resonator. In the linear regime, such a set-up cannot produce optical isolation owing to a fundamental principle called optical reciprocity, which holds even in the presence of (linear) gain and loss. This states that light propagating from one port to another necessarily receives the same net gain or loss as it would if the input and output ports were reversed[9]. Optical nonlinearity, however, breaks reciprocity and allows for the possibility of optical isolation. Based on these ideas, non-reciprocal propagation (without isolation) has previously been demonstrated in PT-symmetric optical waveguides[3], and the realization of optical isolation using PT-symmetric resonators has been theoretically proposed and studied in an electric-circuit analog[8]. The work of Peng *et al.* is the first experimental realization of this type of optical isolator.

It is worth noting that exact PT symmetry is not required for the isolator to function; indeed, PT symmetry generally breaks down when optical nonlinearity is present. Rather, approximate PT symmetry serves as a convenient way to produce pairs of modes with closely matched frequencies, but very different spatial characteristics and gain/loss rates. The resulting device performs remarkably well: Peng *et al.* note that it has a lower minimum operating power and better contrast between forward and backward transmission than many of the nonlinear optical isolators thus far studied in the literature. A future version of this isolator, in which the resonators are coupled to integrated optical waveguides, could serve as a vital component in an integrated optical circuit. Even in the linear regime, this work could be developed into a platform for the exploration of exotic optics, such as the effects of gain and loss in coupled resonator lattices. ❐

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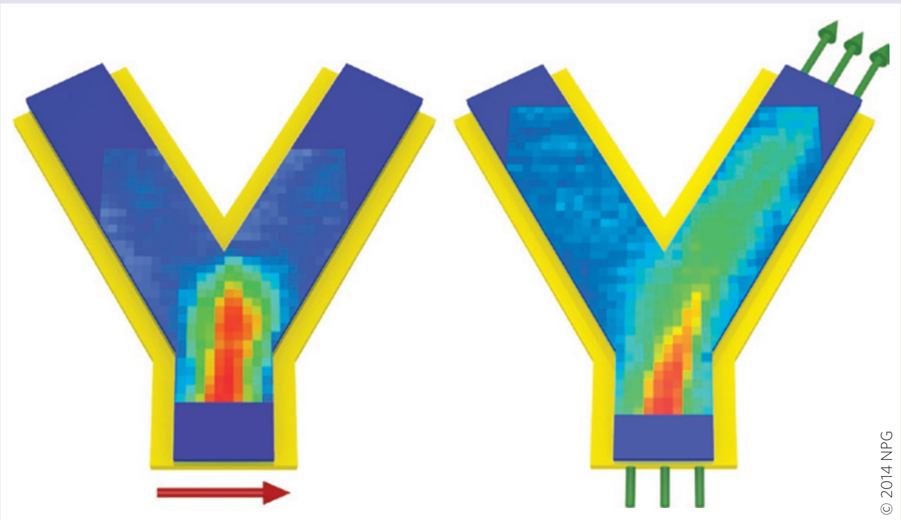
SPINTRONICS

Mux ado about magnons

The future of spin-based devices looks likely to profit from the creative control of magnons, the quantized spin waves occurring within magnetic materials. Magnons allow for the transfer of spin angular momentum without the need for charge transport — bypassing the Joule heating that arises from the scattering of electrons. Although progress has been made towards magnon-based logic, controlling spin-wave propagation has proved challenging. By employing local magnetic fields, Helmut Schultheiss and colleagues have made an important step towards the development of a magnon-based processor, demonstrating a spin-wave multiplexer (*Nature Commun.* http://dx.doi.org/10.1038/ncomms4727; 2014).



Unlike sound or light waves, spin waves have a highly anisotropic dispersion. This means that their energy is strongly dependent on the angle between the propagation direction and the magnetization orientation. Magnetic fields can therefore be used to influence spin-wave propagation, but the need for applying global external fields also restricts the complexity of magnon-based circuits.

To get around this problem, the authors fabricated a gold channel underneath their permalloy spin-wave guide. When a direct current ran through the channel, local magnetic fields were generated, with an insulating layer preventing the current from flowing in the permalloy. These local fields forced the magnetic moments to point in a direction transverse to the waveguide, providing an energy-efficient path for spin waves.

This is not the first time that local fields have been used to influence spin-wave propagation, but the authors went further. By patterning their permalloy layer into a Y-shaped waveguide (pictured), they were able to make several advances. By applying a global field in the absence of any current, they were able to prevent spin waves from propagating down both arms of the device. Without the application of an external field, they showed that they could select the propagation direction simply by controlling the direction of current flow. They termed this device a spin-wave multiplexer, or mux.

Although their device was micrometres in size — restricted by the Brillouin light-scattering technique they used to image the spin waves — the authors believe that there are no physical limitations to prevent them from scaling down to a nanometre sized device. Therefore, these results could represent a promising route towards magnon-based logic devices with increased complexity.

LUKE FLEET