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γ-ray spectroscopy of ^{131}Xe from α-induced reaction

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Introduction

Nuclei around A~130 are interesting to explore the effect of the complex interplay of the single-particle and the collective degrees of freedom on the variety of nuclear shapes and to test the predictive powers of nuclear models at both low and high spins. Having both proton and neutron excitations in the same major shell, the higher spin states in this mass region originate from the coupling of unique parity $h_{11/2}$ orbital with the other available orbitals. Xe isotopes are known for their shape transitions from prolate to an oblate or triaxial one with increase in neutron number. For example, oblate band is reported in ^{129}Xe [1] whereas in ^{125}Xe, experimental results indicate weak triaxial and a prolate shape [2]. Compared to these lower mass Xe isotopes, spectroscopic data on ^{131}Xe are rather scarce. The previous available data on ^{131}Xe are from β-decay studies [3], (α, n) [4] and (α, 3n) [5] reactions. Being situated close to beta stability line, ^{131}Xe is difficult to populate with any heavy ion induced reaction because of lack of suitable target-projectile combination. With the availability of high efficiency gamma detector array, it is now possible to obtain precise spectroscopic data of yrast and non-yrast structures using Alpha induced reaction.

Experiment

In the present work, excited levels of ^{131}Xe were populated using the fusion-evaporation reaction ^{130}Te (α, 3n) ^{131}Xe at beam energy 38 MeV delivered from K-130 cyclotron at VECC (Kolkata). The used target was 2mg/cm^2 thick with a 200 μg thick myler backing. Indian National Gamma Array (INGA) at VECC consisting of seven Compton suppressed Clover detectors were used to record the data in both singles and coincidence mode. Four detectors were at 90°, two were at 125° and one detector was at 40° with respect to the beam direction. PIXIE based digital data acquisition system [6] was used to acquire the time stamped LIST mode data.

Data sorting

A set of programs called IUCPIX package [6] was used to sort the data to form the Eγ-Eγ symmetric matrix and Eγ-Eγ-Eγ cube. These programs were also used to form the DCO matrix between the 90^0 detectors and the backward 55^0 detectors to determine the multi-polarities of the observed γ-rays from DCO ratio. The parallel and perpendicular scattering of the Clover detectors at 90^0 were utilized to determine polarization asymmetry of the decaying γ-rays to find their electric/magnetic nature.

Results

The existing level structure of ^{131}Xe is significantly extended on the basis of coincidence analysis from this present work. From preliminary analysis, the yrast negative parity state is extended upto 35/2$^-$ state with the placement of three new E2 transitions.

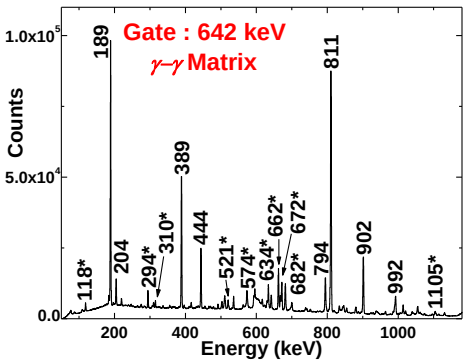

Fig 1 : Coincidence spectra corresponding to 642 keV trasition of ^{131}Xe. Newly observed transitions are marked with '*'.

In a previous work [7], the spin parity of this negative parity band was tentatively assigned, but from this work, those are confirmed. Fig.1 represents the coincidence spectrum of 642 keV (15/2$^-$ → 11/2$^-$) γ-ray. The newly observed γ-rays are marked with '*'.

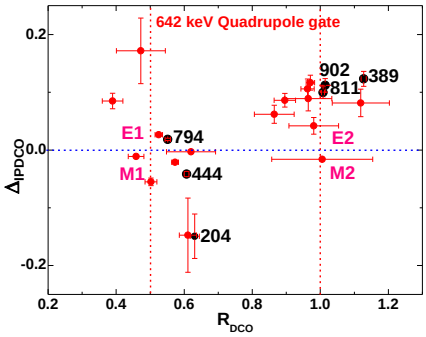

Fig 2 : Conventional R_{DCO} vs Δ_{IPDCO} plot to determine the multipolarities of the observed γ-rays in the present work.

A new band structure above 17/2$^+$ state consisting of dipole transitions has also been established. Fig. 2 shows the conventional R_{DCO} vs Δ_{IPDCO} plot, which is used to assign the multipolarities to the decaying transitions.

Another set of transitions above the 11/2$^-$ isomer and in parallel with the main yrast cascade are also identified in this work. The level sequences above the 3/2$^+$ ground state and bypassing the 11/2$^-$ isomer, have been extended upto a possible spin of 21/2$^+$.

Discussion

The yrast band built on 11/2$^-$ is based on the $\nu h_{11/2}$ orbital and a spin difference with the next 3/2$^+$ ($d_{3/2}$) level makes it a isomer of 11.8 days. The yrast band is seen to have a neutron pair alignment at a frequency of 0.4 MeV.

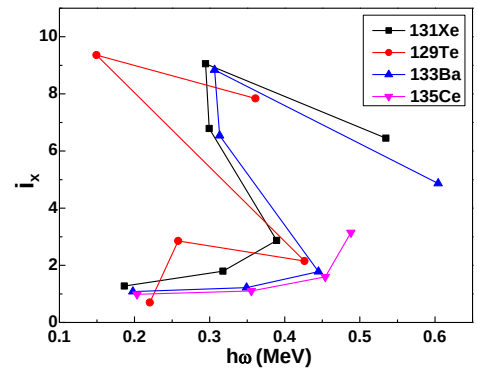

Fig 3: Alignments(i_x) plots for the yrast 11/2$^-$ band for N=77 isotones.

Neutron alignments at similar frequency are reported in nearby isotones and are shown in Fig.3.

Acknowledgement

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