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New Light and New Science: Terahertz-Induced Extreme Nonlinear Optical Transients in Semiconductor Quantum Wells[1]

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Interaction of THz radiation with condensed matter is a highly diverse subject. The wide spectrum of assorted phenomena ranges from the lattice vibrations and the intraband transitions in semiconductors to the dynamics of complex fluids, electron spins, and strongly correlated electrons. The unique and advanced techniques of THz spectroscopy are a powerful tool to explore the material properties inaccessible until recently. When strong THz pulses are applied to a semiconductor quantum- well system, time resolved optical measurements reveal remarkable quantum effects. The optical response of semiconductor quantum-wells displays excitonic resonances with a typical energy spacing of 1 to 100 meV. To directly access transitions between these resonances, one can apply electro- magnetic fields in the terahertz frequency range. The resulting quantum dynamics and associated nonlinear optical effects are of great interest. They both manifest fundamental physical processes, such as many-body interactions and Coulomb correlations; and also have broad applications for optoelectronic devices. We report an uncharted regime of THz excitations: quantum coherent transients of internal excitonic transitions in semiconductor QWs driven by ultrafast THz pulses. We employed a THz-pump and optical-probe technique to investigate time-resolved nonlinear optical effects induced by intense single-cycle THz pulses. The most distinctive feature of this approach is that we can observe the THz-induced effects with the temporal resolution of 0.1 ps, limited by the femtosecond laser pulse duration.

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