Vector Vortex Beam Transmitarrays Composed of Split-ring Slot Elements

Caner Guclu, Mehdi Veysi, and Filippo Capolino
Department of Electrical Engineering and Computer Science, University of California, Irvine, CA, 92695

A novel birefringent transmitarray capable of local polarization conversion in infrared regime is presented. In particular an incident beam with linear polarization can be transformed into a radially or azimuthally polarized vector beam and in general a wide continuum of polarization states are realizable on the higher order Poincare spheres. The transmitarray is composed of a rectangular array of double-layer double split-ring slot nanoantennas. The double layer element, chosen here, enables high transmission coefficient amplitude, thus increases the efficiency of conversion to the vector vortex beams. The array element exhibits anisotropy with respect to the field polarization on the transmitarray plane, where the transmission coefficients for two orthogonal linear polarizations are almost equal in magnitude and have almost a 180° phase difference. This transmission condition is crucial in the geometric phase control method employed here and it is satisfied in a certain frequency band. The local polarization transformation on the array is controlled through manipulating the angular orientation of the slot elements with respect to element centers. Locally the phase of circularly polarized transmitted waves are advanced or delayed with a phase equal to twice the rotation angle. This phase control method is purely geometrical and it is not frequency dependent. For a certain transmitarray, the generated beam's polarization map is also a function of incident beam polarization. We then study the interesting case of azimuthally E-polarized vortex beams which are a superposition of the Laguerre Gaussian (LG) beams carrying certain orbital angular momentum (OAM) states. Such beams have a strong longitudinally polarized magnetic field on the propagation axis of the beam where the total electric field vanishes. We demonstrate analytically and through numerical field calculations, the evolution of electric and magnetic fields as the beam propagates. These finding are particularly interesting in the view of optical spectroscopy systems related to dipolar transitions and for optical manipulation of particles with spin and orbital angular momenta.