# Optical Spin Waves

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**Abstract:** The precession of the magnetic moments in magnetic materials, forming spin waves, has many applications in magnetism and spintronics. We show that an optical analog of spin waves (OSW) can be generated in arrays of plasmonic nanohelices.

The concept of chirality is ubiquitous, impacting fields from biology and medicine to physics and materials science [1,2]. In optics, chiral effects is usually linked to helical waves carrying angular momentum. Recent research has explored the concept of photonic skyrmions by analogy to skyrmions in magnetic material [3,4]. Similarly, we investigate the possibility of generating a photonic counterpart to the spin waves propagating in ferromagnets.

Utilizing gold-coated carbon helices, we demonstrate that near-field coupling between adjacent homochiral helices results in optical waves with intrinsic angular momentum tied to the nanostructures' handedness. These waves propagate independently of the helix direction and are reflected at interfaces between enantiomeric nanohelices, forming heterochiral arrays (see Figure 1). Such a property mirrors the reflection of spin waves between two magnetic materials of opposite magnetization (i.e., of oppostite precession handedness). We fabricated chains of helical nanoantennas and observed energy transport indicative of optical spin waves. The ability of these waves to be guided and reflected within the nanoantenna arrays highlights their potential for integrated photonic applications. The experimental results confirm our theoretical predictions [5].

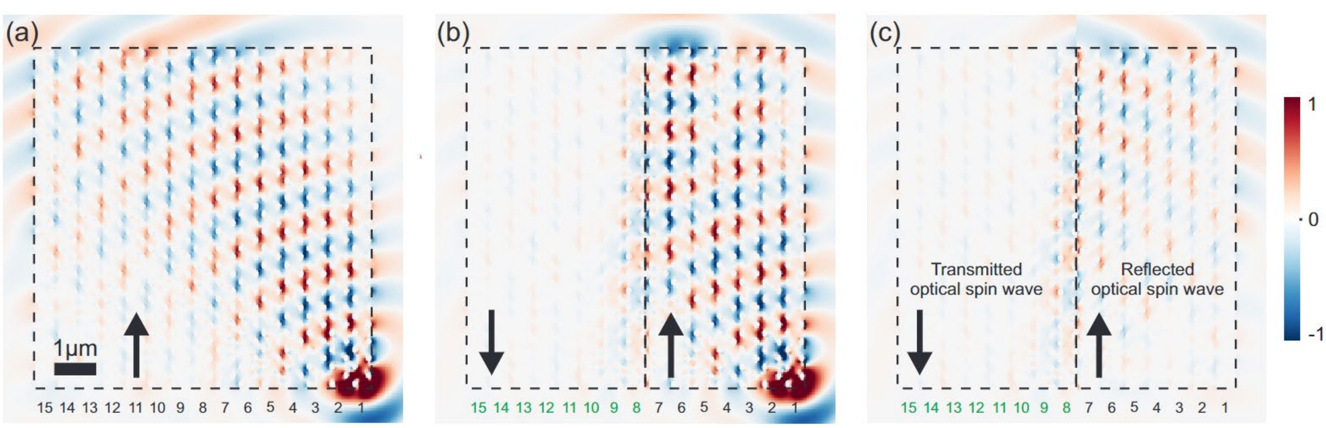


**Figure 1**: Reflection of a spin-wave at the interface between two homochiral helix chains of opposite handedness. (**a**) Real part of the x-component of the electric field in a homochiral array of fifteen 19-pitch helices. The array is excited with a y-polarized dipole source positioned at the bottom end of the rightmost helix

(λ = 1.55μm). (**b**) The handedness of 8-15 helices is inverted, leading to 2 helix arrays of opposite handedness. In (**a**) and (**b**), the homochiral helix arrays are delimited with dashed lines. The helix handedness in each domain is represented with an arrow. (**c**) Transmitted and reflected optical spin waves on either side of the interface.

The ability of OSW to be guided in a chain of subwavelength chiral structures and to be reflected at the interface between enantiomeric elements holds promise for angular momentum transfer and manipulation in compact integrated platforms. Spin-optical functionalities may arise from the combination of diverse operations on OSW including waveguiding, focusing, interference, steering and modulation, within metamaterials and metasurfaces possibly merging positive and negative refractive indices.

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