A PHONON CRANKING MODEL†

Torunn Fogel, P. Haapakoski and P.O. Lipas
University of Helsinki, Finland

According to the cranking description [1], $H_\omega = H - \omega J_x$ is the Hamiltonian in the nuclear rest frame. Its eigenstates ϕ_ω give the total laboratory energy as

$$E = \frac{(\phi_\omega,\ H\phi_\omega)}{(\phi_\omega,\ \phi_\omega)}$$

with ω determined from $(\phi_\omega,\ J_x\phi_\omega) = \hbar\sqrt{J(J+1)}$.

We use this formalism to calculate the ground band rotation energies from the phonon Hamiltonian

$$\hbar\omega_2\left[\sum_m b_m^\dagger b_m + \frac{5}{2} - d(b_0^\dagger+b_0) + d^2\right] \quad ,$$

which describes harmonic quadrupole vibrations in an axially deformed body ($d\propto\beta_0$). We have used it previously as the intrinsic Hamiltonian in <u>projection</u> calculations [2].

To solve the H_ω problem we express J_x in terms of the phonon operators and seek a ground state solution of the form $\exp\Sigma_m W_m b_m^\dagger|0\rangle$ as an extension of the $\omega=0$ case [2]. The solution is exact, and the rotational energies are given by

$$E_{rot} = \frac{1}{2}\omega^2\ \frac{6d^2\hbar\omega_2(4\omega^2+\omega_2^2)}{(4\omega^2-\omega_2^2)^2}\ ,\quad \frac{6d^2\omega_2^3\omega}{(4\omega^2-\omega_2^2)^2} = \sqrt{J(J+1)}$$

in terms of two parameters, ω_2 and d.

The moment of inertia in the limit $\omega\to 0$, $6d^2\hbar/\omega_2$, agrees with the result given by the Inglis formula. Further, taken to order ω^4, our E_{rot} agrees with Harris' (and Mariscotti's) two-parameter rotational description. Fits to data are similar. Our upper and lower limits on E_4/E_2 are $10/3 = 3.33$ and $\sqrt{10/3} = 1.83$, in agreement with the Goldhabers [3].

In contrast to most rotational phenomenology, ours also provides <u>wave functions</u> upon projection from $\exp\Sigma_m W_m b_m^\dagger|0\rangle$. The resultant B(E2) values and quadrupole moments resemble those from the projection model [2].

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[1] W.A. Friedman and L. Wilets, Phys. Rev. C 2 (1970) 892.

[2] P. Haapakoski, T. Honkaranta and P.O. Lipas, Phys. Lett. 31B (1970) 493.

[3] G. Scharff-Goldhaber and A.S. Goldhaber, Phys. Rev. Lett. 24 (1970) 1349.