10-2003

Examination of Focused Beam Propagation through a Finite Non-reciprocal Planar Chiral Slab Using Complex Fresnel Coefficients and Dual Transforms

Monish Ranjan Chatterjee
University of Dayton, mchatterjee1@udayton.edu

Sumit Nema
University of Dayton

Partha P. Banerjee
University of Dayton, pbanerjee1@udayton.edu

Examination of Focused Beam Propagation through a Finite Non-Reciprocal Planar Chiral Slab Using Complex Fresnel Coefficients and Dual Transforms

Monish R. Chatterjee, Sumit Nema and Partha P. Banerjee
Department of Electrical and Computer Engineering, University of Dayton, Dayton, Ohio 45469

Abstract: Recently, uniform plane wave propagation across a nonchiral-chiral interface was examined via the development of appropriate Fresnel coefficients. In this extension, propagation of focused uniform and profiled beams through a finite, planar nonreciprocal chiral slab is investigated using complex Fresnel coefficients via angular plane wave decomposition and dual transforms.

Summary

Propagation of electromagnetic waves in non-reciprocal chiral media has been studied by several investigators. Specific chiral devices, such as chirolenses of different shapes have been studied using a variety of mathematical approaches. In particular, Yokota *et al.* have investigated the propagation of higher-order Gaussian beams through a spherical chiral medium using a multipolar field expansion formalism.[1] In an earlier approach, a dual-transform technique was developed to study the problem of propagation in an unbounded chiral material under paraxial and slow envelope variation conditions.[2] In recent work, the computation of profiled beam propagation in unbounded chiral media has been extended to non-reciprocal chiral media, and also to the case of the derivation of complex Fresnel coefficients for uniform beam propagation across a nonchiral-chiral interface.[3,4]

The dual transform technique consists of using a transverse spatial Fourier transform on a set of paraxial wave equations in order to develop the field spectra in the transverse domain. Thereafter, an additional Laplace transform is carried out to obtain a set of algebraic field solutions in the (s,z) transform plane. A first inverse transform of the algebraic field solutions yields transverse field spectra under strictly paraxial conditions. Using the spectra of the incident profiled planar fields as boundary conditions this paper, we first outline some of the results obtained using the dual transform technique for arbitrary boundary conditions, a second inverse Fourier transform finally yields the spatial electric field solutions inside the chiral medium.

Calculations involving the use of the above approach to a profiled beam assumed to pre-exist at the input end *within the chiral medium itself* indicate the emergence of beam radii of curvature and spot sizes that are dependent on the chiral and reciprocal parameters.[4] Linear incident polarizations are shown to morph into circular polarizations, as is expected; additionally, an (X,Z) incident field propagates with all three components, with the longitudinal component being a modification of the non-fundamental Gaussian wave solution in an unbounded, linear, nonchiral medium.[5] In this paper, we use complex Fresnel coefficients together with the dual-transform strategy to determine the propagation behavior of uniform and profiled optical beams (with initial lensing) through a finite non-reciprocal chiral slab. These calculations may have some direct impact on the understanding of devices such as chiral resonators and lenses, as well as a possible chiral Z-scan system.

References

1. M.Yokota, S.He, and T.Takenaka, “Scattering of a Hermite-Gaussian beam field by a chiral sphere,” J. Opt. Soc. Am. A **18,** 1681-1689 (2001).
2. M.R.Chatterjee and P.P.Banerjee, “Investigation of the transient and steady-state characteristics of reciprocal and nonreciprocal chiral media using a dual-transform technique,” Conference Program, OSA Annual Meeting 1996, Rochester, NY, p.100.
3. M.R.Chatterjee and S.Nema, "Examination of the transverse and axial intensity distributions of reciprocal and non-reciprocal chiral media using dual transforms," Conference Program, OSA Annual Meeting 2002, Orlando, FL, p.51.
4. M.R.Chatterjee and S.Nema, "Revisiting the Fresnel coefficients for uniform plane wave propagation across a non-chiral, reciprocal and chiral, non-reciprocal interface," to be presented at the SPIE Annual Meeting, San Diego, CA, August 2003.
5. H.A.Haus, *Waves and fields in optoelectronics* (Prentice-Hall, 1984), Chap.5.