elsewhere. The effect is to blur the electron-density distribution in the 6D unit cell. The intrinsic disorder creates ambiguities that, despite the huge data set, prevent the unique assignment of every atom to its own specific site.

Takakura and company therefore had to interpret their recent diffraction data in concert with a model based on what are called approximants, crystalline phases whose compositions vary ever so slightly from the quasicrystal but whose structures are periodic and well known. Comparing the structures of the cubic approximants $YbCd_6$ and $Yb_{13}Cd_{76}$ with the reconstructed electron density of the quasicrystal, the team realized that the largest common building block for the approximants, a rhombic triacontahedron (RTH) decorated by 92 Cd atoms on its edges and vertices, also makes up the bulk of $YbCd_{5.7}$ (see the figure on page 24).

Like a nested set of Russian dolls, four subshells fit concentrically inside the RTH. The oddball among them is the four-sided tetrahedron, whose symmetry breaks the otherwise fivefold icosahedral symmetry of the rest of the lattice. The tetrahedron's Cd atoms are likely to rotate among several symmetry-equivalent orientations, as they do in the $YbCd_6$ approximant when temperatures rise above 100 K.

Only two other geometrical motifs are required to reconstruct the quasicrystal lattice: acute and obtuse rhombohedra that link the RTH clusters together. One can liken the researchers' approach to assembling the pieces of a puzzle in which every atom is assigned a plausible position. The x-ray data confirm the model's prescription of where Yb and Cd reside within the various clusters and reveal the packing and distribution of those clusters in the lattice.

The 3D slab pictured here represents a finite part of their solution. The cogwheel complex, the stellate polyhedron, and their fragments illustrate the rich variety of shapes that can form locally from particular arrangements of acute and obtuse rhombohedra.

A strength of the model, according to Carnegie Mellon University's Michael Widom, lies in its flexibility: Though deterministic, the model accounts for certain degrees of freedom in the arrangement of building blocks while the linkages between clusters are preserved. Clusters may dynamically and subtly flip from one configuration to another. It remains unclear to what extent quasicrystals are stabilized by adopting an ideal, deterministic arrangement of clusters that minimizes the system's energy or by adopting an ensemble of arrangements that maximizes its entropy. But one can now ask whether the new structural elements found in the quasiperiodic phase provide any energetic dividend. That would be a step toward answering an even more fundamental question than Bak's: Why should quasicrystals form at all?

Mark Wilson

References

1. P. Bak, *Phys. Rev. Lett.* **56**, 861 (1986).
2. W. Steurer, *J. Non-Cryst. Solids* **334**, 137 (2004).
3. H. Takakura, C. P. Gómez, A. Yamamoto, M. de Boissieu, A. P. Tsai, *Nat. Mater.* **6**, 58 (2007).

to chaos. They discovered that integrated optics show intrinsically nonlinear dynamics but that the nonlinear behavior is remarkably stable over the life of the chip and reproducible from one batch of chips to another. Thus, according to Yousefi, far from being a problem, the dynamics can be exploited to optimize the integrated photonic circuits. (M. Yousefi et al., *Phys. Rev. Lett.* **98**, 044101, 2007.) —PFS

Treating industrial wastewater with solar energy. In the so-called Fenton reaction, an iron cation, Fe(II), gets oxidized to Fe(III), while hydrogen peroxide (H_2O_2) gets reduced to OH^- and the hydroxyl radical $HO^\bullet$, which reacts with a great many organic substances. In water, the Fe(III) eventually converts back to Fe(II), and the process can begin again. Although chemically very efficient at removing organic pollutants from water, the Fenton reaction requires UV or visible radiation (below 400 nm) to efficiently reconvert Fe(III) to Fe(II) in the last step. A team of researchers in Brazil, led by Claudio Nascimento of the University of São Paulo, has now explored the feasibility of using sunlight instead of expensive UV lamps to expedite that crucial step in the process. Using demonstration reactors, such as the parabolic-trough reactor shown here, the scientists ran a series of

experiments, typically for several hours in the afternoon under various sky conditions. They found that in the photo-Fenton process, sunlight worked effectively at degrading various pollutants, including silicone polymers from the textile industry, pesticides, phenols, and hydrocarbons. Overall, no new pollutants are created, residual Fe(III) can be precipitated as iron hydroxide, and residual H_2O_2 spontaneously decomposes into water and molecular oxygen. (C. A. O. Nascimento et al., *ASME J. Sol. Energy Eng.* **129**, 45, 2007.) —SGB

A step toward tomography of protons. In medical tomography, a planar slice of tissue is imaged and its three-dimensional structure is built up by stacking the planar views. By analogy, physicists at the Thomas Jefferson National Accelerator Facility in Virginia are attempting to image the quarks inside protons, one planar slice at a time, in momentum space. The probe is an intense beam of electrons and the target is liquid hydrogen. The physicists seek rare events called deeply virtual Compton scattering (DVCS) in which an incoming electron sends a virtual photon (a high-energy gamma ray) ahead of it. The virtual photon scatters from one of the elementary quarks in the proton and a real gamma ray re-emerges, leaving the target proton intact. Detection of the outgoing electron and photon provides information about the status of quarks inside the proton. For example, the probability of a quark's spatial position inside the proton, transverse to the direction of the virtual photon, can be related to the angle and energy of the outgoing gamma ray. In high-energy electron scattering, the square of the transferred four-momentum (Q^2) from electron to quark determines the spatial resolution. Beyond a certain point, however, a larger Q^2 does not provide greater resolving power because individual point-like quarks have no structure of their own. That the present experiment shows the scattering to be independent of Q^2 above about 2 GeV^2 is evidence that the technique is indeed imaging the distribution of the elementary quarks inside the proton. (C. Muñoz Camacho et al., *Phys. Rev. Lett.* **97**, 262002, 2006.) —PFS ■