to Mirkin offering to include him as a co-author on the paper. Schwartz says he received no response from Mirkin; Villa-Komaroff responded that he should not try to publish without Mirkin's input. She says Schwartz's decision to seek patents was "premature" and may have compromised Mirkin's intellectual property. The university "has a responsibility to help mediate" disputes such as this, she says, but not to resolve them.

After *Langmuir* accepted the paper in early March, Mirkin wrote to the journal's editor, David Whitten, arguing strongly against publication. Members of the Mirkin lab also sent letters backing Mirkin. Among other things, Mirkin wrote, publishing the paper would be unethical if it didn't include other lab members as co-authors. But, he added, simply including their names wouldn't solve what he considered the main problem with the paper: Mirkin and other lab members say they need more information to reproduce the results. Finally, Mirkin raised a legal issue: *Langmuir* "has tarnished my reputation by willfully sending this manuscript out to review … with only Schwartz's perspective," Mirkin wrote. Premature publication would also affect the group's intellectual property, said Mirkin, who urged *Langmuir* not to go ahead, "knowing that there is a significant and documented authorship issue as well as a major scientific problem."

Langmuir cancelled plans to publish the paper. After getting legal advice, ACS's director of publishing operations, Mary Scanlan, wrote to Whitten that the society "cannot publish the manuscript … until the matter of authorship is resolved," and that "it is not the function of the ACS to act to resolve authorship disputes." Whitten could not be reached for comment.

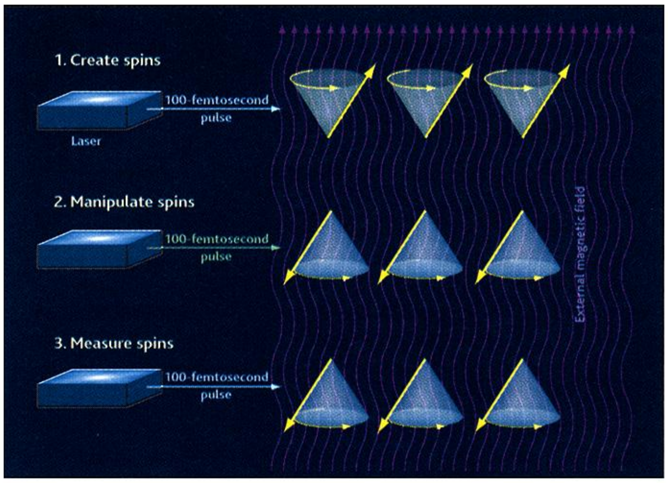
Schwartz says he doesn't want to withdraw the paper: "I just want it to be published." Mirkin says he's defending the authorship rights of his team: "It's really unusual to have a situation like this. I have never experienced it before, and I don't know anyone else who has." If his team at NU can reproduce Schwartz's work, Mirkin says, he will try to publish a paper that includes Schwartz as a co-author. –**ELIOT MARSHALL**

ULTRAFAST LASERS

Lighting the Way to a Quantum Computer

For researchers working to build a quantum computer, speed is of the essence. The bits of quantum data that scientists create last just billionths of a second, or nanoseconds. That's too short to allow researchers to do any meaningful computation. But a group of California and Pennsylvania researchers may have found a way to beat the time crunch. Their work takes a small but important step toward creating a machine that can carry out in seconds calculations that would take eons on even the most sophisticated supercomputer.

On page 2458, physicist David Awschalom and his colleagues at the University of California, Santa Barbara (UCSB), and Pennsylvania State University, University Park, report a new ultrafast way to manipulate bits of quantum data. Using a trio of vanishingly brief laser pulses, the team managed to tweak bits of quantum data in as little as 100 quadrillionths of a second, or femtoseconds. At that rate, they could theoretically carry out 1 million such manipulations before the quantum information falls apart. The group hasn't demonstrated any computation power yet. Nevertheless, the ability to manipulate quantum information so quickly "is a very important milestone," says Stuart Wolf, a quantum-computer expert at the Pentagon's Defense Advanced Research Projects Agency in Arlington, Virginia.



Spin control. Laser pulses make electrons spin in unison around the axis of a magnetic field, tip the spins, and measure the result.

ILLUSTRATION: A. STONEBRAKER

In both conventional and quantum computers, data are represented by bits that reside in one of two states, a 0 or 1. But quantum computers have an extra trick. They take advantage of the fuzzy notion of a superposition of states from quantum mechanics, which says that a quantum system—such as the orientation of an electron's spin—exists as a superposition of all its possible states at once until it is measured or observed. Instead of being a simple 0 or 1, a quantum bit, or qubit, can be 63% 0 and 37% 1, or 51% 0 and 49% 1. When this fuzzy qubit is plugged into a logical operation, the computer essentially computes all possible outcomes simultaneously. String just 300 qubits together, and a quantum computer would instantly calculate all 2^{300} possible results, a number roughly equivalent to all the elementary particles in the universe.

Although still far from that goal, quantum-computation experts have made some headway. The most promising approach creates qubits by using magnets to manipulate the spins of atomic nuclei in molecules in solution. Such liquid qubits maintain their information up to seconds at a time before they "decohere," or fall apart. That gives researchers ample time to coax them into carrying out rudimentary logical operations. The downside is that it's difficult to scale the technique up by coupling many qubits together.

Two years ago, a team of Japanese researchers made a qubit in a tiny solid state device, which carried the potential to be scaled up readily (*Science*, 30 April 1999, p. 722). But qubits in solid state devices tend to decohere in just 10 or so nanoseconds. It's this problem that Awschalom's group set out to solve by finding a way to manipulate quantum information more quickly. For this early-stage study, however, the team didn't make qubits, which switch between two states only. Rather, they chose a simpler task of manipulating electrons that can sit in many states.

The team—which included UCSB grad student Jay Gupta and Penn State professor Nitin Samarth and postdoc Rob Knobel—started with a semiconducting material called zinc cadmium selenide (ZnCdSe) and a laser setup designed to jockey electrons in the material. Like all electrons, those in ZnCdSe have spin, a quantum-mechanical property associated with magnetism. The spin of an electron can point in various directions, and those pointing in different directions have slightly different amounts of energy. If researchers could control the movement, they might use the different spin directions to represent bits of information.

Normally, the spins on different electrons in ZnCdSe tend to make them wander their own way. So the group's first task was to coax them all to share the same spin, giving them a common starting point. To do that, they blasted the semiconductor with an initial 100-femtosecond pulse of circularly polarized blue light. Circularly polarized photons spiral like corkscrews as they travel. When the spiraling photons smacked electrons in the semiconductor, they gave up both their energy and their spins. The photonic barrage kicked a group of electrons in the semiconductor so that they all carried the same spin (see diagram).

To manipulate these spins, Awschalom's group fired a second 100-femtosecond pulse, this one containing photons of blue-green light. Individually, such lower energy photons are too weak to be absorbed by the electrons in the semiconductor. But as they passed through the semiconductor, Awschalom explains, their collective presence effectively created a brief magnetic field. This field tapped the electron spins into a new orientation, much as the flick of a finger alters the precession of a spinning top. In a final step, the group used a third 100-femtosecond pulse to spot the electron spins in their new state.

The UCSB–Penn State team's success marks the first-ever all-optical processing of electron spins in a solid. But it still falls short of being a quantum computer. To stake that claim, the researchers must clear two more hurdles. First, they must create qubits. The key to that, Awschalom says, may be creating specks of semiconductors called quantum dots, capable of trapping single electrons that can harbor spins in two directions. Then the team must learn to manipulate at least two qubits, so that changes to the state of one qubit affect the state of the second—a necessity for performing quantum computations. Each feat, say researchers, will mark a major stride on the road to quantum computing.

–ROBERT F. SERVICE

CELL BIOLOGY

NO Helps Make Fireflies Flash

Incandescent and fleeting, the firefly embodies sultry summer nights. Light is the firefly's language of love. Each evening, males take flight, emitting telltale flashes. From the ground or bushes, females beckon with their own bursts of light. Long the object of study, fireflies have yielded many secrets of this mating ritual. But a key step in triggering the burst of light has defied elucidation. Now, neurobiologists have identified that missing link. And much to their surprise, it turns out to depend on nitric oxide (NO)—a versatile cell-signaling molecule that our cells use to make blood vessels dilate, reports Barry Trimmer of Tufts University in Medford, Massachusetts, on page 2486.

Neurobiologists have long known that the firefly's abdomen contains a lantern made of specialized cells, called photocytes, filled with a protein called luciferin. An enzyme called luciferase activates luciferin; oxygen then causes the protein to emit light. A nerve signal called octopamine controls the flash pattern, which varies from species to species. But how it does so has been unclear, as the nerve ending isn't in direct contact with the photocytes.

In 1998, while listening to a graduate student discuss his thesis on firefly sexual behavior, Trimmer, who studies NO in the caterpillar brain, was struck by the similarity between the cell types that control the lantern and the cells he worked with, which release NO. That summer, he and his colleagues collected fireflies from local fields. Initial biochemical tests determined that the enzyme that makes NO, nitric oxide synthetase, was both present and active in the lantern. "Elegant," is how Shireen Davies, an integrative physiologist at the University of Glasgow in Scotland, describes the experiments.

To show that NO is actually involved in flashing, Trimmer's team then analyzed the molecule's role in intact fireflies. When they exposed fireflies in a closed container to increasing concentrations of NO, the fireflies glowed nonstop. The researchers still didn't know, however, whether NO was working in the lantern or simply affecting the nerves that trigger the flashing. So Trimmer's team devised a way to remove the nerves going into the lantern but leave much of the abdomen intact, enabling them to test where NO was acting.

When they added NO to this stand-alone lantern, it glowed. But when they added a chemical that sopped up NO as fast as it was produced, the flashing stopped—even when they were stimulating the lantern with the nerve signal. "That implies that NO is the mediator," Trimmer explains.

The arrangement of cells in the lantern provides clues about how NO likely works, he adds. The lantern consists of air ducts called trachea, whose cells are encircled by photocytes. The nerve endings from the top of the abdomen reach the tracheal cells but do not contact the photocytes. Inside each photocyte, mitochondria are clustered along

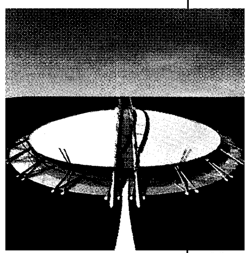
CREDIT: (BOTTOM) GREGORY K. SCOTT/PHOTO RESEARCHERS

Night light. Nitric oxide plays a role in enabling fireflies to brighten the evening sky.

ScienceScope

Synchro Wars The race to build Australia's first synchrotron is heating up. The Victoria state government said last week that it has found $82 million to build an x-ray facility that researchers can use to probe the atomic structure of everything from proteins to new materials. The announcement surprised and upset officials in Queensland and New South Wales, two other states that are fiercely competing to host the device.

Last May, the three states submitted proposals to the federal government to win $15 million in synchrotron start-up funds, with a decision due in August. But Victoria premier Steve Bracks upstaged the competition by saying that his state will pony up $52 million for its planned device (right), with industry and research institutes adding $30 million more.



The preemptive strike took federal science minister Nick Minchin "totally unawares," says a spokesperson. Minchin cautiously praised the initiative but noted that the government will still evaluate the pending proposals. Queensland premier Peter Beatty says Victoria's move was unsporting and that his state will stick to its "more honorable approach." He urged the warring parties to meet soon to sort things out.

Warning Shot For months, the Department of Energy (DOE) has been fielding questions about how *PubSCIENCE*, its free Web index of scientific journals and articles (*Science*, 8 October 1999, p. 195), might compete with private businesses. Now, Congress has gotten into the act. On 25 June, a House appropriations committee decided that *PubSCIENCE* poses a threat to private vendors of scientific information.

The House energy and water appropriations subcommittee voted to cut $730,000 from the current funding of DOE's Office of Scientific and Technical Information, in the name of cutting waste. In a report accompanying the bill, the committee notes that DOE "should carefully review its information services such as *PubSCIENCE* to be sure that such efforts remain focused on appropriate scientific journals and do not compete improperly with similar services from the private sector." It is not yet known whether the Senate will include a similar warning in its version of the funding bill, to be considered later this year.

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