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SYSTEMATICS OF BANDCROSSING FREQUENCIES OF THE $\pi h_{9/2}[541\ 1/2^-]$ INTRUDER CONFIGURATION IN ODD-Z RARE-EARTH NUCLEI*

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Systematics of bandcrossing frequencies, $\hbar\omega_c$, are presented for the $\pi h_{9/2}[541\ 1/2^-]$ Nilsson intruder configuration and contrasted with the $(0,+)$ yrast configuration in the even-even rare-earth nuclei. Predictions from Cranked Shell Model calculations, based on frequency diabatic configurations, are compared with the experimental data.

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In several odd-Z rare-earth nuclei, the $\pi h_{9/2}[541\ 1/2^-]$ Nilsson configuration with $\alpha = +1/2$ exhibits some anomalous features concerning the rotational frequency $\hbar\omega_c$, and gain in aligned angular momentum Δi_x, at the crossing with the S-band, in which the first pair of $i_{13/2}$ quasineutrons have aligned. Compared to the corresponding crossing in the neighbouring even-even isotones, a noticeable shift to higher crossing frequencies for proton numbers between 67 and 75 is observed, see Fig. 1,[1] and the gain in aligned angular momentum is often smaller. In contrast, most other rotational bands in these odd-Z nuclei behave normally. They have the same or very similar crossing frequencies and gain in aligned angular momentum as the even-even neighbours.

For the nuclei in question, it is the low-Ω components of the neutron $i_{13/2}$ intruder shell which comprise the aligning quasi-neutrons at the crossing with the S-band. The crossing frequency and the gain in aligned angular momentum are closely related to both the neutron pairing strength, Δ_ν, and

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[1] A list of references for the shown data at Fig. 1 and 2 will be given in a future paper.

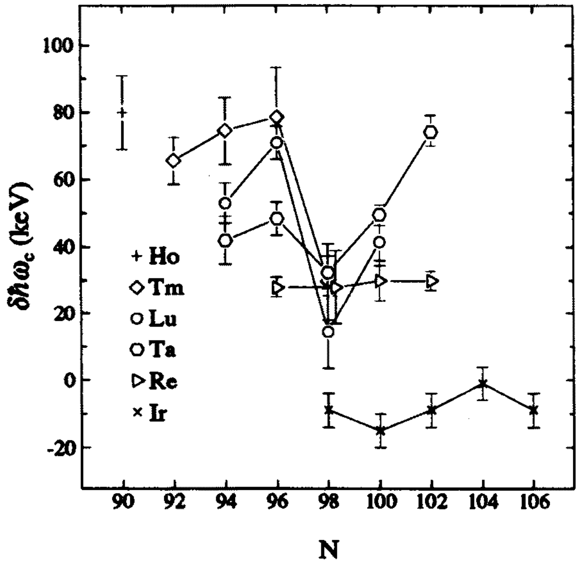

Fig. 1. The measured shifts, $\delta\hbar\omega_c$, of the S-band crossing frequency, for the $\pi h_{9/2}[541\ 1/2^-]$ configuration with respect to the average of this crossing in the neighbouring even-even isotones.

the position of the neutron Fermi level, λ_ν, relative to the aligning quasi-neutrons. Both of these quantities depend on the deformation. For proton numbers below $Z \sim 75$, the $\pi h_{9/2}[541\ 1/2^-]$ configuration is expected to drive the nucleus towards larger prolate deformations and is therefore expected to influence $\hbar\omega_c$ and Δi_x. Cranked Shell Model calculations [1] based on both experimentally determined [2] and expected changes in equilibrium deformations [3] have so far been able to explain a fraction of the shift varying from 20-60% of the observed $\delta\hbar\omega_c$ [4].

The major drawback of these calculations is that constant deformation parameters and pairing strength have been used. In a new and improved approach, using a new version [5] of the *Ultimate Cranker* [6], based on a modified oscillator potential with Nilsson parameters from [7], we have attempted to eliminate these problems by:

1. calculating frequency diabatic quasiparticle configurations, [8], for both the [541 1/2$^-$] g- and S- configuration in odd-Z nuclei and the yrast (0,+) g- and S- configuration in even-even nuclei,
2. minimizing energy with respect to deformation parameters ε_2, ε_4 and γ as function of rotational frequency for both the g- and S- configurations,
3. performing particle number projection and appropriate blocking, — details can be found in Ref. [8], and

4. applying a "semi" selfconsistent treatment of proton and neutron pairing for both the g- and S- configurations. The monopole pairing gaps, Δ^g_π, Δ^g_ν and Δ^S_ν, at each $(\varepsilon_2, \varepsilon_4, \gamma)$ mesh point in the deformation plane are optimized by minimizing the energy with respect to the size of the pairing gaps, for selected nuclei and appropriate deformations close to the band crossing for both the g- and S- configurations. See [8] for more details.

On Fig. 2a and 2b the experimentally determined crossing frequencies (solid lines) are compared with predicted crossing frequencies (dashed lines) for Er, Yb, Hf, W, Tm, Lu, Ta, Re and Ir isotopes with neutron numbers between 94 and 102. Typical deviations between predicted and experimental crossing frequencies for the even-even nuclei are around 45 keV with relatively small fluctuations, whereas the deviations in the odd-Z cases range from 40 to 100 keV (if the data at $N = 98$ is excluded) with large fluctuations. It is therefore not possible to explain the observed shifts, $\delta\hbar\omega_c$, within the present model. Calculations of the crossing frequency for the normally behaving $\pi h_{11/2}[514\ 9/2^-]$ configuration, in the Ta isotopes, give deviations very similar to those found for the Yb and Hf isotopes, emphasizing the special problem of the $\pi h_{9/2}$ configuration.

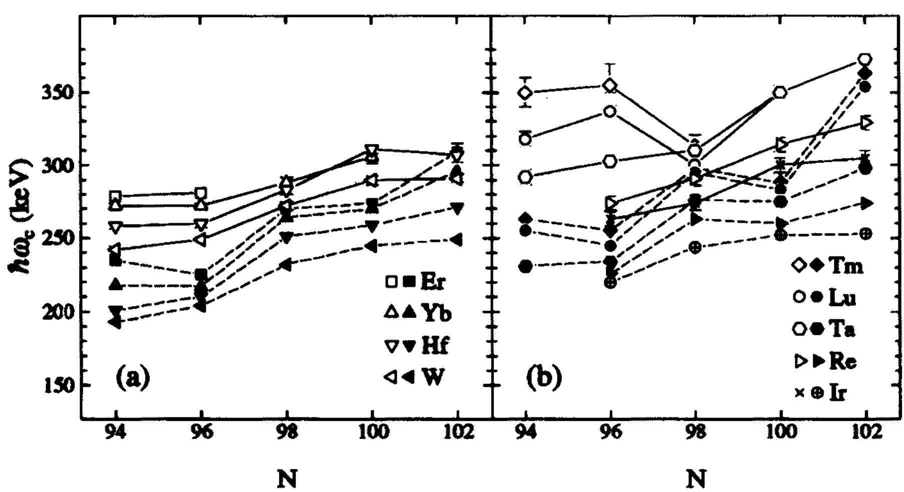

Fig. 2. Experimental (solid lines) and predicted (dashed lines) frequency of the crossing with the S-band, $\hbar\omega_c$. (a) the $(0,+)$ yrast configuration in even-even nuclei and (b) the $\pi h_{9/2}[541\ 1/2^-]$ configuration in odd-Z rare-earth nuclei, for neutron numbers between 94 and 102.

It is still necessary to further investigate the treatment of monopole pairing in the model before effects such as quadrupole pairing and residual neutron-proton interactions are included in future calculations. In this connection information about aligned angular momentum and deformation provide additional tests for the model.

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