MAX PLANCK INSTITUTE
FOR THE STRUCTURE AND DYNAMICS OF MATTER

Date & Time: **MONDAY, JULY 13th at 16:00**

Location: **MPSD 900.EG.136**

Speaker: Junichiro Kono
Rice University, Houston, Texas

qcmd - Seminar

mpsd

Cavity-Dressed Quantum Matter

There is a growing realization that a material's fundamental properties can be radically transformed by placing it in an optical cavity. Within these confined spaces, the **quantum vacuum fields** surrounding the material can trigger nonintuitive modifications of electronic states. This process, driven by **ultrastrong vacuum–matter coupling (USC)**, produces "vacuum-dressed" materials with entirely novel physical properties.

Theoretical models predict that these cavity-induced environments can enhance electron–phonon coupling, trigger superconductivity or electron pairing, and induce exotic states such as the anomalous Hall effect, ferroelectric phase transitions, and quantum spin liquids. Reaching the USC regime is the critical prerequisite for these phenomena; it occurs when the interaction energy becomes a significant fraction of the bare photonic and matter excitation frequencies.

Most intriguingly, under USC conditions, the material's ground state contains **virtual photons**. This non-perturbative virtual driving—occurring without any external fields—can lead to phase transitions even in thermal equilibrium. In this talk, I will describe our recent studies of USC phenomena across various solid-state cavity quantum electrodynamics (QED) systems. We leverage **Dicke cooperativity**—the many-body enhancement of light–matter interaction—to explore new quantum-optical strategies for creating, controlling, and utilizing novel phases of condensed matter enabled by the quantum vacuum.