Dynamic Quantum Sensing and Terahertz Lightwave Control of Entangled Many-Body Systems

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Quantum systems are typically arrangements of trapped ions or electrons in which quantum interactions between components can be tuned to produce specific behaviors. In solid state materials, quantum states have been mostly manipulated, so far, by tuning static parameters, such as chemical substitution, pressure, electric or magnetic fields, or by structural engineering of, e.g., photonic crystals and meta-atoms.

Recently, "sudden" quantum quench and pre-thermalization have emerged as a cross cutting theme for non-equilibrium manipulation and discovery of emergent states of matter, such as quantum criticality and generalized Gibbs ensembles of cold atoms, quark-gluon plasmas, or metastable phases in the early universe. In this talk, I will review some recent successes of our theory-experiment team:

(1) THz lightwave sub-cycle dynamical symmetry breaking via gauge fields to drive a long-lived (ns) gapless superfluidity state in model superconductors and (2) a remarkably long-lived (many 100's ps) Cooper-pair-breaking process in a non-equilibrium state of iron-based superconductors that reveal non-equilibrium formation of exotic collective modes. We will demonstrate a dynamical quantum spectroscopy by harnessing THz Light-matter Coherence, Nonlinearity and Entanglement and validate it by showing how to control Entangled Cooper Pairs, Higgs and Anderson pseudo-spin Collective Modes, Nonlinear Super-currents, and Non-equilibrium Quantum Phases in superconductors.