

# PHYSICS UPDATE

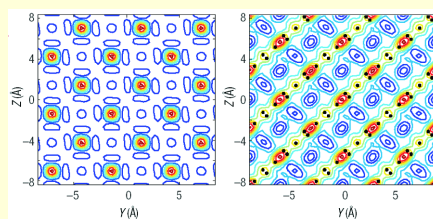
► **QUAOAR** is the provisional name for a large, newly discovered planetlike inhabitant of our solar system. First spotted on 4 June 2002, Quaoar (pronounced KWAH-o-wahr) lives in the Kuiper Belt debris zone beyond Neptune's orbit. Its diameter of 1250 km is about half that of Pluto, and its distance of 42 astronomical units from Earth is far beyond Pluto's current distance of about 30 AU. (One AU is the mean distance of Earth from the Sun, about 150 million kilometers.) Caltech scientists announced the finding in October at the meeting of the division for planetary sciences of the American Astronomical Society, held in Birmingham, Alabama. (Abstract 9.04, *Bull. AAS* **34**(3), 2002. Also see <http://www.gps.caltech.edu/~chad/quaoar>.) —PFS

► **THE FRAGMENTATION OF POSITRONIUM** due to collisions with helium atoms has been experimentally investigated. The lightest "atom" made of an electron and a positively charged mate is not hydrogen but positronium, a bound electron-positron pair. Ps lives for only about 140 nanoseconds before its constituents annihilate each other, but that can be long enough to do an experiment. In recent years, physicists have been able to generate Ps beams and measure total cross sections for Ps scattering from various targets. Now, a team of physicists at University College London has conducted an experiment in which Ps scatters inelastically off helium atoms and splits apart. The separated electrons and positrons continue to be highly correlated, and the measured cross section is in good agreement with a coupled-state calculation. A longitudinal-energy peak suggests that some of the resulting electrons are lost to the continuum. (S. Armitage et al., *Phys. Rev. Lett.* **89**, 173402, 2002.) —PFS

► **THE QUANTUM ORIGIN OF OXYGEN STORAGE** in cerium oxide has been elucidated. Many environmentally friendly technologies, such as catalytic converters and solid-oxide fuel cells, exploit an amazing property of solid  $\text{CeO}_2$ , also known as ceria. Under oxygen-poor conditions, ceria can release oxygen, transforming itself into  $\text{Ce}_2\text{O}_3$ . The  $\text{Ce}_2\text{O}_3$ , in turn, easily takes up oxygen under oxygen-rich conditions and changes back to ceria. Now, physicists from several universities in Sweden offer a detailed quantum-mechanical description of how these reactions occur. The researchers showed that the pivotal transition from  $\text{CeO}_2$  to  $\text{Ce}_2\text{O}_3$  results from the formation of an oxygen vacancy, in which the oxygen leaves behind two electrons that become localized on two nearby cerium ions. The charge on that pair of ions then changes from +4 to +3, and a series of reduced compounds form, ending with  $\text{Ce}_2\text{O}_3$ . The ability of solid cerium oxide to store, transport, and release oxygen is therefore an

industrially important example of the quantum process of electron localization. (N. V. Skorodumova et al., *Phys. Rev. Lett.* **89**, 166601, 2002.) —BPS

► **ATOMIC-RESOLUTION STRUCTURE** of thin films and interfaces has been directly determined using a new x-ray diffraction technique. Coherent Bragg rod analysis (COBRA) was developed by a multi-institutional team and has now been applied to a gadolinium oxide ( $\text{Gd}_2\text{O}_3$ ) film grown on a gallium arsenide (GaAs) substrate. The diffraction patterns consist of coherent contributions from the substrate and the film. COBRA provides both the amplitude and the phase of the complex scattering factors, which in turn yield a three-dimensional image of the film and interface structure at subangstrom



resolution. Shown here are (left) the eighth GaAs monolayer beneath the interface and (right) the

ninth  $\text{Gd}_2\text{O}_3$  monolayer above the interface. The physicists discovered that the first layers of Gd atoms are displaced in order to lock in to the positions of the GaAs. Moreover, the  $\text{Gd}_2\text{O}_3$  layers do not stack up as in bulk  $\text{Gd}_2\text{O}_3$ , but rather continue to conform to the substrate. Yizhak Yacoby says that the COBRA technique is very general and can even be used on films made with large organic molecules. (Y. Yacoby et al., *Nat. Mater.* **1**, 99, 2002.) —SGB

► **A STRETCH-FIT TEMPLATE** for films of organic and inorganic molecules. Many biological processes, such as bone formation, require hard inorganic materials to grow on a soft macromolecular substrate, although precisely how the two mesh has been something of a mystery. To examine that issue, physicists at Northwestern University floated a two-dimensional array of a fatty acid (a Langmuir monolayer) on a supersaturated solution of barium fluoride ( $\text{BaF}_2$ ), which then crystallized at the interface. Separately, the two lattices are incommensurate. Using x-ray diffraction, the researchers observed that both lattices adapted in order to register with each other. The lattice of the  $\text{BaF}_2$  thin film contracted by a few percent and the organic lattice expanded by tilting the molecules. The result was that the facial areas of the unit cells fell into a commensurate ratio of 1.5.  $\text{BaF}_2$  is not a biologically important mineral, but Pulak Dutta says he and his fellow group members expect to look directly at biomineralization in an upcoming phase of their work. (J. Kmetko et al., *Phys. Rev. Lett.* **89**, 186102, 2002.) —PFS ■