PHYSICS

High-Tech Materials Could Render Objects Invisible

No, this isn't the 1 April issue of *Science*, and yes, you read the headline correctly. Materials already being developed could funnel light and electromagnetic radiation around any object and render it invisible, theoretical physicists predict online in *Science* this week (www.sciencemag.org/cgi/content/abstract/1125907 and … 1126493). In the near future, such cloaking devices might shield sensitive equipment from disruptive radio waves or electric and magnetic fields. Cloaks that hide objects from prying eyes might not be much further off, researchers say.

No see? Forget the Invisible Man's transparency potion; new materials might ferry light around an object, making it invisible.

The papers are "visionary," says George Eleftheriades, an electrical engineer at the University of Toronto in Canada. "It's pioneering work that sets the stage for future research." Greg Gbur, a theoretical physicist at the University of North Carolina, Charlotte, notes that others have studied invisibility but says the new papers describe more precisely how to achieve it. "Each gives specific examples of how you might design an invisibility device," he says.

From spaceships that vanish in *Star Trek* movies to Harry Potter hiding beneath his imperceptible cloak, invisibility has been a mainstay of science fiction and fantasy. But it might become a reality thanks to emerging "metamaterials," assemblages of tiny rods, c-shaped metallic rings, etc., that respond to electromagnetic fields in new and highly controllable ways. John Pendry of Imperial College London and colleagues, and Ulf Leonhardt of the University of St. Andrews, U.K., independently calculated how the properties of a shell metamaterial must be tailored to usher light around an object inside it. An observer would see whatever is behind the object as if the thing weren't there, Leonhardt says.

The theorists exploit the fact that light is always in a hurry, taking the quickest route between two points. That's not always a straight line, because light travels at different speeds in different materials, and it opts for the path that minimizes the total time of transit. So when light passes from, say, air into glass, its path may bend, which is why ordinary lenses focus light.

Pendry and colleagues and Leonhardt calculated how the speed of light would have to vary from point to point within a spherical or cylindrical shell to make the light flow around the hole in the middle. Light must travel faster toward the inner surface of the shell. In fact, along the inner surface, light must travel infinitely fast. That doesn't violate Einstein's theory of relativity because within a material, light has two speeds: the one at which the ripples in a wave of a given frequency zip along, and the one at which energy and information flow. Only the second must remain slower than light in a vacuum, as it does in a metamaterial.

The invisibility isn't perfect: It works only in a narrow range of wavelengths.

The authors map out the necessary speed variations and leave it to others to design the materials that will produce them. But researchers already know how to design metamaterials to achieve such bizarre properties, at least for radio waves, says Nader Engheta, an electrical engineer at the University of Pennsylvania. "It's not necessarily easy, but the recipes are there," says Engheta, who last year proposed using a metamaterial coating to counteract an object's ability to redirect light, making combination nearly transparent.

Cloaking devices for radio waves could appear within 5 years, Gbur says, and cloaks for visible light are conceivable. Pendry notes that even a cloak for static fields would, for example, let technicians insert sensitive electronic equipment into a magnetic resonance imaging machine without disturbing the machine's precisely tuned magnetic field.

Alas, even if invisibility proves possible, it may not work the way it does in the movies. For example, a cloaking device would be useless for spying, Pendry says. "Nobody can see you in there, but of course you can't see them, either." Keeping track of your always-invisible device might be a pain, too.

–ADRIAN CHO

U.S. COURTS

'Disappointed' Butler Exhausts Appeals

Thomas Butler's legal journey has come to an end. On 15 May, the U.S. Supreme Court declined to take up the case of the physician and microbiologist who received a 2-year prison sentence for shipping plague samples to Tanzania without the required permits and for defrauding his employer, Texas Tech University in Lubbock (*Science*, 19 December 2003, p. 2054).

Butler declined to be interviewed, but his wife Elizabeth says her husband is "very disappointed." Butler is working in Lubbock at a job unrelated to his professional training, she says, and weighing offers to rebuild his career. "This has been a tremendous blow," she adds, "but we are healing little by little."

In January 2003, Butler reported vials containing the plague bacterium *Yersinia pestis* missing from his lab; after questioning by the FBI, he signed a statement, which he later withdrew, saying he had accidentally destroyed the samples. In his trial, the jury dismissed all but one of the government's charges relating to illegal shipping and handling of plague samples but found Butler guilty of fraud involving fees for clinical trials he had conducted at Texas Tech. Last fall, a three-judge panel on the U.S. Court of Appeals for the Fifth Circuit upheld his conviction (*Science*, 4 November 2005, p. 758); the full appeals court declined to review the case.

"I have never in my career seen someone who was handed such a gross injustice," says his attorney, George Washington University law professor Jonathan Turley. Turley says that the fraud charges, which the government added after Butler refused to accept a plea bargain, concerned a dispute between the researcher and his employer that would not otherwise have been prosecuted criminally.

Butler, 64, was transferred to a halfway house in November after having served 19 months of his sentence and came home in late December. His supporters, including chemistry Nobelist Peter Agre of Duke University in Durham, North Carolina, are hoping against hope for a presidential pardon, if not from George W. Bush then possibly from his successor.

–MARTIN ENSERINK