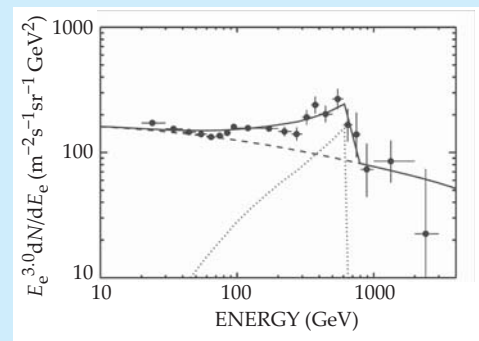


content for calibration, a neutron detector a few meters above the ground can give precise measurements of soil moisture on the time scale of minutes to a few hours. As the figure shows, the hourly soil moisture determined by a cosmic-ray neutron detector (top) agrees with that determined by time-domain reflectometry probes (middle) and with the monitored daily precipitation (bottom). (M. Zreda et al., *Geophys. Res. Lett.* **35**, L21402, 2008, doi:10.1029/2008GL035655.) —RJF

Signs of dark matter? Two groups of cosmic-ray observers have reported unexpectedly large fluxes of high-energy electrons and positrons. Those excesses suggest either that there are undiscovered astrophysical sources such as radio-quiet pulsars surprisingly nearby or that the positrons and electrons are annihilation products of WIMPs—weakly interacting dark-matter particles hundreds of times more massive than the proton. Standard cosmology predicts that dark non-baryonic matter dominates the material content of the cosmos. But its constituent particles have yet to be identified. The ATIC

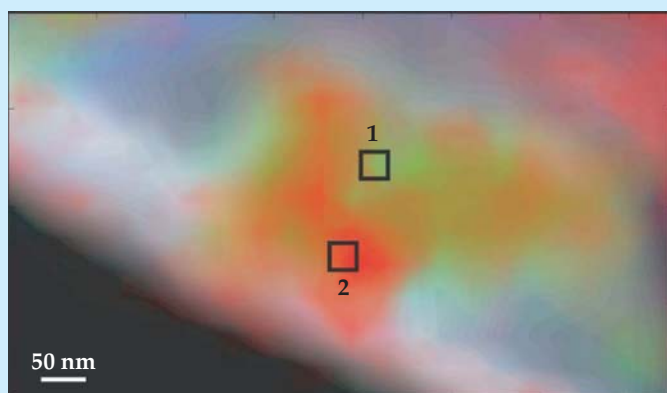


balloon collaboration, led by John Wefel of Louisiana State University, reports a significant enhancement in the spectrum of cosmic-ray electrons, peaking near 600 GeV (see the figure). The peak suggests that 600-GeV WIMPs of the kind predicted by extradimensional extensions of standard particle theory might be annihilating with each other to create e^+e^- pairs in very dense concentrations of dark matter not far from our solar system. The ATIC detector cannot distinguish positrons from the much more abundant cosmic-ray electrons. But the magnetic spectrometer aboard the orbiting PAMELA satellite can. Positrons are routinely produced in collisions between cosmic rays and ordinary interstellar matter. The ratio of such positrons to cosmic-ray electrons was expected to fall steeply with increasing energy. Instead, the PAMELA collaboration, led by Piergiorgio Picozza of the University of Rome "Tor Vergata," reports that the positron fraction grows steadily with energy from 10 GeV to 100 GeV. So it appears that there must be some additional source of high-energy positrons. The collaboration will continue taking data for at least another year, hoping to find spectral structure suggestive of WIMPs or anisotropy pointing to a nearby astrophysical source. Both WIMP annihilations and pulsars are expected to produce high-energy gamma rays. So for the moment, all eyes are on the recently launched Fermi Gamma-ray Space Telescope (originally called GLAST), which is designed to pinpoint gamma-ray sources and spectral features but can also confirm the ATIC electron result with higher statistics. (J. Chang et al., ATIC collaboration, *Nature* **456**, 362, 2008; O. Adriani et al., PAMELA collaboration, <http://arxiv.org/abs/0810.4995>.) —BMS

Ultrasound's role in wire bonding. In almost all integrated circuit chips, the wires that connect the internal circuitry to the external packaging are attached by a process called wire bonding. In that technique, ultrasound is used in combination with heat and pressure to weld the tip of the wire, usually gold, to the surfaces to be connected. It's been known for 40 years that ultra-

sound can make metals easier to work, an effect called acoustic softening. But the process of working the metal can have its own impact on the metal's hardness. Thus it's been difficult until now to get a clear picture of what's going on, and wire bonding has remained a largely empirical process. By placing gold microballs under different levels of applied force and ultrasound and measuring their resulting deformation, a team of researchers from the University of Waterloo in Canada and Tsinghua University in Beijing has succeeded in separating the softening contributions of the ultrasound from the effects of the mechanical force. The researchers were also able to quantify the residual effects of ultrasound on gold, and they found residual softening that increased with greater ultrasound amplitude above a certain threshold. They attribute the residual effects to the net balance between ultrasound's dynamic annealing and its potential opposing effect on activating and multiplying dislocations. (I. Lum et al., *J. Appl. Phys.*, in press.) —RJF

A catalyst caught in the act. Catalysts are ubiquitous in today's chemical industry, but there remains much to be learned about the specific mechanisms by which many of them work. Though such knowledge could lead to improved or new catalysts, obtaining atomic-scale information about in situ chemical changes in a hot environment at atmospheric pressure has presented a difficult challenge. A Dutch team led by Frank de Groot and Bert Weckhuysen of Utrecht University has recently demonstrated the potential of a new approach to imaging catalysts at work: scanning transmission x-ray microscopy. As a catalyst and reactants interact, the valence states and chemical bonding of the participating atoms evolve. STXM detects those changes by looking at the absorption of x rays by the atoms' inner electron shells. The researchers demonstrated the technique by looking at the iron-based catalyst for the Fischer-Tropsch process, in which hydrogen and carbon monoxide are converted to hydrocarbon chains. Soft x rays used in STXM are strongly attenuated in matter, so the research team used a nanoreactor of thickness 50 μm ; the reactor was connected to gas lines and mounted on an adapter that was scanned in 35-nm steps through the focus of a monochromatic x-ray beam. In that way, two-dimensional absorption maps at various x-ray energies could be recorded.



The researchers paid particular attention to energies near the absorption edges of carbon, oxygen, and iron. Analyzing the maps they obtained, the researchers could extract the carbon hybridization states and determine the extent to which the iron atoms, which started off in iron oxide, had been reduced, formed other oxides, or reacted with the silicon dioxide substrate or with carbon. The figure maps the distribution of the inferred iron compounds, each represented by a different color. With better optics and detection techniques, the team hopes to