does. The theory seems sound, but the fact that brown dwarfs are born faint and fade quickly makes them a tricky quarry. Even now, other astronomers are cautious about the Leicester group's claim, but many agree that some of the new candidates, at least, look like a good bet. "It's very promising," says spectroscopist Roberta Humphreys of the University of Minnesota.

If brown dwarfs were going to be found anywhere, the Pleiades—full of young stars, and relatively nearby—was a likely place. "People have been poking at the Pleiades for some time," says astronomer George Rieke of the University of Arizona, who has also been studying a small region of the cluster in the infrared. Using the UK Infrared Telescope at Mauna Kea in Hawaii, Jameson and his colleagues found that the cluster is dotted with faint, infrared-emitting objects. By measuring their brightness at a number of infrared wavelengths and using a model describing how the infrared "color" of young, low-mass stars varies with mass, the researchers found that 22 of the objects fell short of the lower mass cutoff for true stars, suggesting that they are brown dwarfs.

That wasn't conclusive, since young brown dwarfs are easy to confuse with old true stars—so the objects seen by Jameson's group might just be ancient stars outside of the Pleiades that happen to lie in the same line of sight. But by measuring the movement of the infrared sources across the night sky, the team showed that, like birds in a flock, they are moving along with stars in the Pleiades. "Their data are incredibly compelling," says Claia Bryja, a student in Humphreys' group at Minnesota who is looking for brown dwarfs in the older Hyades cluster.

Even so, the case isn't watertight, says Bryja, because the models that relate the color of a newborn star to its mass are riddled with unproven assumptions. "It's still very plausible that everybody's models are systematically off," she says. Given such uncertainties, brown dwarf hunters suspect that many of the 22 objects claimed by Jameson's group will turn out to be true stars, albeit puny ones. But even the skeptics remain excited about two of the sources, which the model puts at less than 0.04 solar masses. Given such low masses, Cambridge University astronomer Gerry Gilmore estimates that the chances that Jameson's team has discovered at least some brown dwarfs are "much better than 50:50."

Jameson hopes to improve the odds even more by analyzing complete infrared spectra for some of the sources. That should decrease the uncertainties in fitting the data to the model—and, he hopes, finally bear out astronomers' conviction that brown dwarfs do exist. Says Gilmore: "The sun exists, and the earth exists. It's ludicrous to propose that there's nothing in between."

–Peter Aldhous

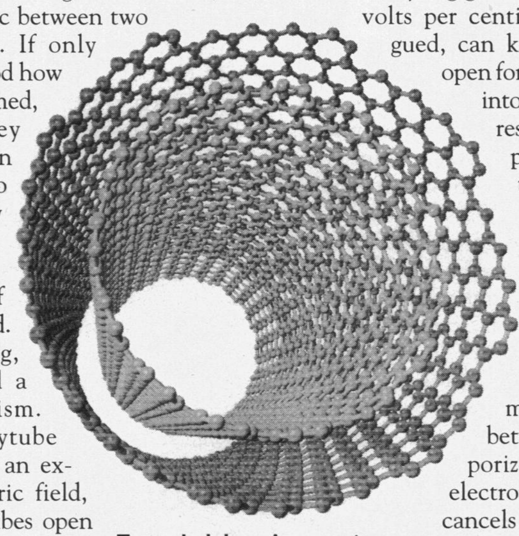
MEETING BRIEFS

Condensed Matter Physicists Shrink Their Horizons

In the world of the condensed matter physicist, a micron is a chasm and a millimeter an ocean. At the March American Physical Society meeting in Seattle, some of the 4500 physicists probed the hazards of the micro world, where weird quantum effects can scramble information. Others outlined its opportunities: Molecular engineering that is leading to new information storage materials, and minute structures that could form tethers and containers in some future nanotechnology.

How to Grow Buckytubes

Rice University physicist Richard Smalley dreams of making hollow carbon strands thin enough to mold a single file of atoms into a wire and so strong that, woven into a rope a few millimeters thick, they could hold up the Golden Gate Bridge. Why not? he asks: Last summer, without knowing just how, physicists at NEC Corp. in Japan formed just such strands—tiny, micron-long stubs of them, in any case—in the arc between two carbon electrodes. If only physicists understood how these structures formed, says Smalley, they might some day spin out "buckytubes" (so called because they are related to the soccerball-shaped carbon molecules) of any length they liked.


Tunnel vision. A computer simulation of two concentric buckytubes.

JOHN MINTMIRE, NAVAL RESEARCH LABORATORY

At the meeting, Smalley suggested a possible mechanism. The key to buckytube growth, he said, is an extremely high electric field, which holds the tubes open so that carbon atoms can accumulate on the outer edge. "It happens for the same reason that if you connect your head to a voltage source your hair stands on end," he says. Much like charged hair strands, carbon atoms at the end of the tubes get polarized by the field and feel a repulsion strong enough to counteract their tendency to bond together. Smalley suggested that the NEC workers who first created buckytubes may have done so by inadvertently creating much higher electric fields than they ever suspected. Still higher fields, Smalley thinks, might fertilize the growth of his dream buckytubes.

In speculating about buckytubes, Smalley was on familiar ground because he and other researchers discovered the prototypical material, buckyballs, in 1985. Buckyballs and buckytubes both form in an apparatus in which a carbon arc is enclosed in high-pressure helium gas. Both come from carbon atoms that vaporize from the graphite electrodes and link together into chicken-wire-like sheets that can roll up into balls or multilayered onions, or curl into tubes.

The tubes are the less stable of the two configurations, says Smalley: "Tubes fry into onions, so onions should be more stable than tubes." Only a gigantic electric field—10^{14} volts per centimeter—Smalley argued, can keep the membranes open for long enough to grow into tubes. True, the NEC researchers' voltage appeared to be a million times lower than that. But in a tiny region near one electrode, Smalley says, the electric field may have been higher than it seemed.

Across most of the millimeter-wide gap between electrodes, vaporized carbon ions and electrons move in a way that cancels out the electric field from the applied voltage, says Smalley. Only near the negative electrode does the voltage difference emerge, creating a powerful electric field over a distance of 100 nanometers. If this scenario is right, says Smalley, there might be other ways to set up a powerful electric field that would yield longer tubes.

Success could turn buckytubes from a laboratory curiosity to an exciting new material. Studies of the stubby buckytubes made so far show that they form virtually free of defects, giving them strength surpassing other known materials, says Massachusetts Institute of Technology physicist Mildred Dresselhaus: "They are strong because they are perfect." And then there's the prospect of exploiting the inner surfaces—perhaps to create tiny test tubes. NEC's Thomas Ebbesen points out that such devices could open up a whole world of tiny physics. Or the tube could serve as a mold for atomic-diameter metal wire. The NEC workers have already demonstrated the principle by filling their nanotubes with lead; drawn out to a length of centimeters, such a wire would have unbeatable thermal and electrical conductivity.

Smalley pictures such nanowires connecting atomic-scale electronic circuits as the world progresses toward the ultimate in miniaturization: "What a wonderful world of technology would open up if we could make the nanotubes of our dreams."

New Plastics, New Tricks

Once, capturing memories in plastic meant embedding a keepsake in lucite. But a team of IBM researchers think plastics are poised for new feats of recollection. At the Seattle meeting, the group announced a new data- and image-storing material that may have the potential, they say, to hold the *Encyclopaedia Britannica* in an object no larger than a dime.

The plastic does this by virtue of a property researchers have long hoped to create in a low-cost material. It's "photo-refractive," which means that laser light can create a lasting change in the refractive index of the material, as if a beam of sunshine could distort a windowpane. As a result, beams of light can "write" images on the material, much as holograms are written on credit cards—and, to boot, store hundreds of images in the same spot, at least in theory. The idea isn't new; scientists have explored high-density image storage in photorefractive crystals since the 1960s. But the crystals' high cost made them virtually unmarketable, says IBM physicist W.E. Moerner. The new material is about 100 times cheaper, and it may open the way to plastic data-storage chips or memory elements for optical computers.

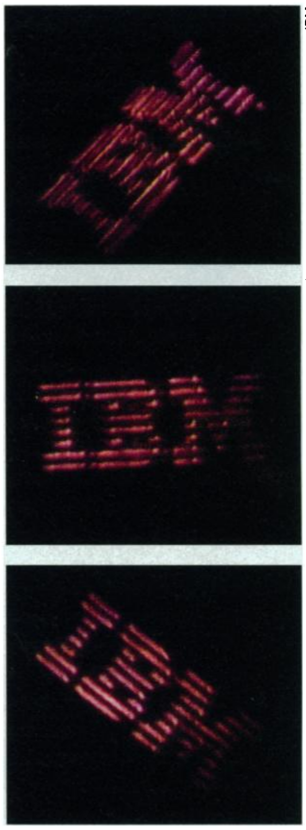
This research is heir to work done 2 years ago at IBM, where physicists created the first photorefractive plastics by experimenting with a variety of polymers, laced with impurities known as dopants. When the plastics were illuminated, the dopants released electrical charges that migrated, creating an electric field pattern that changed the plastic's optical properties. But because the photorefractive effect was weak, it took powerful light beams just to record a dim image.

The new IBM material—the acronym is PVK:F-DEANST:TNF—approaches the efficiency of inorganic crystals. "We made a tremendous step forward," said Moerner at a press conference at the meeting. The brightness of stored pictures beats that seen in earlier plastics by a factor of 100—an improvement so dramatic that images retrieved from the material can be seen by the naked eye.

Such images are stored when two "writing" light beams, one of them holding the image, the other blank, cross within the polymer. These two beams interfere with each other, creating a pattern of bright and dark areas that is recorded within the polymer as a pattern of varying refractive index. And because overlapping images can be stored at different angles, many images can occupy the same patch of material, says Moerner. Later, the different images can be retrieved by probing the material from different angles with a "reading" beam.

So far, the IBM researchers have stored just five or so images on the same piece of material. But with more tinkering, says Moerner, photo-refractive plastics may someday make a cheap and lightweight storage device for digital data—the stuff of computers—as well as images. Data could be stored in an array of dark and light bands or spots, and it could be read much faster than traditional magnetic discs because there would be no need to spin the photo-refractive material to get at the data.

Other researchers in the field, however, warn that we shouldn't expect plastic films to replace computer disks tomorrow. "It's an exciting accomplishment," says University of Arizona materials researcher Nasser Peygambarian. "But they have a long way to go." Before they go to market, he says, someone will have to figure out a faster system for writing the images. The polymer needs work as well, since over time the pattern imposed by the writing beam relaxes. "Successful materials will have to withstand millions of write/read cycles," agrees Moerner, without losing their memories or falling apart.



IBM

Three in one. Lighted from different angles, a single piece of "photo-refractive" plastic reveals three different images.

Upscale Quantum Mechanics

On the subatomic level, physicists have accustomed themselves to the seemingly impossible. It happens all the time: An electron seen on one side of a barrier, for example, suddenly pops up on the other side without ever passing through it—an effect known as "tunneling." In theory, at least, larger objects can also perform such atomic-scale magic, says physicist Eugene Chudnovsky of the City University of New York. You could walk through a wall, or a mountain could move, or the spins of all the electrons in your atoms could suddenly line up, turning your body into a magnet that would stick to a refrigerator. It's all allowed by quantum mechanics, but fantastically unlikely on a large scale.

But using some special tricks, physicists have just opened up a new terrain for quantum magic on an intermediate scale: Grains of magnetic material containing thousands of atoms each. At the meeting, David Awschalom of the University of California, Santa Barbara, showed how the magnetic grains can suddenly reverse orientation, like tiny bar magnets switching their poles.

Chudnovsky, for one, isn't surprised; as long ago as 1980 he had predicted that some weird tunneling effects could pop up, as he puts it, "on scales smaller than humans and larger than electrons." But finding particles of just the right size wasn't easy. In the end, Awschalom turned to microscopic magnetic proteins called ferritins, which come from the spleens of horses. To observe magnetic tunneling, he lined up 35,000 of these ferritin particles in an array, cooled then to near absolute zero and shielded them from Earth's magnetic field.

No one would notice if just one particle suddenly flipped its magnetic pole, nor would the effect show up if different particles flipped at different times. But the effect might emerge if the particles could be made to flip in unison, and Awschalom figured out how to apply a voltage at the right frequency to "drive" the system in phase. Even then the effect was minuscule—so tiny he could only measure it with superconducting devices known as Josephson junctions, which respond to tiny magnetic fields by losing their superconductivity.

The effect is more than a curiosity, says Awschalom. In theory, tunneling could make mischief with magnetic data storage systems, which store data in the magnetic direction of small magnetic particles. With today's magnetic disc drives and tapes, in which each bit of data covers a region of many individual magnetic domains, a few tunnelers wouldn't matter. But before the end of the decade, information storage may reach a scale at which tunneling is a threat.

Then again, says Awschalom, maybe this quantum magic can be put to use. In one scheme, information might be encoded not in a fixed magnetic direction but in the frequency of quantum tunneling. Says Awschalom, "We might be able to exploit this to make a new generation of devices."

–Faye Flam