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Merging Photonics and Plasmonics

Abstract: Silver and gold nanoparticles have unique optical properties that are associated with the excitation of collective excitations of the conduction electrons known as plasmon resonances. The resonance frequencies are sensitive to particle shape and size, which means that the color of the nanoparticles can be tuned over a wide range of wavelengths, and they are also sensitive to the arrangement of the nanoparticles into aggregates and arrays. This talk will emphasize recent theory and experiments which have studied the optical properties of arrays of plasmonic particles in 1D, 2D and 3D. The arrays in 1D and 2D can be made using standard lithography tools, but much of the talk will emphasize bottom-up assembly of arrays that is possible using DNA-functionalized nanoparticles and self-assembly of nanoparticle superlattices driven by DNA hybridization. We show that the array structures lead to new kinds of hybrid optical modes in which localized surface plasmon resonances in the nanoparticles are coupled with photonic modes of the lattices, including Bragg modes, Fabry-Perot modes and other modes. These hybrid modes are often much narrower than the isolated particle plasmons, and films composed of these superlattices have unusual metamaterials properties. We also show that for 2D lattices it possible to generate a new class of sub-wavelength laser in which excitons in laser dyes are coupled with the hybrid lattice modes to produce enhanced stimulated emission.