Ultra-thin plasmonic optical phased array based on phase discontinuities and application to the generation of optical vortex beam

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A flat optical device that generates optical vortices with a variety of topological charge is demonstrated. It spatially modulates light beams over a distance much smaller than the wavelength in the propagation direction by means of an array of V-shaped plasmonic antennas with sub-wavelength separation, which shapes the wavefront of light. Optical vortices are shown to develop after a sub-wavelength propagation distance from the array, a feature that has major potential implications for integrated optics.

Traditional optical components that control the wavefront of light beams rely on the phase accumulated while light propagates in materials [1]. This concept has been extensively used to create a variety of optical components such as lenses, prisms, gratings, and spiral phase plates. Recently a method to control the phase and amplitude of light beams was demonstrated by using the concept of phase discontinuities, which has led to a generalization of the laws of reflection and refraction [2].

In this presentation, I will present detailed experimental and theoretical study of single- and doubly charged vortices generated with our optical phased arrays and I will demonstrate that the phase profile is controlled over a sub-wavelength propagation distance. Using the concept of phase discontinuities, we have achieved independent control of the phase and the amplitude for a state of polarization orthogonal to the incident polarization. Our experiments, in excellent agreement with simulations, show that optical vortices with different orbital angular momentum can be created when conventional Gaussian beams traverse an interface that imprints a screw-like phase profile on the incident beam. The concept of phase discontinuity introduced in [2] opens the door to the development of ultra thin and integrated photonics devices. We envision creating reconfigurable spatial light modulators by using materials whose optical properties can be tuned by means of external excitations.
