Quantum Coherence and Entanglement Controlled by Light:
From Higgs Bosons to Chiral Fermions

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Revolutionary properties of quantum materials are often manifestations of coherence and entanglement, e.g. it exists between the Cooper pairs in high-temperature superconductors (SCs); it protects chiral charge transport from disorder scattering in topological states of matter (TSM). The recent development of ultrafast and terahertz (THz) spectroscopy tools facilitates discovering and understanding driven coherent systems involving SCs and TSM controllable by light. In this talk, I will discuss strategic advantages, with help of some recent examples, of implementing this approach to probe and control many-body quantum phases and collective modes by light-driven coherence, e.g., light-induced gapless superconductivity and high harmonics [1], forbidden Anderson pseudo-spin precessions [2], hidden gapless quantum fluid [3], hybrid Higgs modes [4], spin-exciton modes [5], phonon-controlled topology switching [6, 7] and light-induced Weyl states [8]…. We argue that the light-driven coherence and sub-cycle dynamic symmetry breaking demonstrated in these work represent universal principles for emergent materials discovery and light-matter quantum control for quantum information science and topological electronics.