Dept. of Physics & Engineering Physics
Fall 2021 Physics Colloquium Series

remotely via ZOOM / Boggs 240
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Tunable Strong Coupling in Terahertz Metasurfaces

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Recently, the study of ultrastrong light-matter coupling has gained increased interest due to its potential application in optoelectronics, plasmonics and circuit quantum electrodynamics. One common way to achieve strong coupling is to place an emitter near or inside an optical cavity. In this case, the emitter-cavity system, the spatial overlap between the emitters and the cavity is often the key factor that limits the light-matter coupling strength. The cavities can be either photonic microcavities, which can have very high quality factors, or surface plasmon resonators, whose mode volume can be in the deep subwavelength regime. In contrast to microcavities, where the light field is confined by two metallic layers or dielectric mirrors, an alternative approach to achieve strong coupling is provided by metamaterials (MMs) in which the confinement is provided by the evanescent field of localized plasmons. This has led to the demonstration of strong-coupling regime with a number of quantum systems including phonons, intersubband transitions and cyclotron resonances. In addition, resonant coupling leads to light-matter hybridization into two normal modes with an energy separation known as the vacuum Rabi splitting (VRS).

In this work, we investigate a THz planar metamaterial and observe the excitation of a polaritonic state as well as a VRS with a coupling strength of ~21%. Strong splitting results in the formation of a forbidden frequency gap that can be evaluated as a transparency window caused by the hybridization of two eigenmodes. The physics of the transparency window is analogous to the lattice induced transparency effect in which there are limited demonstrations in the literature of strong coupling due to cavity-cavity interactions. Further, we show that by increasing the capacitive gap width of the MM unit cell, we increase the overall capacitance of the MM and demonstrate an anti-crossing behavior; a key signature to strong-light matter coupling. Lastly, we present new results for the formation of bound states in the continuum driven in a THz metasurface by varying the polarization with experimental evidence supporting numerical simulations for the tunability of capacitive-mediated strong coupling.

Thomas A. Searles joined University of Illinois Chicago in Fall 2021 as an Associate Professor, under the University System's Distinguished Faculty Recruitment Program. Prior to UIC, he was a Martin Luther King Visiting Professor at MIT and served as the Director of the IBM-HBCU Quantum Center. Thomas received his Ph.D. in Applied Physics from Rice University in 2011 and upon his appointment at Howard University, he established a new research program in applied and materials physics, which now focuses on quantum materials, metamaterials and quantum information. In recognition for his research in light-matter interactions and his capability to mentor students in Physics and Engineering, Thomas was awarded the inaugural AIP-NSBP Joseph A. Johnson Award for Excellence and an NSF CAREER Award.