Computational and Mathematical Approach to Wave Functional Materials

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The study of electromagnetic and acoustic waves dates back to the antiquities. Their diverse applications form the very pillars of modern technology. About two decades ago, revolutionary ideas emerge in this classic field, which demonstrates the feasibility of realizing man-made materials with wave manipulation functionalities beyond the defined limits of those found in nature. These novel functional materials include photonic/phononic crystals, metamaterials and plasmonic structures. We will give some examples to show how mathematical and computational physics can design new artificial materials that can make possible some novel effects that were previously thought to be impossible. I will begin by explaining what these materials are and what they can do. I will then give examples that include invisibility, optical illusion, extreme effective parameters (such as zero-refractive index), artificial magnetic fields, geometric phases, topological states and topological points in momentum space which can be source or sink of Berry flux.