Investigations on Negative Refraction of Magnetic Meta Materials

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ABSTRACT

Manipulation of electromagnetic response of materials provides a powerful means of controlling the interaction between light and matter. Negative refraction is one of the signature effects of metamaterial Physics and its exciting demonstration became a frontier for material and electromagnetic research. The dramatic Physics exhibited by the metamaterial is underpinned by the resonant response of the metamolecules. A wide range of tunable terahertz (THz) resonance frequency provides a technological breakthrough in metamaterials. Most metamaterial so far designed have been based on complicated resonant elements such as split rings and hyperbolic metamaterials. Unfortunately, magnetic response of most of the materials tails off at higher frequencies. Higher frequency excitation in metamaterials requires more complicated designs or toroidal moment. Interestingly the toroidal excitations are naturally maintained in some magnetic quasi structures such as magnetic vortices and make it suitable for THz resonances. Magnetism and left-handed behavior are two extreme phenomena that do not seem to be compatible and the coexistence of both cooperative effects was not foreseen. Terahertz spintronics is an emerging field that bridges the boundary between magnetism and photonics, which make the magnetic material suitable for photonic applications. The work presented in thesis aims at the design and the study of negative permeability property in naturally occurring magnetic materials. Here, we present a theory on the high frequency negative permeability resulting from THz spin wave resonances in two dimensional arrays of magnetic swirling structures and in artificial spin ices. Numerical and analytical approaches are used to demonstrate THz negative refraction and the mechanisms that allow such structures to produce the excitation of electromagnetic resonances.