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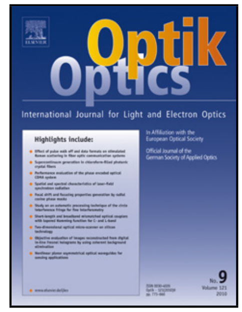


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# Characteristics of electromagnetic waves in slab waveguide structures comprising chiral nihility film and left-handed material claddings

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## Abstract

We analytically present the dispersion equation of an asymmetric three-layered chirowaveguides, in which the core and the claddings are different chiral materials. Then, we produce the dispersion equation for a symmetric three-layered chirowaveguides, in which the claddings chiral materials are the same, but different from the one in the core. After that, two modes of propagation through a chiral nihility core and left handed material (LHM) claddings waveguide are treated in details. The characteristic equations and the cut-off frequencies for both even and odd modes are derived. The electric field profiles are plotted and discussed. We show that each mode (odd and even) can be separated into right-handed and left-handed circularly polarized (RCP and LCP) modes. The results reveal that novel properties such as peculiar dispersion curves.

**Keywords**: slab waveguides, chiral materials, left-handed materials.

## 1. **Introduction**

Macroscopic parameters such as the index of refraction (n), permitivity (ε), and permeability (μ) are used to study the interaction of an electromagnetic wave with a material, where it is impossible to take each atom or electron into account. Most materials have positive permitivity and permeability and are called douple posittive materials [1]. On the other hand, Veselago, in 1968, investigated therotically double negative materials with simultaneausly negative permitivity and permeability [1]. The features of these materials made them reffered to as left-handed materials (LHMs) or also to as negative index materials (NIMs). Comparing with conventional dielectric materials, LHMs have some unique properties such as a negative refrative index, sub wavelength imaging, backward wave propagation, and reverse Doppler and Cherenkov effects [2-17]. However, these materials do not exist in nature normally. After thirty years, Pendry developed the concept of a perfect lens [18]. The concept to make LHMs is to treat permitivity and permeability separately. Pendry used thin wire structure (wire array) to produce negative permitivity and magnet-free split-ring resonator (SRR) structure to produce negative permeability [19,20]. The first experimentally LHM was released by Shelby et al. where negative refraction in the microwave region was confirmed [21]. In the visible region, recent publications showed that obtaining negative values of real parts of the permitivity and permeability becomes available, but achieving a negative index of refraction becomes quite difficult because of high values of imaginary parts of permittivity [22]. Since then, much attention