Intrinsic and extrinsic chirality in metamaterials

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It has been known since Louis Pasteur's pioneering work in 1848 that optical activity, i.e. the ability to rotate the polarization plane of light, can be observed in intrinsically 3D-chiral substances (e.g., consisting of helical molecules). Almost 160 years passed until it was discovered that also intrinsic 2D chirality (e.g., think of flat spirals) leads to a fundamental electromagnetic effect, the directionally asymmetric transmission of circularly polarized waves [1].

While chiral effects in natural materials are relatively weak, intrinsic 2D and 3D chirality in metamaterials lead to very large effects. In particular, optical activity, which is associated with different refractive indices for right-handed and left-handed circularly polarized waves, can become so large that it drives the refractive index negative for one circular polarization [2].

Even more intriguingly, we recently found that in metamaterials neither optical activity nor asymmetric transmission require materials with intrinsic chirality. This is possible in the presence of extrinsic 2D and 3D chirality associated with the entire experimental arrangement including the direction of incidence onto a non-chiral structured interface [3, 4].

We will give an overview over the concepts of intrinsic and extrinsic 2D and 3D chirality and the resulting electromagnetic phenomena illustrated by recent experimental results.

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