Correlation of beta band energy with the RVI coefficient

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The low energy collective spectra of the even-even nuclei in the medium mass region of the nuclear chart comprise three rotation-vibration bands, known as the ground state band, $K=0_2$ beta band and the K=2 gamma band. The energy ratio $R_{4/2}=E(4)/E(2)$ is a measure of the deformation of the nuclear core. It varies from 2.0 for a spherical vibrator to 10/3 for an axially symmetric deformed rotor in the geometric picture of the unified collective model of Bohr-Mottelson [1]. The nuclei with intermediate value of $R_{4/2}$ are called the shape transitional nuclei. While the energies in the ground state band are related to the ratio $R_{4/2}$, no relation of the band heads of the $K=0_2$ and K=2 bands have been established so far.

Gupta et al. [2], in an earlier study of the shape transitional nuclei, suggested the use of the energy equation, in the Rotation-Vibration Interaction (RVI) model (Eq. 1) for studying the collective nature of the yrast states.

$$E(I)=aI(I+1)+bI+cI^2(I+1) \qquad (1)$$

Here, the first term expresses the rotational part and the second term expresses the vibrational part. The third is the rotation-vibration interaction term. The ratio of the first term, called ROTE, to the energy of 2_1 state was used to express its rotational content [3].

The interaction term is negative in sign, and small for the well deformed nuclei. For beta-soft rotors, the absolute magnitude of the c-term is larger. Similarly, it was observed in [3], that for the well deformed nuclei, the band head of $K=0_2$ band lies high and moves to lower energy for beta soft nuclei. The low energy beta band valley at N=88-90 was related to the dip in the (absolute) values of the RVI coefficient [3].

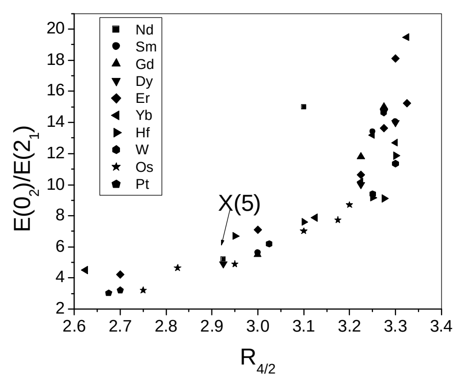

Fig. 1. The relative energy $E(0_2)/E(2_1)$ versus the ratio $R_{4/2}$.

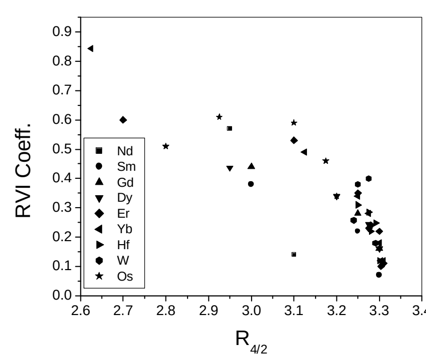

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Fig. 2. The RVI coefficient 'c' versus the ratio $R_{4/2}$.

In the present work, we extend this study to search for a more close correlation of the $K=0_2$ band head energy with beta softness of the nuclear core. Since the energy of first 2^+

state fixes the energy scale; we look at the ratio $E(0_2)/E(2_1)$. We shall call it the *relative band head energy*. In Fig. (1), we plot the dependence of the relative band head energy on the energy ratio $R_{4/2}$. Only the nuclei with $R_{4/2}>2.6$ are included here. In Fig. 2 we plot the dependence of absolute value of the RVI coefficient 'c' on $R_{4/2}$. In Fig. 3 we look at the correlation of the relative band head energy on the RVI coefficient.

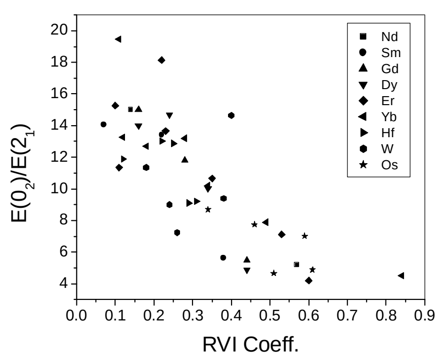

Fig 3. The relationship of the relative band head energy $E(0_2)/E(2_1)$ with the RVI coefficient 'c'.

Fig. 1 shows the rise of relative band head energy $E(0_2)/E(2_1)$ with increasing $R_{4/2}$. In other words, it reflects the rising of beta band head with increasing deformation. It may be noted here, that our plot excludes the very β-soft nuclei at N=88, where $R_{4/2}$ is rather small.

In Fig. 2 one observes that as $R_{4/2}$ *increases*, the RVI coefficient *decreases*, as expected for more deformed nuclei (good rotors). In Fig 3, the relationship of the relative band head energy $E(0_2)/E(2_1)$ with the RVI coefficient 'c' is apparent, in spite of some scatter. The relative band head energy falls with the increasing RVI coefficient (less deformed nuclei), the latter being the measure of the rotation–vibration interaction which increases with beta softness of the core.

In conclusion, we have illustrated the close relationship of the softness of the nucleus (with $R_{4/2}>2.6$) as indicated in the RVI coefficient 'c', obtained from the yrast energies, with the $K=0_2$ band head (relative) energy. Thus the ground band itself yields some information about the excited bands.

In the newly identified critical symmetry [4], called X(5), for which analytical solution is obtained under the assumption of separation of the beta and gamma degrees of freedom at the shape phase transition point, a relation of $K=0_2$ band head energy to $E(2_1)$ is predicted to be equal to 5.7. Our study suggests a general co-relation of the $K=0_2$ band head with the ground band level pattern in a general way, at least for $R_{4/2}>2.6$ nuclei, i.e. for β-soft deformed to well deformed region in medium mass nuclei of the nuclear chart.

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