Laser Fusion: Frequency Not So Critical

Experimenters trying to produce controlled thermonuclear fusion by imploding targets of fusible material (deuterium and tritium) by bombarding them with laser light have been saying that the best possible laser for the purpose should be one of fairly short wavelength. Something in the blue or green part of the spectrum, most say, would have the ideal qualities for most efficient coupling of energy from the light into the pellet of fuel. Such a laser should also have high power and the ability to run at a high repetition rate. In other words, it should be an easily cooled laser, probably one in which the lasing material is a gas.

Such an object does not yet exist. The highest-powered lasers are made of glass doped with neodymium, which means they need a lot of cooling time. Still, they have the power and the fairly good wavelength of 1.06 microns, so they are being used for experiments (especially at the Lawrence Livermore Laboratory). Meanwhile, work on gas lasers is coming from the opposite direction, high power and easy coolability, but a wavelength that seems far out of the range of usefulness, 10.6 microns. (Green = 0.5 microns.)

Now comes Damon V. Giovanelli of the Los Alamos Scientific Laboratory, where much of the work on carbon dioxide lasers is in progress, to say wavelength doesn't really matter all that much. Experiments show, he argues, that even the factor of 10 difference between 1.06 microns and 10.6 microns of neodymium-glass and carbon dioxide is not all that important at the high-power density levels that will be involved in real-life laser fusion. He presented his case at the annual meeting of the Plasma Physics Division of the American Physical Society last week in San Francisco.

Calculation of the expected mode of energy deposition in the target had led to the negative opinion regarding long wavelengths. It was expected that shorter wavelengths would penetrate further into the target. Long wavelengths would invest too much of their energy in making very hot electrons at the surface, which would penetrate the target and preheat it, making the ultimate compression more difficult. The shorter the wavelength, the deeper it would go, delivering more energy to produce a significant ablation of atoms from the surface of the fuel pellet. A more energetic ablation causes a stronger implosion.

However, the real world of laser fusion is an area of power flux greater than 10^{15} watts per square centimeter. Here experiment seems to show, Giovanelli says, that the energy invested in hot electrons is not so different even over the factor of 10 difference in wavelength nor is the difference in the penetration of the target so critical. In the absorption region of targets, where laser beams produce an expanding, ablating plasma to drive the implosion of the rest of the target, the expansion rates seem to be comparable for both kinds of lasers.

The neodymium-glass and carbon dioxide lasers are the only two kinds with which laser-fusion experimenters have extensive experience. The region between these wavelength extremes is largely unexplored. But the implication of what Giovanelli says is that if this comparability in performance holds across the board, future searches for the right laser may be able to pay less attention to the question of wavelength and more to such questions as power, coolability, repetition rate and economy of production. It could relieve a serious bottleneck in the progress toward the laser fusion reactor, because experts have been saying all along that the main outstanding problem was development of the proper laser. □

Princeton Large Torus: Big surprises

The Princeton Large Torus is alive and well and working happily at the Plasma Physics Laboratory associated with the university in that peaceful New Jersey town. The PLT is important because it is the largest experimental apparatus for controlled thermonuclear fusion of the type called tokamak yet built in the United States, and it was deliberately designed to push the technology of tokamaks to outer limits.

A tokamak is a toroidal or doughnut-shaped device in which the plasma of atomic nuclei and electrons that have been stripped from them is confined in the doughnut-shaped tube by magnetic fields along and around the tube. The plasma is heated by electric currents running around the circle through the center of the doughnut tube to provide the confinement and temperature necessary for fusions to happen.

An entire session of the meeting of the American Physical Society's Plasma Physics Division last week in San Francisco was devoted to the Princeton Large Torus.

The PLT, as one of the group working with it, Wolfgang Stodiek, describes it, is a doughnut almost without a hole. The hole is only 30 centimeters in radius, while the cross section of the tube is 50 centimeters in radius. This required putting a lot of the electromagnetic circuitry that would normally go outside the tube on the inside. This ultrafat doughnut shape was chosen because according to theory, improvements in temperature and confinement time, the prime parameters to be increased as the experiment moves toward a practical thermonuclear reactor, bear a direct relation to the increase in the ratio of tube size to hole size. It's a case of concentrating on the doughnut and not the hole.

The first big surprise, says Stodiek, was that the experimenters could get a plasma to form and perform in a machine of this shape and with this distribution of magnet windings and current elements.

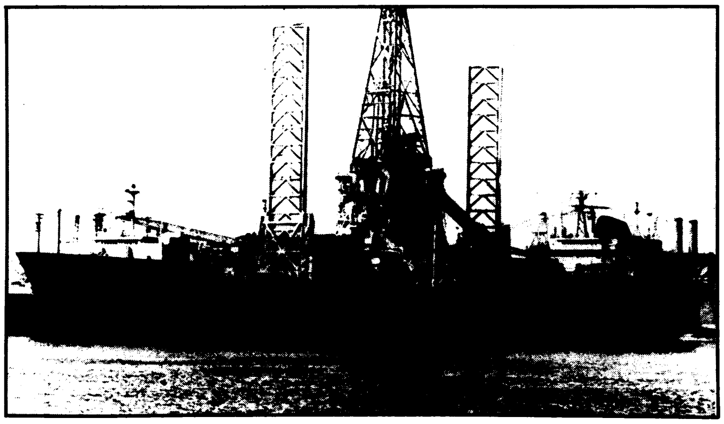
The second big surprise, he says, is that the apparatus seems to work well without the traditional copper shield around it. Shields of electrically conducting copper have been a feature of tokamaks since their earliest design and have long been thought necessary to get the proper configuration of magnetic and electric fields to do the work of the experiment properly. Not only are the shields expensive, they are a nuisance to experimenters and a big impediment in any schemes to scale up the tokamak configuration to a true fusion reactor. In a reactor, energy would have to be gotten out by making use of energetic particles coming away from the nuclear fusions going on in the plasma, and these could hardly get through such a shield. For tokamak progress the shield had to be eliminated, which now seems possible.

The machine has been operating for about half a year but only at about half the plasma current it was designed for and with a toroidal magnetic field of 35 kilogauss instead of the designed 50 kilogauss. These magnetic fields are ultrastrong and touchy to work with. A picture of the machine shows the doughnut almost entirely obscured from view by a frame of heavy steel bars intended to counteract the twisting force of the magnetic field. The plans are to approach the highest possible field slowly and carefully.

Experiments with plasmas of helium and hydrogen show relatively good behavior with plasma densities up to 7.3 particles per cubic centimeter, ion temperatures on the order of a kilo-electrovolt and confinement times for the total plasma energy up to 53 milliseconds. All this tends to surpass smaller tokamaks and to compare favorably with the Soviet apparatus of comparable size, T-10. The figures vary according to the number of kiloamperes plasma current put through the doughnut. The full 50 kilogauss of magnetic field, 1 megapere of plasma current and confinement times on the order of 100 milliseconds are expected to be achieved if outstanding problems can be overcome.

A final footnote to the whole business is that big physics has reached its ultimate. There have been papers signed with two or three dozen names—in some cases the list of authors is longer than the paper. There have been papers modestly inscribed by the X group of Y laboratory or the so-and-so experimental group. Here comes the end. The first paper in the PLT session at San Francisco was signed by "everybody." To pile up the irony, in the act it was presented by "nobody." The material in it was combined with Stodiek's presentation. □

Glomar Explorer: Conversion to science?



The sophisticated salvage ship Glomar Explorer may be converted to handle deep-sea drilling, extending research to previously impossible areas.

After the Central Intelligence Agency gave up attempts to raise the rest of a sunken Russian submarine, with its specially constructed salvage vessel, the Glomar Explorer (SN: 3/29/75, p. 204), the government found itself holding a uniquely designed, $300 million white elephant. A year-long effort to commercially lease the vessel has found no takers, and the Explorer is languishing unused.

Now the National Science Foundation has authorized a feasibility study to determine what would be necessary to modify the ship for deep-sea scientific research drilling. The $75,000 study is expected to take three months and will be conducted by Global Marine Development, Inc., of Newport Beach, Calif.

As a research vessel, the Glomar Explorer could offer some unique advantages. The ship is 618 feet long by 115 feet wide and displaces 21,000 tons. This displacement is nearly twice as large as that of the vessel currently used for deep-sea scientific drilling, the 400-foot Glomar Challenger. The greater size, coupled with a larger derrick and more powerful engines, means that the Explorer has a lifting capability nearly 10 times greater than the Challenger and could operate under more adverse conditions of weather or currents.

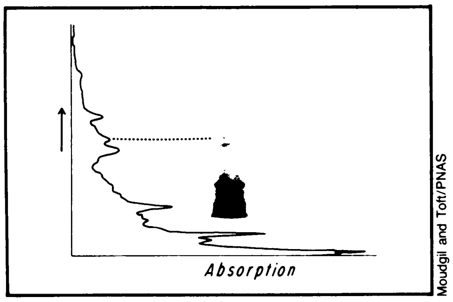
These developments come at a time when the current Deep Sea Drilling Project (DSDP) is approaching the limits of what can be accomplished with the Glomar Challenger. After years of virtually round-the-clock operation, the Challenger is beginning to show signs of age, and the ship is expected to be returned to its owners, Global Marine, Inc., in 1979. Also there have been three major areas of the oceans where the Challenger has not been able to function adequately: deep trenches, arctic seas and regions with hydrocarbon deposits.

The NSF project officer for DSDP, Peter E. Wilkniss, told SCIENCE NEWS the Glomar Explorer might be able to operate in these three neglected areas for an expanded research drilling effort in the 1980s. With its thicker hull it could probably venture farther into icy areas of the arctic seas. With a greater lifting capacity, it could hold the heavier drills needed for obtaining cores from deep trenches, and it could handle the complex, self-contained "riser system" and "blowout preventer" needed to drill safely in oil or gas fields. (Risers circulate viscous "drilling muds" around a drill to equalize pressure in case of striking a subterranean gas chamber, and should a "gusher" occur, the blowout preventer seals the hole.)

Scientifically, ocean trenches are particularly interesting since it is unknown whether ocean sediment is concentrated in them or carried away under a continental plate. An expanded drilling program obviously has practical implications also; mineral deposits may be found in trenches and new petroleum beds may be discovered in previously unexplored areas of the continental shelves. Drilling in arctic seas is important for determining the history of climate changes, since organisms in these areas are most susceptible to temperature variations.

Officials at NSF hope the feasibility study will be completed in time to submit it to the next meeting of the international consortium that finances DSDP. A changeover to the Glomar Explorer would probably entail a doubling of expenses, Wilkniss estimates. □

Cell receptors pinch-hit as enzymes



Progesterone receptor (position indicated by broken line).

Cell receptors are one of the hot topics in molecular biology these days. Researchers have discovered that these tiny proteins, which may have sugar chains attached, reside on cell membranes and catch hormones, drugs, viruses, neurotransmitters and other chemicals that pass by. Receptors, they have found, can sit inside cells and pass along or interpret chemical messages that enter cells. Receptors even appear to play a role in diabetes, obesity and some other diseases (SN: 8/16/75, p. 110).

Now that scientists have learned quite a bit about *what* receptors do for cells, they want to better understand *how* the receptors do it. In the case of cell membrane receptors for protein hormones, for instance, the receptors probably pass a chemical message from hormones to a membrane enzyme, which then activates the intracellular messenger cyclic AMP. But how about those receptors that operate inside cells, say the receptors for the steroid hormones? Two Mayo Clinic molecular biologists have found that one of these receptors, for progesterone, actually works as an enzyme. "This activity," they declare in the October PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, "could represent a major event in the mechanism of steroid hormone action."

Last year the Mayo scientists, Verinder K. Moudgil and David O. Toft, found that the progesterone receptor interacts with ATP, the primary high-power energy molecule inside cells. But what kind of interaction? Moudgil and Toft attempted to find out, and they now report that the receptor catalyzes an exchange reaction between ATP and pyrophosphate. In other words, the receptor works as an enzyme.

Specifically, ATP, which had been previously shown to bind to the progesterone receptor, is apparently split into an AMP-enzyme complex and pyrophosphate, and can be totally regenerated in the presence of pyrophosphate. This exchange reaction is totally dependent not only on the receptor, the investigators have found, but also on ATP and magnesium cations. Other cations, such as calcium, and nucleotides,