Electromagnetic Response of Transdimensional Quantum Materials

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I will briefly review the recent experiments [1-3] and enlarge on our theoretical efforts to understand the nature of intrinsic strongly correlated quasiparticle excitations responsible for the electromagnetic (EM) response of ultrathin transdimensional (TD) metallic and semiconductor nanostructures. TD regime is neither 3D nor 2D but something in between, turning into 2D as material thickness tends to zero, calling to study what the 3D-2D transition has to offer to improve material functionalities [4,5]. TD quantum materials are ultrathin finite-thickness nanostructures composed of a precisely controlled number of monolayers [4-8]. Depending on their thickness, material composition and dielectric surroundings, ultrathin TD materials can restructure the spectral and spatial distribution of not only real but also virtual EM modes, to create new modes of light that pertain to vacuum processes such as spontaneous emission and Casimir interactions [9-14]. For light-matter coupling in general, processes that spontaneously generate new modes of light require a quantum theory since all of them stem from the spontaneous emission process which can only be understood in terms of fully quantized theoretical models [15,16]. In this talk, the basic optical properties of ultrathin finite-thickness TD metasurfaces and films will be reviewed in terms of medium-assisted quantum electrodynamics (QED) [15], with focus on the confinement-induced nonlocality of their EM response [6-8] and its manifestation in quantum light emission, absorption, and scattering [9-13], radiative heat transfer [14], and more [17].

Acknowledgements: This research is supported by the U.S. Army Research Office under Award #W911NF2310206.

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