Laser Fusion: Toward 'Brand X'

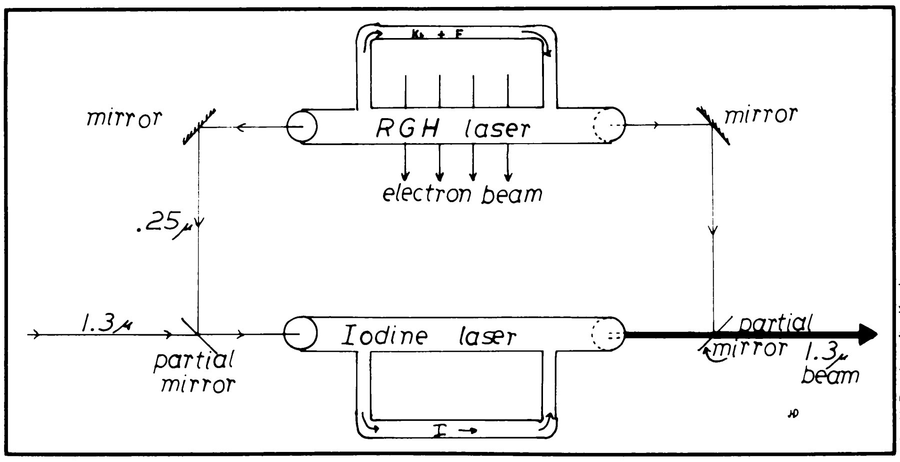
In roughly three years, the idea of laser fusion has grown from a germ of speculation, discussed only by a few specialists, to a heavy-weight contender of "big science"—with a proposed budget of just over $100 million for next year and a small army of engineers talking about "milestones" and "systems approaches." Both topics were widely discussed last week at a joint technical symposium of the Society of Photo-Optical Instrumentation Engineers and the Society of Photographic Scientists and Engineers, in Reston, Va. Perhaps more important was analysis of the impact a new lasing technique may have on producing a workable fusion system.

The "milestones" of laser fusion were set forth by John D. Hunsuck, project director for the Energy Research and Development Administration (ERDA). He predicts "scientific breakeven" (fusion energy out equal to laser energy in) by 1981-82 and an operating test system by the late 1980s. A demonstration plant may be completed by the mid-1990s, he said, but the final thrust to such a practical system will be "a long, hard haul." At that point, the main concern may be how to find materials capable of withstanding the intense neutron flux that results from fusion.

Before any of the milestones beyond scientific breakeven can be reached, however, a fundamental change must occur away from present experimental systems—the combination of lasers and target pellets being used today cannot simply be scaled up to higher power levels. This realization has led some experts to speculate on the need for a high-powered "Brand X" laser, probably radiating in the visible spectrum rather than in the infrared as in today's experimental devices. This speculation was discussed at the Reston conference by W.F. Krupke of Lawrence Livermore Laboratory.

According to the Brand X theory, the simple spherical target pellets now in common use would have to be compressed by some as yet undiscovered laser that could achieve 10 percent energy efficiency at around 0.5 microns (green light). Krupke, however, points to an alternative stratagem. He says more complex targets might ease the restrictions to allow use of an infrared laser (1.0 to 2.0 microns) with an efficiency as low as 1 percent. (Long wavelength photons of infrared light are inherently less energetic and capable of compressing a pellet than the photons of visible light.)

Complex pellets, containing multiple layers and heavy elements in addition to the fusion reactants, have already apparently found increasing use (SN: 6/14/75, p. 384). Now, within the last few months, a new type of laser has been developed that may aid the search for Brand X. It is the rare gas-halogen (RGH) laser, which radiates in the ultraviolet and can be used to pump other lasers to produce desired wavelengths in either the visible or infrared spectrum. (Brand X would almost certainly be a flowing gas laser, to remove heat generated.)



An RGH laser pumps iodine laser: Similar combinations may lead to fusion system.

So-called rare gases (krypton, argon, etc.) do not ordinarily form any chemical compounds, but when their atoms absorb energy they can form loose molecules with the very reactive atoms of the halogen gases (fluorine, chlorine, etc.). To create these energetically excited states, the reactants are bombarded with an electron beam in the presence of a third gas, which helps transfer the energy. Once formed, the new molecules (say, KrF) quickly dissociate again, releasing energy (in this case, ultraviolet light of 0.25 microns).

The dissociation is so fast that not enough energy can apparently be stored by RGH lasers for use directly in causing fusion, so the ultraviolet light is used instead to "pump" a laser of some other material. One of the first materials that appeared to have the right combination of properties (to be pumped by an RGH laser and in turn to lase at approximately the right wavelength) was iodine, which emits light in the "near" infrared (1.3 microns). Several laboratories are now exploring this laser combination, but an even more promising set-up appears to be emerging. Calculations show that if an RGH laser can be used to pump the vaporized atoms of certain "rare earth" elements (say, terbium), they should lase right in the middle of the visible spectrum (in this case, green).

It is still too early to tell whether an RGH-pumped rare earth laser will turn out to be Brand X—the first experiments are just now in progress—but the new technique has already opened several new avenues of approach. In an interview, Krupke said of the RGH lasers: "It looks like they will have a major impact on the laser community, both in isotope separation and in fusion." He estimated that in perhaps as little as two years, a decision can be made on what combination of targets and lasers to use in future power-generating fusion reactors.

Meanwhile, in the corridors, talk turned to what the Soviet Union is up to in this field. Administration of the Russian laser fusion program has reportedly shifted from a pure research institute into the USSR equivalent of ERDA, and communication on the subject—once quite open—has suddenly grown quiet. Speculated one knowledgeable scientist: "Either they've found out how to do it, or they've run into trouble." □

Electron beam fusion: Soviets claim advance

Although the Soviets are extremely close-mouthed (and close with their typewriters too) about their progress in controlled thermonuclear fusion research, occasionally something surfaces that gives a bit of an idea of what approaches they are into.

One such avenue that they have chosen to follow is a variant offshoot of the laser-fusion idea in which beams of accelerated electrons instead of laser light are used to implode the target pellets. This idea was taken up because it seems it might be able to get around some of the difficulties that are beginning to appear in the laser-fusion business. (It seems easier to couple the electron energy into the targets, and the targets can be larger.) Both the United States and the Soviet

Union are energetically pursuing laser fusion, and at the same time both have taken up electron-beam work. Now, workers at the Kurchatov Institute in Moscow, where Soviet fusion work of all kinds seems to be concentrated, have claimed an important advance in electron-beam fusion experiments.

The report came not in a scientific journal, but in an article in the March 10 Pravda written in connection with the 25th Communist Party Congress. The article dealt mostly with other thermonuclear fusion experiments underway at the Kurchatov Institute (notably tokamaks) but devoted one paragraph to the electron-beam work.

The paragraph claimed the achievement of some fusions. It said electron beams had compressed fuel pellets containing deuterium to 100 times their original density. The crushing raised the temperature of the fuel to nearly 11 million degrees K. The reaction gave off more than a million neutrons, which the Russian physicists claim as evidence that fusions actually took place in the fuel.

The number of neutrons, if in fact they do come from fusions, is still a long way from what is necessary for a practical device producing useful energy, but the achievement is a significant step, in the opinion of Gerold Yonas of Sandia Laboratories in Albuquerque, who heads the American program in electron-beam work. On receiving the Pravda report, Yonas telephoned the leader of the Soviet group, Leonid I. Rudakov, to determine whether the report was accurate, to offer his congratulations if so, and to seek further information. He was assured that the report was correct, offered his congratulations and got no further information.

What Yonas was especially interested in was the diagnostic methods used at the Kurchatov Institute to determine what happened in the imploded fuel pellets. There are a number of possible sources of neutrons in such events, and it takes delicate methods to be sure that the neutrons seen are really those thrown off as excess when two nuclei fuse, and not the result of some other process. Rudakov would not describe the diagnostic methods, but referred Yonas to a forthcoming scientific publication in an unspecified journal at an unspecified date.

The American program has so far succeeded in crushing dummy pellets but has yet to experiment with targets filled with fuel, which in this case will be a mixture of deuterium and tritium. The American effort, as described by Yonas's colleague M. J. Clauser at a meeting last fall, uses electrons of 100 million electron-volt energy and protons of 10 million electron-volts to irradiate the targets. What the energy of the Soviet electron beams may be is not known, nor have they said whether they are also trying protons or any of the other ions that have been suggested. ☐

Miniaturizing flies with membrane leaks

Three California biologists have discovered an enzyme from bee venom that can cause fruit fly larvae to grow up tiny. The miniaturizing effect is due to the enzyme's action on cell membranes; it causes them to leak. Although this fly "shrinking" phenomenon can carry the imagination off to science fiction scenarios, the enzyme will be mainly a tool for basic membrane research. Sadly, for those inclined to wonder about such applications, it won't be at all useful for shrinking overweight humans.

Cell biologists Peter H. Lowy, Herschel K. Mitchell and Ursula W. Tracy of California Institute of Technology report the leak phenomenon in the April issue of TOXICON. Lowy and Mitchell discovered the miniaturizing enzyme purely by accident five years ago. They were studying a bee venom enzyme that causes biological molecules to break down. They injected a control group of fruit fly larvae with a different venom enzyme. To their amazement, they found that the injected larvae hatched into perfect, miniature adults that produce a second generation of normal-sized flies. The team has since studied the action of this enzyme, which is called phospholipase A-2, and can now state that it causes permeability changes—leaking.

In order to determine the mode of action, the team immersed human cancer cells (HeLa cells), red blood cells and mitochondria (metabolic organelles) into weak solutions of phospholipase A-2. The enzyme has no apparent effect on the red blood cells, but it attaches to HeLa and mitochondrial membranes and causes them both to leak. Mitochondria have a double membrane, and the inner layer allows larger than normal molecules to pass through in the presence of phospholipase A-2. The HeLa cells accumulate lipid droplets. This is due either to a change in membrane permeability or to a release of lipids within the cell, the team suggests.

The miniaturizing effects on fruit fly larvae are probably a result of membrane permeability changes, too, Mitchell says. Insect larvae are essentially eating machines, but fruit fly larvae injected with phospholipase A-2 don't eat at all. When they metamorphize, there is just too little larval tissue to create full-sized adults. The insects' lethargy is probably due to muscle and nerve dysfunction resulting from leaky membranes.

Phospholipase A-2 in bee venom and its counterpart in cobra and rattlesnake venom seems structurally similar to the phospholipase present in normal cell membranes. This similarity suggests, Mitchell says, that normal cell phospholipase may have a permeability regulating function. The bee venom enzyme should be a useful tool for studying that normal membrane regulation.

As for miniaturizing overweight humans, Mitchell replies to the somewhat facetious question, "the enzymes would be useless—in fact, worse than useless." The enzymes will arrest the growth of insects at a certain stage of development, but "if an organism is already big, there is no reason to believe it will get smaller." Besides, "you just wouldn't want to do this to a person. The change in his membranes might cause him to stop eating, but he also might stop breathing. Breathing is a membrane function, too." ☐

The hidden energy of silent quakes

It's almost as though violent earthquakes, with their rumblings and sudden upheavals, are just diversionary tactics. According to geophysicist Hiroo Kanamori of the California Institute of Technology, much of the real, large-scale earth-moving along the faults and trenches surrounding the Pacific basin seems to reveal itself only in slow, ponderous "silent earthquakes," whose seismic waves don't even show up in the measurements used to rate quakes on the Richter scale.

Kanamori's research was reported this week at an international symposium conducted by Columbia University at Arden House in New York, in honor of the late Maurice Ewing, whose name is associated with many of the great discoveries in marine geophysics in the last 30 years.

His findings are based on a study of the "repeat time"—the time between periods of heavy quakes—for the various earthquake zones around the basin. His findings, coupled with plate-tectonic theory, suggest that the major recorded quakes have not been sufficient to account for all or even most of the earth movement that plate-motion studies indicate has been taking place.

Off the coast of Japan, for example, where the Pacific crustal plate is said to be thrusting under the Asiatic plate, the repeat time, by Kanamori's calculations, is about 100 years. (The entire subduction zone broke within the last 25 years, while the previous sequence of breaks was between 1850 and 1900.) Each major quake sequence, he says, involved a relative slip between the plates of 6 to 9 feet, yet the Pacific plate advances beneath the Asiatic plate about 30 feet every 100 years. The difference, Kanamori concludes, must be due to slippage without the accompanying ground-shaking. In other words, the silent quakes.

The seismic waves of the silent quakes as Kanamori defines them are those with periods of 300 seconds or more—frequencies, that is, of 12 cycles per *hour*