2nd URSI AT-RASC, Gran Canaria, 28 May – 1 June 2018

Exotic properties of spoof surface plasmon polaritons in metamaterial crystals

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A polariton is a special kind of electromagnetic mode that arises in a multiple scattering medium when locally resonant scatterers are arranged at a scale that is subwavelength with respect to the background medium. When the scatterers are located on a surface, these subwavelength states become surface waves, also known as spoof surface plasmon polaritons. These mesoscopic analogs of surface plasmons are interesting because they provide a way to manipulate electromagnetic fields at the subwavelength scale and enhance wave matter interactions.

A relevant platform to observe and engineer the propagation of surface plasmon polaritons is a two-dimensional metamaterial crystal. Metamaterials crystals, which are built from simple, spatially local, resonant subwavelength inclusions, support strong spatially dispersive effects that are due only to their locally-resonant crystalline structure [1]. Unlike photonic crystals, they can be scaled down without changing their frequency of operation and functionality [2], which allows for deep subwavelength wave guiding [3,4] or focusing [1]. Different from conventional bi-anisotropic metamaterials, in which all spatially dispersive effects are engineered at the inclusion level, crystalline metamaterials remarkably exhibit strong multiple scattering at the level of their subwavelength lattice structure, allowing for full control of spatial dispersion well beyond second order and across much smaller spatial scales.

In this talk, we discuss our recent research advances in the field of subwavelength electromagnetics using two-dimensional metamaterial crystals. We will demonstrate how it is possible to guide and route electromagnetic power along two-dimensional subwavelength paths, built by doping the medium with defect lines of resonators [2]. Then, we will discuss the possibility to tailor the internal structure of the crystal to induce topological properties that can be exploited to improve the robustness of subwavelength waveguides to structural defects or frequency disorder [4,5]. Finally, we will demonstrate how subwavelength spatially dispersive effects, when properly combined with a source of broken time-reversal symmetry, can be used to build a nonreciprocal crystal in which only a single one-way propagating mode is allowed [6].

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