Physics Update

NONCONTACT FRICTION can be enhanced by photon tunneling. Usually, two bodies in relative motion feel friction when the respective surface atoms are in contact. In contrast, noncontact friction is similar to the van der Waals force, a common but weak attractive force that arises when an atom or molecule spontaneously develops an electric dipole moment due to a thermal or quantum fluctuation. The short-lived atomic polarity can induce a dipole moment in a neighboring atom or molecule some distance away. A new study of van der Waals friction by theorists Alexander Volokitin and Bo Persson of the Institute of Solid-State Research at Germany's Research Center Jülich found that when surfaces are separated by about 1 nm, the van der Waals friction can be greatly enhanced in three ways. First, they found that the friction increases a 100-fold or more when two clean conducting surfaces move toward or away from each other rather than in parallel relative motion. The other two effects involve resonant photon tunneling. For semiconductor surfaces, photon tunneling can generate surface plasmons whose interaction can increase the noncontact friction by several orders of magnitude. And resonant tunneling between vibrational modes of adsorbate atoms on otherwise clean conducting surfaces can enhance the van der Waals friction over that of the clean surfaces alone. The adsorbate atoms act like tiny antennas: When the emitters and receivers are in tune, their electromagnetic interaction is greatly enhanced. The researchers' calculation showed a seven-orders-of-magnitude enhancement for this effect, consistent with previously unexplainable experimental results with scanning tunneling microscope probes. (A. I. Volokitin, B. N. J. Persson, *Phys. Rev. Lett.* **91**, 106101, 2003.) —PFS

A SPINLESS BOSE–EINSTEIN CONDENSATE, insensitive to external magnetic fields, has been created. Researchers at Kyoto University made their BEC with ytterbium-174, a rare-earth element with two valence electrons. The physicists used light beams to trap approximately 1 million Yb atoms in the singlet state, in which the valence electrons' spins point in opposite directions. The hotter atoms evaporated, leaving a gas cloud of about 5000 atoms that formed a magnetically unresponsive BEC at temperatures below 790 nK. The spinless BEC may be useful for precise atomic deposition and atom interferometry. Also, the heavy mass of Yb makes it desirable for studying certain fundamental physics effects, such as atomic parity violation and time symmetry violation. Moreover, the many stable isotopes of Yb (five are bosons, two are fermions) raise the possibility of creating a BEC and a Fermi degenerate gas in the same cloud. (Y. Takasu et al., *Phys. Rev. Lett.* **91**, 040404, 2003.) —BPS

VIBRATIONS HELP A FROG LOCATE TASTY PREY. Living in southern Africa, the aquatic clawed frog *Xenopus laevis laevis* finds insects by localizing their vibrations on the water's surface. Hunting at night and unable to see well, the frog gets a wealth of information from about 180 sensory organs (the white "stitches" in the photo, collectively called the lateral-line system) on its skin. As an insect sloshes around, the moving water triggers signals in hair cells attached to the organs.

Now, a group of researchers in Germany, led by Leo van Hemmen (Technical University of Munich), have developed a simple model, with a minimal set of assumptions, that explains how the lateral-line system works. Strikingly, the model suggests that the frog can both reconstruct the waveform of the water disturbance and determine its direction. The model thus explains the frog's ability to distinguish between two different water disturbances coming simultaneously from insects—one of which might be inedible—in different directions. The model also agrees with experiment in showing that the sensory system can operate even if some of the lateral-line organs do not function properly. The researchers' model may also be applicable to the mechanosensory systems of other animals, such as fish and crocodiles, which have similar receptor organs (J.-M. P. Franosch et al., *Phys. Rev. Lett.* **91**, 158101, 2003.) —BPS

HIGH-PRESSURE PHOSPHOROUS could be useful for spintronics. Found in teeth and bones as well as in fertilizers and DNA, phosphorus is an insulator at room temperature. However, at very high pressures, a series of phase transitions occur. At 10 GPa, phosphorous becomes metallic and can superconduct at about 10 K. At 262 GPa, it takes on a body-centered-cubic (bcc) crystal structure. Now, Sergey Ostanin of the University of Warwick in the UK and his colleagues have studied the high-pressure phase diagram of phosphorous, and calculated that the bcc crystals achieve superconductivity at slightly higher temperatures, somewhere around 20 K. Furthermore, they found that the bcc phase might be stabilized in thin films grown at ambient pressure on some other bcc material. Such a phosphorous film, perhaps sandwiched between films of iron, might be very useful in spintronics applications. For example, a superconducting spin switch could flip-flop from superconductor to regular conductor depending on the spin state of the iron films. (S. Ostanin et al., *Phys. Rev. Lett.* **91**, 087002, 2003.) —BPS