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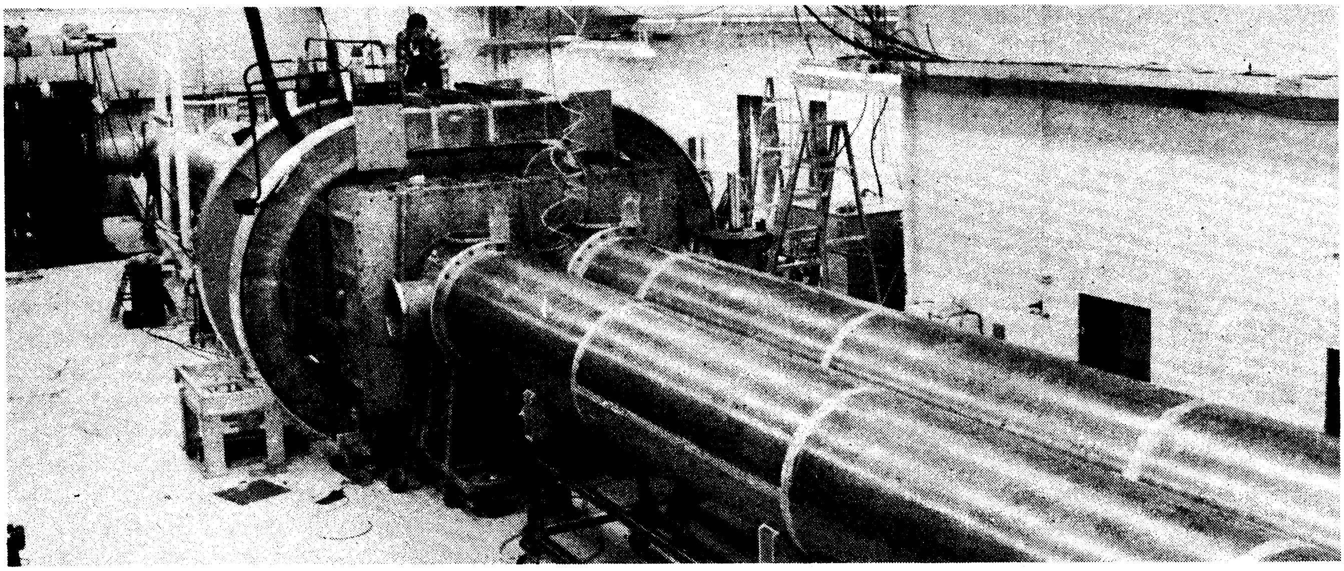

The krypton fluoride laser successfully tested this June.

Los Alamos x-ray laser advance brings beam weaponry closer

by Charles B. Stevens

Researchers at Los Alamos National Laboratory in New Mexico report that they scored a major advance in the development of efficient, short wavelength lasers with the successful firing of their 20 kilojoule maximum output krypton fluoride (KrF) gas laser system in June. This breakthrough in high-power laser technology has major implications for the development of commercial laser fusion and anti-missile beam weapons.

It has been known for some time that the KrF electron beam driven laser has ideal characteristics for both fusion and military applications if it could be scaled up to an optimal size:

1) short wavelength (0.248 microns) for efficient coupling of light energy to fusion and military targets.

2) the capability of being scaled cost-effectively to large size;

3) the ability to fire repeatedly;

4) good efficiency for conversion of input electrical energy into high power laser light (4 to 7 percent).

Los Alamos has now achieved the scale-up to optimal size for the KrF. According to Dr. Allen Hunter, leader of the Los Alamos Advanced Laser Technology Group which built the KrF, "No other laser system has all of these attributes."

"Initially, the laser-fusion community asserted that krypton-fluoride laser development was too complicated and too costly to consider for laser fusion applications," Hunter stated in an interview, "but the desirable wavelength was something we thought we had to pursue, and our laser works—in 15 months we have developed a laser that this week successfully delivered light energy for an unprecedented low cost." Hunter further pointed out that: "We have shown that this laser is neither complicated nor expensive, and that it can have high efficiency compared with other demonstrated short wavelength laser systems."

These Los Alamos developments completely confirm the projections made in a September 1980 article in the magazine of the Fusion Energy Foundation, *Fusion*, entitled, "Exclusive: Behind the Classified Foster Report; Is Krypton Flouride the 'Brand X' Laser?" At that time the Carter administration had sabotaged the U.S. inertial confinement fusion (ICF) and high energy laser programs through suppressing the results of the official Department of Energy review of laser fusion by the Foster Committee. The Foster Committee, so named because its chairman was Dr. John Foster of TRW,

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had completed a favorable review of the magnetic fusion program in 1978. During 1979 the Foster Committee reviewed the laser fusion effort and concluded that its budget should be doubled based on the potential of the KrF laser for both the research and commercial stages of inertial confinement fusion development. The Carter administration classified the Foster Laser Fusion Review "top secret." As a result Congress cut the overall laser fusion research budget and funds for KrF development in particular. As the *Fusion* article noted, these actions were to "retard the development of commercial inertial confinement fusion as well as halt important scientific advances essential to national defense."

Wavelength and target coupling

EIR founder Lyndon H. LaRouche detailed why short wavelength lasers are most effective in an April 13 Washington, D.C. address to government and diplomatic representatives. (See *EIR*, April 26, 1983 for complete text):

> First, if we concentrate even a fairly small quantity of wattage on a sufficiently small area, the concentration of energy . . . can be made sufficient to "boil," so to speak, any material. This much seems to be explainable in terms of the widely acceptable theory of heat; the second principle cannot be so explained. Second, lasers have a property which is sometimes called "self-focusing." This is described more accurately by reporting that each range of the upper electromagnetic spectrum [ranges of shorter wavelength] has very distinct qualities of harmonic resonance. In one [wavelength range], this focuses the energy on the molecular scale, and in higher ranges [shorter wavelengths], the subnuclear scale. To cause a laser to work as desired, one must tune the laser to monochromatic frequencies such that very little of the laser's beam is absorbed by the medium through which it is transmitted, and the beam is tuned at the same time to the part of the spectrum of matter of the target selected. . . .
>
> The principles governing the way in which a coherent, directed beam does work on its target are, most immediately, the principles defined by Bernhard Riemann's 1859 paper, "On the Propagation of Plane Air Waves of Finite Magnitude.". . . In the process leading to the production of the shock-wave, the upper part of the wave overtakes the mid-point of the wave, creating a steep front, which is the shock-wave. The greater the ratio of the height of the wave to the length of the wave, the greater the tendency to produce shock. Obviously, the shorter the wavelength, the more work we get out of the beam used, which is why the upper ranges of the electromagnetic spectrum are so attractive for us.

In terms of existing scientific and technological capabilities, the KrF represents an ideal laser for use in combination with optical systems—mirrors and lenses. No known materials are capable of efficiently focusing or reflecting electromagnetic radiation at wavelengths below one tenth of a micron. At 0.248 microns the KrF is at the very end of the wavelength range which can be efficiently focused and reflected.

On the other hand, the volume of optics needed to focus a laser beam to a given target-spot size varies with the square of the wavelength. In fundamental terms this is because beam divergence, diffraction limitations, increases with increasing wavelength. For example, it is reported that one needs a 10-meter diameter mirror in order to focus a 2.7 micron chemical laser beam onto a missile several thousand miles away. With a 0.248 micron KrF, only a one-meter diameter mirror is needed to achieve the same degree of concentration.

But, as Mr. LaRouche details in theoretical terms, shorter wavelengths are qualitatively superior. This is reflected in the more efficient and qualitatively superior coupling of shorter wavelength laser light to both ICF and military targets. In crude terms this superiority is measured in terms of hydro efficiency, which measures the percent of the incident beam energy that is converted into a shock wave propagating through the target. Longer wavelength chemical laser beams have an inherently low hydro efficiency—most of their energy is deposited as simple heat—while in the quarter micron range a significant portion of the incident beam energy is converted into that of the shock.

But relative hydro efficiencies are only indicative. Qualitatively, the difference is much more dramatic. As a simple illustrative example—which is only a theoretical example and should only be attempted by competent experts—place a few ounces of black powder on a table top and throw a match into it. What happens? The powder will hiss and burn, but in general only the table top will be a little scorched. Alternatively, if we had thrown a sheet of paper over top the black powder just after throwing the match into it, the result would be quite different. And in fact, the table top could end up with little scorching while the walls of the room would have been blown down. By placing the paper over top of the powder we have "shaped" the evolution of the powder's combustion, generating a deflagration wave instead of simple burning. This generates a shock wave which harmonically tunes in to the mechanical structure holding the walls of the room up. If we further shape the explosive into a hollow cone and place at a structural weak point, an entire building or rock formation can be brought down in one fell swoop.

The shorter wavelength ranges of coherent electromagnetic radiation are inherently tuned in for most efficiently coupling to a target and generating the most efficient form of shock wave to achieve the desired result. In the case of ICF this is to produce the most efficient compression of matter to super densities—the so-called isentropic compression. In the case of military targets it is to most efficiently generate a form of shock wave which most effectively penetrates into the fragile innards of the target.

Because of this and because of its ability to utilize optics and most effectively propagate through air, the KrF represents the leading edge of laser beam weapons qua lasers, at the present time and for the near future. The shorter wavelength x-ray lasers (.04 microns) are indeed more efficient in terms of target kill, but they are limited to operation outside the atmosphere, since they cannot penetrate the atmosphere. Also, because optics cannot be utilized with such short wavelengths, the KrF, which can, represents a crucial complement to x-ray laser space-based beam weapons.

Future developments

While the KrF has not yet been fired at full power, Los Alamos researchers foresee little difficulty in achieving this. More significantly, Los Alamos has now demonstrated that the KrF can be scaled to optimum 20 kilojoule size module for high power levels. Upwards of 30 of these optimum scale modules could be combined to generate sufficiently large single laser pulses needed for achievement of laser pellet fusion net energy generation or for practical beam weapon applications.

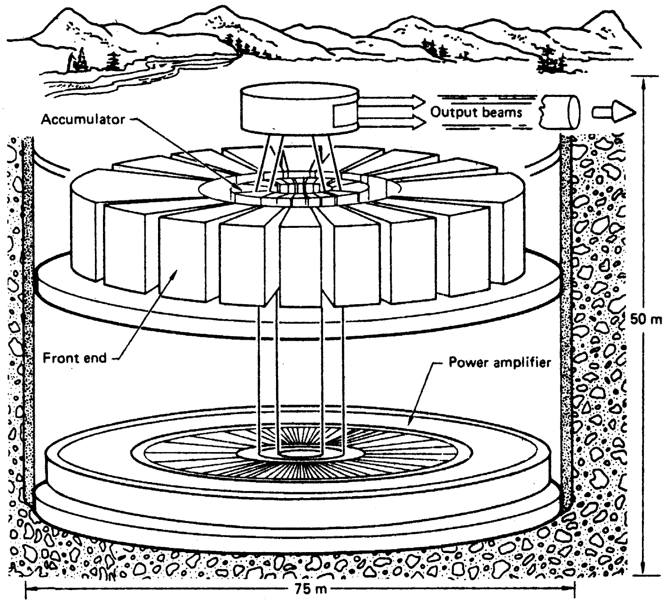
The KrF is an "eximer" type of gas laser which is energized by relativistic electron beams. In order to achieve the maximum efficiency in terms of conversion of input electron beam energy into output laser energy, the KrF laser pulse must be at least several hundred nanoseconds long.

The current pulse-length of the Los Alamos KrF is 500 billionths of a second—500 nanoseconds. Both for effective military application and achievement of laser pellet fusion, this beam pulse-length would have to be compressed by a factor of 100—to 5 nanoseconds. According to leading national laboratory laser experts, this pulse compression can be achieved in a straight forward manner utilizing optical techniques. The specific techniques being projected for further KrF scale-up are those of angular multiplexing and combined aperature operation.

Angular multiplexing consists of breaking the initial laser pulse into a number of smaller pulses, which are then optically stacked in time and space through the use of hundreds of mirrors. Combined aperature operation consists of simultaneously directing the output from several KrF 20 kilojoule modules onto the same set of angular multiplexing mirrors—i.e., one mirror system is able to optically stack the output from many KrF modules at one time. For military applications, after pulse compression, the laser beam optical quality would be improved through the non-linear Raman interaction between the laser light and a gas. This will permit the accurate and efficient long distance transmission of the laser beam through the atmosphere.

The September 1980 *Fusion* article predicted that million

Hardened KrF Beam Weapon



The above diagram, taken from a June 1981 national laboratory report, shows the overall mockup for a 2-megajoule KrF laser beam weapon system. The system would be buried in the ground and would have a pop-up turret for shooting the beam.

joule KrF laser systems could be built with angular multiplexing for pulse compression at a "cost between $200 and $300 million." A million joule high power laser based on existing glass laser technology is currently projected to cost above $1 billion. The Los Alamos developments confirm the accuracy of *Fusion*'s projections.

Beam weapon applications

Because of its size, a multi-megajoule KrF beam weapon would most likely be based on the ground. Such a laser could operate both directly against incoming warheads as a terminal point defense system and, in combination with space based mirrors for redirection of the laser beam to any spot on Earth, as a strategic area defense system for interception of missiles at any stage of their trajectory. In the second case systems of orbiting mirrors would be kept on station during peace time and backup mirrors would be placed on rockets which would only be launched once an ICBM attack was detected.

While megajoule KrF lasers—if sufficient funds are invested in their development—could be realized within the next five years, there is another fruitful line of development currently being pursued by the national laboratories. This consists of combining the KrF with the free electron laser (FEL). The FEL would be utilized to amplify an input KrF laser beam. Such a combination could increase the overall efficiency of the laser system by more than 25 percent. Experts indicate that this hybrid KrF-FEL system could also be realized within the next five years.