DEVELOPMENTAL BIOLOGY

Earn your wings

The ecological success of the migratory brown planthopper (*Nilaparvata lugens*; pictured), a rice pest, depends on its ability to develop into two different forms in response to environmental cues. On page 464 of this issue, Xu *et al.* show that, during development, the binary action of two distinct insulin receptor proteins, dubbed NlInR1 and NlInR2, controls the switch between these two forms (H.-J. Xu *et al. Nature* **519,** 464–467; 2015).

The long-winged planthopper escapes adverse habitats to search for resources, whereas the short-winged form is highly fertile, but cannot fly. The authors delineate a molecular signalling cascade, in which the production of an insulin peptide in the brain acts on NlInR1 to trigger the formation of long wings. NlInR2 impedes the action of the cascade to prevent wing growth. The relative expression levels of each receptor therefore determine which form each planthopper adopts.

These results help to show how environmental cues regulate generation of the highly fertile short-winged insects, and could be used to develop ways to control these agricultural pests. **Nathalie Le Bot**

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QUANTUM PHYSICS

Atomic doughnuts from single photons

Analysis of the interaction between a photon and an ensemble of some 3,000 atoms trapped between two mirrors has revealed a form of multi-atom quantum entanglement that has no counterpart in classical mechanics. SEE LETTER P.439

JAMES K. THOMPSON

What is the most that could happen when you analyse a single particle of light after sending it through a few thousand atoms? On page 439 of this issue, McConnell *et al.*[1] demonstrate that the single photon creates a special quantum link between nearly all of the atoms, a link known as entanglement. The authors show that the particular 'flavour' of entanglement observed has no classical analogue — a first for such a large collection of atoms. Extending our ability to create entanglement in large systems may one day allow highly precise measurements of time, fields and accelerations, lead to new materials, and enhance our understanding of the transition from the quantum to the classical world.

In the quantum world, the act of measurement can profoundly change the state of the object being measured. McConnell and colleagues exploited this fundamental principle to create entanglement between almost 3,000 atoms that are laser-cooled to only a few ten-millionths of a degree above absolute zero. The atoms were levitated between two highly reflecting, weakly transmitting mirrors. Each of the atoms can be thought of as possessing an arrow, which corresponds to the orientation of the atom's total quantum spin. All the arrows add up to make one big arrow that initially points in some direction, call it *x*, which lies on the equator of a sphere.

A weak pulse of light is injected through one of the mirrors and then detected after it leaks back out of the other mirror. The light also has an arrow attached to it, denoting its polarization (the direction of the light's electric field). As the light bounces back and forth between the mirrors, it passes roughly 5,000 times through the atoms, each time being partially absorbed and then re-emitted back into the original pulse of photons (Fig. 1a).

If the total atomic arrow were pointing slightly north or slightly south of the *x* direction, because of quantum Heisenberg uncertainty in its orientation (Fig 1b.), then the polarization of the light would be slightly rotated clockwise or anticlockwise, respectively, when it was re-emitted. For each pulse of light sent through the mirrors, McConnell *et al.* checked to see whether they detected any rotated light. On most trials, they did not detect even one rotated photon.

Failing was no problem. They just tried again until they finally detected that a single photon had been rotated. This told the experimenters that, on that particular trial, the total atomic arrow was not quite on the equator, but must have been pointing slightly north or south of *x*. The researchers verified that the arrow was no longer at the equator by making a second and much more precise measurement of the total atomic arrow's north–south orientation.

The measurement apparatus fundamentally could not tell whether the polarization rotation of the single detected photon was clockwise or anticlockwise. With no further information, one would expect the measurement of a single photon to collapse the total atomic arrow into a quantum superposition state in which the arrow was simultaneously both north and south of the equator.

But confirming with the precise measurement that the total atomic arrow does not lie