using an optical frequency comb—the equally spaced modes of an optical cavity—as the qumodes.[4] A suitably designed OPO could entangle many pairs of modes with a single pump mode, because there are many pairs of modes whose frequencies sum to the pump frequency. The researchers developed a scheme whereby a single OPO and a pump spectrum of 15 frequencies suffice to create the topological equivalent of an arbitrarily large cluster state. Pfister and his experimentalist colleagues have now taken the first step toward implementing the scheme in the lab.

Entangling qumodes

Flammia, Menicucci, and Pfister found that to create a cluster state with the

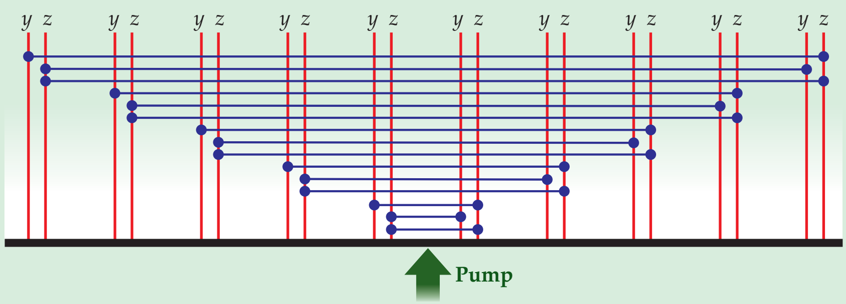
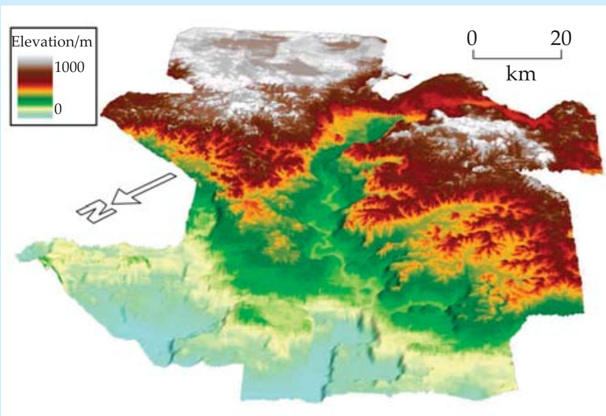


Figure 2. Entangling many modes (red lines) in an optical frequency comb with a single pump mode. The green arrow represents half the pump frequency; an optical parametric oscillator generates entanglements, represented by the blue lines, between modes whose frequencies add up to the pump frequency. Because the *y* and *z* polarizations of each frequency are treated as separate quantum modes, the modes are entangled in groups of four.

An ancient buried landscape. The mountainous river-cut topography in the figure resembles that of the Ozark Plateau in the southwestern US. In fact, as Ross Hartley of Cambridge University and his colleagues have discovered, the craggy landscape lies off Scotland's northern coast, buried beneath both the Atlantic Ocean and 2 km of rock. Hartley and his colleagues found the river-cut landscape in a three-dimensional seismic survey of Europe's continental shelf. Being made of sedimentary rock, the landscape must have formed under water, but it was evidently once above sea level and exposed to the elements long enough for water to erode a network of valleys. How did the uplift take place? Water carves valley networks in more or less predictable patterns. When Hartley and his colleagues modeled the landscape's erosion history, they found a surprise: The patterns could be explained only if the uplift took place over a total of 1 million years in three discrete steps, each about 200–400 m



high. The uplift is consistent with the action of the putative Icelandic plume, a convective upwelling of hot material that extends from the lower mantle. When the plume reaches Earth's crust, it spreads radially beneath the crust, exerting upward pressure. An unusually strong upwelling event could have lifted the now-buried landscape temporarily above sea level. (R. A. Hartley et al., *Nat. Geosci.* **4**, 562, 2011.) —CD

Soda cans focus sound to subwavelength spots. Beating the diffraction limit requires accessing a field's evanescent waves, which harbor its subwavelength spatial details but don't propagate—they are stuck to the field's source. The scanning probe of a near-field microscope can directly access those evanescent waves (see PHYSICS TODAY, July 2011, page 47). But it's also possible to directly convert the standing waves to propagating ones by scattering them with a metalens—a cluster of strongly coupled subwavelength resonators—an approach introduced last year by ESPCI ParisTech researchers led by Geoffroy Lerosey. The Paris group has now demonstrated that broadband, audible sounds can be manipulated and focused onto spots as small as 1/25th of their wavelength λ. In a refreshingly low-tech experiment, various tones near 400 Hz from eight loudspeakers surrounding an array of empty soda cans were used to excite resonant modes with spatial variations as small as the diameter of a can. Using the principle of time reversal (see PHYSICS TODAY, March 1997, page 34), the researchers then focused the modes by adding them coherently at a specific time and location and incoherently at other times and positions. Microphone-recorded maps of the acoustic pressure upon time reversal before and after cans are introduced demonstrate the subwavelength focusing. (Videos also show the dynamic acoustic intensity as the modes are focused.) The authors say the approach may lead to exotic new designs of smart sensors and actuators. (F. Lemoult, M. Fink, G. Lerosey, *Phys. Rev. Lett.* **107**, 064301, 2011.) —RMW

Acoustic levitation. A popular 1980s television commercial featured a man being blown backward by the sound coming from his stereo. Though a speaker's pressure field isn't nearly that strong, acoustic pressure can suspend millimeter-sized objects against the force of gravity. New work by Pierre Lambert and colleagues at Belgium's Université libre de Bruxelles compares existing theoretical models, numerically computes the strength and direction of the acoustic forces, and validates those results with experimental measurements on objects suspended in standing waves. The researchers find that for spherical objects with radii bigger than one-sixth of the acoustic wavelength—or for nonspherical objects—analytical models don't suffice and numerical modeling is required. The team's calculations and experiments show that at pressure nodes, levitation in an axially symmetric standing wave is stable for both small displacements and angular tilt. Furthermore, when an instrument such as tweezers is inserted laterally into the field, the pressure distortions will push the levitated object to the probe, turning the levitator into a component feeder. Levitation could also find use in a wide variety of other settings; isolated analysis of small samples of proteins and the sorting and separating of items according to their size are just a few examples. (V. Vandaele, A. Delchambre, P. Lambert, *J. Appl. Phys.* **109**, 124901, 2011.) —RJF