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Two-dimensional materials have attracted significant interest recently as candidates to replace silicon in microelectronics, with a recent focus on many novel monolayer systems like transition metal dichalcogenides (e.g. MoS<sub>2</sub> and related compounds). Compared to more traditional quantum confined systems, however, many of the optical and electronic properties of these materials that have been measured have been strongly influenced by disorder, given the short period of time that these materials have been studied and the relatively unsophisticated methods that are used to produce monolayer materials. The modulation doped gallium arsenide two-dimensional electron gas, in contrast, has seen extensive study and the growth of high quality samples with mobilities exceeding  $10^6 \text{ cm}^2 \text{ V}^{-1} \text{ s}$ , which provides a model system to study the electronic and optical properties of two-dimensional materials in the “clean” limit. Traditional measurement of these materials have been electrical transport measurements [e.g. Phys. Rev. Lett. **48**, 1559 (1982)], while the study of these materials on subpicosecond time-scales is relatively recent [e.g. Phys. Rev. B **93**, 155437 (2016).]. These ultrafast spectroscopic techniques are a frequently employed and powerful technique that can be used to unravel complex and often competing processes in condensed matter systems on a femtosecond time scale. High Magnetic field spectroscopy is a particularly useful optical tool for unraveling complex interactions in these systems, which are a particularly rich source of novel materials physics due to the relative absence of disorder in 2DEG’s. In this talk, I will discuss our work using terahertz time-domain spectroscopy to study Landau level populations and coherences in high mobility two-dimensional semiconducting systems and our extensions of these techniques to higher magnetic field spectroscopy. We model our results using the Optical Bloch Equations to determine the dephasing lifetime as a function of temperature and explain our low temperature results using ionized impurity and bound interface charge scattering in the conducting layer. In the second part of my talk, I will discuss our recent work to study these materials in high magnetic field using the 25 Tesla Split-Florida Helix magnet at the National High Magnetic Field Lab. Our results reveal a complex interplay between conventional (electron transport) and complex (many-body) electronic interaction on an extremely fast time scale.

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**Short Biography:** Dave Hilton received B.S. (1997) and M.S. (1999) degrees in Optics from the University of Rochester. He received a M.S. (2001) and Ph.D. (2002) in Applied Physics from Cornell University. From 2002 to 2006, he was a postdoctoral researcher at Los Alamos National Laboratory in New Mexico, where his research focus shifted to terahertz spectroscopy of correlated electronic systems. From 2006 to 2007, he was a postdoctoral researcher at Rice University, where his interests included the development of novel spectroscopic measurement techniques for high-resolution spectroscopy in high magnetic fields. He joined the faculty as Assistant Professor of Physics at the University of Alabama at Birmingham and was promoted to Associate Professor in 2013. His research program focuses on the study of insulator-to-metal phase transitions in transition metal oxides and ultrafast investigations of high mobility 2DEGs and dichalcogenides.

