figure 1. The liquid sample (methanol) was placed between two sets of Helmholtz coils, which produced a 260-μT field, $\mathbf{B}_r$, rotating at 9.6-kHz in the xy plane (with oscillating components B_{rx} and B_{ry}). A second set of coils on top of the B_{ry} coils produced a 3.3-μT static precession field B_p in the y-direction, which was used to measure the resulting spin polarization. No stationary field was applied in the z-direction. The SQUID was immersed in liquid helium-4 at 4.2 K while the sample, insulated in its double-walled glass insert, was kept at room temperature by heating coils. The entire apparatus was shielded from ambient magnetic fields so that the residual field was 0.24 μT.

Any magnetization induced by $\mathbf{B}_r$ is expected to persist after $\mathbf{B}_r$ is turned off, because the relaxation time of nuclear spins in the liquid is long, on the order of 1 second. The relaxation time was much shorter than 1 second in the 1957 Columbia experiment on electrons.

Once $\mathbf{B}_r$ was turned off, the static precession field B_p was turned on, causing the induced magnetization vector to precess around the y-axis. The SQUID recorded the resulting variations in flux through its pickup coils. With time, the amplitude of those variations decreased due to the decay of the magnetization.

Figure 2a shows the magnetization induced in the protons of the methanol as a function of the time that the rotating field is left on. The magnetization saturates with a time constant (350 ms in this case) that is not very different from the longitudinal relaxation time for the protons in the liquid. Figure 2b shows $\mu_0 M$ as a function of the strength of the rotating field. The solid curve is not a fit to the data but is calculated from the modified Bloch equations with no fitting parameters.

Possible applications

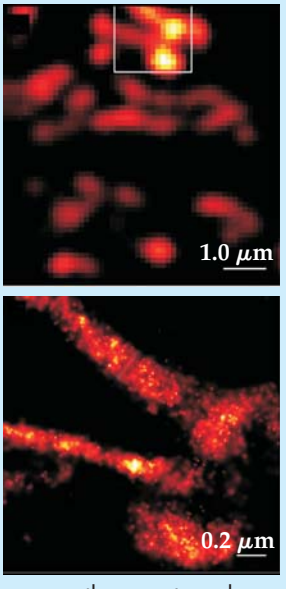
The magnetizations produced are extremely small, and the measurements are quite daunting. Nevertheless, the Berkeley researchers still mention one possible application in their paper, and have tested for it. They point out that polarizing nuclei with a rotating field might be particularly advantageous for NMR measurements on a liquid in the presence of magnetic materials. As an example from the field of geochemistry, one could determine the diffusion rate of water in iron-containing rocks by measuring spin echoes on the induced proton polarization. In turn, the diffusion rate provides information on the porosity of the rock, which is of considerable interest in evaluating potential oil wells. The rotating-field technique helps avoid complications of time-dependent, inhomogeneous fields due to remanent magnetization of the rock.

physics update

Supplementary material related to these items can be found at www.physicstoday.org.

Dune tunes. World travelers, including Marco Polo and Charles Darwin, have occasionally come across sand dunes that issue loud sounds, sometimes of great tonal quality. Now, a team of scientists has proven that the sounds come not from some musical resonance such as vibrations of the dune as a whole, but rather from the relative motions of sand grains in avalanches larger than a critical size. Using field studies and controlled experiments, the scientists—from the University of Paris VII (France), Harvard (US), the CNRS (France), and the University Ibn Zohr (Morocco)—also found that the grains couple into synchronized layers that vibrate like a musical instrument's soundboard, creating a pressure wave. It takes only a few layers to generate the observed acoustic power of about 110 dB. The mechanical coupling depends crucially on the grains' surfaces, which in singing dunes were found to have a silica gel coating known as desert glaze. The online version of this update item has links to sound files. (S. Douady et al., *Phys. Rev. Lett.* **97**, 018002, 2006.) —PFS

Optical molecular microscopy. In recent years, several techniques have been developed to beat the diffraction limit for optical microscopy. Two independent teams of researchers have now developed another diffraction-beating technique, based on a workhorse of modern cell biology—a fluorescing molecule, or fluorophore, that can be made to attach to a variety of targets in a cell. In the new technique, the fluorophores are photo-switchable; when dimly and briefly illuminated at an appropriate wavelength, only a few in the field of view are activated at any one time. The brightest ones can then be localized to within a few nanometers. By repeatedly imaging the same area and adding up many such sparse images, researchers build a composite that displays the entire field of view with near-molecular resolution. A group led by Eric Betzig (Howard Hughes Medical Institute [HHMI], Janelia Farm Research Campus, in Ashburn, Virginia) and Harald Hess (NuQuest Research LLC in La Jolla, California) calls the technique PALM, for photoactivated localization microscopy. A PALM image can be acquired in 2–12 hours. Shown here is a standard fluorescence microscopy image (top) of mitochondria in a frozen thin slice of a cell; the boxed area is enlarged in the PALM image below, in which more than 5500 molecules were localized. Meanwhile, a group led by Xiaowei Zhuang (Harvard and HHMI) calls the technique STORM, for stochastic optical reconstruction microscopy, and acquires complete images in minutes. Zhuang's group uses fewer molecules than the other group but still resolves 10–20 of them within a normally unresolvable area. An additional complication Zhuang's group solved involves using a fluorophore that can be switched on and off hundreds of times. (E. Betzig et al., *Science*, DOI:10.1126/science.1127344, 2006; M. J. Rust et al., *Nature Methods*, DOI:10.1038/nmeth929, 2006.) —SGB



A BEC magnetometer. Physicists at the University of Heidelberg have used a highly elongated Bose–Einstein condensate as a sensitive probe of the magnetic field emanating from a nearby sample. Where the field is weaker, more atoms within the BEC pile up in the trap, which hovers just a few microns from the surface under study. The density of atoms in the BEC can thus be converted into a map of the field at the sample surface. The sensi-