High Spin States of N = Z nucleus: ^{72}Kr

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Due to recent advancements in γ-ray detecting systems, it has been possible to measure the high-spin states of the N = Z nuclei viz. ^{72}Kr, ^{76}Sr and ^{80}Zr [1, 2]. In some of these nuclei viz. ^{72}Kr, the shape coexistence, shape transition and neutron-proton correlations at low and high spin states have been obtained within the complex version of the Excited Vampir variational approach [3] and afterwards ground state rotational bands have been extended by Fischer *et al.* [4]. Moreover, high-spin states have been studied in ^{72}Kr using the ^{40}Ca + ^{40}Ca at 164 MeV, and the properties and configurations of the high-spin bands observed have been interpreted using paired cranked relativistic Hartree-Bogoliubov (CRHB) calculations [5]. In addition, at Argonne National Laboratory with fusionevaporation reaction previously observed bands in ^{72}Kr were extended to a higher excitation energy and higher angular momentum of $30\hbar$ [6]. Recently, ^{72}Kr has been studied with the total absorption spectroscopy technique at ISOLDE (CERN) by Briz *et al.* [7] and high-spin structure of the even-even ^{7280}Kr isotopes have been analyzed using the Projected Shell Model (PSM) by Wu *et al.* [8].

Encouraged with recent studies on high-spin structure of N = Z nucleus ^{72}Kr [7, 8], we have investigated high spin states in ^{72}Kr within the framework of cranked Hartree-Fock-Bogoliubov (CHFB) using the pairing + quadrupole + hexadecapole model interaction Hamiltonian [9–11].

We employ a quadrupole-plus-hexadecapole-plus-pairing model interaction hamiltonian,

$$H = H_0 - \frac{1}{2}\sum_{\lambda=2,4}\chi_\lambda\sum_{\mu}\hat{Q}_{\lambda\mu}(-1)^{\mu}\hat{Q}_{\lambda-\mu} - \frac{1}{4}\sum_{\tau=p,n}G_\tau\hat{P}^\dagger_\tau\hat{P}_\tau\ , \quad (1)$$

where, H_0 stands for the one-body spherical part, χ_λ term represents the quadrupole and hexadecapole parts with λ = 2, 4 and the G_τ term represents the proton and neutron monopole pairing interaction. Explicitly we have

$$\hat{Q}_{\lambda\mu} = (\frac{r^2}{b^2})Y_{\lambda\mu}(\theta,\phi)\,, \quad (2)$$

$$\hat{P}^\dagger_\tau = \sum_{\alpha_\tau,\bar{\alpha_\tau}} c^\dagger_{\alpha_\tau}c^\dagger_{\bar{\alpha_\tau}}\,. \quad (3)$$

In the above $c^\dagger$ are the creation operators with $\alpha \equiv (n_\alpha l_\alpha j_\alpha m_\alpha)$ as the spherical basis states quantum numbers with $\bar{\alpha}$ denoting the conjugate time-reversed orbital. The standard mean field CHFB equations are solved self-consistently for the quadrupole, hexadecapole and pairing gap parameters. For more details, one can refer Ref. [9, 10].

To study high spin structure we first check the energies of the yrast levels in comparison to the experimental values. This is displayed in upper panel of Fig. 1. Our results are in good agreement at lower spins upto J = $12\hbar$ but calculated values of excitation energies are found smaller for larger spins as compared to the experimental energies [12] however similar trace by theoretical values in parabolic shape is satisfactory. Now to investigate change in structure as a function of angular momentum we plot variation of angular momentum with respect to rotational frequency ω by which

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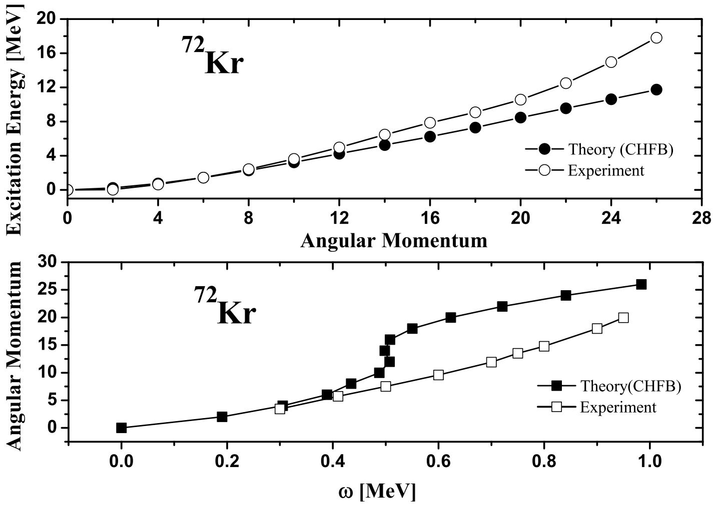

FIG. 1: Upper Panel: Excitation Energies of yrast states are compared with experimental values for ^{72}Kr [12]. Lower Panel: Variation of angular momentum with respect to rotational frequency ω is compared with experimental data [13].

one can deduce moment of inertia measuring slope of this curve (J = Iω). It is important to note that many of Kr isotopes are found showing backbending through various theoretical approaches and experimental investigations [4, 10]. We see from lower panel that an upbend is reported here at 0.5 MeV at which a sharp change in the value of angular momentum is evident from Fig.1 but ^{72}Kr is not found with an upbend at this frequency from experiments [4]. However, It is to be noted that such kind of upbend is in agreement with PSM calculations [2]. It would also be interesting to dig such kind of behaviour of ^{72}Kr and to compare these upbend of ^{72}Kr with other near isotopes viz. ^{74,76}Kr. These detailed studies will be published elsewhere.

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