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Capturing the Fastest Charge and Spin Dynamics in Nanosystems using Tabletop High Harmonic Beams

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High harmonic generation (HHG) is a unique quantum light source with fundamentally new capabilities producing fully spatially and temporally coherent beams with linear or circular polarization throughout the extreme ultraviolet (EUV) and soft X-ray region, all on a tabletop. This talk will introduce and review recent developments in HHG sources, as well as exciting advances in spectroscopy of materials. In recent work we showed that HHG spectroscopies can uncover several new excited-states of quantum materials that traditional spectroscopies are simply blind to.[1-3] We showed that the electron-spin system in a laser-heated ferromagnet can be driven into a previously unknown super-excited state, where the magnetic phase transition is launched on timescales 10 times faster than previously realized, within a fleeting 20 fs. We also measured the shortest lifetime of any state to date, at 21230 attoseconds, corresponding to an excited state in the band structure of a material. More recently, using a new technique called attosecond-ARPES (angle resolved photoemission) we measured the fastest electron dynamics intrinsic to materials, making it possible to distinguish sub-femtosecond electron-electron scattering and screening for the first time.

1. Tengdin et al., Critical Behavior within 20fs Drives the Out-of-Equilibrium Laser-induced Magnetic Phase Transition in Nickel, Science Advances 4, 9744 (2018).
2. Chen et al., Distinguishing Attosecond Electron-Electron Scattering and Screening in Transition Metals, PNAS 114, E5300(2017).
3. Tao et al., Influence of the Attosecond Final-state Lifetime on Photoemission from a Transition Metal, Science 353, 62 (2016).