

**CMP Seminar**  
**Michigan State University**

**Tyler Cocker**  
**University of Regensburg**

***Sub-cycle terahertz microscopy on the atomic scale***

A new experimental frontier has recently emerged with the potential to significantly impact physics, chemistry, materials science, and biology: the regime of ultrafast and ultrasmall. This is the domain in which single atoms, molecules, and electronic orbitals move. It also corresponds, on larger scales, to the territory of low-energy elementary excitations such as plasmons, phonons, and interlevel transitions in excitons. These processes are of particular importance for nanomaterial functionality. Moreover, they typically survive for only femtoseconds to picoseconds after photoexcitation and can evolve within a single oscillation period. In this talk, I will show how these diverse dynamics can be studied with new techniques that combine terahertz technology with scanning probe microscopy. First, I will describe how ultrafast near-field microscopy has been employed to perform sub-cycle spectroscopy of single nanoparticles, reveal hidden structure in correlated electron systems, and resolve transient surface plasmons in van der Waals heterostructures. Then, I will discuss the invention and development of a related technique: lightwave terahertz scanning tunneling microscopy. In this novel approach, the oscillating electric field of a phase-stable, few-cycle light pulse can be used to remove a single electron from a single molecular orbital within a time window faster than an oscillation cycle of the terahertz wave. I will show how this technique has been used to take ultrafast snapshot images of single molecular orbitals and watch the motion of a single molecule for the first time.

**Monday, February 20, 2016**

**4:10 p.m.**

**BPS 1400**

**Prof. Chong-Yu Ruan - Host**