UNIVERSITY OF EXETER | Centre for Metamaterial Research and Innovation

Nonreciprocal devices: optical isolators and circulators from theory to applications

PhD project at the Centre for Metamaterial Research and Innovation

Supervised by C. A. Downing, University of Exeter

Keywords: nonreciprocity, optical devices, metamaterials, quantum optics

Reciprocity in the animal kingdom gave rise to the evolution of reciprocal altruism: "you scratch my back, and I will scratch yours". Aside from mere grooming, the consequences of reciprocity for the sharing of food, medicine and knowledge are profound. However, the breakdown of reciprocity, perhaps fueled by a lack of affinity or obligation, can also lead to certain benefits for the non-reciprocator, who can profit from the nonreciprocal interaction.

Introducing the concept of nonreciprocity into metamaterials research also allows one to profit from nonreciprocal interactions, with immediate technological applications. Nonreciprocal devices, such as optical circulators and isolators, rely on the directional transfer of energy and information at the nanoscale. Furthermore, the realization of nonreciprocal waveguides will lead to extraordinary propagation lengths, being immune to backscattering.

In this project, we will construct theoretical models inducing nonreciprocity in metamaterials, for example those built from nanoscopic lattices of meta-atoms. We will consider how topology, dissipation and various symmetries can be employed to create a new class of nonreciprocal metamaterials with extraordinary transport and directional properties. Our work will be done in close collaboration with the leading experimentalists at the CMRI, where the novel phenomena that we discover can be simulated by, for example, acoustic waves or microwaves. The results of this project should guarantee future applications in wave physics, metamaterials and nanotechnology, particularly via the exploitation of the unidirectional flow of excitations.

Please contact me at C.A.Downing@exeter.ac.uk for further details of the project.

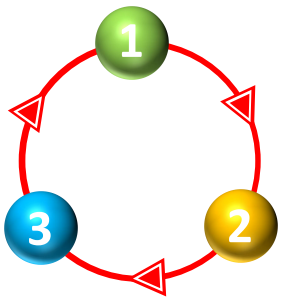

Figure 1: A sketch of an optical circulator composed of three meta-atoms.