# Mode Conversion and Resonant Absorption of Electromagnetic Waves in Inhomogeneous Chiral Media

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***Abstract*—The mode conversion and the resonant absorption of electromagnetic waves occurring in inhomogeneous chiral media are studied theoretically. The resonant absorption is found to occur when the inhomogeneous medium contains a region where the effective refractive index vanishes.**

## I. Introduction

A detailed understanding of the propagation and the coupling of electromagnetic waves in complex metamaterials is crucial in the development of novel photonic devices. Electromagnetic waves incident on a metamaterial made of metal or semiconductor can generate several different kinds of plasma waves in the free electron plasma inside the metamaterial. We are mainly interested in the excitation of volume plasma waves in spatially inhomogeneous metamaterials, where some parameter corresponding to the effective refractive index vanishes in a narrow resonance region, and the mode conversion and resonant absorption phenomena associated with it [1]. It is possible to excite plasma waves in the resonance region, where the energy of transverse electromagnetic waves is converted into that of longitudinal electromagnetic waves. In the presence of a small dissipation in the resonance region, this leads to a resonant absorption of wave energy.

## II. Method

We study the resonant absorption phenomena in one-dimensionally inhomogeneous chiral media theoretically, using the invariant imbedding method [2]. Starting from the Maxwell's equations, we derive the wave equations in stratified chiral media. These equations are transformed into a set of ordinary differential equations called the invariant imbedding equations, using which we calculate the reflectance $R$, the transmittance $T$, and the fraction of the absorbed energy, as well as the electromagnetic field distribution inside the media in a numerically precise manner [3]. The calculations are performed for various kinds of configurations, where the dielectric permittivity $\epsilon$, the magnetic permeability $\mu$ and the chirality index $\gamma$ depend on one spatial coordinate $z$.

## III. Results

In uniform isotropic chiral media, circularly polarized waves are eigenmodes. The effective refractive indices for right-hand and left-hand circularly polarized waves are $\sqrt{\epsilon\mu}+\gamma$ and $\sqrt{\epsilon\mu}-\gamma$ respectively. It turns out that mode conversion occurs when the effective refractive index is zero in this case. In Fig. 1, we plot the absorptance versus incident angle when linearly polarized waves are incident on a nonuniform chiral medium, where both $\epsilon$ and $\mu$ change from 1 to -1 in a linear manner in a slab of thickness $2.5\lambda$, where $\lambda$ is the vacuum wavelength. The imaginary parts of $\epsilon$ and $\mu$ are chosen to be $10^{-8}$. We find that the maximum value of the absorptance is about 70% when $\gamma = 0.9$ and the absorption occurs for a broad range of the incident angle. When $\gamma = 1.1$, there is no region where the effective refractive index vanishes, therefore there is no absorption.

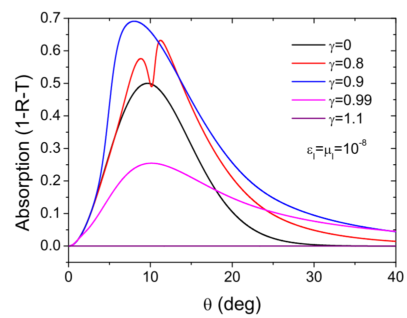


Fig. 1. Absorptance plotted versus incident angle for an inhomogeneous chiral medium.

## IV. Conclusion

In conclusion, we have studied the resonant absorption and mode conversion phenomena due to the excitation of longitudinal plasma waves in nonuniform chiral media. The results obtained here can be useful in designing efficient absorbers and novel nonlinear photonic devices.

## References

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