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TITLE: NUCLEAR INERTIA FOR FISSION IN A GENERALIZED CRANKING MODEL

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INERTIA FOR FISSION IN A GENERALIZED CRANKING MODEL

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cranking model [1] has been widely used to calculate the associated with collective degrees of freedom. After the ring correlations, theoretical results obtained with the or nuclear rotations and γ-vibrations were in relatively ith experimental data. Calculations of β-vibrational iner- erformed in the cranking model for fission deformations. lts were several times the irrotational values [2] and gave ment with experimental spontaneous-fission lifetimes [3,4], study a renormalization factor of 0.8 was required [4].

pointed out by many authors (see ref. 5), the Inglis crank- ses two serious deficiencies. First, problems arise when cle potential contains momentum-dependent terms. Second, in ge pairing strength the inertia approaches zero instead of a onal) limit.

approaches to the cranking model which did not lead to such ults were developed by Migdal [6], Belyaev [7] and Thouless They showed that these deficiencies of the cranking model k of self-consistency, since the reaction of the mean field motion is neglected in the Inglis model. In ref. 5 we ents and developed a generalized cranking model for station- otion. Here we show how to develop a time-dependent formal- to β-vibrations and fission [9].

th the time-dependent equation for the generalized density

$$] \quad , \qquad (1)$$

ned that the Hamiltonian $\mathcal{H}$ and consequently the generalized depend on the collective variable ε. Furthermore, we notion is adiabatic, which permits the replacement

.

Choosing the basis so that

$$[\mathcal{H}_0, \mathcal{R}_0] = 0 \quad , \tag{2}$$

we then obtain to lowest order in the collective variable the equation

$$i\hbar\dot{\mathcal{R}}_0 = [\mathcal{H}_0, \mathcal{R}_1] + [\mathcal{H}_1, \mathcal{R}_0] \tag{3}$$

for the generalized density matrix. Here $\mathcal{H}$ and $\mathcal{R}$ symbolize the matrices

$$\mathcal{H} = \begin{pmatrix} h & -\Delta \\ \Delta^* & -h^* \end{pmatrix} \text{ and } \mathcal{R} = \begin{pmatrix} \rho & \kappa \\ -\kappa & 1-\rho^* \end{pmatrix} .$$

The usual cranking-model approximation consists of neglecting the $\mathcal{H}_1$ term in eq. (3). We obtain $\dot{\mathcal{R}}_0$, which appears on the left-hand side of eq. (3), by differentiating eq. (2) with respect to time.

From this point onwards we proceed analogously to ref. 5 and evaluate the first-order correction to the generalized density matrix $\mathcal{R}_1$. Its trace with the generalized collective momentum operator then yields the nuclear inertia B. However, in contrast to the stationary formalism, the time-dependent formalism leads to an additional pairing-vibration coupling term [3] because of the implicit dependence of the pairing gap on the collective variable.

Keeping the $\mathcal{H}_1$ term in eq. (3) gives rise to two additional contribution to the inertia that are proportional to h_1 and Δ_1. The h_1 contribution arise when the potential contains momentum-dependent terms. In the stationary case one obtains

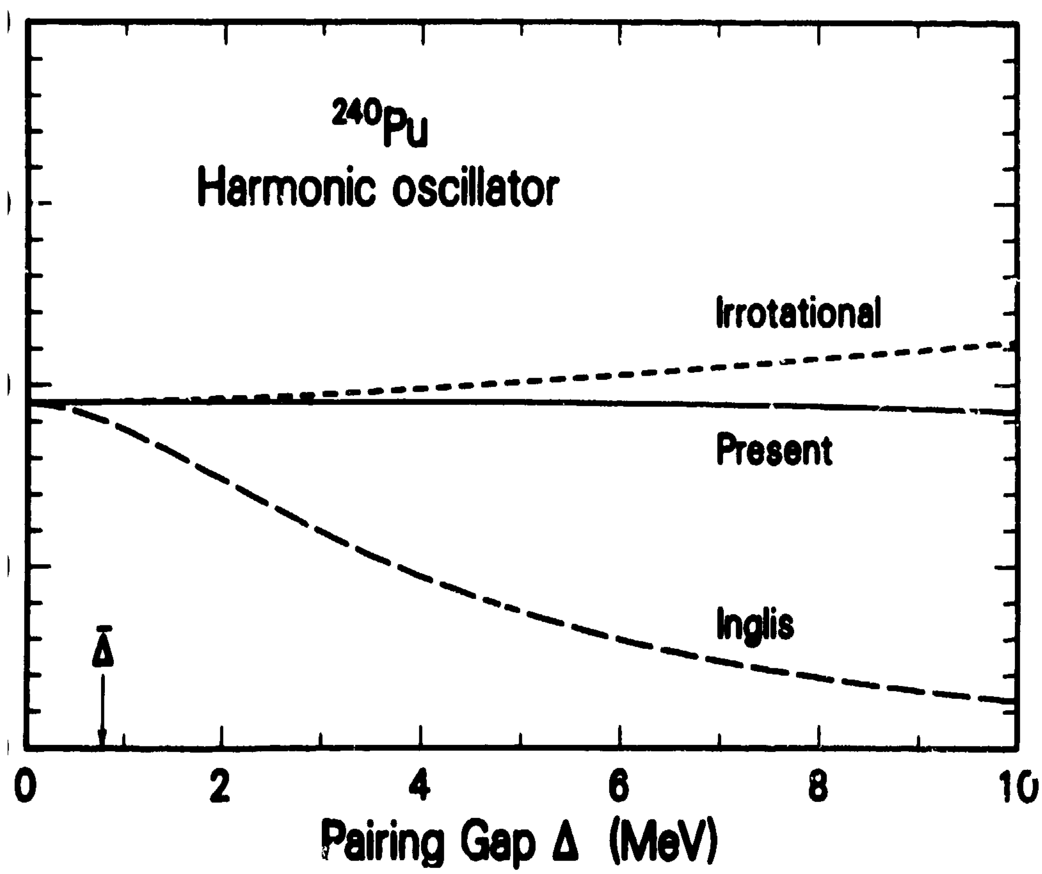
$$h_1 \propto (1 - m/m^*) \quad , \tag{4}$$

where m^* is the effective mass. This can lead to a considerable change in th inertia [5]. We expect a similar relationship to also hold in the time-dependent case [10]. The additional Δ_1 term, for which an explicit expression is obtained from the continuity equation [6], keeps the nuclear inertia finite i the limit of large pairing strength.

To demonstrate the effect of the Δ_1 contribution on the inertia, we now specialize to the harmonic-oscillator potential. In the limit of zero temperature and a constant pairing gap, we obtain for the inertia

$$\hbar^2 \sum_{p,q} |\langle p| i \frac{\partial}{\partial\varepsilon}|q\rangle|^2 \frac{E_pE_q - h_ph_q + \Delta^2}{2E_pE_q(E_p + E_q)} + \hbar^2 \sum_p \frac{1}{8E_p^5} (h_p'\Delta - h_p\Delta')^2 \quad , (5)$$

rime denotes differentiation with respect to ε. Note the plus sign of Δ^2 in the first term, which arises from the Δ_1 contribution. ig. 1 we show the first term of the inertia for β-vibrations a a of pairing strength, calculated with respect to Nilsson's spheroi- mation parameter ε [2,4,5]. The pairing-vibration coupling term een considered here, since it vanishes for large pairing strength. he Inglis cranking inertia approaches zero for large pairing, the nertia containing the Δ_1 contribution remains finite and close to



1. Dependence of the β-vibrational inertia upon the pairing gap Δ in a harmonic-oscillator potential at the equilibrium deformation . The solid curve gives the present result calculated in the gen- cranking model with 15 oscillator shells, the long-dashed curve corresponding result calculated in the Inglis cranking model and -dashed curve gives the irrotational result.

the limiting irrotational value. The deviation arises from the slow convergence of the cranking inertia with increasing basis size [5].

For a harmonic-oscillator potential with an effective mass, relation (4) holds, and the reaction of the pairing field to the collective motion is given by

$$\Delta_1 \propto Y_{20} \quad .$$

For a more realistic modified-harmonic-oscillator potential we expect similar results. In particular, we expect that the proper inclusion of the effective-mass term h_1 for β-vibrational inertias may account for the renormalization factor of 0.8 that was originally needed to reproduce experimental spontaneous-fission lifetimes [4].

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