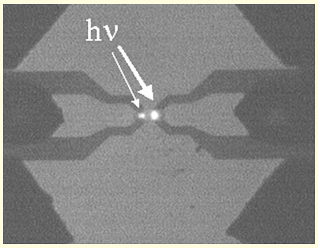
Physics Update

Spinning the nucleon into sharper focus. In the simplest picture, a proton or neutron is made up of three "valence" quarks. A more complete picture also includes not only a sea of quark–antiquark pairs that pop in and out of the vacuum but also gluons, which hold the quarks together. Working at the Thomas Jefferson National Accelerator Facility in Virginia, a multinational research team has precisely measured the distribution of spin for a neutron's valence quarks. Firing a 5.7-GeV polarized electron beam at a polarized helium-3 target, the researchers could focus on the valence quarks by choosing an excitation region where electron interactions with gluons and sea quarks are screened out. The physicists then combined their new neutron data with existing proton data and concluded that the spins of the proton's two valence up quarks are aligned parallel to the overall proton spin, but the same is not true for the proton's valence down quark. The results agree well with predictions from the relativistic constituent quark model, which considers the quarks' orbital angular momenta within a nucleon. However, they disagree with predictions from a commonly used approximation of perturbative quantum chromodynamics that does not account for the quarks' orbital angular momenta. (X. Zheng et al., *Phys. Rev. Lett.* **92**, 012004, 2004.) —BPS

Light frozen in a hall of atomic mirrors. A few years ago, two different groups succeeded in slowing and then storing a pulse of light in atomic vapor. In that work, the properties of incoming photons were vested in the spin orientations of the atoms in the vapor; the light pulses no longer existed but could later be reconstituted into propagating light beams. A new experiment has brought light to a halt and left it intact as an optical entity. Harvard's Mikhail Lukin and his colleagues began, as in the earlier work, by converting the incoming light pulse into a corresponding ensemble of spins in a gaseous medium. But then they brought a pair of counter-propagating control beams to bear on the medium. Those beams not only eased the optical pulse back into existence but also created a standing-wave pattern that generated spatially varying atomic absorption. The atoms then acted like a stack of mirrors that trapped the reconstituted electromagnetic radiation within a fixed stationary envelope. Thus the light pulse was literally frozen in space. When one of the control beams was turned off, the light traveled in the direction of the remaining beam. Lukin says that this work may lead to new nonlinear techniques for generating interactions between faint light beams. (M. Bajcsy, A. S. Zibrov, M. D. Lukin, *Nature* **426**, 638, 2003.) —PFS

A light-emitting transistor (LET) has been demonstrated. Researchers at the University of Illinois at Urbana-Champaign used indium gallium phosphide and gallium arsenide to build a transistor with an infrared optical output port in addition to the conventional electrical input and output ports. Although the LET produces light in essentially the same way that light-emitting diodes operate, the transistor can modulate light at much higher speeds. Limited not by the optical recombination time but by the transistor itself, the device's speed can be greater than its current 1 MHz. The emission, shown here under normal bipolar bias, comes from a 1-μm^2 region in the base layer. (M. Feng, N. Holonyak Jr, W. Hafez, *Appl. Phys. Lett.* **84**, 151, 2004.) —JRR



Chaos in general relativity is coordinate invariant. A new study shows that general relativity, a nonlinear theory in which observers in different reference frames measure time differently, is not incompatible with chaos, a theory for nonlinear systems in which events unfold in absolute time. A physical system—a weather system, say—is chaotic if a very slight change in initial conditions sends the system off on a very different course. How different? The degree to which a system is chaotic can be encapsulated in a parameter called the Lyapunov exponent: When it is positive, the system is chaotic; when negative or null, the system is nonchaotic. For many years, physicists worried that a shift in a frame of reference might also alter the time parameter in such a way as to change the Lyapunov exponent from null or negative to positive or vice versa. Adilson Motter of the Max Planck Institute for the Physics of Complex Systems in Dresden, Germany, has now laid this matter to rest by showing that a change of time parameter does not alter the sign of a well-defined Lyapunov exponent. (A. E. Motter, *Phys. Rev. Lett.* **91**, 231101, 2003.) —PFS

The fine-structure constant appears to be constant after all. In 1999, an analysis of spectra from quasars led researchers to conclude that α, the stalwart of quantum physics, might change slightly over cosmological time (see PHYSICS TODAY, March 1999, page 9, and October 2001, page 9). But now, Keith Olive (University of Minnesota) and his colleagues have shown that a first generation of highly evolved intermediate-mass stars in quasar absorption systems could change the previously assumed isotopic abundances of magnesium enough to account for the puzzling spectra. Thus, according to Olive, the quasar observations might be teaching us important lessons about the chemical evolution of the universe. (T. Ashenfelter, G. J. Mathews, K. A. Olive, *Phys. Rev. Lett.*, in press.) —SGB