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A Chiral Inverse Faraday Effect Mediated by an Inverse-designed Plasmonic Antenna

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The inverse Faraday effect (IFE) allows the generation of stationary magnetic fields through optical excitation only [1,2]. This light–matter interaction in metals results from the creation of drift currents via nonlinear forces that light applies to the conduction electrons [1]. The IFE was believed, until now, to be a symmetrical phenomenon, meaning that a right-handed circularly polarized wave will create a magnetic field oriented toward light propagation. In contrast, excitation by a left-handed circularly polarized wave will generate a magnetic field opposite this propagation. Here we demonstrate, via the manipulation of light in the near field of a plasmonic nanostructure, the generation of a chiral IFE. Specifically, using an inverse design algorithm based on evolutionary optimization, we generate a chiral plasmonic nanostructure creating a stationary magnetic field by IFE for one specific light helicity. This chiral behavior is due to the generation of a non-zero spin density for the chosen helicity only. Furthermore, we demonstrate that using the enantiomer opposite to the optimized structure generates a magnetic field for an opposite helicity of light. Moreover, at the optical powers considered here, the amplitude of the magnetic field generated is 500 mT. The results presented here are remarkable since the plasmonic approach is today the only one allowing the generation of stationary magnetic fields at the nanometer scale and at extremely short time scales [3]. Therefore, using chiral plasmonic nanostructures to generate a chiral IFE opens the door to producing a stationary magnetic field by non-polarized light. The outcomes of these results are multiple, in particular the manipulation of magnetic processes at ultrashort timescales, such as spin precession, spin currents, and skyrmions become possible. This would find applications, for instance, in data storage at an ultrahigh rate.

References

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