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A new approach to hyperbolic metamaterials

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A new approach to hyperbolic metamaterials

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The theoretical aspects concerning the propagation of homogeneous, inhomogeneous and leaky electromagnetic waves in uniaxial, dielectric waveguides have been of interest for some considerable time.[1,2] The current metamaterial world, however, is still only partially served by investigations that set out to incorporate some form of general asymmetry into the behavior of hyperbolic metamaterials[3,4]. Stimulated by this situation, a dramatic change will be presented here by formulating a completely general approach to the constructive, and often unusual, positions that the optic axis position can adopt in such vital media. In the context of this work, it is acknowledged that an inspiration towards the dramatic development of the new pathways exposed here was reported some years ago[5].

In order to sustain an investigation of how the orientation of the optic axis of a hyperbolic metamaterial affects guided waves, a thin film device will be examined and the optic axis will be permitted to adopt a wide range of interesting, and practical positions. The role of loss will also be estimated but this type of metamaterial is non-resonant, so loss will often not be competitive with the criticality of the optic axis orientation.

Clearly, the full control of light propagating in complex waveguides is an immensely important global topic so nonlinearity is a critically important tool for device creation. Indeed, in a nonlinear context, the use of metamaterials is seminal to the development of new devices. An initial nonlinear model will be developed and it will be shown that changes to the boundary conditions, due to the presence of effective media, permit even modest amounts of power to initiate elegant control of the effective group velocity. These outcomes will be strongly coupled to the optic axis-control in a manner that substantially modifies the dramatic linear investigations presented earlier on.

It will be emphasized that full control of solitonic metamaterial waveguides will need to be established through external influences, like a magnetic field, under the general heading of magnetophotonics. An outline of such a general optic-axis driven theory will be given. Finally, some pointers towards vortex formation in this new optic-axis driven environment will be critically commented upon because enhancing the addition of angular momentum to special light beams in this novel manner will also point to new, and important, devices, in the medical world for example..

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