Coherent Terahertz Spectroscopy of Electron Plasmas in Solids

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We describe novel phenomena in time-domain terahertz (THz) spectroscopy of plasmas in solids with different dimensions: i) lightly-doped *n*-type InSb (3-D plasma) [1], ii) a high-mobility two-dimensional electron gas (2DEG) in a modulation-doped GaAs quantum well (2-D plasma) [2], and iii) highly-aligned single-walled carbon nanotubes (1-D plasma) [3]:

Interference-Induced THz Transparency in n-type InSb: We have observed a novel type of thermally- and magnetically-induced transparency in a semiconductor plasma, revealed by coherent THz magneto-spectroscopy. We observed a sudden appearance and disappearance of transmission through a slab of electron-doped InSb over narrow temperature and magnetic field ranges. We explain these striking observations in terms of coherent interference between the left- and right-circularly polarized eigenmodes of the low-density magneto-plasma in InSb.

Coherent Cyclotron Resonance in High-Mobility 2DEG: We have observed very long-lived (up to 50 ps) THz quantum coherence in a high-mobility 2DEG in GaAs. Quantum coherence manifested itself as cyclotron resonance oscillations. The decay time and frequencies can be directly determined by fitting the data with exponentially-decaying sinusoidal oscillations. These oscillations can be thought of as a free induction decay of a coherent superposition between the lowest unfilled Landau level and the highest filled Landau level created by the incident THz pulse.

Anisotropic THz Dynamics of Carbon Nanotubes: The one-dimensional character of confined carriers in single-walled carbon nanotubes (SWNTS) leads to extremely anisotropic properties. Even in bundled samples their anisotropic properties are expected to be preserved to a large degree, even though systematic optical spectroscopy studies have been limited. We have studied highly-aligned samples, ideal for polarization-dependent studies. We found that the absorbance is virtually absent when the THz polarization is perpendicular to the tube axis.

1. X. Wang, A. A. Belyanin, S. A. Crooker, D. M. Mittleman, and J. Kono, *Nature Physics* **6**, 126 (2010).
2. X. Wang, D. J. Hilton, L. Ren, D. M. Mittleman, J. Kono, and J. L. Reno, *Optics Letters* **32**, 1845 (2007); *Optics Express* **18**, 12354 (2010).
3. L. Ren, C. L. Pint, L. G. Booshehri, W. D. Rice, X. Wang, D. J. Hilton, K. Takeya, I. Kawayama, M. Tonouchi, R. H. Hauge, and J. Kono, *Nano Letters* **9**, 2610 (2009).