DECAY OF SINGLE-PROTON METASTABLE STATES IN ORIENTED DEFORMED NUCLEI

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A time-dependent approach to the general problem of quantum tunneling is applied to the proton decay from metastable states in axially symmetric deformed nuclei. Our method uses the numerical solution of the time-dependent Schrödinger equation (TDSE) in cylindrical coordinates $\psi(\rho, z, t)$ to calculate two physical quantities: 1) The total proton decay rate $\lambda(t)$ (from the probability $\rho(t)$ that the proton has tunneled at time t) and 2) The proton angular distribution with respect to the deformation axis (from the tunneling probability along different directions θ).

The feasibility of this method lies on two facts: a) The predictions for the main observables do not depend on the procedure used to prepare the initial state and b) One does not need to go longer in time to calculate the decay of long-lived low-lying states as compared with short-lived excited states.

Deformed states defined by only one dominant partial wave l exhibit similar decay patterns as states in spherical nuclei, i.e., after a short transient time (5×10^{-22} s), the decay rate reaches an asymptotic value. On the contrary, the decay rate of states containing more than one dominant l-value continues to vary in time. This variation was found strongly correlated with the variation of the average angular momentum $< l > (t)$ indicating that it represents an interference effect.

It will be also shown that the high numerical precision neccessary to calculate ground-state proton half-lives ($\sim$ 1s) can be attained with the present method.

The directions of emission with respect to the nuclear z-axis are mainly determined by the quantum numbers of the decaying state, i.e. by its spatial distribution, rather than by the anisotropy of the potential barrier. Therefore measuring the angular distribution of protons emitted from oriented nuclei could provide direct information on the probability densities of single-protons in nuclei.

Microscopic pictures of bidimensional tunneling are finally presented through current density plots $\vec{\jmath}(\rho, z, t)$ that make a detailed understanding of the decay process possible.

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