Evolution of Beam-Tilted-Foil Excited Hydrogen Atoms through Electric Fields

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The transmission of an energetic beam of protons through a very thin foil results in the neutralization and coherent excitation of a significant portion of the beam particles. Because of the high degree of spatial anisotropy inherent in the impulsive excitation of the beam particles by transmission through the foil, the electrons in the ensemble of excited states are often distributed non-uniformly in the various magnetic sublevels of a given $n$ state manifold. This anisotropic electron distribution is manifest in the polarization of radiation emitted as these states decay to lower energy levels; and the analysis of such polarization can provide insight into the state of the atom at the instant of electron capture.

Additional information can be obtained by forcing the excited states to pass through an applied electric field. The magnetic-sublevel electron population of the beam-foil excited states is redistributed as these states traverse the field due to the Stark mixing of the levels. The observed polarization then exhibits an oscillatory dependence on the applied field strength. These oscillations, which are a direct result of the quantum-mechanical phase interference experienced by the split states, are called quantum beats.

Recent measurements of the field-induced quantum beats in the polarization of Balmer-Alpha radiation emitted following the transmission of 20- to 40-keV protons through a thin a-C foil will be presented in this paper. Also, these measurements will be compared to theoretical calculations which are based on the quantum-mechanical evolution of a hydrogen density matrix from the moment of electron capture until the emission of a photon as the state decays.