guidance and support. I would also like to thank my collaborators for their support and valuable suggestions in various stages of this work. The INGA collaboration, partly funded by DST and UGC, is duly acknowledged for making the detectors available and setting those up at IUAC. The financial support of the Council of Scientific and Industrial Research (CSIR) and University Grant Commission (UGC) is thankfully acknowledged.

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