

Broadband wavefront engineering with phase discontinuities: Flat optics based on metasurfaces

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Conventional optical components such as lenses, prisms and holograms rely on gradual phase shifts accumulated during light propagation to shape light beams. New degrees of freedom in optical design can be attained by introducing in the optical path abrupt phase changes over the scale of the wavelength [1]. This has been initially implemented using a two-dimensional array of plasmonic resonators in form of V-shape antennas with spatially varying phase response and sub-wavelength separation that imprint phase discontinuities on propagating light. In particular a linear phase variation on the interface between two media leads to anomalously reflected and refracted beams in accordance with generalized laws of reflection and refraction derived from Fermat's principle [1]. This research, initially performed in the mid-infrared spectrum has been extended to the near infrared [2]. If we now consider an interface with a phase gradient arbitrarily oriented with respect to the plane of incidence rather than parallel to it as in Refs. [1] and [2], the reflected and refracted beams are non-coplanar with the incident beam, leading to a three-dimensional generalization of the new laws of reflection and refraction [3]. Out of plane refraction has been experimentally demonstrated [3].

Phase discontinuities enable wavefront engineering with unprecedented flexibility, which is promising for a wide variety of planar optical components. We have performed theoretical and experimental study of birefringent arrays of two-dimensional (V- and Y-shaped) optical antennas which support two orthogonal charge-oscillation modes and serve as broadband, anisotropic optical elements that can be used to locally tailor the amplitude, phase, and polarization of light [4] [5]. Flat optical components such as lenses free of monochromatic aberrations (spherical, astigmatism and coma) [6], axicons [6], background free broadband quarter wave plates and spiral phase plates that create optical vortices [7].

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