EVOLUTION OF TRIAXIAL SHAPE IN A $\sim$ 120: THE CASE OF ^{125}Xe, ^{114}Te, AND ^{119}I

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Chapter 7

Conclusions and Future Perspective

7.1 Summary of Contributions and Conclusions

This thesis reports a comprehensive experimental investigation of three nuclei in A $\approx$ 120 region. The present study concentrated on three nuclei: ^{114}Te, ^{125}Xe, and ^{119}I. Three different experiments were performed at three different facilities to populate these nuclei. The ^{114}Te were populated by using the reaction ^{112}Sn(^{4}He, 2n)^{114}Te at a beam energy of 37 energy. The de-excited gamma rays are observed by using VECC-INGA setup. The ^{125}Xe nucleus was studied with a Gammasphere spectrometer using the reaction ^{82}Se(^{48}Ca, 5n)^{125}Xe at a beam energy of 205 MeV, which was delivered by ATLAS, placed in the USA. For the study of the ^{119}I, ^{109}Ag(^{13}C, 3n)^{119}I reaction were used with beam energy of 54 MeV and de-excited gamma rays were observed by TIFR-INGA.

This thesis initially focuses on deformed rotor Xe isotopes. The deformation induced in these isotopes strongly depends on the number of protons and neutrons occupied in the intruder $h_{11/2}$ orbital. In odd-mass Xe isotopes, the $h_{11/2}$ neutron orbitals form the yrast (with large signature splitting) and yrare bands. However, the behavior of signature splitting is opposite in yrare bands compared to yrast bands. The observation of large signature splitting has been reviewed in many nuclei, and they have been found to exhibit the wobbling motion, which is one of the most important signatures of triaxiality. A similar investigation has been carried out in ^{127,131}Xe where the evidence of wobbling motion is observed in ^{127}Xe. Although ^{131}Xe nucleus is proposed to be triaxial, no evidence of wobbling motion is observed. In the present thesis, the neighboring odd isotope of ^{127}Xe *i.e.*, ^{125}Xe, was considered to check whether it is exhibiting motion or not. The partial level scheme of ^{125}Xe has been studied with the main motivation to measure mixing ratios of the ΔI = 1 interconnecting transitions between yrast and yrare bands and determine $E2$ admixtures of these transitions, as the large $E2\%$ represents an important fingerprint for wobbling. Evidence for first and second phonon wobbling excitations in this nucleus has been established based on a large $E2$ fraction. A signature partner band of the yrast band has also been established. The increasing nature of wobbling energy with respect to spin indicates the presence of longitudinal wobbling motion in this nucleus. The observed wobbling energy has been compared to the triaxial projected shell model, which also supports the longitudinal wobbling motion in ^{125}Xe.

After probing the structure of ^{125}Xe, this thesis focuses on the level structure of ^{114}Te nucleus. The Te isotopes are well known to exhibit collective vibrational features appearing on top of non-collective excitations. Paul *et.al*. Grinberg *etal*. studied the existence of these structures with Total Routhian Surface and quasiparticle phonon model, respectively. However, due to a lack of theoretical and experimental B($E2$) values, they were unable to explain the nature of these states. The present thesis focuses on these states in ^{114}Te with the Ultimate Cranking model and Shell model calculations. The level scheme of ^{114}Te has been extended by the addition of 35 new gamma transitions with $\gamma - \gamma$ coincidence measurement. The spin parity of different states have been established on the basis of directional correlation ratios and polarization measurements. All the observed bands were probed within the framework of shell model calculation. The shell model calculations were found to be in good agreement in the low-spin regime; however, calculations were found to deviate from the observed result at higher spin. Several non-collective oblate states at higher spins, which are predicted by Paul *etal.al*. were discussed by using the ULTIMATE CRANKING model. The observation of nearly degenerate 7^+ states within the energy range of 100 keV was also explained by the Ultimate Cranking model.

Furthermore, Te isotopes have proton and neutron counts that are close to the octupole magic number (56), making them an excellent option for studying this phenomenon. Octupole correlation has been established in neutron-deficient Te isotopes (A $\approx$ 108–110) based on the B($E1$)/B($E2$) ratio. The observation of several $E1$ transitions between bands b2 and b1 and between b4 and b2 in ^{114}Te indicates the presence of octupole correlation in this nucleus. Further, Covariant density functional theory with PC-PK1 relativistic point coupling has been used, which shows that it is rather soft in the octupole direction.

In subsequent to these two nuclei, the present thesis focuses on one of the iodine isotopes *i.e*, ^{119}I. Iodine isotopes lie between the vibrational-like Te isotopes and deformed rotor Xe isotopes; therefore, looking for the triaxiality-related phenomena in these nuclei is very interesting. Although chirality-like doublet bands have been suggested in ^{120,123}I, it demands further theoretical investigation to check the evolution of chirality in these isotopes. Also, another signature of triaxiality *i.e*, wobbling motion has not been observed in any of the isotopes. To confirm the wobbling motion in this nucleus, we have measured the $E2$ fraction of the interconnecting transitions decaying from the previously reported unfavored signature partner band to yrast band. Observation of a large $E2$ fraction indicates the presence of wobbling motion in ^{119}I. The observed signature partner band in this nucleus is highly unfavorable. A pair of chiral doublet bands is also observed with negative parity. The observed variation of excitation energies, staggering parameter, and B($M1$)/B($E2$) with respect to spin demonstrates a similar type of behavior in both bands, which are characteristic of the chiral partner's band.

7.2 Future Perspectives

Based on this thesis work, the following future directions of research may be pursued:

- The observation of octupole correlation in ^{114}Te, and in earlier reported $^{108-110}$Te isotopes sets a platform to study this phenomenon in neighboring isotopes.
- In even Te isotopes several degenerate states with spin 6^+ , 7^+ , 8^+ and 10^+ states are experimentally observed. Their existence can be discussed within the framework of the Ultimate cranking model.
- In odd Xe isotopes, the experimental signature of wobbling motion is observed in ^{125,127}Xe. Although the ^{131}Xe has been reported to be triaxial, no evidence of wobbling motion is observed in ^{131}Xe. As a result, it would be fascinating to probe the chain of all odd Xe isotopes experimentally and theoretically, to determine the criterion under which the nucleus can exhibit wobbling motion.
- Even though Xe nuclei are triaxial, another signature of triaxiality, *i.e.* chirality, has not been reported in Xe isotopes. Therefore, looking for a chiral-like partner in the Xe isotope would be interesting.
- Observation of wobbling and chiral modes in ^{119}I, encourages the search for both signatures of triaxiality in neighboring nuclei of A$\approx$120. Also, a relevant theoretical model is needed to explain the criterion of the existence of both phenomena in a nucleus.