Linear and Nonlinear circular dichroism in metal-dielectric nanostructures

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Symmetry is a central component of physical world and many conservation laws in physics are the result of symmetry properties. An example is momentum conservation that is a property of translational invariance. There are systems in which symmetry properties are reduced to a minimum. An example of this are chiral systems which have a property of asymmetry .

Chirality has become a very much studied property due to its potential applications in different areas, as analytical chemistry, crystallography, molecular biology, and new chiral materials may find application for example in polarization control devices. Systems that cannot be superimposed to their mirror image are said to be chiral, the word chirality deriving from the Greek, χειϱ, which means hand, that is the most familiar chiral object (the term was first used by Lord Kelvin). A chiral object and its mirror image are called enantiomorphs or, when referring to molecules, enantiomers.

From the optical point of view, chiral structures possess the ability to rotate the plane of polarization of electromagnetic waves (optical activity), and give rise to dichroism (again from the Greek διϰϱως, two-colored) that is the property to split a beam of light into two beams with different wavelengths. A dichroic material is either one which causes visible light to be split up into distinct beams of different wavelengths (dichroic mirrors) or one in which light rays having different polarizations are absorbed by different amounts. When the polarization states in question are right and left-handed circular polarization, one refers to circular dichroism [1, 2].

Optical activity effects arise from different interactions of chiral molecules with left and right-hand circular polarized light. Conventional optical activity effects, such as circular dichroism and polarization rotation, arise from molecular chirality and occur in isotropic bulk liquids (e.g. sugar solutions) and molecular crystals. Circular dichroism may be obtained also by using metamaterials. For example, it is possible to obtain a chiral behavior by engineering the elementary cell of a periodic structure with a chiral arrangement of non-chiral objects (intrinsic chirality or structural chirality).

Recent nanofabrication techniques have made it possible to prepare samples with so-called planar or two-dimensional chirality. Very strong optical activity has been demonstrated in a metamaterial system consisting of molecules that by itself are not chiral, but chirality is drawn extrinsically from the mutual orientation of the wave propagation direction and the two dimensional metamaterial. The effect can be seen when oriented non-chiral molecules make a chiral triad with the wavevector of light (extrinsic chirality). In what follow we describe some properties of chiral metasurfaces [3, 4].

REFERENCES

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