Alignment gain through shape-coexistence in ^{123}Xe

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Introduction

For transitional nuclei in $A \sim 125$ region, opposite shape-driving trends of protons and neutrons in $h_{11/2}$ orbital lead to nuclear shape transition from prolate to oblate via intermediate triaxial shape. Once all the valence particles outside the shell closure get aligned about the rotational axis, terminating state is reached. As a result, nucleus attains non-collective oblate shape [1, 2]. Previous probes in this mass region have revealed existence of triaxial shapes [3–5]. Low and medium-spin structure within the regime of triaxial deformation, often witness band crossings dictated by paired alignments of valence particles. The frequency of band crossing depends upon the blocking parameter of the nucleus. The first band crossings in ^{123}Xe, ^{125}Xe and ^{122}Xe have mostly been observed around $\hbar\omega$ = 400-500 keV [2, 3, 6]. These nuclei happen to be triaxial with deformation parameters, $\gamma \sim$ -40° and $\beta \sim 0.20$. Similarly, in Cs isotopes [1, 5], the alignments are attributed to paired crossings based on $h_{11/2}$ neutrons. Of course, competition between the contribution from $h_{11/2}$ protons and neutrons have been argued at length [7, 8]. Though, observation of delayed or blocked alignment in odd mass counterparts, indicate the involvement of neutrons in most of the cases. But, a breakthrough happened when the full crossing was observed for positive-parity band in ^{124}Cs [5] which revealed that the observed alignment gain was too large to be addressed with alignment of odd number of particles in the mid of Fermi level. It was observed that the dominant contribution in aligning the total spin comes from the protons while the shape transits from triaxial to prolate, whereas the neutrons are usually difficult to be aligned at prolate than at $\gamma \sim$ -40°. With these motivations, experimental results on less explored ^{123}Xe were discussed by Anwesha Basu *et al.* [9]. Here we discuss the nucleus in the framework of cranked Nilsson Strutinsky model calculation.

Model calculations

Calculations were performed with parameters derived for A = 110 region [10]. Energies were calculated relative to a standard rotating drop energy preferably Lublin-Strasbourg drop with diffused surface. The calculations facilitate comparison of nuclei in different mass region owing to application of an absolute energy scale [11, 12] based on mass excess. Thereafter, the calculated energy was minimized w.r.t. deformation parameters $(\varepsilon_2, \varepsilon_4, \gamma)$. Configurations were labeled as $[p_1 p_2, n_1]$, where p_1 and p_2 are the number of protons in orbitals $g_{7/2}d_{5/2}$ and $h_{11/2}$ respectively, whereas n_1 is the number of neutrons in $h_{11/2}$.

Results and Discussion

Negative parity band 8 was reported to show alignment gain of $5\hbar$. The crossing in band 8 was described as $\nu(h_{11/2})^3$ by Schmidt *et al.* in analogy to similar crossing in ^{125}Xe where neutron crossing in $h_{11/2}$ overtakes that of proton [4]. To look into the shape deformation, potential energy surfaces were plotted from $I = 12.5^-$ to 30.5^- for negative parity states. At $I = 12.5^-$, the nucleus is stabilized by a shape with negative γ parameter whereas, at $I = 24.5^-$ four different shapes coexist.

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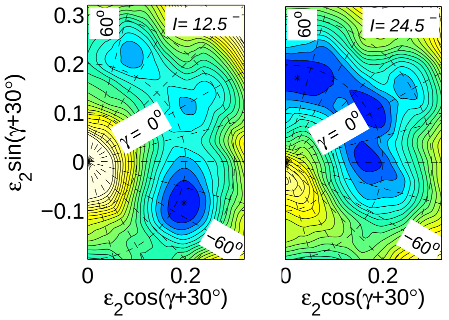

FIG. 1: Total energy surfaces with the constraint, $\pi = -$, $\alpha = 0$. The contour line separation is 0.25 MeV.

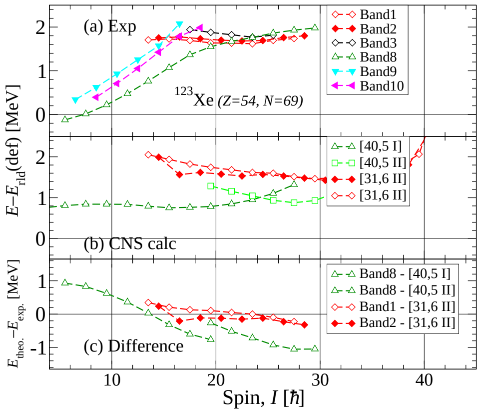

FIG. 2: (a) Experimental excitation energy w.r.t. spin for ^{123}Xe. (b) Calculated excitation energy vs spin for negative parity bands. (c) Comparison of experimental and calculated excitation energies as a function of spin. Configurations shown with I are calculated with parameters, ϵ = 0.2 and γ = -35° (oblate) whereas those with II are drawn with ϵ = 0.2 and γ = 0° (prolate).

Observed excitation energy w.r.t. a liquid drop was plotted as a function of spin (Fig. 2). The same is compared with the calculated results for a few selected configurations. From the plot, it is concluded that configuration [40,5] can be assigned to band 8. For the given configuration, triaxial parameter γ transits from negative value before alignment to prolate after the crossing. Bands 1 and 2 feed to band 8 and were observed to show alignment gain of $8\hbar$. By comparing with the calculated results, bands 1 and 2 are assigned [31, 6] signature partners. Band 3 with similar characteristics as those of bands 1 and 2 should be explained with similar configurations.

Positive parity bands mostly show alignment gain of $6\hbar$ and interestingly decay to both positive and negative energy states. According to previous literature, these bands might be predominantly prolate which decay to triaxial shape [2]. Configuration [31,5] describes bands 12 and 13 convincingly. Either of bands 14, 15 and 16 agree well with [40,6] configuration though exact signature partner was not observed in calculated result. Detailed results will be discussed during the conference.

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