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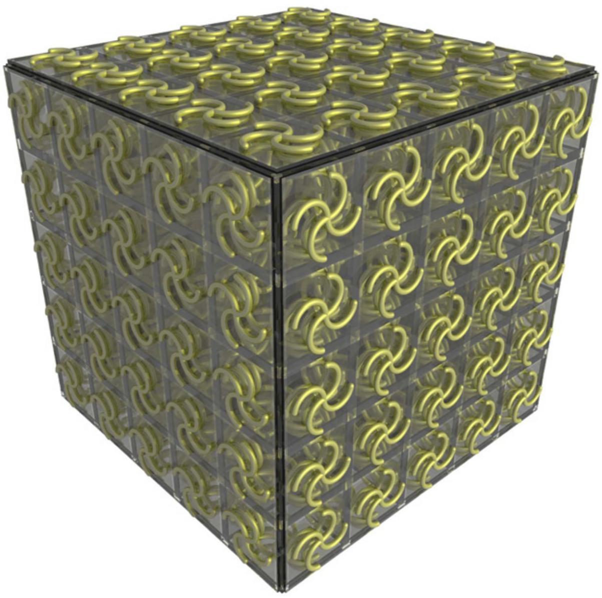
EDITORIAL

Artificial chiral materials

Martin Wegener
Karlsruhe Institute of Technology
Nikolay I Zheludev
University of Southampton
Guest Editors

In 1898 Acharya J C Bose, a researcher from Calcutta, India, wrote in the *Proceedings of the Royal Society of London*: 'In order to imitate the rotation by liquids like sugar solutions, I made elements of "molecules" of twisted jute, of two varieties, one kind being twisted to the right (positive) and the other twisted to the left (negative).... The twisted structure produces an optical twist of the plane of polarization'. This paper[1], published 111 years ago and reporting experimental microwave tests on the optical activity of the artificial chiral medium, was the first publication on what has now become a flourishing and dynamic field of metamaterials—man-made media with all sorts of unusual functionalities that can be achieved by artificial structuring smaller than the wavelength scale of the external stimulus.



Artistic impression of a 3D chiral metamaterial structure. (Courtesy of E Plum, University of Southampton.)

This special section is a reflection on the recent dramatic increase in interest in optical manifestations of chirality and chiral metamaterials that is driven by the opportunity to achieve negative refraction or other unusual properties in such media. The word chirality is derived from the Greek stem $\chi\epsilon\iota\rho \sim$ (hand-) and refers to objects that cannot be brought into congruence with their mirror image ('enantiomers') by mere rotations and translations in space—just like our two hands. Chirality is ubiquitous in nature; for some chiral molecules you can even smell their twist. In optical materials composed of chiral molecules, circularly polarized waves propagate differently through the left- and right-handed versions, respectively. This leads to optical activity and circular dichroism. In fact it is now

[1] Bose J 1898 *Proc. R. Soc. London* **63** 146

understood that chirality of the mutual orientation of the light beam and non-chiral molecules in a metamaterial is sufficient to create a 'twist direction' along which optical activity and circular dichroism could be seen.

A material exhibiting strong optical activity and circular dichroism may totally inhibit the propagation of one of the two circular polarizations in a certain frequency regime, leading to a polarization filter (or polarization stop band). Furthermore, the real parts of the two refractive indices can become so different that one of them, e.g. that for right-handed circular polarization, becomes negative. Polarization rotatory power exceeding that of natural media by several orders of magnitude is needed for negative refraction, which was recently demonstrated in chiral metamaterials in the microwave and terahertz parts of the electromagnetic spectrum. If the medium is simultaneously isotropic, negative reflection of light has been predicted by theory—a phenomenon which is even more mind-boggling than negative refraction of light.

An increasing number of researchers are currently designing, fabricating and studying artificial metamaterials composed of tailored chiral building blocks that may be viewed as 'artificial chiral molecules'. This special section is devoted to this vibrant and emerging research direction and has a special emphasis on the theory of light interactions with artificial chiral media.