Light Propagation with Phase Discontinuities: Generalized Laws of Reflection and Refraction

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Conventional optical components rely on gradual phase shifts accumulated during light propagation to shape light beams. New degrees of freedom are attained by introducing abrupt phase changes over the scale of the wavelength. A two-dimensional array of optical resonators with spatially varying phase response and sub-wavelength separation can imprint such phase discontinuities on propagating light as it traverses the interface between two media. Anomalous reflection and refraction phenomena are observed in this regime in optically thin arrays of metallic antennas on silicon with a linear phase variation along the interface, in excellent agreement with generalized laws derived from Fermat's principle. Phase discontinuities provide great flexibility in the design of light beams with the potential of generating a new class of planar high performance optical components.