Seminar

Institute for Plasma Research

Title : Studies on Dispersion Characteristics of Electromagnetic Waves in Magnetized One Dimensional Ferrite Photonic Crystals

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Abstract :

Photonic crystals (PhCs) are periodically structured electromagnetic (EM) media which exhibit a forbidden frequency region, which is known as photonic band gaps (PBGs). The PBGs are a range of frequencies for which propagation of EM waves through PhCs is strictly prohibited. In these structures, there is periodic modulation of
refractive index on the length scale of operation. The appearance of this PBGs leads to provide a way to control and manipulate photons in engineered EM environment for different novel applications. The field of PhCs research gain momentum after the historical paper by E. Yablonovitch and S. John in 1987. Thereafter lots of scientific efforts were dedicated to carry research pertaining to the field of photonics research.

Depending on the geometry of the structure, PhCs can be categorised into one, two and three dimensional PhCs. The periodicity of the crystal plays a very important role in the formation of useful PBGs. The actual width of PBGs depends on the geometry, feature size, spacing and the materials which make up the crystal. However, to employ the high-technology potential of PhCs, it is crucially important to achieve a dynamical tunability of their properties. In the natural PhCs, wavelengths in the PBGs are dynamically controllable. For example, structural colour in peacock feather or chameleons colour are often dynamic, as PBGs properties can be adjusted by external
physical or chemical stimuli through manipulation of refractive index contrast and lattice constant in PhCs structures. Chameleons shift their colour through active tuning of a lattice by applied stress on their skin and shows variable structural colours. Inspired by tunability of PBGs in natural PhCs, researchers across the globe have used different method to make PBGs tunable viz. using electric field, acoustic waves, change in temperature, etc.

The external magnetic fields can be used to change the permittivity and permeability of constituent materials in the unit cell of the PhCs. The magneto-optical photonic or magnetic PhCs are the extension of PhCs where one of the constituent in the unit is magnetic material. Here use of external magnetic field make permeability anisotropic and is used to tune the PBGs externally. Recently, PhCs containing ferrite materials, namely ferrites photonic crystals (FPhCs) have attracted the attention of researcher across the globe due to its novel magneto-optical properties such as cavity enhanced Faraday rotation, non-reciprocal super-prisms, ultra compact isolator, highly-directive miniature antenna arrays, non-reciprocal propagation, electromagnetic unidirectionality, integrated devices, etc. The EM responses of these composite periodic structures are externally controllable and the dispersion properties of EM waves show external field dependence. These FPhCs have periodic arrangement of magnetic layers (ferrite materials) and other media such as dielectrics, semiconductor and metal layers of various geometries. The ferrite is a dispersive material in which the permeability changes with incident wavelength. Also, the permeability is magnetic field dependent. So, we can tune the permeability of ferrite using external magnetic field and by altering the frequency of incident wave. Therefore, FPhCs properties are externally controllable using external magnetic field. In our thesis, we have used ferrite-ferrite materials in the unit cell and investigated the dispersion characteristics of EM waves in the magnetized one dimensional FPhCs.

The main objectives of my research is dynamic tunability and external controllability of EM wave propagation in periodically structured EM media using external magnetic fields. In this thesis, we have modelled and studied the dispersion and phase index properties of EM waves in magnetized one dimensional FPhCs using transfer matrix method. Parametric studies on dispersion behaviour of EM waves are carried out for transverse electric (TE) and transverse magnetic (TM) modes when external magnetic fields are perpendicular and along the propagation direction of EM waves.