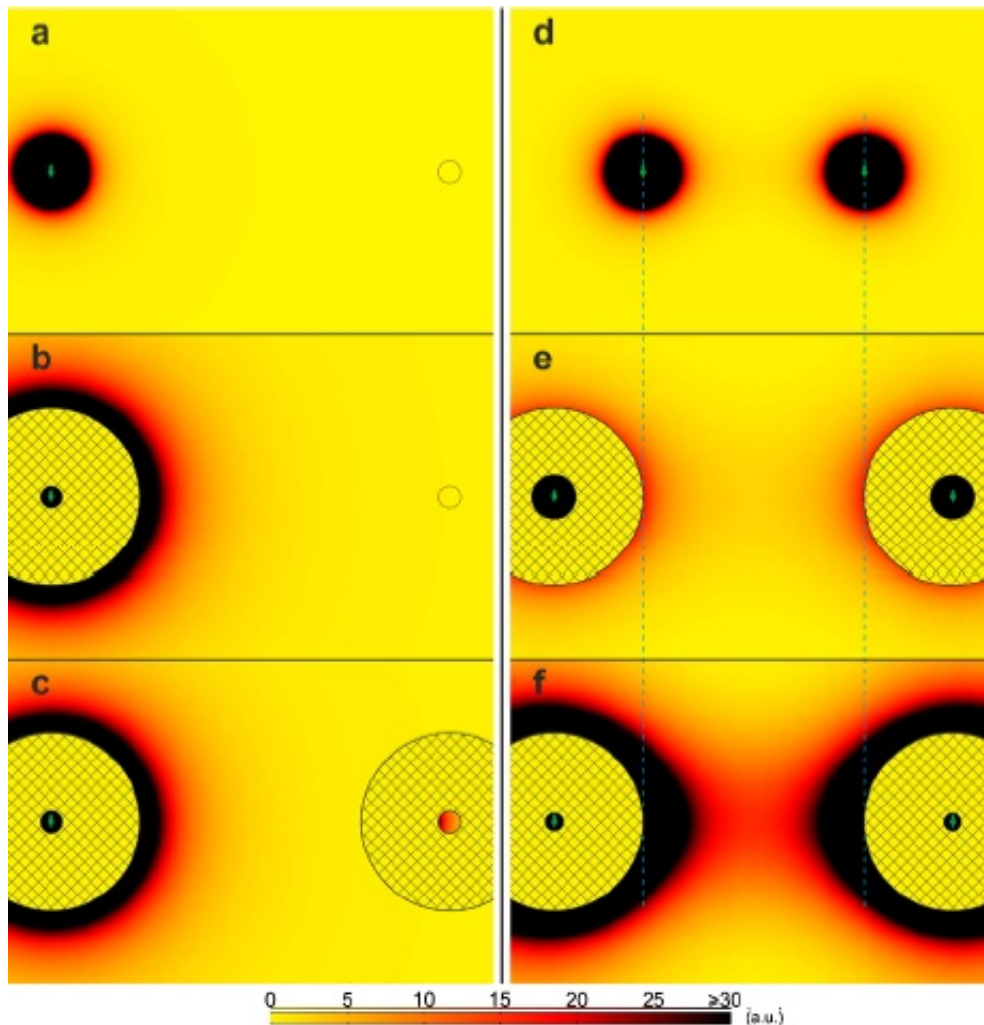


Magnetic shell provides unprecedented control of magnetic fields

January 4 2013, by Lisa Zyga



The newly designed magnetic shell can either expel or concentrate magnetic energy. In the left panels, a small dipole magnet in (a) is surrounded by a magnetic shell in (b), which expels its magnetic energy further outward. In (c), a second shell harvests the energy and concentrates it into its center hole; in this

way, magnetic energy is transferred through empty space. In the right panels, two dipole magnets in (d) are surrounded by shells in (e) that expel their magnetic energy. As shown in (f), the result is magnetic coupling between the two dipoles. Credit: Carles Navau, et al. ©2012 American Physical Society

(Phys.org)—A general property of magnetic fields is that they decay with the distance from their magnetic source. But in a new study, physicists have shown that surrounding a magnetic source with a magnetic shell can enhance the magnetic field as it moves away from the source, allowing magnetic energy to be transferred to a distant location through empty space. By reversing this technique, the scientists showed that the transferred magnetic energy can be captured by a second magnetic shell located some distance away from the first shell. The second shell can then concentrate the captured magnetic energy into a small interior region. The achievement represents an unprecedented ability to transport and concentrate magnetic energy, and could have applications in the wireless transmission of energy, medical techniques, and other areas.

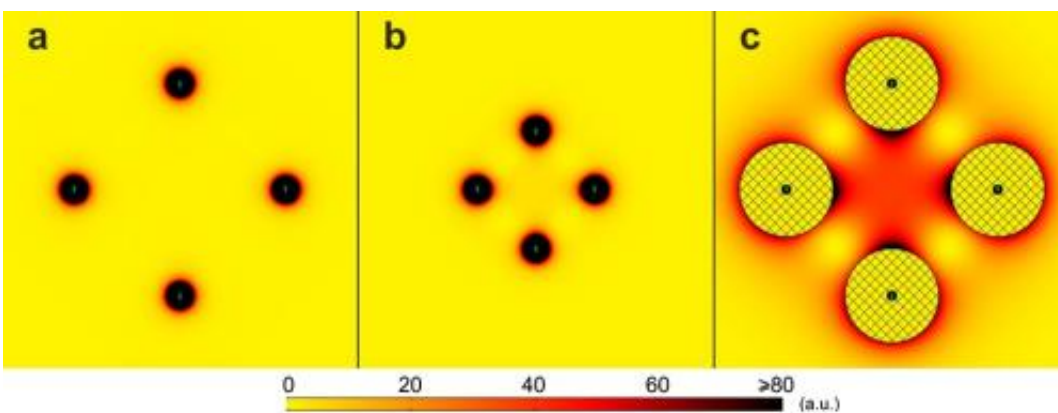
The physicists, Carles Navau, Jordi Prat-Camps, and Alvaro Sanchez at the Autonomous University of Barcelona in Spain, have published their results on their new method of magnetic [energy distribution](#) and concentration in a recent issue of [Physical Review Letters](#).

"We have tried with this work to open new ways of shaping magnetic fields in space," Sanchez told *Phys.org*. "Since magnetic fields are so crucial for so many technologies (e.g., almost 100% of the energy generated uses magnetic fields), finding these new possibilities may bring benefits."

The basis of the technique lies in transformation optics, a field that deals

with the control of [electromagnetic waves](#) and involves metamaterials and [invisibility cloaks](#). While researchers have usually focused on using transformation optics ideas to control light, here the researchers applied the same ideas to control magnetic fields by designing a magnetic shell with specific electromagnetic properties.

The shell can be used to control magnetic fields in two ways, depending on its location relative to a magnetic source. When a magnetic source is placed inside the shell, the shell expels the magnetic energy outside. When the shell is placed near a magnetic source located outside the shell, the shell harvests and concentrates the magnetic energy from the source into a hole in the shell's center.



Magnetic shells can be used to increase the magnetic energy of multiple magnets: The four magnetic dipoles in (a) interact very weakly, even when they are moved closer together in (b). However, when all four dipoles are surrounded by a shell as in (c), their exterior fields become enhanced, yielding a stronger magnetic field in the center region. Credit: Carles Navau, et al. ©2012 American Physical Society

In both cases, the shell works by dividing the space into an exterior and

interior zone and then transferring the magnetic energy completely into one domain or the other. This method differs from the way that superconductors and ferromagnets distribute magnetic energy, where the energy always returns to the domain where the magnetic sources are.

Although no material exists that can perfectly meet the requirements for the magnetic shell's properties, the physicists showed that they could closely approximate these properties by using wedges of alternating superconducting and ferromagnetic materials.

For practical purposes, this approximation is sufficient to work for a variety of potential applications, in which the magnetic shell's two functions (transferring and concentrating) can be used together or independently. For instance, by surrounding two magnetic dipoles with their own shells, the magnetic coupling between them can be enhanced, which could be used to improve the efficiency of wireless power transmission between a source and a receiver.

With its ability to concentrate nearby magnetic fields, a single magnetic shell could also be used to increase the sensitivity of magnetic sensors. The scientists demonstrated that a magnetic sensor placed inside the shell can detect a much larger magnetic flux from an external magnetic source than it would when using a typical concentration strategy involving superconductors. Magnetic sensors are often used in consumer electronics, factory automation, navigation, and many other areas.

The magnetic shell could also have medical applications, such as for biosensors that measure the brain's response in magnetoencephalography, a technique used for mapping brain activity. The [physicists](#) also showed that the shells can be used to surround multiple magnetic sources arranged in a circle, allowing them to concentrate magnetic energy in the center of the circle. This arrangement could be used in transcranial magnetic stimulation (TMS), a

technique used to treat psychiatric disorders. While TMS generally targets regions near the brain's surface, the magnetic shells could help extend the reach of magnetic fields to deeper targets.

Magnetic energy also plays a vital role in power applications, such as in power plants, magnetic memories, and motors. All of these applications require magnetic energy to be spatially distributed or concentrated in a certain way. By enabling the control of [magnetic energy](#) in new ways, the magnetic shells could improve these applications and others due to their many possible configurations.

"We are presently working on extending these ideas of applying transformation optics to the magnetic case into different directions, and see how future designs can be implemented in practice (in the present case, we suggested superconductors and ferromagnetic materials as a practical implementation of the magnetic shell)," Sanchez said.

More information: Carles Navau, et al. "Magnetic Energy Harvesting and Concentration at a Distance by Transformation Optics." *PRL* 109, 263903 (2012). [DOI: 10.1103/PhysRevLett.109.263903](https://doi.org/10.1103/PhysRevLett.109.263903)

Copyright 2013 Phys.org

All rights reserved. This material may not be published, broadcast, rewritten or redistributed in whole or part without the express written permission of Phys.org.

Citation: Magnetic shell provides unprecedented control of magnetic fields (2013, January 4) retrieved 10 April 2024 from <https://phys.org/news/2013-01-magnetic-shell-unprecedented-fields.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.
