Using terahertz light to control material properties

Jeremy A. Johnson

Brigham Young University,
Department of Chemistry and Biochemistry, Provo, UT

Intense pulses of terahertz (THz) light are enabling the study and control of matter in new and exciting ways. Structure-function relationships are central to designing new materials for high-speed, low power electronics. We use high-field THz light to move millions of atoms in solid materials in concert, far from their equilibrium positions. This extreme excitation can lead to new dynamic properties due to the inherent structure-function relationships in these materials. However, when intense electromagnetic pulses are used in any kind of spectroscopy, several nonlinear excitation pathways can result, leading to scenarios that required the development of multi-dimensional spectroscopies to illuminate the observed dynamics.

I'll begin describing a combined data mining and computational approach that enabled us to discover organic materials that can be used to efficiently convert infrared light into THz light pulses [1]. We can use THz light for automated hyperspectral imaging [2]. And I'll discuss examples where 2-dimensional (2D) THz spectroscopy allows us to distinguish between nonlinear-excitation pathways in crystalline materials. We also can use pairs of THz pulses to excite chiral ionic motion in solids to induce a transient magnetic moment. Such studies are the foundation to being able to develop new materials with picosecond-functionality, controlled by THz light pulses [3-5].

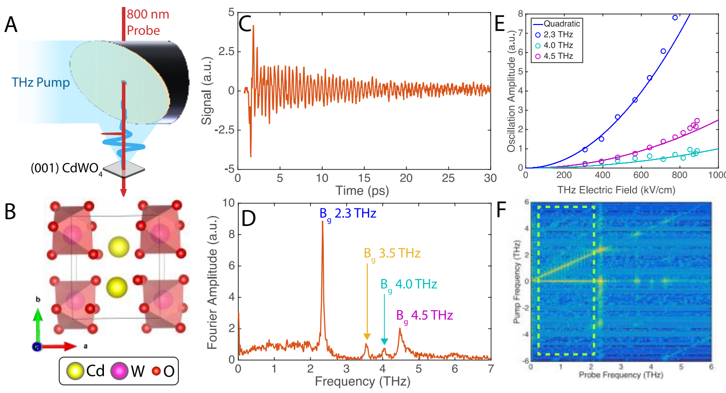

Figure 1. A. High-field THz generation pump–optical probe measurements on $CdWO_4$ (B.). C. Nonlinear vibrational response in $CdWO_4$. D. Spectrum of excited vibrational modes. E. Nonlinear vibrational amplitude dependence. F. 2D THz-Raman signal response. Adapted from [4].

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