DAMOP10-2010-000319

Abstract for an Invited Paper
for the DAMOP10 Meeting of
the American Physical Society

How Initial State Correlation Controls Sequential Laser Tunnel Ionization[1]

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The description of multiphoton ionization by laser-induced tunnelling emerged in the 1960's. Since then, numerous experiments have probed sequential multiphoton ionization, especially in rare gas atoms. Aside from re-collision, each successive ionization stage appeared to loose memory of previous one. We[2] show that, unobserved in all of these studies has been a strong space-time correlation between the two ionized electrons. The correlation arises because each electron must pass through a narrow laser-imposed momentum filter. In many systems this momentum filter only allows a localized hole in the electronic distribution of the atom to be created. A second electron is sensitive to the hole left from the previous stage. We show that the directional entanglement of the continuum electrons evolves with time, driven by spin-orbit coupling in the intermediate ion. Our experiment (on Ne, Ar and HCl) opens a new path to studying multielectron correlations in complex systems – both in the time domain, (which we demonstrate) or in the frequency domain.

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