Nuclear Structure around A = 100 of Zr isotope

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The mass region around mass number A =100 is of special interest due to sudden change in symmetry from nearly spherical to strongly deformed shape by increasing neutron number N = 60 from N = 58. For odd mass nuclei around ^{100}Zr, studied in [1] lifetimes of low lying excited states using γ-γ fast-timing techniques and an experimental setup consisting of four LaBr3(Ce) detectors in the nuclei ^{99}Zr and ^{99}Nb. The experimental results are compared with interacting boson-fermion model IBFM and discussed in the context of shape transition and shape coexistence.

Here, in this interested mass region A=100 around for even-even nuclei, for Sr, Zr, Mo, Ru, Pd and Cd nuclei, having experimental energy $E(2_1^+)$ from NNDC [2] of spin $I^\pi=2^+$ in MeV is plotted with neutron number N in Fig.1. For Cd (Z = 48) at N=54, the value of energy $E(2_1^+)$ is lie high and after that slowly decreases and becomes almost constant having symbol of positive sign (+). The $\boldsymbol{E}(2_1^+)$ for Pd nuclei also follow the same trend, but the curve lie below the curve of Cd nuclei, having cross symbol (×). For the Ru nuclei, the value of energy lie low at N = 54 and the curve lie below the curve of Pd nuclei having symbol downward triangle (∇).

For N = 54, the value of energy $E(2_1^+)$ lies high and curve lies above from N = 54 to N = 56, then start decreasing and below at N = 58 and at N = 60 and onwards the curve of Mo nuclei lie below the curve of Ru with symbol of upward triangle (Δ). For Sr nuclei, the energy at N = 54 lies high than the energy of Mo nuclei and remains almost constant up to N = 58, then suddenly drop to lower having value less than the other nuclei at N = 60. The energy at N = 54 of Zr lies high than other nuclei and rises suddenly to 1.7 MeV from N=54 to 56, then starts decreasing from N = 56 to 60, and then almost uniform and lies above the curve of Sr nuclei as shown in Fig. 1. Due to sharp change in systematic of energy in Zr isotopes. We want to study the nuclei in light of empirical work and interacting boson model -1 [3].

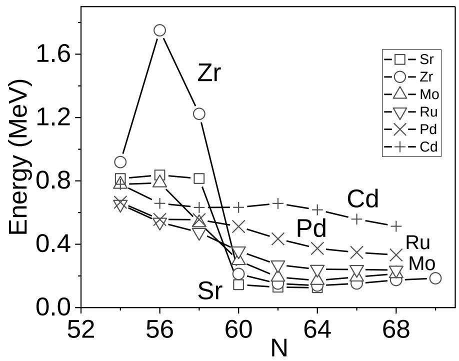

Fig. 1. Energy $E(2_1^+)$ (in MeV) for Sr, Zr, Mo, Ru, Pd and Cd versus Neutron number N.

The energy ratio of spin $I^\pi = 4^+$ and $I^\pi = 2^+$ is $R_{(4)} = E(4_1^+) / E(2_1^+)$ give the information of the shape of the nuclei from the vibrational (spherical) having ratio 2.0 to rotational having ratio 3.33. The plot of the energy ratio's at N = 54, of all the nuclei is same nearly 2.15 whereas the ratio for Zr nuclei is 1.6 and up to N = 58 it remains almost uniform and then suddenly rises at N = 60 to 62 having value 2.7 to 3.2. After that the energy ratio becomes almost uniform and curve lies higher the curves of other energy ratios as shown in figure 2.

The energy ratio $R_{(4)} = E(4_1^+) / E(2_1^+)$ for Zr nuclei, N = 40 is 2.9 and here shape of the isotope is X(5) symmetry. As neutron number N increases from, 40 to 42, the energy ratio decreases and the shape of the isotope is nearly $O(6)$. The N = 44, the shape is between the $O(6)$ and $E(5)$ and energy ratio is 2.3. For N

= 46, the energy ratio comes 2.2 and shape of the nucleus is *E*(5) symmetry. For the nucleus *N* = 48, the energy ratio decreases and becomes equal to 2.0 and shows U(5) symmetry having vibrational character. For *N* = 50, the energy ratio becomes less than 2.0 and shape of the nucleus is closed shell nuclei.

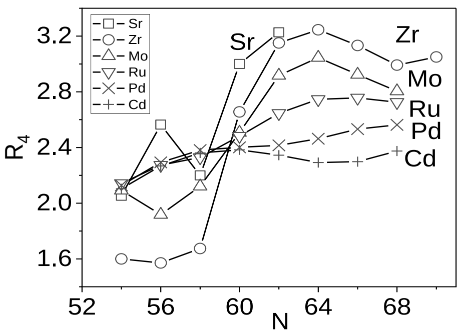

Fig. 2. Plot of energy ratio $R_{4/2}$ of Sr, Zr, Mo, Ru, Pd and Cd versus neutron number *N*.

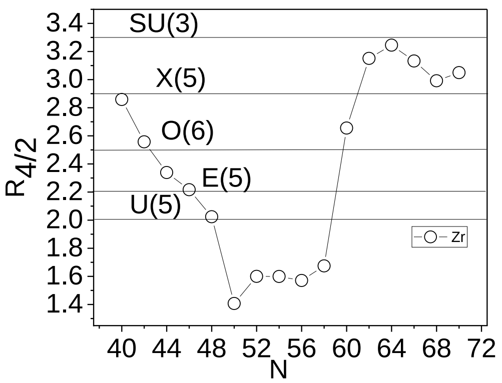

Fig 3. Plot of energy ratio $R_{4/2}$ of Zr isotopes related to critical point symmetries.

For further increasing the neutron number from *N* = 50 to *N* = 58, the energy ratio slightly increases but less than 2.0 and nuclei shows closed shell symmetry. But at *N* = 58 to *N* = 60, there is sudden rise of energy ratio from 1.6 to 2.7 and shows nearly X(5) character. The energy ratio further rises on increasing *N* from *N* = 60 to 64 and at *N* = 64 shows nearly SU(3) symmetry as rotational character. Then further increasing *N* = 64 to 68, the energy ratio slightly decreases and from *N* = 68 to 70 is almost saturated and shown in Fig. 3.

The $E(2_1^+)$ energy of spin $I^\pi = 2^+$ and $B(E2)\uparrow$ electromagnetic transition between spin $I^\pi = 0_1^+$ and $I^\pi = 2_1^+$ is taken from the [4] (Pritychenko et. al., (2016), Here the inverse of the $E(2_1^+)$ i. e. moment of inertia is plotted with the reduced electromagnetic transition probability. It shows almost a linear rising trend between *N* = 50 to *N* = 42 for A = 82-90 Zr isotopes (as shown in Fig 4 of the poster).

For N > 50, the linearity relation (to shown in fig. 5 of the poster), here both region showed shape phase transition. The systematics of energy and electromagnetic transition is also studied with interacting boson model -1 (to be shown in poster).

Conclusion:

The systematics of reduced electromagnetics transition [4] with the inverse of energy showed the linearity realtion (to be shown in poster). The systematics of power index parameter [5] for N <50 and N > 50 are studied and shows shape phase transition (to be shown in poster).

References

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