Tiny nano-electromagnets turn a cloak of invisibility into a possibility

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A team of researchers at the FOM institute AMOLF (The Netherlands) has succeeded for the first time in powering an energy transfer between nano-electromagnets with the magnetic field of light.

This breakthrough is of major importance in the quest for magnetic 'meta-materials' with which light rays can be deflected in every possible direction. This could make it possible to produce perfect lenses and, in the fullness of time, even 'invisibility cloaks'.

The AMOLF researchers - Ivana Sersic, Martin Frimmer, Ewold Verhagen and Vidi laureate and group leader Femius Koenderink - published their results in the authoritative journal Physical Review Letters.

The artificial 'meta-materials' studied by the researchers consist of very small U-shaped metal 'nano-rings'. The electromagnetic field of light drives charges back and forth, thereby inducing an alternating current in each U shape. The tiny opening at the top of the ring makes sure that the current zooms around at the frequencies of light. In this way, each ring becomes a small but strong electromagnet, with its north and south poles alternating 500 billion times per second.

The researchers made an important discovery by measuring how much light passes through a thick grid of these electromagnets. It appears that when the tiny currents of the rings are actuated by light the nano-magnets also influence each other and can power each other.

The researchers have also shown for the first time that the interaction with the magnetic field of light is very strong in these materials; just as strong as the interaction with the electrical field in the best 'classical' optical materials. This improved understanding of the nano-magnets and their interaction with light gives the researchers all the ingredients they need to disperse light along arbitrary paths.

We are all familiar with rod-shaped magnets: they are described as 'dipolar', with a north pole and a south pole, and the tendency to attract each other’s opposite poles and repel similar poles. We also know that, just like a compass, magnets align themselves along a magnetic field. This is how you can manipulate magnets with magnetic fields, and - vice versa - you can exercise control over magnetic fields using magnets. This commonplace intuition works particularly well for slowly changing magnetic fields, but not for those in a state of rapid flux.

Light is an electromagnetic wave consisting of a very rapidly fluctuating electrical field and an associated magnetic field. In principle, you can direct electromagnetic waves at will by manipulating both the electrical field and the magnetic field. But at the very high frequencies of light (500 THz - 500 billion vibrations per second), atoms scarcely respond to magnetic fields. This is why normal materials only control the electrical field of light and not the magnetic field, and is also why normal optical devices (lenses, mirrors and glass fibres) are handicapped in the way they work. But this type of control is actually possible with these artificial 'meta-materials'.

More information: Electric and magnetic dipole coupling in near-infrared split-ring metamaterial arrays, I. Sersic, M. Frimmer, E. Verhagen and A. F. Koenderink. From 20 November 2009 online, Physical Review Letters 103, 213902 (link.aps.org/doi/10.1103/PhysRevLett.103.213902)

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