Manipulating magnetic forces with light

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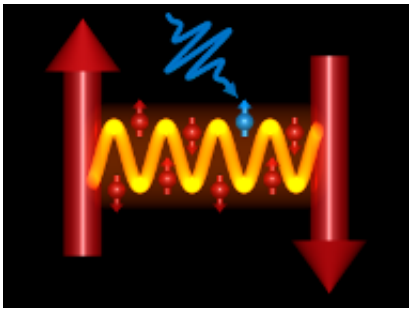

Artist impression of the manipulation of magnetic forces (yellow) with light. A laser pulse (blue) excites electrons which changes the interaction between the spins (big red arrows). Credit: Johan Mentink

The magnetic forces in magnetic materials like iron can be rapidly manipulated with light. Rubicon Researcher Johan Mentink, together with Martin Eckstein from the University of Hamburg CFEL/MPSD, has theoretically demonstrated this for the first time. Rapid and effective manipulation is of immense fundamental and technological value. For example, it could be used for the production of faster hard disks. An article about this has been published in *Physical Review Letters*.

The interaction between microscopically small 'spins' (magnetic moments) determines the strength of magnets and is dependent on the interactions between the electrons in magnetic materials. These electrons can be rapidly manipulated with an electric field such as one from laser light. But what subsequently happens with the magnetic forces? This forms a highly challenging problem because existing theoretical concepts

and formulas cannot account for such a rapid magnetism.

Metink and Eckstein have combined two state-of-the-art methods to calculate this ultrarapid magnetism. They found that the magnetic forces could be quickly and effectively manipulated with light. This forms an important link in physics research and also creates possibilities for the further experimental study of magnetic manipulation with light.

Weaker magnetism for stronger hard disks

Weakening the magnetism makes it easier to switch magnetic bits. That happens from north (0) to south (1), a mechanism used in hard disks, for example.

With the best current technology it takes about one nanosecond to switch magnetic bits. Mentink and Eckstein have demonstrated that magnetic forces can be weakened more than 10,000 times faster than the fastest switching time possible with current technology. This knowledge can be applied to an entirely new generation of magnetic devices that respond to electric fields, just as modern laser technology is used in medical equipment, for example.

Creating magnetism

The researchers initially worked with a relatively simple model for an insulating material and discovered a large effect for this. This result forms a starting point for further research to perform calculations for other materials and different types of lasers and to measure whether the magnetism can also be strengthened, for example. Mentink: 'Our dream is to make a non-magnetic material magnetic so as to add greater value to its use. It is still too early to make specific predictions but imagine, for example, that you could make silicon or graphene magnetic. That

would have an enormous impact on future technological developments.'

More information: "Ultrafast Quenching of the Exchange Interaction in a Mott Insulator." J. H. Mentink and M. Eckstein. *Phys. Rev. Lett.* 113, 057201 – Published 29 July 2014. journals.aps.org/prl/abstract/ … ysRevLett.113.057201

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