Spectroscopy of low lying states of ^{132,134}Xe from β-Decay

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Introduction

Nuclei near ^{132}Sn present a unique opportunity to study the properties of nuclei with few valence particles or holes outside the Z=50 and N=82 magic shell closure. Spectroscopy of nuclei in this region provides valuable information about the two body matrix elements corresponding to the effective residual interaction used in shell model calculations. The even-even nucleus ^{132,134}Xe, with four proton particles and few neutron holes with respect to Z=50 and N=82 shell closure are good candidates to study the single particle excitations in this region of neutron-rich nuclei. The low lying states of ^{132}Xe studied earlier from offline decay of ground state and high spin isomeric state (8^-) of ^{132}I using few Ge(Li) detectors [1,2]. On the other hand, the spectroscopy of ^{134}Xe from beta decay of ^{134}I was previously carried out using one Ge(Li) and one NaI(Tl) detectors [3,4]. But these studies were not able to resolve close lying γ energies and are not very efficient to detect high energy γ rays (>1 MeV), mainly due to limited efficiency and resolution of the detectors used. In the present work the low lying excited states of ^{132,134}Xe have been investigated by offline decay spectroscopy using HPGe Clover detectors and Low Energy Photon Spectrometer (LEPS).

Experiment

The neutron-rich nuclei in medium (A=130-140) mass region is difficult to produce in conventional fusion evaporation reaction. In the present work the neutron-rich Xe isotopes are populated from the beta decay of corresponding Iodine isotopes, produced from alpha induced fission of $^{nat.}$U target using 32 MeV alpha beam from the K-130 cyclotron at VECC (Kolkata). The Iodine isotopes were radio-chemically separated from other fission products. Four Clover detectors and two LEPS detectors were used for counting the decaying gamma rays [5].

Analysis and Results

Placement of new γ rays in ^{134}Xe was confirmed from γ–γ coincidence analysis as well as from following their decay half-lives and a new level scheme has been obtained [5]. Complete intensity balance of all the levels including the new ones has been done to obtain the decay feeding to excited states of ^{134}Xe. The coincidence information about the low lying states in ^{132}Xe from the decay of ground state and isomeric state of ^{132}I has been reported earlier [6]. The present paper reports the angular correlation analysis of the decaying gamma rays in ^{132,134}Xe and shell model calculations to interpret of the excited states in ^{132,134}Xe.

The angular correlation function between two consecutive γ rays in a cascade emitted from an unoriented state can be expanded as,

$$W(\theta)=\sum A_{kk}P_{kk}(\cos\theta) \qquad (1)$$

Where, θ is the angle between the two γ rays which are emitted successively; A_{kk} are the angular correlation coefficients; while P_{kk} are Legendre polynomials. By choosing the direction of the first γ-ray of known multipolarity, A_{kk} coefficients take some specific values depending upon the dipole or quadrupole nature of the second γ-ray. It is also possible to calculate these A_{22} and A_{44} values from theoretical formulae with mixing taking into consideration [7]. After comparing the experimental A_{kk} values with the theoretical ones, the mixing ratio (δ) of the transition can be determined. In the present experiment, three Clover detectors were positioned at 90^0, 135^0, 180^0 angles with respect to another Clover detector. It is convenient to normalize equation(1) to $W(90^o) = 1$, introducing new coefficients $a_{kk} = A_{kk}/A_{00}$, while the error of intensity at 90° has been included in the errors for the data points at other angles. The a_{kk} coefficients are also corrected for finite detector size. Fig.1 shows the angular correlation of some of the transitions corresponding to ^{132,134}Xe. The 1806 keV γ-ray is known transition but 1505 keV is a new one in ^{134}Xe. The 954 and 919 keV γ-rays are from ^{132}Xe. Comparison of experimental a_{kk} values with the theoretical ones with various mixing ratio (δ) are shown in Fig.2. From the preliminary angular correlation analysis, the spins of 1613, 2408, 2547, 2588, 2653 keV levels in ^{134}Xe are expected to be as 2^+, 5^+, 5^+, 3^+, 3^+ respectively. These are in good agreement with the known values [8]. Further improvements in angular correlation analysis considering all detector combinations, taking into account the crystals of each Clover detectors and comparing with theoretical coefficients is under progress.

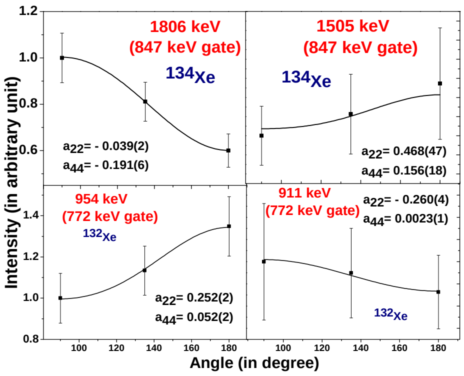

Fig. 1: Angular distribution of some of the γ transitions of ^{132,134}Xe

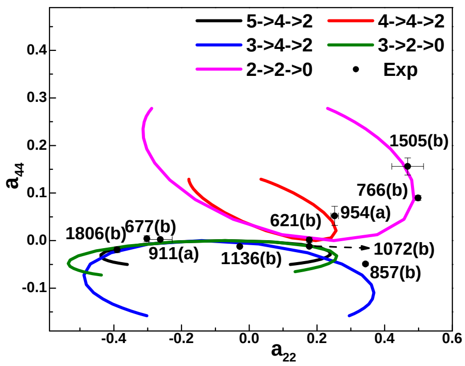

Fig. 2: Theoretical plots of angular correlation coefficients with varying δ compared to that of experiment for transitions 132Xe (a); 134Xe (b).

Log *ft* values have also been calculated from the deduced feeding to the corresponding energy levels and are found to be consistent with the angular correlation results.

Theoretical Calculations

The large basis shell model calculations were carried out using the code OXBASH [9] to characterize the excited levels of ^{132,134}Xe. The sn100pn effective interaction [10] was used to carry out the calculations in full model space (Z=50, N=50 core) without any restriction. The valence space consists of $1g_{7/2}$, $2d_{5/2}$, $2d_{3/2}$, $3s_{1/2}$, $1h_{11/2}$ orbitals for both neutron and protons. Fig.3 represents the comparison between theoretical and experimental levels of ^{134}Xe.

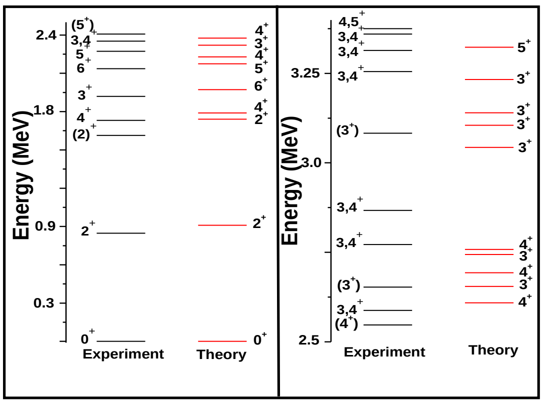

Fig. 3: Comparison of shell model calculations with the experimental levels of ^{134}Xe.

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