**A New Way to Hide Things.**

**Broadband Ground-Plane Cloak**
Authors: R. Liu, C. Ji, J. J. Mock, J. Y. Chin, T. J. Cui, and D. R. Smith.
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**Recommended with a Commentary by Stephen Berry, University of Chicago.**

Physicists have developed extremely clever ways to make materials with unusual optical properties. Specifically, materials that have inhomogeneous optical properties, dielectric constants and indices of refraction that vary from point to point, can bend light beams in all sorts of ways. By designing the spatial distribution of the variations in the dielectric properties, one can make those beams go wherever one wishes. The basic theory for this appeared in 2006[1]. Now experiments have demonstrated this phenomenon in a rather dramatic way; one can literally hide an object on a surface by covering them with a material that bends light beams away from the object and then back again as if the object were not there.

Specifically, Pendry, Shurig and Smith[1] showed how it would be possible to surround a sphere with a material that would bend parallel light rays around the sphere and return them to a parallel state so that, to someone looking at the incoming and outgoing beams, it would seem that there was nothing in the path of the light. Only the line of light precisely along the central diameter of the sphere would not be bent around it. There was one possible constraint, that the phenomenon might only be attainable over a relatively limited spectral band.

Then, in January of this year, Leonhardt and Tyc showed that using a curved, non-Euclidean space, specifically the effective electromagnetic space of the radiation, the cloaking as it is called can occur over a broad spectral band[2]. A perspective in the same issue discusses the article[3].

The culmination came with the experimental demonstration of cloaking of an object placed on a plane in the paper highlighted above. Liu, Ji, Mock, Chin, Cui and Smith, using radiation of 1316 GHz, were able to show that an appropriately covered object is invisible to a probe in that spectral range. A central part of the challenge was creating the metamaterial with the appropriate dielectric properties to bend the space of the radiation path. They determined the spatial distribution of the index of refraction that would accomplish this; outside the bending region, the index n was 1.331; in the

bending region, it varied between 1.08 and 1.67. The cloaking cover was surrounded by another layer to match the impedance and bring the radiation from and back into the surrounding air. The nonuniform cloaking medium was comprised of more than 10,000 cells, each 2mm x 2mm in exterior size, most of them with unique internal structure that gave the desired refractive index. The results of the construction and the probing by radiation showed that the bump on the plane was indeed invisible to that radiation. The result stimulated a News of the Week in Science shortly afterward[4]. There is indication that experimenters may probe the phenomenon in the near future with visible radiation.

Can we expect to encounter full-length garments soon after that, that we could only see if they were wrapped, and that would hide us so we could walk, unobserved, into movie houses and baseball games?

1. J. B. Pendry, D. Shurig and D. R. Smith, Science 312, 1780 (2006).
2. U. Leonhardt and R. Tyc, Science 323, 110-112 (2009).
3. A. Nicolet and F. Zolla, Science 323, 46-47 (2009).
4. A. Cho, Science 323, 701 (2009).