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.

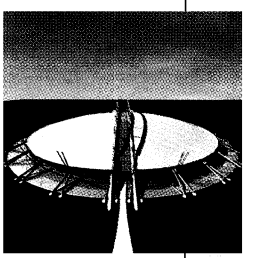
The arrangement of cells in the lantern provides clues about how NO likely works, he adds. The lantern consists of air ducts called trachea, whose cells are encircled by photocytes. The nerve endings from the top of the abdomen reach the tracheal cells but do not contact the photocytes. Inside each photocyte,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

**Contributors: Jocelyn Kaiser, Xiong Lei, Elizabeth Finkel, Eliot Marshall**

the edge closest to the tracheal cells. So, Trimmer suggests, when the lantern is off, these mitochondria "are a barrier" that soaks up oxygen before it reaches luciferin.

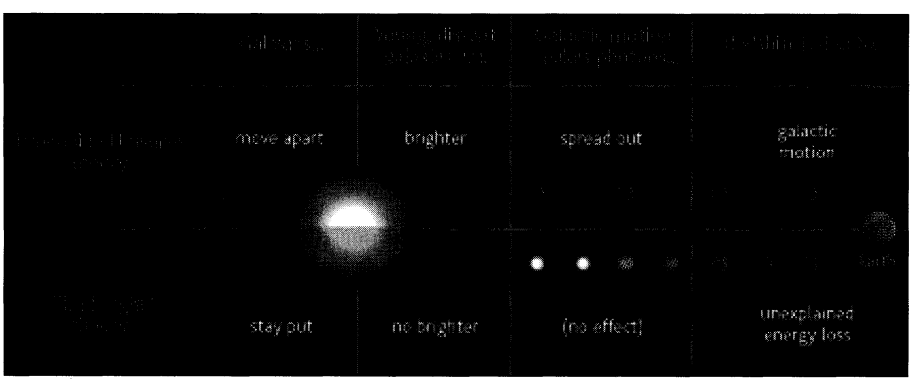
When it's time to flash, however, the NO concentration increases in the air-duct cells and diffuses over the mitochondria, briefly shutting down this oxygen barrier. In response, the oxygen concentration rises in the photocytes, setting off the light. Then "the lantern in and of itself turns off the NO reaction," says William Sessa, a pharmacologist at Yale University, because, as other research has shown, light inhibits NO.

Trimmer has yet to prove that this is how the lantern works. But to Gerd Bicker, an NO specialist at the Hannover School of Veterinary Medicine in Germany, the work stands on its own merits. "I am very pleased," he says, "that NO appears to be involved in such an esthetical aspect of cellular communication." **–ELIZABETH PENNISI**

ASTROPHYSICS

## 'Tired-Light' Hypothesis Gets Re-Tired

The "tired-light" hypothesis, mainstay of a dwindling band of contrarians who deny the big bang and its corollary, the expanding universe, has suffered a one-two punch. Observations of supernovae and of galaxies provide the best direct evidence that the universe is truly expanding and promise to shed light on the evolution of galaxies to boot.




**Beyond the fringe.** "Tired light"—a radical alternative to the standard expanding-universe model of the cosmos—has just failed two crucial tests.

"The expansion is real. It's not due to an unknown physical process. That is the conclusion," says Allan Sandage, an astrophysicist at the Carnegie Observatories in Pasadena, California, and leader of the galaxy study.

It's a conclusion that most astronomers reached long ago. In 1929, Edwin Hubble announced that light from distant galaxies is redder than light from nearby ones. Hubble and others took the redshifts as evidence that the universe is expanding, causing distant galaxies to speed away faster than nearby ones. To an observer on Earth, they reasoned, this would appear to stretch the wavelength of their light, just as the sound of a police-car siren seems to drop in frequency as it speeds away. However, within a few months of the publication of Hubble's paper, astrophysicist Franz Zwicky came up with an alternative explanation: that galaxies' light reddens because it loses energy as it passes through space. In Zwicky's tired-light scenario, the universe doesn't expand at all. Distant galaxies are red not because they are moving, but because their light has traveled farther and gotten pooped along the way.

When experimenters first measured the cosmic microwave background more than 30 years ago, they found that the radiation was too dim to be explained by Zwicky's hypothesis. That realization relegated "tired light" firmly to the fringe of physics, but scientists still sought more direct proofs of the expansion of the cosmos.

Two new papers provide the best direct evidence yet. The first, slated to appear in *Astrophysical Journal*, measures the brightening and dimming of a certain type of supernova. Thanks to Einstein's theory of relativity, if distant supernovae are speeding away from us, they will appear to flare and fade at a more leisurely pace than close-by ones. A team of scientists led by Gerson Goldhaber of the Lawrence Berkeley National Laboratory (LBNL) in Berkeley, California, has shown that this is, indeed, the case with 42 recently analyzed supernovae.

"It's such a clean-looking curve," says Saul Perlmutter, a member of the LBNL team. "It's very unambiguous."

In the second study, Sandage and Lori Lubin of Johns Hopkins University in Baltimore analyzed space-based measurements of the surface brightness of galaxies. Both the standard expanding universe and the tired-light theory, they realized, agree that red-shifted light should make distant galaxies look dimmer than they really are. In an expanding universe, however, time dilation and other relativistic distortions will also dim distant galaxies, making them appear much fainter than tired-light theory dictates. What's more, young stars—and thus young galaxies—tend to be considerably brighter than old ones. When that extra brightness is taken into account, the observations match expanding-universe predictions, as Lubin and Sandage will report in *Astronomical Journal*. For the tired-light theory to be correct, young galaxies would have to be dimmer, rather than brighter, than old ones. "There's no way to explain that," says Lubin.

Although not surprising in themselves, the results are useful for "tidying things up in our cosmology," says Michael Pahre, an astronomer at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, who performed a similar surface-brightness experiment in the mid-1990s. By comparing the expanding-universe theory's predictions with observed values of the surface brightness of distant galaxies, scientists can work backward and figure out how much brighter those galaxies must have been earlier in the history of the universe.

Even so, researchers doubt whether the results will convert tired-light diehards. "I don't think it's possible to convince people who are holding on to tired light," says Ned Wright, an astrophysicist at the University of California, Los Angeles. "I would say it is more a problem for a psychological journal than for *Science*." **–CHARLES SEIFE**

PARTICLE PHYSICS

## Russian Turmoil Rattles CERN

**MOSCOW**—Discord over KGB-style rules that require Russian academics to report contacts with foreign scientists—as well as a management change at a key institute—are raising caution flags about Russia's collaboration on a major international particle physics project being built at CERN, the European laboratory for particle physics near Geneva.

Last month, the Russian Academy of Sciences issued a directive ordering its 55,000 researchers to report any international activities and contacts to the academy's governing presidium. Some observers see the directive as a benign effort to protect researchers from inadvertently divulging classified information. Others, however, view it as a thinly veiled attempt to allow the KGB's successor agency, the Federal Security Service, to exert more control over the scientific community (*Science*, 8 June, p. 1810). Now, similar restrictions are roiling the waters at nonacademy institutes.

At issue are rules requiring all institutes overseen by the Ministry of Atomic Energy