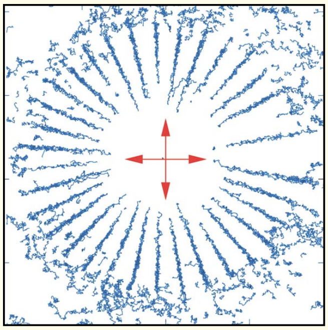
Physics Update

Optical peristalsis. Part of the digestion process consists of peristalsis—the wavelike movement of powerful esophageal muscles urging food particles along the alimentary tract. Now, a similar sort of particle transport has been carried out at the nanoscopic level, using a holographic optical trapping (HOT) technique. David Grier and Brian Koss at the University of Chicago use computer-designed holograms to project up to several hundred optical traps into a volume of about 3×10^5 μm^3. Each trap is a symmetric potential well that can hold a small amount of matter. By repeatedly changing to different holograms whose traps are displaced but overlapping with the previous ones, the matter can be shuttled deterministically, like a bucket brigade, along preordained paths of potential wells. Parallelism is one of the technique's strengths, as shown in this image of 1.6-μm silicon spheres dispersed in water. When subjected to a sequence of hologram patterns with ever-increasing diameters, the spheres were transported radially outward, evacuating the central region. Reversing the sequence concentrates the spheres in the middle. Grier says that their HOT technique can create arbitrary configurations of optical traps in three dimensions and move all the traps independently under computer control. Optical peristalsis is a special case. (B. A. Koss, D. G. Grier, *Appl. Phys. Lett.* **82**, 3985, 2003.) —PFS



Using bubbles to deliver drugs is a step or two closer to reality. Claus-Dieter Ohl and Roy Ikink (University of Twente, the Netherlands) found that tiny bubbles (7–55 μm across) floating in water develop needlelike tips when exposed to acoustic shock waves. The effect was seen with pressure amplitudes of 11–21 MPa, much smaller than needed, for example, to break up kidney stones. The tips formed in the direction of the propagating shock, when the liquid surrounding each bubble was accelerated through the bubble's center and pierced the opposing bubble wall, much like the jet from a syringe. The researchers suggest that, if the tip can actually penetrate a cell's membrane, then drug-coated bubbles could be used for in vivo local drug delivery. Separately, Phillippe Marmottant and Sascha Hilgenfeldt (also at Twente) have experimented with bubbles attached to a substrate. They showed that very gentle bubble oscillations—in an acoustic field of only 0.01 MPa—can set up a flow field that attracts a nearby cell, ruptures its membrane, and then repels the cell. The "sonoporation" technique could prove useful not only for exchanging a cell's interior and exterior fluids in drug or DNA delivery, but also in other cell manipulation or microfluidic applications. (C. D. Ohl, R. Ikink, *Phys. Rev. Lett.* **90**, 214502, 2003; P. Marmottant, S. Hilgenfeldt, *Nature* **423**, 153, 2003.) —BPS

A new optical geometric phase has been directly measured. Geometric phase arises when a system is carried around a closed path in some parameter or state space. For example, parallel-transporting a vector around a loop on the surface of a sphere will change the vector's orientation when it returns to its starting point. Physicists at Colgate University used a laser beam and "mode space," with modes characterized by the surfaces of constant phase within the beam. They sent a Gaussian beam of laser light in a zero-order mode—with planar phase surfaces—through a special diffraction grating. The beam then contained high-order "doughnut" modes with helical phase surfaces that carry orbital angular momentum. The researchers combined a zero-order and a higher-order mode from the same beam and sent them together along the same path to avoid any dynamical phase changes that would swamp the desired signal. They used cylindrical lenses to alter the doughnut mode and trace out a closed path in mode space, and monitored the interference with the unaltered zero-order mode. The group's result agreed well with theory and supports the conjecture that the geometric phase arises from the exchange of angular momentum between the light and the optical system. (E. J. Galvez et al., *Phys. Rev. Lett.* **90**, 203901, 2003.) —SGB

A "water hammer" powers up sonoluminescence. In household plumbing, a water hammer can occur when a sudden slowdown of the water's flow generates a temporary vacuum and a shock wave that together violently shake the piping. Now, Seth Putterman of UCLA and his colleagues have used a water hammer to generate sonoluminescence (SL), bursts of light from collapsing bubbles. The researchers vertically shook a 60-cm-tall, 4-cm-diameter cylindrical tube—containing a small amount of xenon gas dissolved in water—with an acceleration of 2*g*. During a shake cycle, bubbles formed and collapsed sporadically and produced as many as 3×10^8 photons (about a hundred times more than earlier SL experiments). That emission corresponds to a peak power of almost half a watt. (C.-K. Su et al., *Phys. Fluids* **15**, 1457, 2003.) —BPS ■