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Nonlinear terahertz spectroscopy of every phase of matter

KEITH NELSON, MIT

Tabletop generation of intense terahertz (THz) pulses with peak field amplitudes in the 0.1-1 MV/cm range and field enhancement up to 10 MV/cm and beyond has enabled nonlinear responses in solids, liquids, and gases to be driven by THz fields [1,2]. This has enabled nonlinear THz spectroscopy and THz coherent control of a wide variety of samples. In semiconductors and other samples, acceleration of carriers to multi-eV energies by THz excitation pulses has resulted in strong changes in carrier mobility and, in some cases, impact ionization that can lead to dramatic changes in conductivity [3,4]. Tunneling ionization has resulted in insulator-metal phase transitions with associated structural phase transitions [5]. In liquids and gases, THz pulses have produced molecular alignment and orientation [6,7]. Coherent control over molecular rotational motion involving multiple rotational levels has been demonstrated [8]. Recent nonlinear THz spectroscopy and prospects for more extensive THz coherent control over molecules and materials will be discussed.

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