

PHYSICS UPDATE

▶ AN AREAL DATA STORAGE DENSITY of 8 gigabits per square inch has been demonstrated by Thomas Mossberg and his colleagues at the University of Oregon. The Oregon group exposes a frequency-selective recording material to an optical data stream and a constant amplitude reference beam, thereby encoding the data's Fourier transform. Subsequent optical excitation of the material recalls the data. The storage method is essentially holographic (PHYSICS TODAY, January, page 17) but the interference is in the spectral rather than spatial domain. Such "spectral addressing" enabled the group to write the equivalent of 2000 bits of data onto a single spot with an area of about 200 square microns. The resulting data storage density is ten times larger than that achieved for standard optical or magnetic recording methods. Another important figure of merit is the density-bandwidth product (how much data can be transferred how quickly): The Oregon figure is 1.5×10^{17} bits $\text{in}^{-2} \text{s}^{-1}$, a factor of 3 to 10 larger than previously published reports for nonparallel systems. The downside for now is that the material used in the Oregon work—thulium atoms lodged in a crystal—had to be used cryogenically (4–6 K) and had only about 10 ms of unrefreshed data storage time. Mossberg believes that other materials will perform better. (H. Lin *et al.*, *Optics Lett.* **20**, 1658, 1995.) —PFS

▶ KILO-ELECTRON BALLS have been produced in an atom trap by Hans Dehmelt and his colleagues at the University of Washington by compressing about 1000 electrons into spherical plasma drops 300 microns in diameter. Dehmelt says this is small enough to simulate a massive hypercharged point particle. The "kilo-e's" were developed for studying a small frequency shift that had limited the precision in the group's prior measurements of the spin magnetism of the electron. The theoretically predicted shift (between 10 and –10 Hz) is too small to measure on the individual electron studied in the earlier experiments, but the shift is proportional to the number of electrons taking part. Thus, for a 1000-electron plasma droplet, the shift should be in the kilohertz range. By comparing data for kilo-e and hundred-e balls, the frequency shift was measured to be –5 Hz per electron at the fixed magnetic field available at the time. (R. Mittleman, H. Dehmelt, S. Kim, *Phys. Rev. Lett.* **75**, 2839, 1995.) —PFS

▶ GEOMETRIC PATTERNS IN BACTERIAL COLONIES are being studied by physicists, biologists and mathematicians in an effort to elucidate universal mechanisms for pattern formation in nature. For example, a few bacteria placed on a nutrient-rich surface multiply and spread out and, under certain conditions, form visually striking patterns; these in-

clude stripes and spots organized into concentric circles or radial spokes. Two groups have recently developed models to describe such self-organization. Both models use the observation that bacteria aggregate around a diffusing chemical attractant that they themselves secrete. Pattern formation results from the complex interplay between this response and the rate at which the bacteria spread out on the surface. Howard Berg and Elena Budrene of Harvard University and their colleagues have used such a model to describe the rings of *Salmonella typhimurium* and *Escherichia coli* bacteria seen in their recent experiments. Meanwhile, Lev Tsimring and Herbert Levine (University of California, San Diego), Eshel Ben-Jacob (Tel-Aviv University, Israel) and their colleagues in both countries have added more nonlinear interactions—food depletion and waste accumulation—in an effort to describe a spoked pattern seen previously by Budrene and Berg in *E. coli* cultures. In their model, all components (bacteria, nutrients, waste and attractant) are subject to diffusion. Pattern formation is triggered when the concentration of waste reaches a certain threshold. When the bacteria run out of nutrients in a given location, they enter a dormant state, locking the pattern into place. (D. E. Woodward *et al.*, *Biophys. J.* **68**, 2181, 1995. E. O. Budrene, H. C. Berg, *Nature*, **376**, 49, 1995. L. Tsimring *et al.*, *Phys. Rev. Lett.* **75**, 1859, 1995.) —BPS

▶ A NEW TEST OF QED, the most successful theory in physics, shows the need for improved information on the proton. Quantum electrodynamics was initially developed to explain the Lamb shift in the hydrogen atom, arising from the electron's interaction with the swarm of virtual particles in the surrounding vacuum. Calculations of the Lamb shift treat the proton as a sphere in which positive charge is spread out. Currently the two best values for the proton's radius disagree with each other: 0.805(11) and 0.862(12) fermi. Using high-resolution laser spectroscopy, Yale University researchers have now measured the hydrogen Lamb shift to a record accuracy of six parts per million. Their value of 8 172 827 kHz agrees with QED providing they use the larger proton radius, but a significant discrepancy with QED cannot be ruled out until the proton size is pinpointed to within 1 or 2 percent. The group is now measuring the He^+ Lamb shift, for which theory and the best experiment now disagree by 9 standard deviations. Says Malcolm Boshier of Yale: "If our new measurement in singly ionized helium verifies QED, then our hydrogen result can tell us how big the proton really is. On the other hand, a clear discrepancy might indicate new physics." (D. J. Berkeland, E. A. Hinds, M. G. Boshier, *Phys. Rev. Lett.*, **75**, 2470, 1995.) —BPS ■