Physics

Fast sound in liquid and gas mixtures

The atoms or molecules that make up a gas or liquid are in constant motion. Often, the motion of one particle influences its neighbors, producing large-scale collective motions in which particles behave in a coordinated fashion. In 1986, on the basis of a computer model, Jürgen Bosse of the Freie Universität Berlin and his colleagues predicted that a liquid consisting of two components — one made up of lightweight particles and the other of heavy particles — would have a special collective motion that travels through the mixture like a sound wave but at a speed several times faster than that of ordinary sound in the mixture. They dubbed this novel type of internal motion "fast sound."

Now, researchers at the University of Amsterdam in the Netherlands have detected fast sound in a hydrogen-argon gas mixture. Their results, reported in the Dec. 18 PHYSICAL REVIEW LETTERS, agree well with a computer model extending the analysis from two-component liquids to gas mixtures. "The agreement between computed and experimental results is very good," says E.G.D. Cohen, who devised the computer model with Alessandro Campa at the Rockefeller University in New York City.

However, the details of how the constituent particles carry this type of motion are not yet completely understood. The heavy and light components in the mixture apparently behave somewhat independently, and only the light particles carry the fast sound. Indeed, fast sound travels at roughly the same speed at which ordinary sound would travel through a sample consisting only of the light gas. At the same time, because this type of motion dies out more quickly than an ordinary sound wave would, the heavy particles must exert some influence.

"How the separation of these two phenomena takes place, I don't know," Cohen says. "It's far from clear how this whole thing works."

Recently, Maynard J. Clouter and his colleagues at Memorial University in St. John's, Newfoundland, added another twist to the fast-sound puzzle. By observing a number of different two-component gas mixtures, they discovered that heavy particles in a mixture can also have a special collective motion — "slow sound" — that is detectable even in the presence of fairly large concentrations of the lighter component. "Now we require some direction from the theorists," Clouter says.

A gyroscope's gravity-defying feat

Two Japanese scientists have conducted an experiment suggesting that under certain circumstances a spinning gyroscope may partially counter the Earth's gravitational pull. Their startling results, published in the Dec. 18 PHYSICAL REVIEW LETTERS, show that a small gyroscope spinning in one direction suffers a weight decrease of a few milligrams, with the weight loss increasing as the spin rate increases. In contrast, a gyroscope spinning in the opposite direction loses no weight. "The experimental result cannot be explained by the usual theories," conclude Hideo Hayasaka and Sakae Takeuchi of Tohoku University in Sendai.

Physicists who have seen the report express skepticism. Although the experiment, as described in the report, appears to have no obvious sources of experimental error, most experts say they expect that intense scrutiny and attempts to replicate the experiment will show the results to be incorrect.

"I looked at it carefully because it's very puzzling," says Eric G. Adelberger of the University of Washington in Seattle. "I can't see any particular thing that they didn't do or that they did wrong, but there are things that suggest there is something clearly wrong." For one, he notes, the way in which the weight loss depends on the spin direction is unlike any other known physical effect.

Technology

Storing data in 1,000 points of light

When chemist Tuan Vo-Dinh of Oak Ridge (Tenn.) National Laboratory began work on a new soil analysis system for the Environmental Protection Agency, he had no idea that the underlying principle, known as Raman scattering, held potential for an innovative optical data storage technology.

Typical compact disks store a binary code of ones and zeros as microscopic pits and valleys. A detector distinguishes laser light reflected from the contrasting surface features. Vo-Dinh now proposes an alternative storage approach, which he calls surface-enhanced Raman optical data storage (SERODS).

In the 1920s, physicist C.V. Raman discovered that the wavelengths of some of the light scattering from certain molecules differ from the wavelength of the light source, and that these differences carry information about the molecules' structures and abundances. Later, scientists observed that placing molecules close to certain surfaces such as silver enhances the Raman scattering effect, which otherwise is extremely subtle and difficult to detect. Extrapolating from his design of a soil analysis system using the enhanced effect, Vo-Dinh came up with the novel data storage approach. By coating a disk material such as silicon oxide with a film of silver and then with a layer of Raman-active molecules, Vo-Dinh can use a fine laser beam to induce specific microregions of the disk to produce distinctive Raman signals that serve as identifiable data bits. In a working SERODS system, ones and zeros would correspond to altered and unaltered microregions of the disk, respectively. Vo-Dinh's rough calculations predict that an optimized 12-inch SERODS disk could store 1 trillion letters — well over 100,000 years' worth of SCIENCE NEWS.

Preliminary tests show that no more than 1,000 molecules are needed to represent 1 data bit, says M. Guven Yalcintas, director of technology transfer at Oak Ridge. But turning this concept into a working device will take long-term commitments by many companies, he adds.

Crowding memory into magnetic territory

Imagine cramming the information of a 20-volume encyclopedia into a single volume. A team of scientists and engineers at IBM's Almaden Research Center in San Jose, Calif., has achieved a comparable feat in magnetic data storage technology. By crowding 1 billion data bits — or 1 gigabit, equivalent to almost 1,000 issues of SCIENCE NEWS — onto a single square inch of disk surface, they claim to have made the world's most densely packed magnetic storage device.

Barry H. Schechtman, Almaden's manager of storage systems and technology, says this represents a 10- to 20-fold increase over the storage capacity of even next-generation magnetic hard disks. Commercial applications are several years away, he adds.

Increasing storage capacity requires either storing bits on tinier lots of a disk's real estate or improving the detection resolution of the head that reads the bits written on the disk. The IBM researchers pursued both tacks. A combination of precise fabrication methods and a specially composed magnetic cobalt alloy enabled them to store 158,000 bits in each inch-long segment of the 6,350 memory lanes in a radial inch. That amounts to 1,003,300,000 bits per square inch — too dense for reliable reading by conventional inductive heads, which detect data when magnetically stored bits passing underneath induce tiny electrical currents in them. Using methods common in the semiconductor industry, the IBM researchers microfabricated novel heads capable of nearly error-free reading of ultrasmall bits at rates that rank with those of today's fastest systems, they say. The heart of the head is a magnetoresistive nickel-iron alloy that responds swiftly to each bit's magnetic field by changing its electrical resistance.