Dragana Popović

National High Magnetic Field Laboratory and Department of Physics,
Florida State University, Tallahassee, FL 32310, USA

Nonequilibrium transport and thermalization in two-dimensional bad conductors

Abstract:

One of the most fundamental questions in physics is whether an isolated quantum many-body system thermalizes a long time after it is prepared far out of equilibrium. Recently, there has been a lot of interest in mechanisms that break ergodicity and lead to the absence of thermalization. In strongly disordered quantum systems, many-body localization (MBL) provides a robust mechanism for the failure of thermalization, but many questions remain open, especially in dimensions $D>1$. At the same time, experiments have been limited to mostly those on synthetic quantum matter, such as ultracold atoms in optical lattices and superconducting qubits, while observing the absence of thermalization in real, solid-state materials has been a challenge.

This talk will describe the results of experimental studies of nonequilibrium dynamics in strongly disordered D=2 electron systems with power-law interactions $\propto 1/r^{\alpha}$ and poor coupling to a thermal bath. We find that, for α=1, the system thermalizes, although the dynamics is glassy. The behavior of this Coulomb glass is similar to that of a large class of both 3D and 2D systems that are out of equilibrium (e.g., spin glasses, supercooled liquids). In contrast, for α=3, the thermalization is anomalously slow and strongly sensitive to coupling to the thermal bath, consistent with the proximity to a MBL phase. This direct observation of the MBL-like, prethermal regime in an electronic system thus clarifies the effects of the interaction range on the fate of glassy dynamics and MBL in 2D. These are important insights for theory, especially since the results have been obtained on systems that are much closer to a thermodynamic limit than synthetic quantum systems employed in previous studies of MBL. By establishing a new, versatile solid-state platform for the study of MBL, our work also opens new possibilities for further studies of ergodicity breaking and quantum entanglement in real materials.