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# Cooperative effects in periodic and disordered metamaterial lattices

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The electromagnetic properties of metamaterials are defined not only by the properties of their constituting elements (termed metaatoms or metamolecules), but also by their interactions, which can result in emergent response distinctly different from that of the single metamolecule response. Lattices of strongly interacting metamolecules provide control over the radiative properties of metamaterials by resonantly suppressing scattering through the excitation of subradiant collective modes. Such metamaterials are also highly sensitive to disorder and, in fact, introducing disorder in the positions of the metamolecules leads to the appearance of localized excitations, which retain the multipole nature of the single metamolecule response.

Here, we will report on metamaterials with strong inter-metamolecule interactions, targeting at enhancing metamaterial properties and enabling practical applications. In particular, we will present a framework for the analysis and design of light enhancement and confinement, as well as scattering properties in periodic and disordered metamaterials. We will discuss the role of strong interactions in polarisation sensitive light phenomena. Moreover, we will demonstrate that under excitation with specific spatial patterns of evanescent waves, the resonant collective modes supported by the metamaterial are directly related to the spectrum of wavevector of the evanescent landscape. Hence, the far-field properties of the metamaterial convey information about the near-field excitation landscape with implications for sensing, imaging, and spectroscopy.

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