

PHYSICS UPDATE

► **SONOLUMINESCENCE ENERGY** is mainly chemical, according to a new set of experiments at the University of Illinois. Yuri Didenko and Kenneth Suslick quantified the energy consumption during sonoluminescence, the conversion of ultrasonic waves into picosecond light pulses via rapid oscillations of bubbles in a liquid. They found that, during the compression phase, a bubble's interior gets hot enough to dissociate many gas molecules and initiate a furious session of chemical reactions. The researchers carefully monitored the reactant products—mostly nitrite ions (NO_2^-), hydroxyl radicals ($\text{OH}^\bullet$), and light—of a single bubble of air in a bath of water subjected to ultrasound. They found that about 100 times more energy goes into chemical reactions than into light. Their experimental conditions were very different from those used for the recent claim of “sonofusion” (see *PHYSICS TODAY*, April 2002, page 16), and thus their results may not apply to that claim. However, Dan Shapira and Michael Saltmarsh of Oak Ridge National Laboratory did duplicate the sonofusion conditions. They showed that the earlier coincidence data can be accounted for by random coincidences; they also placed an upper limit on the relevant neutron emission that is 10^4 less than that implied by the earlier claim. (Y. T. Didenko, K. S. Suslick, *Nature* **418**, 394, 2002. D. Shapira, M. Saltmarsh, *Phys. Rev. Lett.*, in press.) —PFS

► **THE ROLE OF THE NANOSCALE** in “artificial leaves” has been elucidated. Several semiconductor materials are known to catalyze the removal of excess airborne carbon dioxide in the presence of light and organic molecules, just like real leaves. For example, bulk surfaces of cadmium sulfide and zinc sulfide can photocatalytically fix CO_2 into an organic molecule. Cadmium selenide, however, can only accomplish that task in its Cd-rich nanocrystalline form. Three physicists at Oak Ridge National Laboratory and Vanderbilt University believe they have now found out why. In a series of parameter-free, first-principles calculations, they found that CO_2 is adsorbed only at Se vacancies and then becomes negatively charged and, potentially, more reactive. The CO_2 does not react on the surface; it needs to yank the extra electron out of the semiconductor, desorb, and become incorporated into another molecule elsewhere. For this scenario to occur, the extra electron must first be excited into the semiconductor's conduction band, for example by shining light on it. Still, the energy cost is too high for the charged CO_2 to desorb from bulk CdSe. Enter the nanoscale. As a nanocrystal's size decreases, its energy gap increases. Thus, electrons can flow freely to desorbing CO_2 molecules if the CdSe crystal is small enough. As a bonus, the theorists found that *n*-doping with indium might allow

CO_2 fixation to take place without the need for light. (L. J. Wang, S. J. Pennycook, S. T. Pantelides, *Phys. Rev. Lett.* **89**, 075506, 2002.) —SGB

► **NANOTUBE DIAGNOSTIC X RAYS.** The design of the x-ray tubes used in many medical and dental offices is essentially unchanged from a hundred years ago. A metal filament, the cathode, emits electrons when heated to more than 1000°C . The electrons are accelerated across a vacuum tube into a target, where they generate x rays. Now, a team of physicists and doctors at the University of North Carolina at Chapel Hill and the nearby firm of Applied Nanotechnologies Inc has created an x-ray tube using a room-temperature array of carbon nanotubes in a field-emission triode. They demonstrated a sufficiently large and stable current for practical medical imaging, as shown here by the x ray of a fish. According to the researchers, the device can be much smaller, is expected to last longer, and can produce a more focused x-ray beam than the hot-cathode design. In addition, the response time is sharper and the pulse shape and timing can be programmed, all of which help in the tracking of moving objects. (G. Z. Yue et al., *Appl. Phys. Lett.* **81**, 355, 2002.) —PFS



► **SPIRAL ARMS, COSMIC RAYS, AND ICE AGES.** Most cosmic rays (CRs) are thought to originate in supernovae, and most supernovae occur in the wake of galactic spiral density waves. Nir Shaviv of the University of Toronto and Jerusalem's Hebrew University has developed a new CR diffusion model that includes the presence of arms. Not surprisingly, he found that the CR flux at Earth would vary with time and be correlated with our Solar System's passage through galactic spiral arms as we circumnavigate the Milky Way. He then looked at a historical record of CR flux, in the form of 42 age-dated iron meteorites whose exposures to CRs could be determined. He found a periodicity of 143 million years in the CR flux, which he attributes to passages through spiral arms. On the assumption that CRs ionize Earth's lower atmosphere and can thus influence climate, Shaviv next looked at the geologic record for ice ages and found “a compelling correlation” of both period and phase between CR flux and glaciation epochs during the past billion years. Between 1 and 2 billion years ago, there is no evidence for any ice age, consistent with a slowed star-formation rate during that period of our galaxy's history. Shaviv says that the weakest link in his analysis is the uncertainties in the glaciological record. (N. J. Shaviv, *Phys. Rev. Lett.* **89**, 051102, 2002.) —JRR