Confinement-Induced Nonlocality and Optical Nonlinearity in Transdimensional Plasmonics

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I will review the latest experimental and theoretical developments in studies of the electromagnetic (EM) properties of transdimensional (TD) materials as applied to quantum plasmonics. Plasmonic TD material structures are atomically thin metal, semimetal or doped semiconductor films of precisely controlled countable number of monolayers [1]. Due to the modern progress in nanofabrication techniques [2-5], such materials can be reproducibly grown to offer high tailorability of their electronic and optical properties not only by altering their chemical and/or electronic composition (stoichiometry, doping) but also by varying their thickness [4,5]. So far, the research focus has largely been on either purely two-dimensional (2D) structures including metal-dielectric interfaces, graphene and novel 2D semiconductors [6], or on conventional bulk materials where chemical composition and stoichiometry are the primary factors affecting the EM response. Recently, it was proposed [1] that ultrathin TD plasmonic nanostructures provide a new regime—transdimensional, in between 3D and 2D, turning into 2D as the film thickness tends to zero, challenging to study what the 3D-to-2D continuous transition has to offer to improve material functionalities [4,5,7-10]. In this regime, the strong vertical quantum confinement makes the linear EM response of the film nonlocal (spatially dispersive), and the degree of nonlocality can be controlled by the film thickness [7-10]. This makes plasmonic TD materials indispensable for research into nonlocal and nonlinear light-matter interactions [10-17], where they exhibit extraordinary tailorability including the capabilities of active tuning of the EM response and thus enabling new and unique strongly correlated phenomena [18-20].

Acknowledgements: This research is supported by the U.S. ARO grant No. W911NF23-1-0206.

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