Physics Tip Sheet #39 - November 17, 2003

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Highlights of this tip sheet include a material necessary for ultra-dense data storage, snail neurons on a chip, the connection between ice crystals and proteins, the effect of air bubbles on the speed of sound in water, and magnetic tweezers.

1) Ultra-dense data storage from ultra-smooth carbon films
C. Casiraghi et al.
Physical Review Letters (to appear)

Ultra-smooth diamond-like carbon can provide the nanometer-thin corrosion protection layer necessary for ultra-high density magnetic storage devices, report the authors of this paper. As magnetic hard drives increase in density, they need ever-thinner protective carbon films, which must be must be continuous, dense, and free of holes. Until now it was not known whether any material could meet these requirements. The authors demonstrate that the diamond-like carbon, known as tetrahedral amorphous carbon, has the needed smoothness. It could be useful for other applications as well, as it maintains its ultra-smoothness with increasing thickness, unlike other known materials, which get rougher as they get thicker. The paper also develops a theoretical model that shows that the material's extreme smoothness arises from the process of growing the films, in which heat from ions deposited on the surface dissipates, melting and flattening the surface.

Journal article: Available to journalists on request

2) Pond snail brains on a chip
R. Kaul, N. Syed, and P. Fromherz
Physical Review Letters (to appear)

Researchers have used live pond snail nerve cells to implement a basic element of neural memory on a semiconductor chip. The team isolated two neurons from a pond snail and placed them on a silicon chip. They electrically stimulated one cell with a microcapacitor on the chip and recorded the signal transmitted to the other neuron. Repeatedly stimulating the first cell increased the strength of the connection between the cells, just as neurons in the brain strengthen their connections as part of learning and memory formation. The chip may find uses in brain research and drug development, and may eventually lead to neurocomputers with living nerve cells or microchips that could be implanted in the brain for medical prosthetics.

Journal article: Available to journalists on request

3) What do ice crystals in Greenland have in common with the building blocks of proteins?
J. Ferkinghoff-Borg et al.
Physical Review Letters (to appear)

The size of ice crystals in the Greenland ice sheet and the length of alpha-helices in proteins, two seemingly very different phenomena, are actually both incidences of the same physical processes of diffusion and fragmentation, according to a new paper. Structures like crystals and the building blocks of proteins gradually grow and shrink randomly due to diffusion, which tends to make the largest chunks even larger.

But these structures may break abruptly due to stresses. Combining these two competing processes, the authors derive an equation for the size distribution of fragments, and show that it fits experimental data for both of these very different systems. Many other natural phenomena could also be described by the same processes.

Journal article: Available to journalists on request

4) Air bubbles slow sound waves in water.
A. Krokhin, J. Arriaga, and L. Gumen
Physical Review Letters (to appear)

The speed of sound in water drops sharply with inclusion of just a few small air bubbles, according to a new calculation. Being able to calculate the speed of sound in air-water mixtures is critical for meteorology, oceanography, and air and sea navigation. The paper derives the first exact formula for the speed of sound in any mixture of air and water. Previously only approximations were available, which were inaccurate at higher concentrations of air. In pure water, sound travels about five times as fast as it does in pure air. Just a small amount of air added to water dramatically slows sound waves. But when the air bubbles get big enough to touch each other, sound can propagate through them, and the speed rises somewhat. For the reverse situation of water droplets in air, the water does not play a significant role in sound speed, which explains why we can communicate with sound in rainy weather.

Journal article: Available to journalists on request

5) Magnetic tweezers
L. Helseth, T. Fischer, and T. Johansen
Physical Review Letters (print issue 14 November 2003)

A new kind of "magnetic tweezers" can manipulate single magnetic microparticles with micrometer precision. The authors created a domain wall tip-- a sliver with different magnetization from the surrounding area-- in a thin garnet film by introducing a stress point at the edge of the film. By controlling the tip with an external magnetic field, they can push or pull individual magnetic particles. This technique could be useful in probing and manipulating magnetic structures.

Journal article: http://link.aps.org/abstract/PRL/v91/e208302

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