

Characterization and effective description of complex electromagnetic media and metamaterials

In the analysis of electromagnetic fields interacting with material structures, the response of medium is condensed in dielectric and magnetic material parameters, like permittivity, conductivity, and permeability. In complicated and anisotropic media, these material parameters may need to be generalized from scalar quantities into matrices, or equivalently dyadics. The complicated response of materials is very often of structural origin, in other words the manner in which a heterogeneous mixture is formed determines its macroscopic electromagnetic material parameters. This seminar deals with the variety of ways how one is able to characterize and effectively describe the macroscopic dielectric and magnetic behavior of composite materials with given properties of the constituents and the geometrical microstructure. The rich history of homogenization of mixtures will be reviewed, including Clausius–Mossotti, Lorenz–Lorentz, Maxwell Garnett, Bruggeman, and other homogenization principles, and their ranges of applicability will be assessed. Mixing principles will be applied to mixtures that display very interesting properties that differ strongly from those of the constituent materials, like, for example, aqueous, strong-contrast, lossy, plasmonic, chiral, and bianisotropic mixtures, and metamaterials in general.