A Chiral Route to Negative Refraction

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Veselago gave the original description for negative refraction [1]: when the electrical permittivity and magnetic permeability are both negative light bends the 'wrong way' at an interface. These properties are never simultaneously realised in nature so that it was only much later with the ability to construct artificial metamaterials that his vision could be realised [2-4]. Although Veselago referred to these materials as 'left handed' we stress that the sense in which Veselago used this term has nothing to do with chirality. We prefer to use the expression 'negatively refracting' to avoid confusion. Negative refraction never occurs in nature, and we rely on artificial materials, metamaterials, to realise the effect. Here we discuss the consequences of chirality and show that it offers an alternative route to negative refraction. We produce a practical design which is chiral, has many advantages, and exhibits novel properties.

If we describe the response of a chiral material as follows,

$$D = \mathcal{X}_{EE}E + \mathcal{X}_{EH}H$$

$$B = \mathcal{X}_{HE}E + \mathcal{X}_{HH}H$$

then,

$$k_{-\pm} = \pm\sqrt{\mathcal{X}_{EE}\mathcal{X}_{HH}} - i_{\mathcal{X}_{EH}},$$

where $\mathcal{X}_{EH}$ is assumed to be imaginary. If the material also has a resonant response then a typical dispersion is shown in figure 1. It is evident that if $\omega_0'' > \omega > \omega_0'$ one of the polarisations (dashed line) shows the negative dispersion characteristic of negative refraction. Further details can be found in [5].

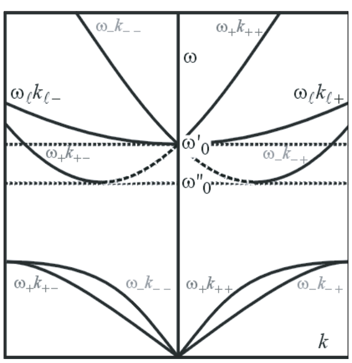

Figure 1 Dispersion of frequency, ω, versus wave vector, k, in an homogeneous and isotropic chiral medium showing the two polarisations as non degenerate. The subscripts on k refer first to the polarisation and second to the sign of the group velocity. In our convention, polarisation is positive if the projection of the photon spin on the z-axis is positive. It does not refer to the projection of spin onto the wave vector. Introducing the resonant dipoles into a chiral medium splits the resonant transverse bands and results in a range of frequencies below ω_0' in which negative refraction can be seen for one of the polarisations.

REFERENCES

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