

Nonlinear and non-local optical response in quantum materials



Bio:

Gururaj (Guru) Naik is an associate professor at Electrical & Computer Engineering Rice University. He received an M.E. from the Indian Institute of Science, India, and a Ph.D. from Electrical & Computer Engineering, Purdue University. During his Ph.D. with Shalaev and Boltasseva groups, he developed new plasmonic materials for nanophotonic applications. After pursuing postdoctoral research at Stanford University, Guru joined Rice University in 2016. His research group focuses on topics at the interface of quantum, nanophotonics, and materials. Guru's research has attracted high citations, many invited talks, and won the MRS 2020 best presenter award. Guru is a recipient of the IEEE Photonics Society Graduate Student Fellowship, an Outstanding Graduate Research Award from Purdue University, and a Gold Medal from the Indian Institute of Science.

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SEMINAR LINK- <https://www.youtube.com/channel/UCAwzWog7PqFw5R0q90KI6KQ/featured>

Abstract:

Quantum materials possess a complex energy landscape arising from the competition between many microscopic processes. A stimulus such as light can tip the fine balance between these competing processes resulting in novel optical phenomena. Understanding such optical phenomena is crucial in mapping the energy landscape of quantum materials and tailoring the light-matter interaction in these quantum many-body systems. Here, in this talk, I will discuss two consequences of light interacting with a quantum many-body system - optical non-linearity and optical non-locality. Optical non-linearity arises from light tipping the balance between competing microscopic processes in a quantum material. As a result, the optical response of the material depends on the strength of this stimulus. Thus, the optical response is non-linear. Optical non-locality arises from the spatial inhomogeneity in quantum materials. Spatial domains corresponding to different microscopic processes often observed in quantum materials lead to this inhomogeneity. Additionally, the spatial spread of quantum many-body effects is not too small (atomic) and thus could result in a non-local response. To study the non-linear and non-local optical responses in quantum materials, we choose 1T-TaS₂. 1T-TaS₂ is a quasi-2D material supporting charge density waves (CDW). We observe that a thin film of 1T-TaS₂ under incoherent white light illumination exhibits an intensity-dependent optical response with a sub-microsecond response time. Our studies show that this non-linear response arises from a reorganization of the stacking order of the CDW domains with light. We observe a similar behavior with an in-plane electrical bias applied to the film. Further, we have begun investigating the non-local optical response in this material arising from the tens-of-nanometer-sized CDW domains. Our study suggests that light could be a powerful tool to understand and control strong correlations in quantum materials.