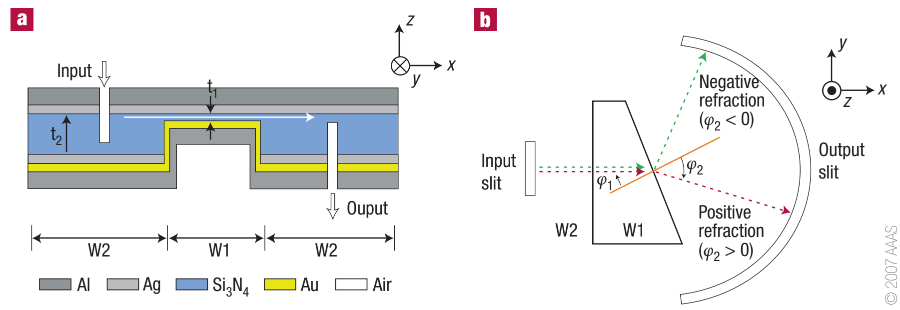

Figure 2 Plasmonic waveguide structure. Illustration of the plasmonic nanostructure used by Henri Lezec and co-workers for the demonstration of all-angle negative refraction in the visible region[1]. The W1 regions support backward waves for green light (forward waves for red light), the W2 regions support forward waves. **a**, Side view and **b**, Top view. Reprinted in part with permission from ref. 1.

optics the sign of the beam displacement in Fig. 1 is strictly identical to that of the refractive index n. The logical conclusion is that we should stop calling the refractive index n 'refractive index'. We should rather call it the 'slowness factor' according to its definition: The phase velocity of light c is slower by factor n inside the material than the vacuum speed of light c_0.

Backward waves may seem strange but they are certainly much less rare a species than it is tempting to believe at first sight. In the visible, damped backward waves occur in your bathroom mirror, reduced-loss backward waves in related metal–dielectric–metal waveguide structures[1–3], as well as in conceptually distinct photonic metamaterials[4,5]. As Lezec and colleagues demonstrate, such tailored metallic nanostructures provide us with many new opportunities for optics and photonics applications that natural optical substances just do not have. More surprises can be expected in future.

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MATERIAL WITNESS

Tendentious tilings

Quasicrystal enthusiasts may have been baffled by a rather cryptic spate of comments and clarifications following in the wake of a recent article claiming that medieval Islamic artists had the tools needed to construct quasicrystalline patterns. That suggestion was made by Peter Lu at Harvard University and Paul Steinhardt at Princeton (*Science* **315,** 1106–1110; 2007). But in a news article in the same issue, staff writer John Bohannon explained that these claims had already caused controversy, being allegedly anticipated in the work of crystallographer Emil Makovicky at the University of Copenhagen (*Science* **315,** 1066; 2007).

The central thesis of Lu and Steinhardt is that Islamic artists used a series of tile shapes, which they call *girih* tiles, to construct their complex patterns. They can be used to make patterns of interlocking pentagons and decagons with the 'forbidden' symmetries characteristic of quasicrystalline metal alloys, in which these apparent symmetries, evident in diffraction patterns, are permitted by a lack of true periodicity.

Although nearly all of the designs evident on Islamic buildings of this time are periodic, Lu and Steinhardt found that those on a fifteenth-century shrine in modern-day Iran can be mapped almost perfectly onto another tiling scheme, devised by mathematician Roger Penrose, which does generate true quasicrystals.

But in 1992 Makovicky made a very similar claim for a different Islamic tomb dating from 1197. Some accused Lu and Steinhardt of citing Makovicky's work in a way that did not make this clear. The authors, meanwhile, admitted that they were unconvinced by Makovicky's analysis and didn't want to get into an argument about it.

The dispute has ruffled feathers. *Science* subsequently published a 'clarification' that irons out barely perceptible wrinkles in Bohannon's article, while Lu and Steinhardt attempted to calm the waters with a letter in which they 'gladly acknowledge' earlier work (*Science* **316,** 982; 2007). It remains to be seen whether that will do the trick, for Makovicky wasn't the only one upset by their paper. Design consultant Jay Bonner in Santa Fe has also made previous links between Islamic patterns and quasicrystals (see http://www.bonner-design.com/publications/self-similar.htm).

Most provocatively, Bonner discusses the late-fifteenth-century Topkapi architectural scroll that furnishes the key evidence for Lu and Steinhardt's *girih* scheme. Bonner points out how this scroll reveals explicitly the "underlying polygonal sub-grid" used to construct the pattern it depicts. He proposes that the artists commonly used such a polygonal matrix, composed of tile-like elements, and demonstrates how these can create aperiodic space-filling designs.

Bonner does not mention quasicrystals, and his use of terms such as self-similarity and even symmetry do not always fit easily with that of physicists and mathematicians. But there's no doubting that his work deepens the "can of worms" that Bohannon says Lu and Steinhardt have opened.

All this suggests that the satellite conference of the forthcoming European Crystallographic Meeting in Marrakech this August, entitled "The enchanting crystallography of Moroccan ornaments", might be more stormy than enchanting — for it includes back-to-back talks by Makovicky and Bonner.

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