Physics Update

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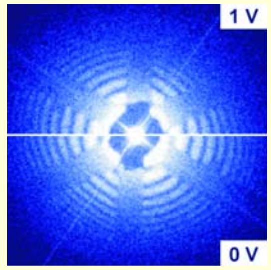
Zooming in on enzyme kinetics. An enzyme is a biological catalyst: It binds to a substrate, the resulting complex forms a biologically relevant product, and the enzyme is then regenerated to do its job all over again. In bulk, the ensemble-averaged kinetics of that process was well characterized back in 1913 by the Michaelis–Menten equation. Taught to medical students ever since, the MM equation serves as a role model for quantitative biology. A Harvard University group led by Sunney Xie has now explored the equation's microscopic underpinnings. The researchers tethered a single bacterial enzyme (β-galactosidase, essential for using sugar) and recorded waiting times between individual product molecules of the catalyzed reaction, each product giving a burst of fluorescence. Xie and coworkers found that at high substrate concentrations, short waiting times tend to be followed by short ones, and long by long. Those results revealed that the enzyme molecule is a dynamic entity with large fluctuations of its activity rate due to conformational (molecular shape) fluctuations at a broad range of time scales. Somewhat surprisingly, the MM equation still holds at the single-molecule level but with a new interpretation: Its apparent rate constant is an average over the ever-fluctuating conformations, otherwise hidden in previous experiments done on large ensembles of molecules. (B. P. English et al., *Nat. Chem. Biol.* **2**, 87, 2006.) —SGB

A new gravity-driven ionospheric current has been identified. The Sun's ultraviolet radiation ionizes the top of Earth's atmosphere and thus creates the ionosphere. At the highest altitudes, the ionosphere has few neutral atoms and behaves much like a collisionless space plasma in which the electrons and ions spiral around Earth's magnetic field lines. At low latitudes, where those lines are almost horizontal, electrons and ions should drift in opposite directions under gravity's influence, setting up an eastward-flowing electric current that is perpendicular to both the magnetic and gravitational fields. Observational evidence for such a current system has now been found by Stefan Maus (National Oceanic and Atmospheric Administration in Boulder) and Hermann Lühr (Georesearch Center in Potsdam, Germany), using data from Germany's *CHAMP* satellite. From the tiny magnetic signature in the data, the geophysicists have determined that the current spans more than 60° of latitude across the equator and, in total, adds up to more than 50 kA. (S. Maus, H. Lühr, *Geophys. Res. Lett.* **33**, L02812, 2006.) —SGB

Phase contrast imaging with a transmission electron microscope (TEM). Physicists in Germany have taken a crucial step toward achieving higher-resolution images of biological samples and other "weak phase" objects typically made of low-weight elements like hydrogen, carbon, nitrogen, and oxygen. In a TEM, most of the electrons pass through the thin electron-transparent sample without scattering; those that are scattered have their phase shifted. Scattered and unscattered electron waves are then focused and recombined into an image. Unfortunately, for weak-phase objects the phase shifting is slight and results in poor contrast. Scientists at the University of Karlsruhe and the Max Planck Institute of Biophysics in Frankfurt have fabricated a special microstructured electrostatic lens. When placed in the objective lens's back focal plane and with a voltage applied, the lens shifts the phase of the unscattered wave by 90°, as shown in the diffractogram, but leaves the scattered wave unshifted. The lens is called a Boersch phase plate in honor of Hans Boersch, who proposed the technique in 1947. (K. Schultheiss et al., *Rev. Sci. Instrum.* **77**, 033701, 2006.) —PFS



Traveling with dollars. A trio of theoretical physicists from the Max Planck Institute for Dynamics and Self-Organization in Göttingen, Germany, and the University of California at Santa Barbara analyzed human travel movements using dollar bills as a proxy. With data on the travels of almost a half-million dollar bills within the continental US, the researchers discovered that the movement of dollar bills resembles superdiffusive motion with a power-law distribution reminiscent of Lévy flights (see "Beyond Brownian Motion," PHYSICS TODAY, February 1996, page 33), but attenuated by long waiting times. With such a mathematical formalism in hand, the spread of human infectious diseases may now be open to a new kind of quantitative analysis. (D. Brockmann, L. Hufnagel, T. Geisel, *Nature* **439**, 462, 2006.) —SGB

Optical discrete surface solitons seen. Nonlinear optical surface waves between two dielectrics have been extensively studied theoretically, but their experimental realization has proven to be difficult. In recent years, however, periodic systems of optically nonlinear materials have enabled the observation of many new phenomena. A multinational team led by the CREOL soliton group at the University of Central Florida now reports the observation of discrete optical surface solitons along the interface between an array of coupled nonlinear optical waveguides and a continuous medium. The soliton power is controlled by the change in propagation constants between the parallel waveguides and the continuous region, and by the coupling strength between adjacent waveguides. Such solitons could prove useful in all-optical circuits. (S. Suntsov et al., *Phys. Rev. Lett.* **96**, 063901, 2006.) —SGB ■