Static Nuclear Electromagnetic moment measurements in the A $\sim$ 130 Region

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The neutron deficient Ba nuclei belong to the transitional region, $N = 66$ to $N = 82$, characterized by γ-softness, triaxiality and the occupancy of unique parity $h_{11/2}$ shell by the protons and neutrons. The model interpretation of excited states in these nuclei, requires both the collective and single particle degrees of freedom. The interplay between collective and single particle degrees of freedom in atomic nuclei is one of the most interesting and intriguing aspects of nuclear structure studies. The transitional region is ideal ground to investigate this and the associated polarization of the core. The rotation and the quasiparticle alignment contribute further additional structural effects. The occupancy of high-Ω orbitals has resulted in the formation of K isomers and it is crucial to know the nature of the participating nucleons in the formation of the state. The knowledge of the static electromagnetic moments is very important for elucidating the structure of coexisting states, as they are providing independent information on the underlying configurations.

This thesis investigates the insight into the nuclear structure of $^{128,129}Ba$ nuclei through static nuclear electromagnetic moment measurements employing $TDPAD$ technique. The almost pure configuration of odd nucleon in these nuclei gives direct information about the nature of alignment and shape of nuclei. Two separate experiments were performed to acquire the requisite data. The presently investigated isomeric states were populated in the fusion evaporation reaction ^{120}Sn(^{12}C, xn)^{128,129}Ba using ^{12}C pulsed beam of 50-60 MeV energy at Inter University Accelerator Centre (IUAC), New Delhi. Due to the very low expected value of g-factor of the different isomeric states, the high internal magnetic field at the recoils in Fe is utilized for the observation of perturbation pattern by $TDPAD$ technique. The internal magnetic field at Ba in Fe is calibrated in the present work for the precise g-factor measurements of isomeric states in ^{128,129}Ba. The ratios of quadrupole moments of the corresponding excited isomeric states is extracted by implanting the recoils in Tb as the electric field gradient is not known at Ba ions in any non-cubic metal.

The perturbed angular distribution pattern of the delayed transitions from two isomeric states, *i.e.* $K^\pi = \frac{9}{2}^-$ & $\frac{23}{2}^+$ states in ^{129}Ba was studied by implanting the excited recoils in Fe host. The pure one-quasiparticle Nilsson configuration $\nu\frac{9}{2}^-[514]$ originating from $h_{11/2}$ shell has been assigned for the $\frac{9}{2}^-$ through the observed value of g-factor, -0.192 (5). This measurement is in confirmation of the systematics of $\frac{9}{2}^-$ isomer in N = 73 isotones. The three quasineutron configuration $\frac{7}{2}^+[404] \otimes \frac{7}{2}^-[523] \otimes \frac{9}{2}^-[514]$ was assigned to the $K^\pi = \frac{23}{2}^+$ isomeric state through in-band analysis. The value of g-factor corresponding to the above mentioned configuration was expected to be same as that for $\frac{9}{2}^-$ state but the extracted value of g-factor, -0.233 (7) is at variance with the results of in-band analysis. The K-mixing is attributed to this discrepancy and serves as a source of contribution towards the enhancement of the g-factor. The possibility of K-mixing was also suggested (effective $K = \frac{19}{2}$ or $\frac{21}{2}$) in branching ratio calculations. The K-mixing is not surprising in the presence of triaxiality. The $\frac{23}{2}^+$ isomeric state is proposed to have admixture of two configurations, $\nu\frac{5}{2}^+[402] \otimes \frac{7}{2}^-[523] \otimes \frac{11}{2}^-[505]$ and

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$\nu\frac{7}{2}^{+}[404] \otimes \frac{7}{2}^{-}[523] \otimes \frac{9}{2}^{-}[514]$ which is at variance with the pure 3-quasineutron configuration $\frac{7}{2}^{+}[404] \otimes \frac{7}{2}^{-}[523] \otimes \frac{9}{2}^{-}[514]$, considered in the intraband analysis.

The K-mixing in case of $K^{\pi} = \frac{23}{2}$ band in ^{129}Ba is further confirmed by quadrupole moment measurements [3]. The ratio of quadrupole moments, $\left(\frac{Q_s(\frac{9}{2}^{-})}{Q_s(\frac{23}{2}^{+})}\right)$, of isomeric states were measured by recoil implantation of excited recoils into non-cubic Tb metal. The ratio of the quadrupole moment is more precise as it is independent of the knowledge of EFG in the host metal. The quadrupole moments of the two isomeric states, $\frac{9}{2}^{-}$ and $\frac{23}{2}^{+}$, is extracted w.r.t. the known quadrupole moment of $\frac{7}{2}^{+}$ isomeric state in ^{129}Ba. Due to the strong coupled nature of the two bands based on the $K^{\pi} = \frac{9}{2}^{-}$ & $K^{\pi} = \frac{23}{2}^{+}$ isomeric states and from intraband analysis, same intrinsic quadrupole moment, (Q_0), is expected for $\frac{9}{2}^{-}$ and $\frac{23}{2}^{+}$ isomeric states. The observed value of Q_0 for $\frac{23}{2}^{+}$ state is at variance with the expected value. The effective K value, $\left(\sim \frac{19}{2}\right)$, was deduced for $\frac{23}{2}^{+}$ state from the observed experimental ratio $\left(\frac{Q_s(\frac{9}{2}^{-})}{Q_s(\frac{23}{2}^{+})}\right)$ of respective spectroscopic quadrupole moments, assuming same intrinsic quadrupole moment for both states. In conclusion, the pure single quasineutron nature for $\frac{9}{2}^{-}$ and the admixture of other three quasineutron in the adopted wavefunction for $\frac{23}{2}^{+}$ state is drawn on the basis of present analysis and results[1].

The 7^{-} isomeric state of the strongly coupled band was interpreted as a high-K band in ^{128}Ba. The configuration assigned to this band, based on in-band analysis, is $\frac{7}{2}^{+}[404] \otimes \frac{7}{2}^{-}[523]$ having parentage from $\nu h_{11/2}g_{7/2}$ configuration. The expected value of g_K, -0.062 corresponding to this configuration is very small as compared to the observed value, $+0.169$, in magnitude and opposite in sign. The admixture of two quasiproton and any other collective contribution, *i.e.* octupole correlation cannot be neglected. The transition from single-particle behavior to collectivity can enhance the g-factor of the state. The orbital component of the wavefuntion responsible for the enhancement of g-factor is due to the admixture of $\pi\frac{3}{2}[411] \otimes \frac{1}{2}[550]$ originating from the spherical subshells $d_{5/2}$ and $h_{11/2}$ respectively. The new underlying structure is expected for 7^{-} isomeric state in ^{128}Ba from intra-band analysis. The quadrupole moment extracted from ratio of quadrupole moments, $\left(\frac{Q_s(\frac{9}{2}^{-})_{129Ba}}{Q_s(7^{-})_{128Ba}}\right)$, are also at variance with the systematic behavior of intrinsic quadrupole moments. The observed value of Q_0 (w.r.t. deformation in ^{129}Ba), 0.81 (6) eb, for 7^{-} state is also less than the value for the *gsb*. Similar behavior was seen for 7^{-} isomeric state in ^{130}Ce. The reduction of Q_0 in case of ^{130}Ce was explained on the basis of K-mixing. The behavior of the variation of deformation with Z is consistent with our results, *i.e* for the same neutron number N, the deformation increases with Z. These results, therefore, imply a complete different structure for 7^{-} isomeric state in ^{128}Ba[4].

The results of the present work stress the need to investigate the structure further through multi-quasiparticle calculations including the nucleon-nucleon interaction and triaxiality in Ba isotopes.

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References

[1] Jasmeet Kaur *et.al*. Physical Review C 87, 064312 (2013).
[2] Jasmeet Kaur *et.al*. Proc. of Frontiers in gamma ray spectroscopy (2012).
[3] Manuscript in preparation.
[4] Manuscript in Preparation.