SCIENCE NEWS OF THE WEEK

First Operation of a Free-Electron Laser

"Ever since the first maser experiment in 1954," a group of physicists from the Stanford University High Energy Physics Laboratory point out, physicists have wished for a maser or laser that was tunable over a wide band of frequencies. Lasers and masers that depend on electrons bound in atoms and molecules are limited to one, or at most, a few, discrete frequencies corresponding to the quantum jumps permitted by the orbital structure of the atom or molecule of the lasing substance. Sometimes harmonics of basic frequencies can be developed, and there are a class of dye lasers that are tunable over short stretches of the spectrum, but pushing them can burn out the dye.

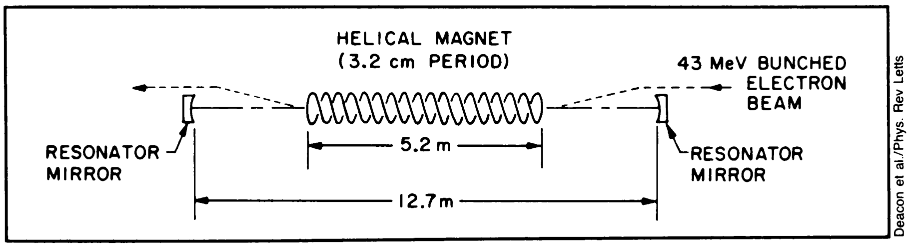
Now the Stanford group reports an important experiment that could lead to a type of laser that, in principle at least, would be tunable over a wide range of the spectrum from infrared through the visible down to the ultraviolet. It uses free electrons as the lasing element. This first operation of a free-electron laser is reported in the April 15 PHYSICAL REVIEW LETTERS by D. A. G. Deacon, L. R. Elias, J. M. J. Madey, G. J. Ramian, H. A. Schwettman and T. I. Smith.

Free electrons are unconstrained by the permitted energy and orbit states of atoms and molecules. If they can be energized and caused to emit coherently, in principle they could emit quanta of any frequency desired. The technique is to take electrons energized by an accelerator and pass them through a spatially periodic magnetic field set up by a coil. The periodic field causes the electrons to corkscrew up and down, and in this state they are likely to produce synchrotron radiation. Passage through the electron beam of a weak beam of radiation of the proper frequency ought to stimulate coherent emissions and laser-style amplification.

The report indicates that this is just what happens. An electron beam of 43 million electron-volts energy from Stanford's superconducting accelerator was passed through a field of 2.4 kilogauss generated by a superconducting magnet coil. The result was coherent emission at a wavelength of 3.417 microns (in the infrared) that exhibited a power gain factor of 100 million over the random unstimulated emission from the electrons.

The mathematical formula that accounts for what happens will apply in principle to any wavelength you like. The wavelength of emission varies with the energy of the electron beam. Since accelerators can give electrons of a very wide range of energies there is, in principle, no wavelength limit.

There is a power gain problem, as Elias points out. The gain falls off at short wavelengths. It depends on the 3/2 power—the square root cubed—of the electron current, so much stronger electron currents are necessary to produce worthwhile power at short wavelengths. Still the paper in PHYSICAL REVIEW LETTERS estimates that currents now available in electron storage rings could provide a reasonable energy gain at wavelengths through the visible part of the spectrum and down to 1,200 angstroms in the ultraviolet. The experimental problem, Elias says, is whether the electron currents can be taken from the storage ring, put through the laser apparatus and returned to the storage ring in a state where they are in phase with the storage ring's operations, and so can be recirculated for repeated passes.



Free electrons in a periodic magnetic field produce laser amplification in infrared.

The group intends to start experimenting with storage-ring currents to see if they can make the method work. They intended to use a 250-million-electron-volt storage ring at the University of Wisconsin, and they may build a small one of their own at Stanford.

Meanwhile, they will be working toward an operating tunable laser in the infrared range. Elias points out that this spectral range is particularly useful for laser chemistry work and separation of different isotopes of a given element, especially the separation of explosive from nonexplosive uranium. Elias says there has been interest in the Stanford experiments from people involved in the laser chemistry work at Los Alamos Scientific Laboratory, where uranium separation is one of the important provinces of the work.

Reed Jensen, one of the leaders of the Los Alamos laser-chemistry work, has to be guarded and nonspecific in his comments because of the classified nature of the Los Alamos operations. But he says that "the work of Dr. Madey's group is very welcome." It is an initial experiment, Jensen reminds us, and "we shouldn't forget that a lot of work has been done with other lasers and that these lasers have carried the burden of the work." Still, "We're delighted with what he's done."

Another center of laser chemistry and isotope-separation work is the Lawrence Livermore Laboratory. The leader of that effort, James I. Davis, calls the Stanford results "a promising preliminary experiment." At the moment, he says, it is too early to discuss applications in the context of Livermore's isotope-separation program, "but we look forward to future work. It is a very original, clever idea."

A laser of this sort would probably not be applicable to thermonuclear fusion, Elias says, because it delivers a high average power rather than the short concentrated bursts desired for fusion application, but there are many other applications in precision chemistry and materials science for this kind of laser if a practical one can be developed. □

The heaviest (99) space molecule yet

"Somewhere, over the rainbow," Judy Garland used to sing, was a world of wonders. The actual world out over the rainbow, interstellar space, may not contain anything as chemically complex as lemon drops, but the molecules that astronomers are discovering there are getting so big and so organic that the suggestion that life—or the compounds that later became alive—originated there gains more and more plausibility. The longest, heaviest and most organic molecule yet discovered is cyanotriacetylene (HC_7N), reported last week.

The compound was found in a cloud in the constellation Taurus by a group of observers from the Canadian National Research Council's Hertzberg Institute, using the Algonquin Park Radio Observatory near Pembroke, Ontario. The discoverers are L. W. Avery, N. W. Broten, J. M. McLeod and T. Oka. They were collaborating with a group at the University of Sussex in England led by Harry Kroto, who were doing laboratory work on the compound.

This compound, like so many others of interest to molecular astronomers, is too reactive to exist under ordinary conditions on earth, although it can last a long while in interstellar space where its chances of meeting something to react with are slim. Since it is not a staple of ordinary bench chemistry, the characteristic spectrum of microwave radio frequencies it emits, by which it can be recognized, was unknown. The first task therefore was to synthesize it under special laboratory conditions so that it could be held long enough to study its microwave emissions. This is what the Sussex group was doing.

As the days hastened on last month toward the time the Hertzberg Institute people had reserved for use of the Algonquin Park equipment, Kroto crossed the Atlantic to be in Canada for the observations. At that point his collaborators had not yet completed the laboratory work. As McLeod tells the story, the observations were already in progress when Kroto got a transatlantic telephone call telling him the frequency to look for. The observers looked and found the compound.

Cyanotriacetylene, based on a chain of seven double-bonded carbon atoms, has a molecular weight of 99. Its discovery follows that of cyanodiacetylene (HC_5N), announced 14 months ago (SN: 2/28/76, p. 132). The next in the series to look for is HC_9N, which has a nine-carbon chain. Actually, says McLeod, the chemists have a more proper name for cyanotriacetylene—cyanohexatriyne—and that is the name the observers will probably use when they publish the result, which they hope to do soon, probably in ASTROPHYSICAL JOURNAL LETTERS.

From there, the road is onward and upward. The simplest amino acid is glycine, and every practicing molecular astronomer would like to be the one to find it in space. A group at Monash University in Australia is already working out glycine's microwave spectrum. □

Brain hears, learns what it wants

It has been said that people hear only what they want to hear. Now, in work with rabbits at the University of Texas, psychologist Michael Gabriel reports that the brain frequently *does* hear what it wants to, and virtually ignores "other signals that have had little meaning in the past."

Gabriel utilized various tones, some of which preceded an action such as the administration of a shock, and others that did not. During such training, the psychologist reports, auditory input pathways are altered "so as to facilitate the transmission of important sounds and hinder transmission of unimportant ones."

His results also indicate that learning does not take place in one area of the brain, but progresses from the outer layers to the inner core as learning progresses. Initial learning takes place in the cortical area, then "after considerable training," is apparently passed on to the thalamus in the core of the brain, says Gabriel. □

Lab grows sleeping sickness parasite

Sleeping sickness, a painful and often fatal disease, has reigned over a wide belt of tropical Africa since ancient times. Each year this disease, called trypanosomiasis, attacks more than 10,000 people and kills hundreds of thousands of domesticated animals. It prevents livestock production in vast and fertile areas of Africa.

The parasites responsible for African sleeping sickness have proved to be evasive adversaries (SN: 1/18/75, p. 44). These single-celled protozoa have a complex life-cycle spent partly in the tsetse fly and partly in the mammalian bloodstream. While in the fly, the trypanosome has a stumpy, noninfective form, but after being injected into a mammal by a tsetse-fly bite the parasite is slender and infective.

Despite numerous attempts over the last 70 years, investigators have been unable to maintain the infective form of the parasite outside a host animal. If infective trypanosomes cannot be grown in the laboratory, it is impossible to obtain large numbers of organisms to use in developing a vaccine or drugs or in examining the basis for the trypanosomes' troubling characteristics.

Researchers working at the International Laboratory for Research on Animal Disease (ILRAD) in Nairobi, Kenya, have now developed a method of growing the infective form of a trypanosome outside a host animal. They work with *Trypanosoma brucei*, which infects cattle and is closely related to the human parasites. With their new method, Hiroyuki Hirumi and John J. Doyle have kept infective trypanosomes in seemingly good health for almost a year after isolation from infected animals.

Their novel method mixes the techniques for growing protozoa and for culturing tissue cells. The trypanosomes thrive best in a soup containing cells grown from cattle blood for several generations in the laboratory. The normal function of those mammalian cells is not known. This type of procedure might also be useful to researchers of other diseases, points out John A. Pino of the Rockefeller Foundation and chairman of the board of trustees of ILRAD.

With the new culture method, researchers may be able to discover the mechanism by which the parasite so successfully eludes the host defense system. An animal's immune system recognizes invaders by their surface proteins, called antigens. The trypanosome parasites, however, continually switch disguises. When the body has wiped out the organisms exhibiting one antigen, a wave of trypanosomes with slightly different antigens arises. In the laboratory, researchers have observed trypanosomes of as many


Eric A. Wells and W. H. Russell Lumsden

Slender parasites in infected rat blood.

as 40 different surface antigen types arising from a single parent cell, says immunologist Carter L. Diggs of the Walter Reed Army Medical Center. Most researchers think that these changes result from different genes being expressed, but no one knows what controls them. The researchers in Nairobi are now attempting to observe the antigens as the parasites switch from the mammalian bloodstream forms to the insect forms and back again. An understanding of this mechanism could also contribute to the problem of control of gene expression during development of more complex organisms.

Although the immediate development of drugs or a vaccine is still far from certain, a major step has been taken. "what is important is the fact that we now have the organism to study and tear apart," Pino says. □

Television violence: A call to arms

As evidence continues to build up that TV violence may harm the mental health of children (and some adults), behavioral scientists are escalating their drive for "more responsible" programming. With some prodding by TV consumer advocate Peggy Charren and the National Citizens Committee for Broadcasting (NCCB), massive organizations such as the American Medical Association and the American Psychiatric Association are expressing public concern over video violence and its potential effects. Last fall, the NCCB's rating of advertisers who most often sponsor violent programs embarrassed a number of ad executives and their companies. Chevrolet most frequently sponsored violent programs, according to the study, followed by Whitehall Labs (Anacin), American Motors, Sears-Roebuck and Eastman Kodak. Those sponsoring the least violent programs included Peter Paul, Hallmark, Texaco, Whirlpool and Prudential.

Last week at the American Orthopsychiatric Association's annual meeting in New York, Charren, NCCB's Ted Carpenter and others called for a continued outcry