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Managing light by scattering from structured materials

Depending on material properties, size and shape, one can manage light-matter interactions, scattering phenomena and exploit resonant responses. More complex scattering units or meta-atoms provide the opportunity to realize bulk materials with unusual electromagnetic properties. In this talk, we investigate the role of local resonances and the effect of some degree of disorder of the meta-atoms on bulk material properties. Coupling between sub-wavelength elements can result in very large field enhancements and index values not predicted by an effective medium model. Similarly, we describe some of the consequences of sub-wavelength periodicity of these elements and their role in defining bulk material properties. The consequences of disorder and coupling in meta-material structures sets limits on the material response due to phase de-coherence. One can draw parallels with the Random Phase Approximation (RPA) which is routinely invoked in condensed matter physics. We have investigated the propagation of radiation through small numbers of meta-atoms or meta-molecules, close to resonant frequencies, to determine how coupling and scattering affects their Q and bandwidth. From a scattering perspective, the coupling of local evanescent fields into propagating waves also contributes to these effective constitutive parameters in a subtle fashion determined by phase coherence. Depending on the materials employed from which the meta-atoms are fabricated, one can observe nonlinear responses. At microwave frequencies and using pulsed illumination, these structures show evidence of an energy exchange between neighbouring (non-orthogonal) resonant modes, suggesting their use for tunable parametric applications as well. We discuss how these properties can be realized at optical frequencies.

Biography

Michael A Fiddy received his PhD from the University of London and was Faculty Member in Physics at Kings College London from 1979-1987. He moved to the University of Massachusetts Lowell in 1987, where he was ECE Department Head from 1994 until 2001. In January 2002, he was appointed the Founding Director of the Center for Optoelectronics and Optical Communications at UNC Charlotte and since 2011 he has been the Site Director for the NSF Industry/University Center for Metamaterials. He is a Fellow of the OSA, IOP and SPIE and serves on the OSA Board of Directors.

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