Generalized reflection and refraction with phase discontinuities: engineering Huygens, Fermat, Bragg and Fresnel laws"

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Abstract:
In conventional bulk materials, the collective electromagnetic properties - such as refractive index, absorption, and birefringence - are inherited by atomic and crystalline lattice properties. Conventional optical engineering is therefore based on structuring such materials, which are selected according to their given electromagnetic properties, as well as on combining more than one material, in structures such as distributed Bragg reflectors and more recently in photonic crystals. A novel perspective has been introduced by metamaterials. What if we design elementary building blocks ("meta-atoms"), and arrange them in macroscopic systems, in such a way that their collective electromagnetic properties are dramatically different from what usually found in nature? Are there interesting tiny structures to be used as meta-atoms, that can challenge our understanding of collective electromagnetic properties properties? For example, what if we combine the structural symmetries of such meta-atoms with symmetries of lattices? In this presentation I will address some of these new questions, by discussing a structure that generalizes classical Snell and Fresnel laws, based on "phase discontinuities" [1]. I will provide an outlook on the predicted and experimentally observed phenomena, from four different and complementary points of view, referred to classical Huygens, Fermat, Bragg, and Fresnel laws. Applications will also be suggested, which include ultra-flat lenses and vortex beam generation.

Reference:
[1] N. Yu et al., Science 334, 333 (2011).