capable of breaking the diffraction limit using a dynamic form of phase conjugation. Phase conjugation — and consequent time-reversed propagation — occurs as an interaction between four mutually coherent beams mediated by the third-order optical nonlinearity of the medium. In essence, two coherent pump beams write a virtual phase hologram into the medium, and the third beam diffracts off this hologram, creating the fourth. This fourth beam is still coherent with the third one, and it happens to be its exact time-reversed replica. This wave-reconstruction process is cheap, sustainable, and supposedly extremely fast; the carbon atoms act here as the aforementioned field sensors, assembled by nature into a perfect gigantic array.

Pendry's proposal¹⁰ brings metals and semi-metals such as graphene back

into the perfect-imaging business, this time with a hope of achieving it in the far-field. All metals are good sources of optical nonlinearities¹¹, but the third-order susceptibility of graphene is two orders of magnitude higher¹². Combine this with its atomically smooth natural surface, and you will understand why graphene is the innate champion of optical phase-conjugation.

Separation between carbon atoms in graphene is only 1.4 Å. Potentially, this means that graphene-based imaging will happen — Harutyunyan *et al.* show negative refraction of a beam unambiguously, yet do not go as far as demonstrating super-resolved imaging. But the big leap forward has now been made. □

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QUANTUM ENTANGLEMENT

Now you see it

We cannot 'see' magnetic fields and yet nobody seems to find magnetism particularly mysterious. That is because we can see its effects, we have all played with fridge magnets and iron filings. It is true that we trust what we can see more. So what about more elusive phenomena, such as quantum entanglement? Would it be less spooky if you could actually see it with your own eyes?

Well, now you can. In the entanglement equivalent of an 'iron filings' demonstration, Robert Fickler and colleagues have used state-of-the-art cameras to image — in real time — the effect of measurement on a pair of entangled photons (*Sci. Rep.* **3**, 1914; 2013).

Movie available via <http://go.nature.com/84ppZp>.

The experiment starts with two polarization-entangled photons. The polarization of one photon is measured directly, whereas the second photon travels through an interferometric set-up that transfers its polarization to a selected spatial optical mode. These modes have clear visual signatures (the first-order Laguerre–Gauss mode is pictured), although their structures become more complex for higher modes. The speed and sensitivity of the ICCD cameras used allow the effect of polarization measurements on the first photon to become visible in the changing pattern of the second photon's

spatial mode. In this way it is possible to monitor the probability distribution of the spatial modes while scanning the polarization states of the first photon.

Visualizing the effect of measurement on one photon of an entangled pair is fascinating, but for multiparticle entanglement things become more complicated. The complexity of entangled states scales exponentially with the number of particles, so testing entanglement in these conditions becomes prohibitively difficult. Nevertheless, significant effort has been devoted to characterizing and quantifying multiparticle entanglement, as well as building understanding through the use of mathematical tools.

In line with this, Michael Walter and colleagues have now found that different classes of entangled states can be associated with geometric objects known as polytopes, which contain all possible local eigenvalues of states in the corresponding entanglement class (*Science* **340**, 1205–1208; 2013). Local information alone can therefore be used to determine whether a pure multiparticle state belongs to that polytope. This approach provides a visual and more practical characterization of entanglement, and more importantly, a local witness of global entanglement.

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