Monopole Corrected Effective Interactions for $T_Z = 0$, 1, 2 nuclei of Kr, Sr, and Zr within Variational Mean Field Theory.

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Recently there has been a rapid growth in the study of the high-spin structure of nuclei in the medium mass region both experimentally and theoretically. Prolate-oblate coexistence has been found for Se and Kr nuclei. The ^{76}Sr and ^{80}Zr nuclei are observed to have the largest ground state deformation with $\beta \geq 0.4$. Alignment delays have been observed for ^{72}Kr, ^{76}Sr, ^{80}Zr [1], ^{84}Mo and ^{88}Ru nuclei. Hence we see that the $N = Z$ nuclei in this region provide the possibility of studying the variation in nuclear structure with occupation of $0g_{9/2}$ orbitals both by neutrons and protons. Due to low-single particle level density, small changes in the Fermi surface are predicted to cause rapid changes in the nuclear shape with variation in mass, spin, isospin and excitation energy.

In the present calculations, we have treated the doubly closed shell ^{56}Ni nucleus as inert core with valence space spanned by the orbits $0f_{5/2}$, $1p_{3/2}$, $1p_{1/2}$ and $0g_{9/2}$. We have employed the monopole component of a general two-body interaction V given by an average over all possible orientations of the two nucleons in orbitals lj and $l'j'$ [2]. This angular average is given by the sum over magnetic quantum numbers m and m' .

$$\langle ljl'j'|V_{mono}|ljl'j'\rangle = \frac{\sum_{m,m'}\langle ljml'j'm'|V|ljml'j'm'\rangle}{(2j+1)(2j'+1)} \quad (1)$$

The 62 from 133 two-body interaction matrix elements (TBMEs) of model valance space have been corrected with the monopole corrected.

From comparison between the V_{MHPU1} and V_{MHPU2} in Fig. (1), we note that the modification to both the realistic interactions is relatively small and attractive for most matrix elements for the T=0 centroids except for the $f5f5$, $g9p3$ and $g9p1$ matrix elements. However, $g9f5$ matrix element for V_{MHPU2} and

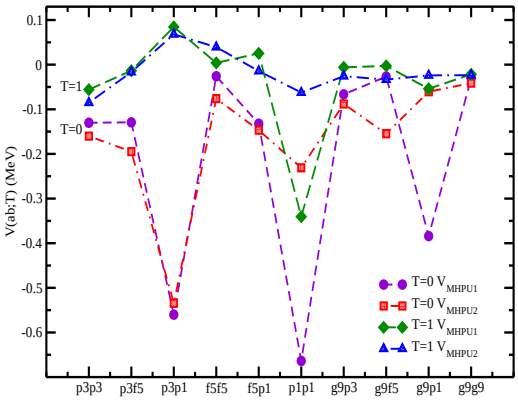

FIG. 1: (Color online) Comparison of the monopole matrix elements V(ab;T) among the new realistic effective interactions.

$g9p1$ matrix element for V_{MHPU1} for $T = 0$ centroid are attractive. For the matrix elements $p3p1$ and $p1p1$, modifications in both the realistic interactions are quite large. The modifications to the $g9p3$, $g9f5$ and $g9p1$ centroids can be of significant importance for the shell evolution i.e the change of the shell structure due to filling of specific single particle orbitals. The experimental and the theoretical yrast band energies have been translated into the usual moment of inertia ($\mathcal{I}$) versus square of angular frequency (ω) by using the following expressions,

$$\mathcal{I} = \frac{(2J-1)}{\Delta E}\hbar^2, \quad (2)$$

$$(\hbar\omega)^2 = \frac{(J^2-J+1)(\Delta E)^2}{(2J-1)^2}, \quad (3)$$

where ΔE = E(J) - E(J - 2) gamma ray en-

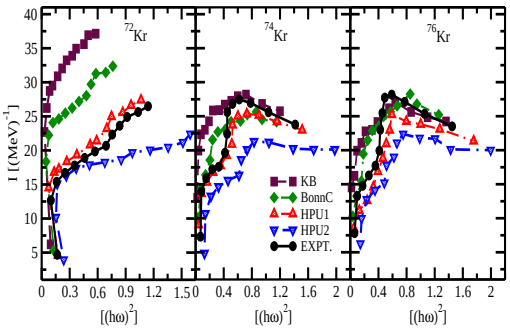

FIG. 2: The moment of inertia $\mathcal{I}$ as a function of square of angular frequency $(\hbar\omega)^2$ for ^{72}Kr, ^{74}Kr and ^{76}Kr nuclei.Here on the x axis the factor h = $\hbar$.

ergy. The VAP-HFB yrast energies of ^{72}Kr for 'HPU1'1' and 'HPU2' effective interactions are low compared to it's isotopes ^{74}Kr and ^{76}Kr. This lower yrast energies of ^{72}Kr point towards delay in rotational alignment in ^{72}Kr compared to ^{74}Kr and ^{76}Kr.

On comparing the moments of inertia of these nuclei in Fig. (2), we have observed a consistent increase in the rotational frequency required to start pair breaking as compared to neighboring nuclei. A reasonable agreement of results with "HPU1" effective interaction can be seen with the experimental results for ^{72}Kr presented by Fischer et al.[1]. However, low yrast energies of ^{72}Kr with "KB" and "BonnC" effective interactions lead to higher moments of inertia at higher spins. Sharp upbends are found in $^{74,76}Kr$ at $\hbar\omega = 0.65$ MeV associated with simultaneous proton and neutron alignment. In ^{72}Kr, no sudden discontinuities of this type are found at low frequency, while a sudden upbend is indicated around $\hbar\omega = 0.8$ MeV for "HPU1" effective interaction. Whereas for "HPU2" effective interaction, this upbend is shifted around 0.10 MeV. However for ^{74}Kr and ^{76}Kr the moment of inertia with "HPU2" effective interaction agrees well with the experimental and the "HPU1" effective interaction results. The present calculations with the VAP-HFB theory with corrected monopole Hamiltonian shows that the rotational alignment is delayed in ^{72}Kr nuclei for "HPU1" and "HPU2" effective interaction. This delay in rotational alignment arises due to "2p-2h" excitations in these nuclei, where particles are excited from the correlated ground state $1p_{3/2}$ and $0f_{5/2}$ to the higher orbital $0g_{9/2}$ and $1p_{1/2}$. Rotational alignment arises due to crossing of the vacuum configuration with the four quasiparticle band containing aligned pairs of $g_{9/2}$ neutrons and protons in $N = Z$ nuclei. Since in $N = Z$ nuclei, neutrons and protons occupy the same shell model orbitals and thus can have the largest probability to interact with each other. Hence, the np pairing interaction is thought to be the cause of consistent delays in the crossing frequencies in the ground state bands of $N = Z$. This opens up a new scope of study for this medium mass nuclei in this theoretical framework.

The $B(E2)$ values associated with the yrast spectra can provide unambiguous signatures of the large structural changes that are likely to occur in the high spin yrast spectra of the medium mass nuclei. The reduced electric quadrupole transition probabilities, $B(E2; J \rightarrow J-2)$ between the yrast states belonging to two different angular momentum states are calculated as,

$$B(E2; J_i \rightarrow J_f) = \left(\frac{2J_f+1}{2J_i+1}\right) | \left\langle \Psi^{J_f}(\beta) || Q_0^2 || \Psi^{J_i}(\beta) \right\rangle |^2. \quad (4)$$

References:

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2) R. K. Bansal and J. B. French, Phys. Lett. **11**, 145, (1964).