Inelastic-Electron-Scattering-Induced Nuclear Excitation Rates and Dynamics in ^{229}Th

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In this work, we investigate the excitation rates and population dynamics of ^{229}Th nuclei induced by inelastic electron scattering, focusing on how electron energy, flux, and ionic charge state influence the excitation process of the nuclei. Using the Dirac Hartree-Fock-Slater method, we calculate cross sections for both the isomeric state (8.36 eV) and the second-excited state (29.19 keV) of ^{229}Th over a wide range of ionic charge states and electron energies. Our results demonstrate that these factors significantly impact the nuclear excitation efficiency. The effect of indirect excitation through the second-excited state on enhancing the accumulation of nuclei in the isomeric state cannot be ignored. By applying rate equations to model the temporal evolution of nuclear populations, we show that under optimal conditions, up to 10% of $^{229}Th^{4+}$ ions can be accumulated in the isomeric state. These findings provide important insights for optimizing electron-nucleus interactions, contributing to the development of ^{229}Th-based nuclear clocks and relevant precision measurement applications.