Magnetic cloak: Physicists create device invisible to magnetic fields

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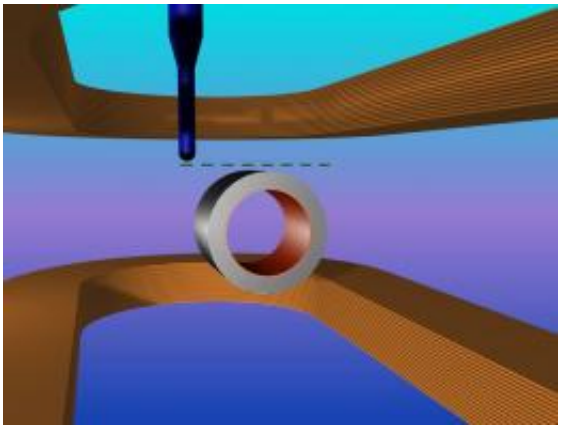


Sketch of the experimental setup. Image courtesy of J. Prat-Camps, C. Navau, A. Sanchez

Autonomous University of Barcelona researchers, in collaboration with an experimental group from the Academy of Sciences of Slovakia, have created a cylinder which hides contents and makes them invisible to magnetic fields. The device was built using superconductor and ferromagnetic materials available on the market. The invention is published this week in the journal *Science*.

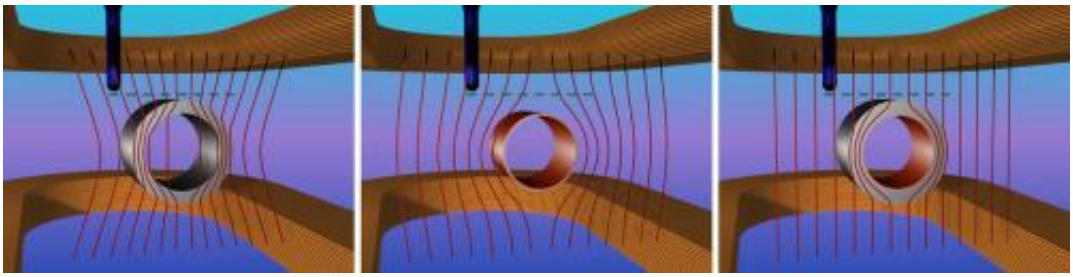
The cylinder is built using high temperature superconductor material, easily refrigerated with liquid nitrogen and covered in a layer of iron, nickel and chrome. This simple and accessible formula has been used to create a true invisibility cloak.

The cylinder is invisible to magnetic fields and represents a step towards the invisibility of light - an electromagnetic wave. Never before had a device been created with such simplicity or exactness in theoretical calculations, or even with such important results in the laboratory.

Researchers at UAB, led by Àlvar Sánchez, lecturer of the Department of Physics, came up with the mathematical formula to design the device. Using an extraordinarily simple equation scientists described a cylinder which in theory is absolutely undetectable to magnetic fields from the outside, and maintains everything in its interior completely isolated from these fields as well.

Equation in hand and with the aim of building the device, UAB researchers contacted the laboratory specialising in the precise measurement of magnetic fields at the Institute of Electrical Engineering of the Slovak Academy of Sciences in Bratislava. Only a few months later the experimental results were clear. The cylinder was completely invisible to magnetic fields, made invisible whatever content was found in its interior and fully isolated it from external fields.

The superconductor layer of the cylinder prevents the magnetic field from reaching the interior, but distorts the external field and thus makes it detectable. To avoid detection, the ferromagnetic outer layer made of iron, nickel and chrome, produce the opposite effect. It attracts the magnetic field lines and compensates the distortion created by the superconductor, but without allowing the field to reach the interior. The global effect is a completely non-existent magnetic field inside the cylinder and absolutely no distortions in the magnetic field outside.



The ferromagnet attracts magnetic field lines (left), the superconductor repels magnetic field lines (middle), and the superconductor-ferromagnetic bilayer cloaks a magnetic field (right). An object inside the cloak would be magnetically undetectable. Image courtesy of J. Prat-Camps, C. Navau, A. Sanchez

Magnetic fields are fundamental for the production of electric energy - 99% of energy consumed is generated thanks to the magnetic camps within the turbines found in power stations - and for the design of engines for all types of mechanic devices, for new advances made in computer and mobile phone memory devices, etc. For this reason controlling this field represents an important achievement in technological development. Scientists are perfectly familiar with the process of creating magnetism. However, the process of cancelling at will is a scientific and technological challenge, and the device created by UAB scientists opens the way for this possibility.

The results of this research project also pave the way for possible medical applications. In the future, similar devices designed by UAB researchers could serve to block a pacemaker or a cochlear implant in a patient needing to undergo a magnetic resonance.

More information: Experimental Realization of a Magnetic Cloak, Science 23 March 2012: Vol. 335 no. 6075 pp. 1466-1468. DOI: 10.1126/science.1218316

ABSTRACT

Invisibility to electromagnetic fields has become an exciting theoretical possibility. However, the experimental realization of electromagnetic cloaks has only been achieved starting from simplified approaches (for instance, based on ray approximation, canceling only some terms of the scattering fields, or hiding a bulge in a plane instead of an object in free space). Here, we demonstrate, directly from Maxwell equations, that a specially designed cylindrical superconductor-ferromagnetic bilayer can exactly cloak uniform static magnetic fields, and we experimentally confirmed this effect in an actual setup.

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