DEFORMED SHELL MODEL FOR T=0, 1, AND 2 BANDS IN ^{68}Se

S. Mishra[1],* C. Das[2], and R. sahu[2]
[1] *Department of Physics, Bhubaneswar Institute of Technology, Bhubaneswar-752054, Orissa, INDIA and*
[2] *Physics Department, Berhampur University, Berhampur-760 007, Orissa, INDIA*

Introduction

In the last few years, with the development of radioactive ion beam facilities and large detector arrays, study of the the structure of heavy (A $\geq$ 44) N=Z nuclei near the proton drip line has become an area of intense research as these nuclei are expected to give new insights into neutron-proton (np) correlations that are hitherto unknown and as they are important for rp-process nucleosynthesis. The initial focus being on heavy odd-odd N=Z nuclei with $A > 60$ as they are expected to give new insights into isoscalar ($T = 0$) vs isovector ($T = 1$) pairing. Recently for ^{62}Ga, ^{66}As, ^{70}Br and ^{74}Rb many $T = 0$ and $T = 1$ levels are identified. On the other hand, inspired by large scale shell model for pf-shell nuclei, there are experiments with new data for $T = 0$ and $T = 1$ bands in ^{46}V, ^{50}Mn and ^{54}Co. Going beyond N=Z odd-odd nuclei, new experimental studies are initiated recently for N=Z even-even nuclei with A > 44 upto A=88. These nuclei are expected to exhibit interesting deformation characteristics, delay in angular momentum alignments at high spins, besides the lowest $T = 0$ band excited $T = 1$ and 2 levels/bands etc. Also in many nuclear models analysis of even-even nuclei is much easier than odd-odd nuclei. With more data accumulating, the N=Z even-even nuclei with $A > 60$ (^{68}Se, ^{72}Kr, ^{76}Sr and ^{80}Zr) are analyzed recently using several models.

Four Particle Isospin Projection In DSMT

For even-even N=Z nuclei one has to go beyond the simple T projection for quasi-deuteron configurations and consider T projection for a $(2p, 2n)$ system in four k orbits. For four particles the allowed isospin values are (2,1,0) with T^2 eigenvalues 6, 2 and 0. As the Young tableaux corresponding to $T = 2$, 1 and 0 are 4, $(3, 1)$ and $(2, 2)$, from the symmetry group S_4 properties, it is easily seen that there must be one $T = 2$, three $T = 1$ and two $T = 0$ states. The T^2 matrix is constructed using,

$$\begin{aligned}
T^2 &= \left(\sum_i t_i\right) \cdot \left(\sum_i t_i\right) \qquad (1)\\
&= \sum_i t_i^2 + \sum_{i \neq j} t_i \cdot t_j \\
&= \sum_i (3/4) \; + \; 2 \sum_{i<j} t_i \cdot t_j \\
&= \sum_i (3/4) \; + \; 2 \sum_{i<j} \left\{ t_0^{i:1} t_0^{j:1} - t_1^{i:1} t_{-1}^{j:1} - t_{-1}^{i:1} t_1^{j:1} \right\}
\end{aligned}$$

In (1) i is the particle index and t is the single particle isospin operator. In the last form in (1) the isospin operator is written in tensorial form. It should be noted that $t_1^1 = -\frac{1}{\sqrt{2}} t_+$ and $t_{-1}^1 = \frac{1}{\sqrt{2}} t_-$. With $|p\rangle = |\frac{1}{2} \frac{1}{2}\rangle$ and $|n\rangle = |\frac{1}{2} - \frac{1}{2}\rangle$, t_+ will change $n \rightarrow p$ and similarly t_- will change $p \rightarrow n$.

Results

The lowest HF intrinsic state, having nearly same energy for both prolate and oblate, is given in Fig.1. Besides the lowest prolate and oblate configuration, we have considered 147 excited prolate and oblate configurations. Out of which 67 from prolate configuration and 80 from oblate configuration. We obtained this particle-hole excited (147) configuration within 8 MeV excitation energy over lowest prolate and oblate configuration, We gate a

---

*Electronic address: `satrujitm@yahoo.co.in`

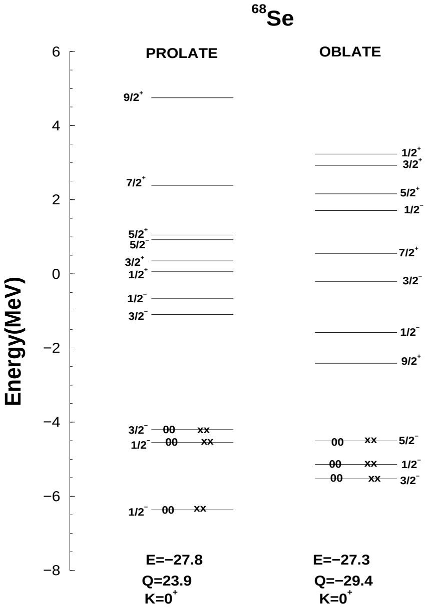

FIG. 1: The spectrum of single particle states for the lowest energy prolate and lowest energy oblate intrinsic HF states generated by KB3 interaction.

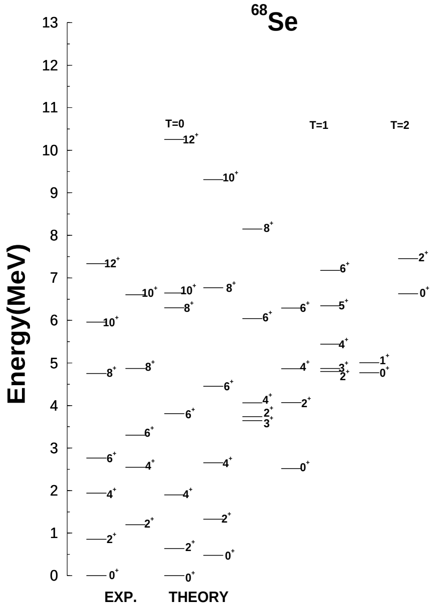

FIG. 2: Experimental [1] and calculated excitation energies for T=0, 1 and 2 yrast and yrare levels in ^{68}Se.

pure T=0 configuration for $A^pA^nB^pB^n$ occupation of the particle. Similarly $A^pA^nB^pC^n$ occupation gives T=0,1 decomposing into one T=0 and T=1 and $A^pB^nC^pD^n$ occupation gives T=0,1,2 decomposing into two T=0, three T=1 and one T=2. Where A,B,C,D represents single particle states and p for proton and n for neutron. For each T separately, band mixing calculations are performed using the J projected states.

The calculated spectrum, using DSMT, is compared with data [1] in Fig. 2. The ground $T = 0$ band is somewhat expanded with respect to the expt data after 4_1^+ levels as found by [2, 3] but otherwise the agreement between the two is reasonably good. Our calculation predicted a 0_2^+ level at 0.48 MeV and 0_3^+ level at 2.516 MeV as predicted by [2] 1.106 and 2.153 MeV respectively. In all theoretical studies no $J = 2^+$ states are closed to the experimental $J = 2^+$ at 1.197 MeV [4] but our calculation for $J = 2^+$ state is 1.329 MeV which is more appropriate than recent calculation [2, 3, 5].

In addition to the $T = 0$ bands, DSMT gives lowlying $T = 1$ bands with $K = 0/1/2/3/4$ and also a $T = 2$ band with $K = 0$. The observed $T = 1$ levels with 2_1^+ and 4_1^+ could be the members of the $K = 0$ band and the 6^+ may be the member of the $K = 3$ band. The position of the first 0^+ level with $T = 2$ is close to the DSMT value. Thus DSMT giving a reasonably good account of not only the $T = 0$ bands/levels but also of the observed $T = 1, 2$ levels.

References

[1] T. W. Burrows, Nucl Data Sheets **97**, 1 (2000).

[2] Faliah H. Al-Khudair, Y. S. Li and G. L. Long Physical Review C **75**, 054316 (2007).

[3] Y. Sun, M. Wiescher, A. Aprahamian and J. Fisker, Nucl. Phys. A **758**, 765 (2005).

[4] S. Skoda et al., Phys. Rev. C **58**, R5 (1998).

[5] K. Kanek, M. Hasegawa and T. Mizusaki, Phys. Rev. C **70**, 051301(R) (2004).