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Frank Isakson Prize Talk: Using ultrafast to probe the slow[1]

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The field of ultrafast optics exploded on the scene with the development of mode-locked lasers, and continues to grow as technology evolves. Although often associated with highly-nonequilibrium phenomena, ultrafast experiments can be performed in a low-power regime in which electronic systems are tickled, rather than blasted. The amplitude and phase stability of today's laser oscillators allows detection of very small changes in optical response that result from weak laser excitation. While these changes can be viewed as a form of linear response, they often reveal properties that are not detected by traditional probes such as electrical conductivity or magnetic susceptibility. In this talk I will describe two examples of this approach, in the fields of high-Tc superconductivity and spin propagation in semiconductors. Somewhat paradoxically, the use of ultrafast techniques allows the observation of some rather slow effects. In the high-Tc materials, the lifetime of the photoexcited state diverges as the optical energy per laser pulse is lowered. The slow dynamics in this regime provide a window to the intrinsic inelastic scattering rate of quasiparticles, a new collective mode, and an abrupt transition in dynamics that takes place as a function of doping. In GaAs quantum wells the stability of the laser oscillator enables phase-sensitive detection of a transient spin-polarization wave generated by the interference of two excitation pulses. Measuring dynamics as function of wave vector fully characterizes the spin propagation, revealing effects such as ballistic to diffusive crossover and spin Coulomb drag. In these systems we again have focused on "slow" phenomena. I will describe some of our recent attempts to create and detect a long-lived, "persistent spin-helix" state, predicted to occur at special points in the spin-orbit coupling parameter space.

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