Estimation of Transverse Vibration Energies of Pre-Fragments in Induced Fission

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The study of fission dynamics in heavy nuclei remains a central challenge in modern nuclear physics, particularly in understanding the mechanisms governing energy dissipation and angular momentum generation. This work investigates induced fission of ^{232}Th and ^{238}U, with a focus on the role of transverse collective oscillations, specifically wriggling and bending modes in determining the spin distributions of fission fragments. The analysis builds upon established theoretical frameworks [1, 2], employing an effective nucleon-nucleon potential to model the potential energy surface of the fissioning system. A key assumption is the "cold nucleus" approximation, where all excitation energy is treated as non-equilibrium deformation energy, simplifying the treatment of collective motion while preserving essential physics.

The model incorporates critical degrees of freedom, including charge and mass asymmetry, interfragment separation, and quadrupole deformations of the nascent fragments. Numerical solutions yield the stiffness coefficients and frequencies of transverse oscillations, allowing quantification of their contributions to the final spin distributions. Experimental data on fragment spins [3] validate the predicted trends, confirming the models applicability.

The analysis reveals a characteristic ratio $\omega_w : \omega_b \approx 2.6$ between wriggling and bending modes, consistent with hydrodynamic predictions for symmetric fission [4], confirming collective motion's dominance in spin generation. Non-equilibrium initial deformations are shown to critically affect scission dynamics and angular momentum sharing between fragments. This study refines the mechanisms of energy and angular momentum transfer in nuclear fission, providing results that can improve theoretical models and predict fission product characteristics for other actinides. Future research will extend to additional heavy nuclei and employ more detailed quantum mechanical treatments of collective oscillation dynamics.

References

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