# Evidence for Octupole Correlation in $^{122}$Cs

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***Abstract:*** High-spin states in $^{122}$Cs have been studied via $^{107}$Ag ($^{19}$F, *p*3*n*)$^{122}$Cs fusion evaporation reaction at beam energy of 93 MeV. We have made an attempt to establish the unknown spin-parity of different bands using the linear polarization measurements. The level structure of $^{122}$Cs has been extended up to excitation energy ~ 7 MeV and spin ~ 28h. We have also confirmed some linking transitions between negative and positive parity bands as the evidence of octupole correlation in this nucleus.

***Keywords:*** Octupole, High-Spin States, Linear Polarization Measurement

## I. INTRODUCTION

The nuclei which lie between the spherical (Z=50) and the well deformed (Z=58) region are of considerable interest because of the competing shape driving tendencies of the orbital occupied by the neutrons and the protons. The proton Fermi level lies below the mid $h_{11/2}$ orbital, which favour prolate nuclear shape, while neutron Fermi level lies above the $h_{11/2}$ mid-shell, which favour oblate nuclear shapes. Because of large nuclear quadrupole deformation induced by the occupation of the high j-orbitals, the intruding $h_{11/2}$ proton orbital displays a large number of alignment properties. The observation of nearly degenerate twin $\pi h_{11/2} \otimes \nu h_{11/2}$ bands has been recently cited [1, 2] as evidence for the chiral symmetry breaking in these nuclei. In this mass region octupole correlation has also been observed in $^{114}$Xe [3], $^{117}$Xe [4], $^{118}$Ba [5] and $^{124-125}$Ba [6] because both the proton and the neutron orbital, $h_{11/2}$ and $d_{5/2}$ ($\Delta$l = 3, $\Delta$j = 3) are near the Fermi surface. Octupole is characterized by the breaking of rotation symmetry. Unlike quadrupole moment, octupole correlation is rather scare. Octupole correlation in atomic nuclei is due to the interaction between the orbitals of opposite parity whose angular momentum differ by 3 ($\Delta$l=3, $\Delta$j=3) near Fermi level. This situation is found between an intruder orbital and normal parity sub shell i.e. for particle number 34 ($g_{9/2}\rightarrow p_{3/2}$), 56 ($h_{11/2}\rightarrow d_{5/2}$), 88 ($i_{13/2}\rightarrow f_{7/2}$) and 134 ($j_{15/2}\rightarrow g_{9/2}$). Experimental fingerprints of octupole correlation are, such as alternate parity bands linked by enhanced E1 transitions (octupole induced dipole transition), very collective E3 transition, and parity doublet in odd-odd nuclei, are in fact long established in proximiting Z=56 N=88 corresponding to $^{144}$Ba, and Z=56 N=56 corresponding to $^{122}$Ba. Octupole correlation can be static, when nuclear wave function breaks the reflection symmetry or dynamic when it preserves the symmetry but quantum fluctuations involving octupole shapes are relevant, but it is very difficult to obtain static octupole correlation only few authors found it until now. It is very difficult to reproduce octupole correlation theoretically. The earlier investigations [7, 8] for the level structure of $^{122}$Cs have not reported any signature for octupole correlation. In the present work, we have made an attempt to establish the unknown spin-parity of different bands using the linear polarization measurements. We have also confirmed some linking transitions between negative and positive parity bands as the evidence of octupole correlation in this nucleus.

## II. EXPERIMENTAL DETAILS

High-spin states in $^{122}$Cs nucleus were populated using the $^{107}$Ag ($^{19}$F, p3n) $^{122}$Cs fusion evaporation reaction at a beam energy of 93 MeV. The beam was provided by the 14UD Pelletron facility at TIFR (Mumbai, India). An isotopically enriched 1-mg/cm$^2$ thick $^{107}$Ag target on a 10-mg/cm$^2$ thick Au backing was used. The de-exciting $\gamma$ rays were detected using the Indian National Gamma Array (INGA) consisting of eight Clover detectors in conjunction with a 14-element NaI(Tl) multiplicity filter. The detectors were coplanar and placed at 60°, 90°, 120°, 150°, 210°, 250°, 285° and 325° with respect to the beam direction. A total of about 200 million triple or higher- fold coincidence events were recorded in the experiment. Multipolarity of the de-exciting γ rays were deduced from the observed γ-γ angular correlation measurements. Multipolarity assignments were further supported by the γ-ray linear polarization measurements.

## III. RESULTS AND DISCUSSION

Figure 1 shows the partial level scheme of 122 Cs from the present work, where the ordering of transitions are based on relative γ– ray intensities and γ–γ coincidence using gates, reverse gating and sum energy relations. Figure 2 shows a spectrum gated with 946 keV γ -transition of band B. In this spectrum one can see the new linking transitions of 547 $(14^-\rightarrow 13^+)$, 678 $(16^-\rightarrow 15^+)$ and 758 $(18^-\rightarrow 17^+)$ keV of E1 or E3 character between the negative-parity band B and the positive-parity band A, which indicate the octupole correlation in this nucleus. Because of strong mixing of $\nu d_{5/2}$ orbital (l=2) of negative parity band B and the $\nu h_{11/2}$ configuration (l=5) of band A, there is a possibility of ∆l=3 octupole transition between these two bands. This, however, needs to be further confirmed with the measurement of the transition probability. This is also very fortunate to obtain signature of octupole correlation when neutron number is greater than 56 i.e. N > 56. So need more appropriate theoretical description of octupole correlation.

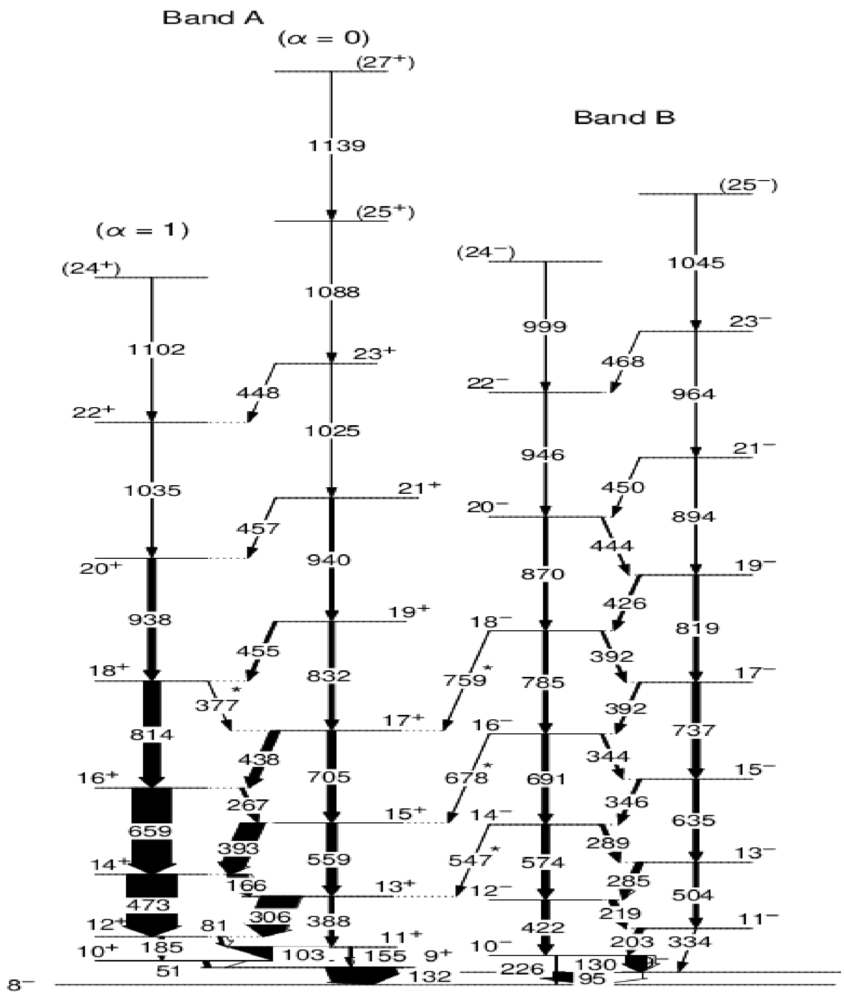


Fig. 1 Partial level scheme of for $^{122}$Cs populated in $^{107}$Ag ($^{19}$F,p3n)$^{122}$Cs reaction. The energies are marked within ±1 keV.

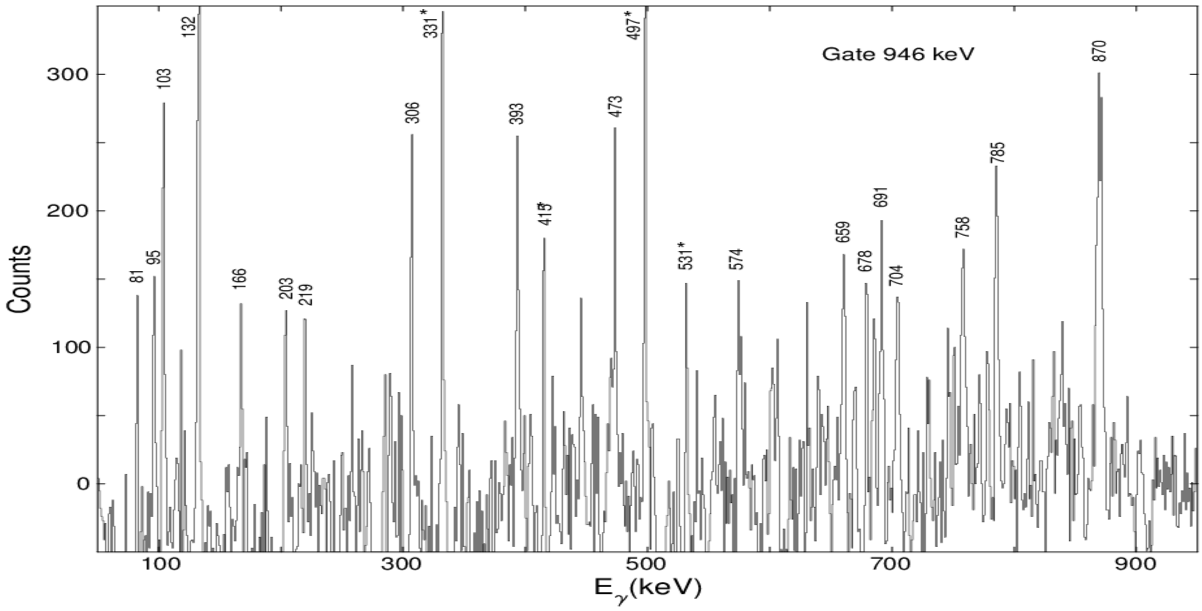


Fig. 2 γ - γ coincidence spectrum with gate on the 946-keV transition.

## IV. CONCLUSION

The earlier investigations for the level structure of $^{122}$Cs have not reported any signature for octupole but in our work we have made an attempt to establish the unknown spin-parity of the bands using the linear polarization measurement. The significant progresses of the octupole correlation in Cs nucleus is reviewed and some results on $^{122}$Cs nucleus which has been studied with eight Clover detectors array using $^{107}$Ag ($^{19}$F, p3n)$^{122}$Cs fusion evaporation reaction are reported.

## ACKNOWLEDGMENT

The author R. Kumar would like to acknowledge financial support from IUAC and from UGC under the scheme Minor Research Project.

**Conflict of Interest**: The authors declare that they have no conflict of interest.

**Ethical Statement**: The authors declare that they have followed ethical responsibilities

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