Far-Field Natural Optical Activity of Disordered Media

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Abstract: We demonstrate natural optical activity in disordered ensembles of non-chiral plasmonic resonators and show that the statistical distributions of the rotatory power and spatial dichroism are strongly dependent on the scattering mean free path in diffusive random media.

The concept of chirality, introduced by Lord Kelvin in order to describe geometrical objects that cannot superimposed with their mirror image, is ubiquitous in the natural world. Despite substantial efforts to understand the optical properties of naturally occurring chiral media and to design artificial ones, disordered media remain an overlooked class of chiral systems. Since disordered systems lack centre and plane of mirror symmetry, they should exhibit natural optical activity. However, previous experimental evidence of natural optical activity in random media has never been attributed to the intrinsic chirality of a random system [1-3], but rather to alternative explanations, such as surface contamination by unwanted chiral substances [1,2].

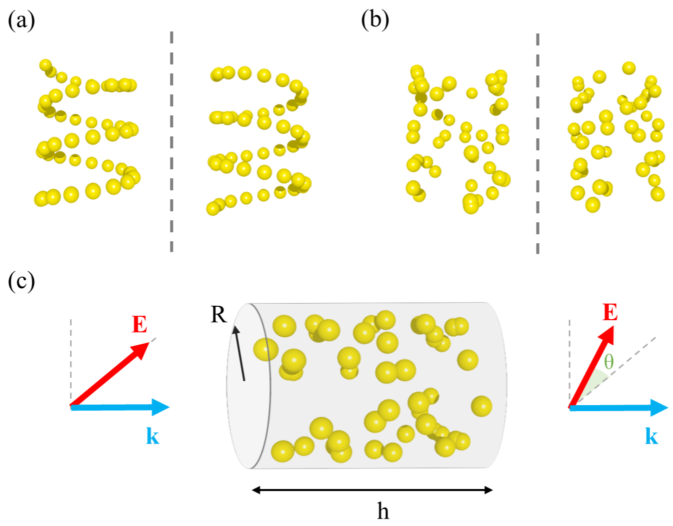

Fig. 1 Examples of chiral ensembles of dipole scatterers: plasmonic nanoparticles arranged in a helix (a) and in a random configuration (b). Similarly to a helix, a random arrangement of nanoparticles cannot be superimposed with its mirror image. (c) Schematic representation of optical rotation in a disordered medium.

Here, we demonstrate natural optical activity due to intrinsic geometric chirality in disordered, diffusive scattering systems, consisting of plasmonic resonators. We employ a microscopic electromagnetic wave transport theory [4] and derive an expression for the rotatory power and the spatial dichroism of a medium consisting of randomly distributed pointlike scatterers (see Fig. 1). By means of a systematic statistical analysis of natural optical activity in random media, we argue that the standard deviation of both rotatory power and spatial dichroism are strongly dependent on the density of scatterers and the scattering mean free path. We independently confirm our results by full-wave finite element simulations and show that disordered ensembles of plasmonic nanoparticles can exhibit dichroism more than an order of magnitude higher than in helical configurations with the same particle density.

References

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