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Control and Manipulation of Matter using Intense Single-Cycle THz Pulses[1]

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The availability of broad-band, single-cycle THz pulses with MV/cm peak fields affords new opportunities for controlling, manipulating, and probing matter. For example, we are using THz pulses to directly drive rotational transitions in molecules, creating and/or modifying, without ionization or electronic excitation, rotational wave packets which exhibit specific time-dependent behavior such as transient field-free orientation. In addition, at fields that are too weak to cause bulk surface damage or induce electronic excitation/ionization from tightly bound electronic states in atoms or molecules, we have shown that THz pulses can transfer substantial momentum and energy (> 100 eV) to free electrons. Accordingly, they can serve as non-invasive time-resolved probes of electron emission or, potentially, modify laser-driven electron trajectories to influence electron re-scattering during HHG or other strong-field physics applications. We have also found that we can produce, without damage, high energy electrons (several keV) from metallic nano-tips exposed to intense THz pulses. The initial emission appears to be the result of Fowler-Nordheim tunneling in the enhanced THz field at a tip's surface. However, the dynamical mechanism responsible for the high electron energies appears to depend on the surface structure.

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