OPTICAL SPIN WAVES

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RÉSUMÉ

The precession of magnetic moments in magnetic materials, forming spin waves, has many applications in magnetism and spintronics. We show that an optical analogue of spin waves can be generated in arrays of plasmonic nanohelices.

MOTS-CLEFS : *Plasmonic helical nanoantennas; Spin waves; Chirality; Optical angular momentum*

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 [5, 6].

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. Such a property mirrors the reflection of spin waves between two magnetic materials of opposite magnetization (i.e., of opposite precession handedness) [7, 8]. We fabricated chains of helical nanoantennas (see Fig. 1) and observed energy transport indicative of optical spin waves. The ability of optical spin waves to be guided and reflected within the nanoantenna arrays highlights their potential for integrated photonic applications. Experimental results confirm our theoretical predictions [9].

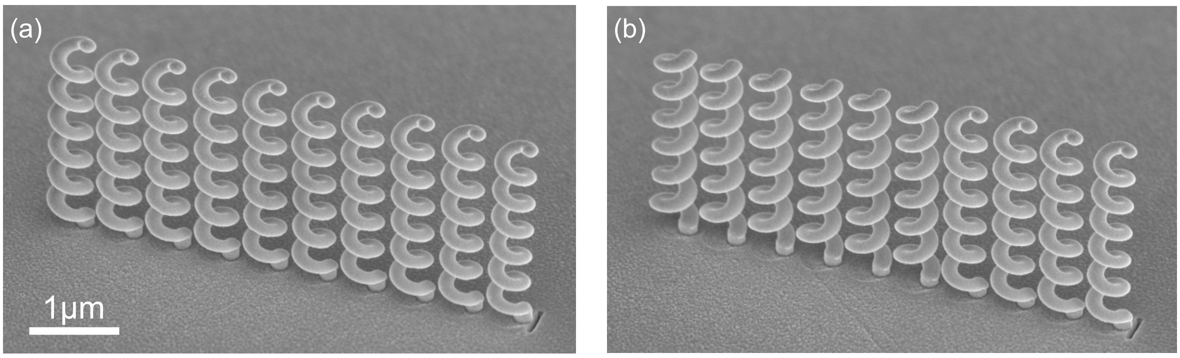

FIGURE 1 : Scanning electron microscopy images (oblique view) of helix arrays sustaining optical spin waves. Each sample consists of ten 6-turn gold-coated carbon helices fabricated on a 100-nm thick gold layer deposited atop a 1-mm-thick glass substrate. The helices are spaced 50 nm apart. The structures are locally excited with a rectangle nanoaperture engraved right at the pedestal of the rightmost helix. Upon back illumination from the substrate, the nanoaperture non-radiatively couples light to the helix chain as a dipole oriented parallel to the chain [10]. (a) Homochiral chain of left-handed helices. (b) Heterochiral chains constituted of two domains of enantiomeric helices : the first domain in contact to the rectangle nano-aperture consists of four left-handed helices

The ability of optical spin waves 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 optical spin waves including waveguiding, focusing, interference, steering and modulation, within metamaterials and metasurfaces possibly merging positive and negative refractive indices.

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