Spectroscopic properties of nuclei in the mass region ~ 130

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1. Introduction

We are interested in the study of spectroscopic properties of nuclei in the mass region ~130. The mass region A~130 represents the experimental understanding of the role of the different intruder and other orbitals at various deformation. Using the picture of the deformed shell model, called the Nilsson model, the variety of structures observed in the A~130 mass region can be explained by opposite shape driving effects due to valence protons and neutrons, respectively.

For the positive quadrupole deformation (ε_2), valence protons filling the lower part of the $h_{11/2}$ subshell tend to stabilize nuclear shapes at prolate deformations, while the valence neutrons being at above or the $h_{11/2}$ mid-shell, favor oblate or triaxial shapes. Many phenomena such as shape co-existence, signature splitting and signature inversion, identical band, superdeformation, band termination, magnetic rotation, high-spin isomer, decoupled band, and chirality, have been observed in this mass region.

2. Experimental Details

Two experiments were performed using Indian National Gamma Array (INGA). One experiment was performed at Inter University Accelerator Centre (IUAC), New Delhi using the 15 UD Pelletron accelerator. In this experiment high spin states of ^{126}Te and ^{127}I were populated using the reaction ^{124}Sn(^{7}Li, p4n)^{126}Te and ^{124}Sn(^{7}Li, 4n)^{127}I respectively at a beam energy of 50 MeV. The target was self-supporting ^{124}Sn of thickness 2.7 mg/cm^2. The INGA set-up consisting of 15 Compton suppressed HPGe clovers detectors was utilized to detect the γ-rays.

In another experiment, a beam of ^{11}B as a projectile was bombarded on a self-supporting ^{124}Sn target of thickness 2.21 mg/cm^2 at beam energy 70 MeV. The experiment was conducted using Palletron-Linac accelerator at TIFR, Mumbai. In this experiment, ^{129}Xe was populated through ^{124}Sn(^{11}B, p5n)^{129}Xe reaction. The INGA set-up consisting of 21 Compton suppressed HPGe clovers detectors was utilized to detect the γ-rays.

Using ^{152}Eu-^{133}Ba source data, the online data were calibrated, and detector efficiency was found. The symmetric E_γ-E_γ matrix and E_γ-E_γ-E_γ cube were constructed to build up the level scheme using the correlation technique. The spin and parity to the excited states of nuclei were assigned using the Directional correlation (DCO) and polarization analysis. The polarizational-directional correlation (PDCO) technique was used to remove the ambiguity in the spin-parity assignment.

3. Results

3.1 Study of ^{126}Te

There was a prediction of an isomeric state which was a good candidate for K-isomerism, 8$^-$ around 3 MeV from the ground state for ^{126}Te [1]. At the time when we began our study, very little was known for ^{126}Te [2]

We were able to add 34 new γ-transitions in the decay scheme of ^{126}Te. Spin and parity of many levels were assigned. Results of ^{126}Te were presented in the DAE symposium and were published as a symposium proceeding [4]. Later, a paper on ^{126}Te was published by A. Astier *et al*., [6] while we were trying to finish the work after our presentation in the DAE symposium.

3.2 Study of ^{129}Xe

The odd mass Xenon nuclei fall in the mass region which provides a testing ground for various modes of nuclear excitations. The possible modes are the coupling of quasi-particles with the vibrating core or with the rotating core. It can even be the weak coupling

of the quasi-particles with the neighboring even-even core nuclei.

At the time when we began our study, very little was known for ^{129}Xe [3]. We were able to add 18 new γ-transitions in the decay scheme of ^{129}Xe. Spin and parity of many levels were assigned. We were able to resolve the ambiguity in the assignment of spin-parity to state decaying *via* 604 keV transition to $19/2^-$ state by utilizing the Polarizational-Directional Correlational (PDCO) technique [10].

We did the Total Routhian Surface (TRS) calculation to get the nature of yrast band of ^{129}Xe. We observed the phenomenon of backbending at $\hbar\omega \approx 0.4$ MeV in the plot of alignment i_x *vs*. $\hbar\omega$. Haris parameters used were $J_0 = 22.465$ MeV$^{-1}\hbar^2$ and $J_1 = 13.621$ MeV$^{-3}\hbar^4$ which were obtained by fitting lowest yrast energy levels of ^{129}Xe. The deformation parameter values were $\varepsilon \approx 0.15$, $\varepsilon_4 \approx 0.00$, $\gamma \approx -118°$ which were obtained from the TRS plot were used for the quasi-neutron Routhian plot. From the quasi-neutron Routhian plot, the second crossing frequency was found to be $\hbar\omega \approx 0.42$ MeV which is approximately the same as the backbending frequency. Therefore, we inferred that the backbending was due to the neutron alignment.

Results of ^{129}Xe were presented in the DAE symposium and were published as a symposium proceeding [5]. Later, further results of ^{129}Xe were presented in the conference "Advances in Radioactive Isotope Science (ARIS2014)" at Tokyo and were published as a conference proceeding in the JPS Conf. Proc. 6 , 030016 (2015) [7]. We did Shell model calculations and were able to reproduce few lowest states of ^{129}Xe. Recently, a paper on ^{129}Xe was published by Y. Huang *et al.* [8].

3.3 Study of ^{127}I

In ^{127}I, a couple of bandheads were assigned tentative spin and parity [9]. All theoretical understanding depends upon right spin and parity assignment. So, correctly assigning spin and parity to these states are very crucial. We were interested in assigning spin and parity to the tentative states of ^{127}I.

We were able to place total four new γ-transitions in the decay scheme as compared to earlier work [9]. Moreover, many previous transitions were missing in our coincidence gated spectra. The spin and parity to the state decaying via (a) 802.1, (b) 490.4, (c) 274.6, (d) 357.8 keV (e) 547.2 transition were assigned using the PDCO technique. Decoupling behavior was observed in ^{127}I.

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