

PHYSICS UPDATE

▶ **A SINGLE-SPIN TRANSISTOR.** Spintronics is a relatively new field in which an electron's spin, not just its charge, is exploited in devices and circuits. Physicists at the Institute for Microstructural Science in Ottawa, Canada, have connected a quantum dot to spin-polarized leads in an external magnetic field. They emptied the dot of conduction electrons and then added them back one at a time. The researchers found that the total spin of the electrons depended both on the number of electrons in the dot and on the applied magnetic field. With fewer than about 20 electrons in the dot, an even number of spins paired off in singlet states with zero net spin, whereas an odd number had a net spin corresponding to the unpaired electron. Above the critical number, however, the additional electrons all had the same spin polarization. Furthermore, the single-spin, singlet, and polarized phases of the dot each allowed different currents to flow through the dot. The physicists controlled the spin state of the dot either by adding electrons or by tuning the magnetic field, and thus produced a prototype single-spin transistor. The group believes their work may play a role in future solid-state forms of quantum information. (M. Ciorga et al., *Phys. Rev. Lett.* **88**, 256804, 2002.) —PFS

▶ **A YOUNG EVOLVING PLANETARY SYSTEM** has been seen. A star much like our Sun when it was only 3 million years old has been winking at astronomers from a distance of about 2400 light years for the past five years. Every 48.36 days, the star suddenly dims to a small percentage of its normal brightness for about 18 days. The duration and depth of these periodic occultations, discovered by William Herbst and his colleagues at Wesleyan University in Connecticut, had not been seen before. Eighteen days is much too long for occultation by a lone planet in a 48-day orbit. The observations' most likely explanation, put forth by Herbst at a meeting at the Carnegie Institution of Washington in June, is that a collection of dust grains, rocks, and perhaps asteroids is strung out in a clumpy arc of an orbiting circumstellar disk, with a larger object like a proto-planet shepherding the material. Now, with a worldwide collaboration watching the star continually, the Wesleyan group has found evidence that the orbital period is, in fact, 96.72 days: The star is being occulted by two separate clumpy regions on opposite sides of the disk. Theoretical models indicate that a single shepherding object could account for both clumps. The 97-day period indicates that the ring-like disk is about as far away from the star as Mercury is from the Sun. The collaboration has also seen the system changing slightly on a scale of months and years, thus tantalizing astronomers with the prospect of viewing planetary evolution in real time. (W. Herbst et al., <http://www.astro.wesleyan.edu/kh15d/>.) —PFS

▶ **RAPID-RESPONSE HYDROGELS**, water-swelled polymers that quickly change their properties when triggered by the right stimulus, have been created. A hydrogel is a 3D cagelike polymer that is relatively sluggish in responding to the application or removal of stress, light, or a change in acidity. Using a novel design based on artificial protein polymers, a collaboration of scientists from the University of California, Santa Barbara, and the University of Delaware has now developed a hydrogel that can recover quickly after the removal of mechanical stress. The novel hydrogel contains two chemical building blocks: one that is highly charged and hydrophilic and another that is hydrophobic and has a special shape that causes the polymers to link and form a porous hydrogel at very low concentrations in solution. After the gels were shaken vigorously to break down their structure, they recovered 80% of their strength in a matter of seconds, even at 90°C. The rapid response and highly porous nature of the new hydrogel potentially opens up new biotechnological uses for the compound. Possibilities include an organic scaffolding to hold regenerating tissue within the body and a drug-delivery capsule to hold large proteins and release them when given the right stimulus. (A. P. Nowak et al., *Nature* **417**, 424, 2002.) —BPS

▶ **BALLISTIC MAGNETORESISTANCE (BMR)** is yet another way in which spin orientation can modify electrical resistance in a circuit. The sensitive part of the circuit might consist of sandwiches of alternating magnetic and nonmagnetic layers (giant magnetoresistance and tunnel magnetoresistance) or might have no magnetic materials at all (extraordinary magnetoresistance; see PHYSICS TODAY, July 2002, page 9). In BMR, the sensor is a quantum point contact of ferromagnetic atoms between two wires. The contact is narrower than the typical scattering path length for electrons, which therefore move ballistically in straight trajectories. Any scattering an electron suffers will be due only to magnetic effects. If the electrons in the circuit are spin polarized then they will scatter more or less (with greater or lesser resistance) at the contact, depending on the contact's magnetization state and on the faint force exerted by any nearby tiny magnetic storage domain. In a new BMR experiment conducted at SUNY Buffalo, Harsh Chopra and Susan Hua found a remarkably large resistance change in nickel nanocontacts at room temperature. For example, they saw a change in resistance of more than a factor of 30 (from 8 to 260 ohms) in an applied magnetic field of less than 0.016 T (160 gauss). The researchers say that they can reliably reproduce the BMR effect in many samples. (H. D. Chopra, S. Z. Hua, *Phys. Rev. B* **66**, 020403(R), 2002.) —PFS ■