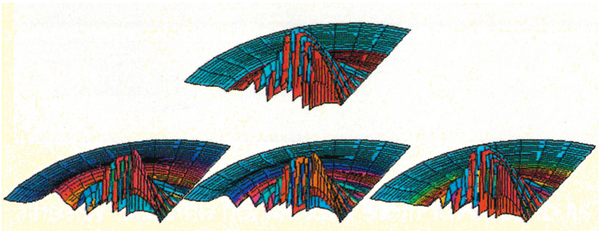
PHYSICS UPDATE

A TIME-VARYING FINE STRUCTURE CONSTANT, α, can now be sought with a new technique. The inherent strength of the electromagnetic force is characterized by α, the value of which determines how well atoms hold together and what wavelengths of light atoms will emit when heated up. Any evolution of such a fundamental "constant" would have profound physical implications. Now, a group of scientists led by John Webb (University of New South Wales in Australia) has explored this possibility by sampling ancient light emitted by ancient atoms, and comparing it with modern light from modern atoms. Light emitted by distant quasars often passes through intervening clouds, where some of it is absorbed. The researchers looked at the relative spacing of multiplets of absorption lines in quasar spectra, comparing lines of ionized iron with those of ionized magnesium. The spacings depend on α, with the much heavier iron atoms being affected more strongly than the magnesium—which therefore serves as an "anchor" to tie the astrophysical data to modern laboratory measurements. After taking into account all the corrections they could think of, the scientists placed a limit on $\Delta\alpha/\alpha$ of about -1.1×10^{-5}, an order of magnitude better than other methods have given. (J. K. Webb *et al.*, *Phys. Rev. Lett.* **82**, 884, 1999.) —PFS

TAILOR-MADE WAVEFUNCTIONS have been produced in Rydberg atoms of cesium. In a process akin to holography, Thomas Weinacht and his colleagues at the University of Michigan used a pair of computer-controlled lasers to directly manipulate the shape of the outermost electron's radial



wavefunction. First, a laser was used to excite a coherent state in the atom. The wavefunction was then measured and compared with a predetermined, desired final state. The information was fed back into the computer, which in turn generated a new laser pulse that altered the shape of the wavefunction. The process was repeated until the desired wavefunction was produced, often in only two iterations—as shown in the accompanying figure (in which height denotes amplitude and color denotes phase), where the top image is the target state and the succeeding three images show the iterations. Such precise reconstruction of a quantum system is important for coherent quantum information processing (T. C. Weinacht, J. Ahn, P. H. Bucksbaum, *Nature* **397**, 233, 1999.. For more on reconstructing wavefunctions, see the article in PHYSICS TODAY, April 1998, page 22.) —BPS

A THEORY OF TACKINESS has been developed that can account for the highly nonlinear force–separation curves observed when sticky objects are pulled apart. The forces primarily involved in making objects sticky are the weak van der Waals forces between molecules, but their effect is enhanced by mechanisms that remain to be elucidated. For example, in controlled experiments in which a metallic probe is removed from a sticky polymer at a constant rate, the required force briefly reaches a peak value, then remains roughly constant at a lower value until it vanishes when the probe is completely removed. Now, Cyprien Gay and Ludwik Leibler of the Unité Mixte de Recherches CNRS—Elf Atochem in France suggest that air bubbles, trapped as the rough surfaces of the metallic probe and of the deformable polymer touch each other, create a suction-cup effect as the probe is withdrawn and the bubbles deform. This effect causes the peak in the force curve. As the probe is withdrawn further, isolated bubbles connect and a network of contact points develops between the probe and polymer. Fractures then propagate through the network, reducing the force required to separate the surfaces, and giving rise to the force plateau. Developing a sophisticated understanding of stickiness will help researchers better design adhesives, coatings and paints. (C. Gay, L. Leibler, *Phys. Rev. Lett.* **82**, 936, 1999.) —BPS

HYDROGEN BONDS IN ICE ARE COVALENT. Within a single water molecule, hydrogen and oxygen are held together by strongly covalent bonds—a purely quantum mechanical effect in which electrons are shared between atoms. Between neighboring molecules in water or ice, however, are much weaker "hydrogen bonds," the precise nature of which has been controversial. Until now. An international team led by Eric Isaacs (Bell Laboratories, Lucent Technologies) used inelastic (Compton) x-ray scattering, which is sensitive to extended electronic states, to directly measure the electronic ground state wavefunction of ice along different directions. By examining the resulting anisotropies, the team determined that, although neighboring water molecules are predominantly held together in ice by electrostatic forces, there is also a significant covalent component to the bond, confirming the prediction advanced by Linus Pauling in 1935. Understanding water, and the real nature of the hydrogen bond, is of great relevance to the many other structures, such as DNA, that contain hydrogen bonds. (E. D. Isaacs *et al.*, *Phys. Rev. Lett.* **82**, 600, 1999.) —BPS