RICE QUANTUM GROUP MEETING SEMINAR SERIES

Date: December 10, 2021, Friday

Time: 3PM - 4PM

Venue: SST 300

Research Group: Prof. Junichiro Kono's Group

Presenter: **NICOLAS MARQUEZ PERACA**

Title: **Quantum simulation of light-matter interactions using $ErFeO_3$**

Abstract: Quantum simulation has an enormous potential for groundbreaking scientific discoveries in the XXI century, with applications ranging from condensed matter physics to cosmology. In recent years, the study of light-matter interaction using analog quantum simulators has blossomed, and regimes that used to be experimentally challenging to implement are now readily accessible using superconducting circuits, nuclear magnetic resonance spins, and ultracold atoms. However, despite the various platforms already in place, it has remained challenging to use these systems to realize, analyze, and control exotic quantum phases of matter, mostly due to the limited parameter space that is accessible with current technologies. Recently, various solid-state cavity quantum electrodynamics simulators have emerged, opening up new and exciting opportunities to explore uncharted territory in the field of ultrastrong light-matter interaction. In this work, we investigate the terahertz response of the rare-earth orthoferrite ErFeO3 as a function of magnetic field, at low temperatures. By constructing an appropriate mapping between this spin-boson system to an extended, multi-mode, anisotropic Dicke Hamiltonian, we found that the unique combination of material parameters and short-range interactions induce a rare multicritical behavior, giving rise to a rich and complex phase diagram with three distinct phases, separated by first and second-order phase transitions, and a triple point. By tuning the temperature and magnetic field to specific values, we were able to explore various regions of interest in the phase diagram, and found drastic spectral changes as this system undergoes these phase transitions. Our findings demonstrate how solid-state simulators can provide crucial insights about the physical conditions required to observe criticality in ultrastrongly-coupled light-matter systems, and how their intrinsic properties make them particularly suitable to access these unusual parameter regimes.

Short Bio: Nicolas Marquez Peraca is a 4th year Ph.D. student in Prof. Junichiro Kono's laboratory at Rice University. Before joining Kono's group, he was a Guest Researcher for two years at the National Institute of Standards and Technology, where he worked on the electric and opto-electronic characterization of multijunction solar cells. His research interests include ultrafast phenomena in condensed matter physics, magneto-transport properties of low-dimensional materials at cryogenic temperatures, and quantum computing.

Note: *Snacks and Coffee will be served during the event.*