Probing the low-level nuclear structure of ^{132}Ba by Coulomb excitation measurements

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In the region around ^{132}Sn, the structure of even-even nuclei demonstrates diverse phenomenon including the transition between some typical quadrupole collective states. The doubly magic isotopic chain of Sn-isotopes seems to be the most interesting mass-region to be studied. Several theoretical and experimental studies have been focused in this mass region, recently [1]. The low-lying spectroscopy of these nuclei is one of the most powerful sources of information about nuclear shapes and shape transitions. Experimental/adopted B(E2↑) values for this mass-region are depicted in Fig. 1.

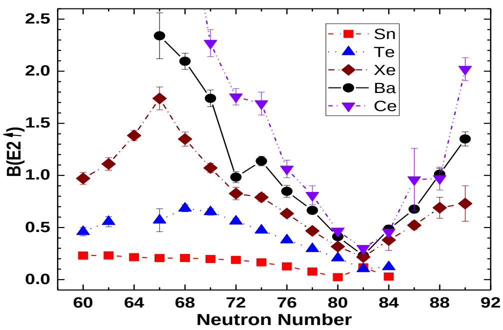

Fig. 1 Experimental/adopted B(E2↑) values of Sn (square), Te (up-triangle), Xe (diamond), Ba (circle), and Ce (down-triangle) isotopes [5].

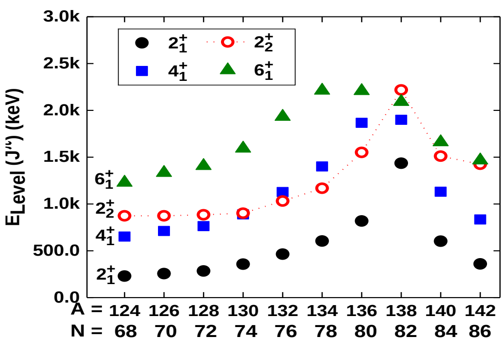

Fig. 2 Variation of low energy levels in Ba-isotopes [5].

Ba-isotopes which show signatures of E(5) symmetry, corresponds to the transitional region from spherical vibrational U(5) to deformed γ-unstable O(6) limits. Low energy level scheme for Ba-isotopes, as given in Fig. 2, show gradual transition of different types of quadrupole collective states with increasing neutron number. Several microscopic, algebraic, and statistical studies viz. Monte Carlo Shell Model [2], Interacting Boson Model with pairing interactions (IBM-2) [3], and General Bohr Hamiltonian calculations [4] etc. have been conferred for these nuclei, in recent years. Most of the stable Ba-isotopes have been studied experimentally, but still there is no sufficient data available for ^{132}Ba.

Therefore, to probe the low level nuclear structure of ^{132}Ba, two complementary experiments were carried out at Inter University Accelerator Centre (IUAC), New Delhi and Heavy Ion Laboratory (HIL), University of Warsaw, Poland. At IUAC, the particle detector (PPAC) [6, 7] was placed at forward scattering angles, where the excitation probability of first 2^+ state is most dominant, while at HIL, Warsaw the particle detectors (PIN diodes) [8, 9] were placed at backward scattering angles where excitation of other higher states is more probable, to cover a wide scattering range for collecting data during the measurements. A detailed description of the experimental setups is given elsewhere [6-9].

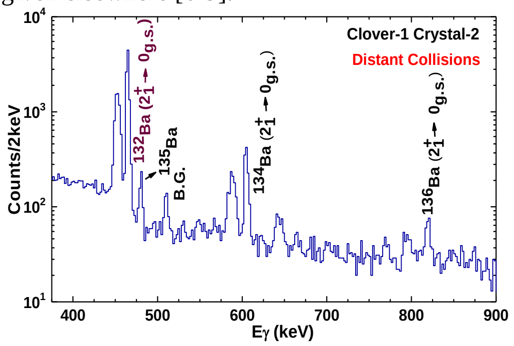

Fig. 3 Doppler shift corrected spectrum for ^{58}Ni+^{132}Ba system for distant collisions.

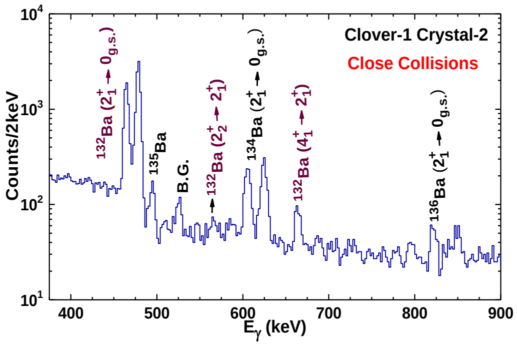

Fig. 4 Doppler shift corrected spectrum for ^{58}Ni+^{132}Ba system for close collisions.

Typical Doppler shift correction was performed for the de-excited gamma rays detected with CLOVER detectors, as discussed in our previous paper [7], and the Doppler corrected gamma-ray spectra are shown in Figs. 3 & 4, for the two cases of distant collisions (^{58}Ni detected in PPAC) and close collisions (^{132}Ba detected in PPAC), respectively.

The excitation strength of the 2^+ state in ^{132}Ba was determined for distant collisions with respect to the first excited 2^+ state in ^{134}Ba, to normalize the systematic errors. This normalization was further corrected for the different CLOVER-crystal efficiency and target enrichments. The theoretical cross-sections were calculated for a set of E2 matrix elements with the Winther-de Boer Coulomb excitation code [10]. The data was also examined for the reorientation effects, but these effects were found to be negligible for the present nuclei. Matrix elements and B(E2↑) values for the first three excited states were determined and compared with the values from Davidov-Filipov model, but right now sign of the diagonal matrix element cannot be assigned, since the $2_2^+ \rightarrow 0_{g.s.}$ gamma-ray couldn't be populated at IUAC, Delhi.

However, this state was detected with HIL, Warsaw [9] set-up and analysis of the data is in progress. These two experiments will be combined by using the least-square search code GOSIA [11], and the results will be discussed during the conference.

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