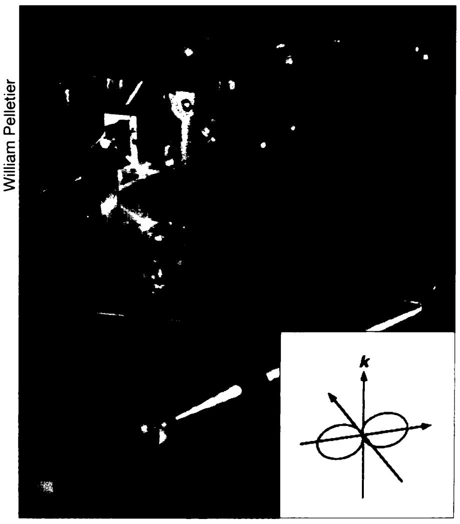
Potent laser twirls electron figure eights

William Pelletier



Accelerated by beams from this University of Michigan laser, electrons whiz through figure-eight patterns (inset) at right angles to the beam's direction of travel (k).

During the past decade, experimenters have developed laser beams of unprecedented power. Like other forms of light, these beams are composed of perpendicular electric and magnetic fields. The laser beams' enormously strong electric fields tear electrons from atoms and accelerate the freed particles almost instantly to nearly the speed of light. Made more intense each year, compact lasers have promised to unlock new areas of physics and usher in practical advances such as X-ray lasers and tabletop particle accelerators (SN: 9/5/98, p. 157).

In a partial fulfillment of that promise, researchers at the University of Michigan in Ann Arbor report a laser experiment confirming a 30-year-old prediction based on Einstein's theory of relativity.

The Michigan findings indicate that high-power, short-pulse lasers have reached sufficient intensities for "opening up a whole new regime" of physics, says Nicolaas Bloembergen of Harvard University, who shared the 1981 Nobel Prize in Physics for pioneering studies using lasers to probe atoms.

As described in the Dec. 17 NATURE, Michigan researchers Szu-yuan Chen, Anatoly Maksimchuk, and Donald Umstadter fired 4-trillion-watt laser bursts lasting less than a half-trillionth second. The bursts tore their target, helium gas, into a plasma of electrons and ions.

Theorists predicted in the 1960s that a laser's magnetic field, which has no effect on low-speed electrons, would exert a force on the fast-moving electrons accelerated by the laser electric field. Because the magnetic field pushes perpendicularly to the electric field, the oscillating fields would force the particles into minuscule figure eights.

Electrons on that swooping trajectory would re-emit light at the frequency of the laser itself but also, more importantly, at harmonics of the laser's frequency. The Michigan team reports that they detected those telltale harmonics.

Moreover, a digital camera showed that the emissions emerged in a cloverleaf pattern, as predicted. "The figure eight [motion] is inferred from this pattern," Umstadter says.

As multiples of the laser-light frequency, the harmonics represent higher energies. Even more energetic harmonics in the X-ray range may be possible. The Michigan researchers are planning new experiments to reach those frequencies.

Toshiki Tajima of Lawrence Livermore (Calif.) National Laboratory agrees that the recent experiment buoys hopes for "a new way to generate bright X rays in a very compact and, perhaps, very cheap way." Umstadter says the new results also have implications for laser-driven nuclear fusion and laboratory tests of astrophysical phenomena.

Eric J. Prebys of Princeton University says that the new work confirms earlier experiments that also demonstrated that electrons can be propelled to near-light speeds by laser electric fields. Umstadter, however, claims that his group is the first to see unequivocally the instantaneous magnetic effect. —*P. Weiss*

Sleeping birds might be proofing songs

Nigel Mann

A center in the zebra finch's brain proves very sensitive to song during sleep.

Are birds learning—or at least fine-tuning—music in their sleep?

That's a suggestion proposed by Daniel Margoliash and his colleagues at the University of Chicago to explain an odd finding in their new study of the song machinery in a bird's brain.

They focused on a structure called the robustus archistriatalis (RA), the control center for the nerves that drive singing movements. Researchers have known that this brain structure can respond to sounds, though just why has been perplexing. In the Dec. 18 SCIENCE, Margoliash's team reports an even more puzzling development: RA is less sensitive to sound, particularly to the bird's own voice, when the creature is awake than when it's asleep or anesthetized.

The birds don't sing in their sleep, and no one is suggesting that the brain has evolved some pathway to detect midnight serenades. Instead, Margoliash speculates that sleeping brain activity might play a role in learning and maintaining a song. Sleeping brain activity in rats seems necessary for them to learn how to navigate new spaces, according to experiments by Bruce L. McNaughton of the University of Arizona in Tucson and his colleagues.

Margoliash studies male zebra finches, which learn to sing as youngsters. He says their chattery strings of syllables sound like "a cross between Bugs Bunny and a squeaky door." To keep singing well, a bird seems to need auditory feedback. If an adult is deafened, his song gradually deteriorates, developing uncharacteristic variety, as well as pops and clicks.

In laboratory experiments, Margoliash and his colleagues implanted electrodes in the birds' brains. When researchers played a recording of a bird's own song, a finch showed 5 to 20 times the RA activity when asleep as when awake.

When no recording was playing, anesthetized birds showed bursts of RA activity synchronized with impulses in a song structure called HVc. Pathways from the cells that detect sound feed into HVc, so Margoliash speculates that it might be downloading the day's sounds to RA. This activity could provide the feedback that keeps a bird singing properly.

The idea that RA plays a role in learning does not seem out of the question to Mark Konishi of the California Institute of Technology in Pasadena, Calif.

He also predicts that the finding will not settle the debate over the motor theory of sound perception, which holds that nerves controlling speech movement also respond to sound and help the brain interpret speech. Fernando Nottebohm of Rockefeller University in New York and his colleagues proposed in 1985 that the theory applies to bird song, as well. Margoliash argues that the theory can't be correct if the motor control center hardly responds until the bird sleeps.

Heather Williams of Williams College in Williamstown, Mass., who co-authored Nottebohm's proposal, agrees that RA's delay makes "far-fetched" the idea that RA serves as an aid in song perception. However, other song-related brain structures, like HVc, might still play that role.

What's more significant about the new report is the novel research angles it opens, she says. "Basically, you 'dream' of your song, and that's how you make adjustments in it. It's an interesting idea." —*S. Milius*