# Co-existing excitation modes in neutron rich nucleus- $^{98}$Zr

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## Introduction

Neutron-rich nuclei in A∼100 mass region exhibits a variety of nuclear structure phenomena such as the existence of different excited $0^+$ deformed states, shape coexisting states, high spin single-particle isomeric states, octupole vibrational states *etc* [1,2]. We are reporting here the different coexisting excitation modes in the medium spin structures of $^{98}$Zr nucleus with the incorporation of the new spectroscopic results obtained from an experiment using the thermal neutron induced fission of $^{235}$U.

## Experimental Details

The experiment was performed at the PF1B line of the high-flux reactor facility at the Institut Laue-Langevin (ILL), Grenoble, France. The collimated and thermalized neutron flux at the target position was of the order of $10^8$ neutrons per sec. per square centimeter. Neutron-rich $A \sim 100$ nuclei were produced as fission fragments following thermal neutron induced fission of $^{235}$U target. The target was in the form of $UO_2$ having thickness of $\sim 600$ $\mu g/cm^2$ with 99.7% enrichment in $^{235}$U, and was sandwiched between thick backings. Deexciting $\gamma$ rays from the fission fragments were detected by an array consisting of eight EXOGAM large clovers, six large coaxial detectors from GASP, and the two clovers from the ILL. BGO anti-Compton shields were used as Compton suppressors for the EXOGAM and GASP detectors in the array. The details of the experimental set up can be found in Ref.[3].

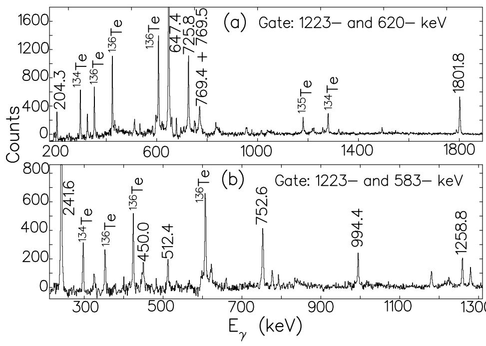


FIG. 1: Representative triple $\gamma\gamma\gamma$ coincidence spectra with the double gates set on (a) 1223- and 620- keV transition of $^{98}$Zr; (b) 1223- and 583-keV transition of $^{98}$Zr. The previously known strong transitions of $^{98}$Zr have been labeled with their transition energies. The transitions belong to the heavier complementary fragments ($^{134,135,136}$Te) have also been identified.

## Results and Discussion

A representative $\gamma\gamma\gamma$ coincidence spectrum of $^{98}$Zr is shown in Fig. 1. A part of the level scheme of $^{98}$Zr as obtained from the present

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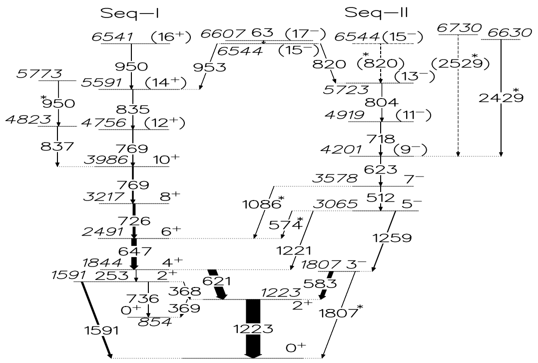


FIG. 2: Partial level scheme of $^{98}$Zr as obtained in the present work. The newly observed transitions have been marked with $*$. The tentatively placed transitions are marked with dotted arrow-lines. The micro-second isomeric $(17^-)$, 6607-keV level has been depicted as per the result from Ref.[4] and not observed in the present investigation.

work is shown in Fig. 2. About sixty five transitions and forty levels have newly been placed in the decay scheme. The preseneted level scheme in this report have been grouped under two heads: Seq-I and Seq-II. As can be seen from Fig. 2, the positive parity sequence (Seq-I) is populated upto the level with $J = 16\hbar$ level and $E_x = 6.5$ MeV. The spin wise evolution of collectivity along the positive parity yrast states of the even-even Zr-isotopes is shown in Fig. 3(a). It is clear from the figure that all the isotopes show a transition from spherical to deform shapes with increasing spin. In $^{98}$Zr, the spherical shape dominates upto a spin around $12^+$ and after that, it develops a weakly deformed rotational character. It is also clear from Fig. 3(b) that the deformation of the observed positive parity band of $^{98}$Zr is less than that of the neighbouring Mo- and Ru-isotones and has the similar deformation to that of $^{96}$Sr. The negative parity band (Seq-II) of $^{98}$Zr has a vibrational character and it is obvious from Fig. 3(c). Evidences suggest that the band head of this negative-parity band can be cosidered as originating from the Quadrupole-Octupole coupling mode.

The single particle $(17^-)$, 6607-keV level [4] which connects the two sequences is a shape-coexisting $\mu$s isomeric level. Thus it appears that the vibrational, rotational, and pure single-particle modes of excitation coexist in $^{98}$Zr at $E_x \sim 6.5$ MeV. The detailed results from the present investigation will be presented during the symposium.

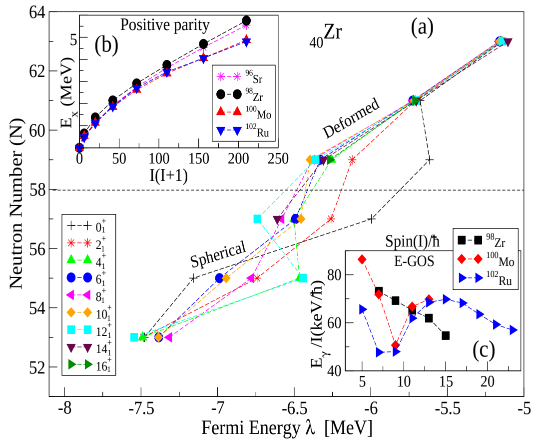


FIG. 3: (a) Backbending plot in gauge space for the positive-parity yrast states of even-even Zr-isotopes following the prescription as mentioned in Ref. [5]. (b) The variation of the excitation energy($E_x$) of the positive parity yrast levels of N = 58 isotones as a function of spin (I(I+1)). (c) E-GOS plot for the negative-parity bands of N = 58 isotones.

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## References

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