Science & Technology

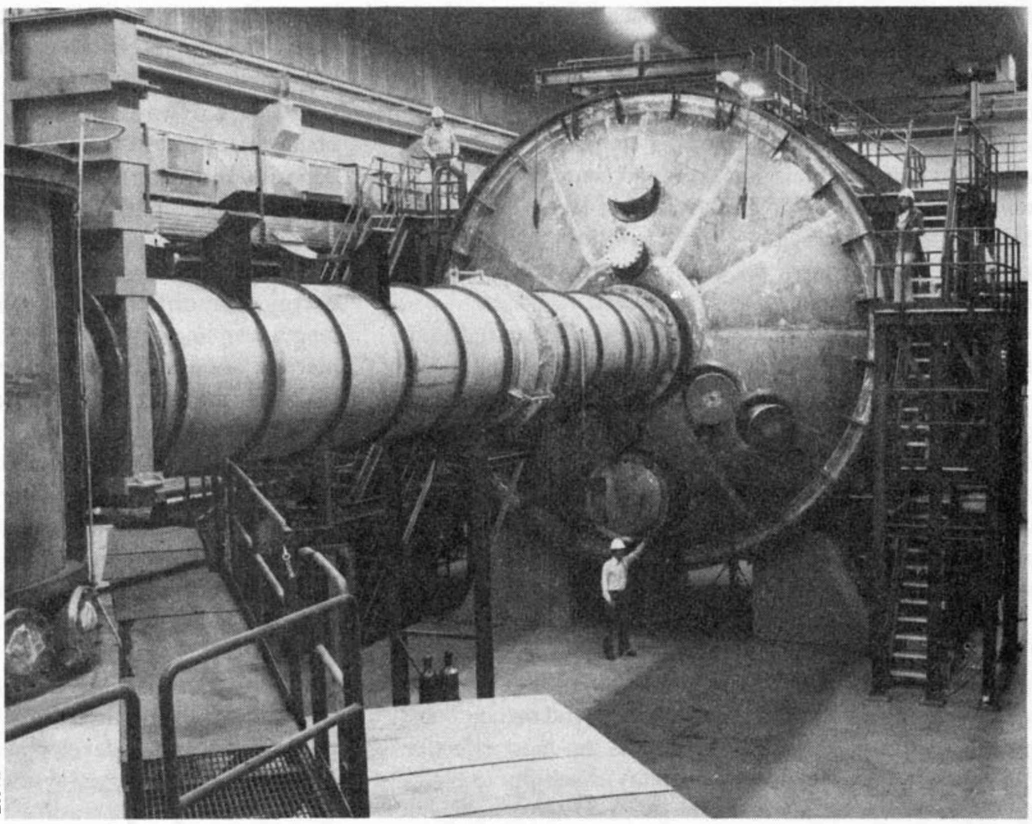
The Los Alamos 'Aurora': New dawn for fusion power, sunset for ICBMs

by Charles B. Stevens

The Los Alamos National Laboratory, in a press release titled "Aurora: New Dawn for Fusion Research?" announced that its krypton-fluoride gas laser was successfully fired on the evening of July 3. The Aurora krypton-fluoride laser, or KrF, is indeed one of the most promising candidates for practical laser fusion electric power reactors. It is also the primary beam-weapon candidate for destruction of nuclear-tipped missiles in their vulnerable boost phase and even during that part of the boost phase which takes place within the atmosphere. When combined with the nuclear bomb-pumped x-ray laser, the KrF provides the overall capability for making offensive nuclear missiles obsolete.

Louis Rosocha, Los Alamos manager for the Aurora project, says that the KrF breakthrough takes us much closer to a fusion reactor because it meets the exacting specifications needed for practical laser fusion energy production: "It has a short wave length for efficient coupling of laser energy to fuel targets, the capability for being cost-effectively scaled to a large size, the ability to fire repeatedly, and a tremendous, economical efficiency in comparison with other lasers—a possible 10% efficiency from the electrical wall socket to the laser output, or more than five times that of some systems."

These same qualities—coupling of laser energy to targets, economic scaling to higher energies, high repetition rates (tens to thousands of shots per second), high laser-beam



The Antares laser, shown here, is a CO_2 laser now operational at Los Alamos National Laboratory. It is not capable of achieving the target coupling necessary for inertial fusion; but by replacing it with a krypton-fluoride Polaris system, a prototype for both laser fusion and beam weapons could be achieved.

generation efficiency (10%)—also make the KrF an effective system against nuclear-tipped missiles.

The test on July 3 achieved a 3,000-joule laser pulse generated within 400 billionths of a second. According to Los Alamos, experimenters plan to soon bring this total energy up to 10,000 joules in the same pulse length. Experiments utilizing what is called angular multiplexing, to compress the pulse length to 5 billionths of a second—increasing the beam energy flux density by a factor of 80—will also be carried out on the Aurora in the near term. (Angular multiplexing is a form of optical compression in which the light pulse is cut up into many parts and spatially stacked to form a more compact and powerful pulse.)

The Aurora KrF laser module is the prototype for a full-scale multi-module laser needed for either fusion or beam weapon applications. Los Alamos scientists are designing a prototype multi-module system, the Polaris, which would be only one stage removed from the million-joule energy levels needed for deployable systems for fusion and beam weapons: "So impressive is the new system, the 50,000 joule laser called Polaris may be under way as early as mid-FY '86." The reason that Polaris could be realized so quickly is that it could make use of the existing structures utilized in the Los Alamos long wave length Carbon Dioxide Laser Antares.

The KrF and the x-ray laser

The nuclear bomb-pumped x-ray laser is the most lethal beam weapon yet demonstrated. Each x-ray laser system popped up into space when a large-scale missile attack is detected could destroy scores of ICBMs as they rise out of the atmosphere. Missiles are most vulnerable during their boost phase, in which only the energy of a man swinging a hammer (several hundred joules per centimeter squared) is needed to puncture their thin skins and cause the missile to self-destruct. Once their primary rocket stages have been detached and the warheads released to follow "ballistic" trajectories, much greater amounts of energy are needed to destroy or deflect them.

But, as many critics have noted, the x-ray laser must kill above the earth's atmosphere (about 70 kilometers altitude), since dense air absorbs x-rays and prevents the propagation of the x-ray laser beams. Some critics have suggested that the Soviets could redesign and redeploy their missiles to achieve boost phase within the atmosphere—even though this would put a great strain on Soviet missile building and significantly degrade the payloads that could be carried by such new ICBMs.

In this regard, the KrF provides a major complement to the x-ray laser. The KrF laser beam is capable of penetrating well below the 70 kilometer altitude limit of the x-ray laser and killing missiles within the atmosphere and in their boost phase. And in fact, the KrF represents the most effective laser for achieving this complementary capability to the x-ray laser, since it has just about the shortest wave length with which optical transmission can be achieved. (At the even shorter wave length of x-rays, all existing types of materials used in optical systems, such as mirrors and lenses, are destroyed by the electromagnetic waves. The .248 micron wave length of the KrF represents the current minimum for which such materials can still be utilized.)

Wave length and lethality

Both in terms of propagation range and coupling of laser energy to a target, wave length is an essential parameter. Laser beam divergence is directly proportional to wave length. So, given laser beam pulses of equal energy and utilizing the same size mirrors, the .248 micron KrF would have a lethal range 10 times that of the 2.7 micron wave length chemical laser.

But it is in terms of coupling that the advantage of shorter wave lengths becomes most evident. For the longer wave length chemical lasers, upwards of several thousand joules per square centimeter may be needed, while the KrF could achieve the same result with just a fraction of the energy flux density. This distinction becomes even more apparent when it is noted that the KrF and x-ray laser pulses achieve "kills" by shock-induced damage, while longer-wave-length lasers depend on burning holes through their targets. This distinction can be seen in terms of a simple fire cracker. If the fire cracker is cut open, the black powder will simply burn and no explosion is generated. The damage it can inflict will be far less than if the fire cracker is lit without being cut open. The paper wrapper holds in the reaction products, so that the fuel burns up much more quickly and a shock wave is generated.

At the KrF wave length, the laser light is deposited right on the target's surface. At longer wave lengths, the energy is deposited instead in the low-density plasma generated during the laser light irradiation of the target. The result is that the energy in the second case is deposited over a larger volume and therefore generates a smaller pressure build-up per unit energy. The difference between the short and long wave-length coupling is like that between driving a nail through a piece of wood and driving a hammer through it.

While the x-ray laser unit itself, because of its small size, would be popped up into space on a small rocket for boost-phase intercept, the KrF laser would most likely be deployed either on mountain tops or large aircraft. The KrF beam would then be transmitted via orbiting mirrors to be directed at the target. Some mirrors could be deployed in orbit during peacetime and others popped up when an attack is detected. Each KrF laser could generate tens to hundreds of lethal shots per second.

With the realization of the Polaris system, deployment would only be a question of engineering resources. Given the recent Los Alamos developments, there appears to be no reason that such deployed systems could not be attained within five years—given a crash effort to do so.