Science & Technology

Los Alamos laser reaches record

by Charles B. Stevens

In his April 19 presentation to the University of Rochester, "Lasers and Particle Beams for Fusion and Strategic Defense Technical Symposium," Dr. Damon Giovanielli announced that the Los Alamos National Laboratory Krypton-Fluoride (KrF) Aurora laser had achieved a record output of 10,500 joules at a power level of about 20 billion watts.

Giovanielli, who is Deputy Associate Director for Fusion Research and Applications at Los Alamos, detailed how this advance in efficient, low cost, short-wavelength lasers can immediately lead to high-power systems needed for harnessing nuclear fusion energy and providing a reliable defense against nuclear-tipped missiles. Besides providing the technology for these major applications, the Aurora KrF excimer, "the largest ultraviolet laser of its kind in the world," will also provide the essential tool for research on the scientific frontiers of laser chemistry, x-ray laser development and non-linear spectroscopy.

How Aurora works

The Aurora is an electron-beam-driven excimer laser. Krypton (Kr) and fluoride (F) gas held at high pressures are irradiated with a high-power electron beam. The incident electrons cause the Kr_2 and F_2 molecules to ionize and reform as excited KrF molecules—"excimers." Because of the high energy density of the KrF excimer, it lases at a high frequency, short wavelength—.248 millionths of a meter—which is virtually at the limits of what ordinary optics (mirrors and lenses) can reflect and transmit. And the shorter the wavelength of a laser, the longer distance over which it can be tightly focused and the more intensely it will interact with matter.

As a direct result of these properties and the fact that it can reach 10% operating efficiencies with extremely high rep rates (hundreds to thousands of shots per second), the KrF excimer laser is one of the best candidates for both laser fusion power plants and missile defense.

The Los Alamos Aurora put out 10,500 joules of .248 micron "blue" ultraviolet laser light within 500 billionths of a second—about a power of 20 billion watts.

As detailed in an April 19 press release, Los Alamos scientists plan to soon upgrade the laser's power 48-fold. This will be accomplished by multiplexing. The idea is that the single 500-billionths-of-a-second laser pulse will be broken up into 48 ten-billionths-of-a-second pulses which can be optically directed to arrive simultaneously at a target. Thus the laser pulse is "compressed" in time 48-fold and its power density increased 48 times.

Missile defense

As reviewed at Rochester by Dr. Robert Hunter of Western Research Corporation, the chief contractor on Aurora, optical multiplexing will primarily be utilized in laser fusion applications. Dr. Giovanielli outlined another approach to pulse compression which is slightly less efficient, but has major applications to missile defense. By utilizing the nonlinear interaction of an incident laser pulse with a gas, the gas can be transformed into an optically reflecting medium in which the "mirror" moves at the speed of light. This results in both laser pulse compression to higher powers and improvement in beam's optical quality. Furthermore, this process, also known as phase conjugation, can also result in a shifting of the laser light wavelength so that the best wavelength for propagation through the earth's atmosphere can be attained.

Phase conjugation can be self-initiated. For example, the KrF is operated in a low-power mode with a diffuse pulse output spread over hundreds of square miles. When a missile comes within this diffuse beam, some of the laser light is reflected back through the laser. This reflected light sets off the phase conjugation and the laser output is compressed and focused onto the missile. This integration of detection, pointing and tracking within the laser weapon itself has numerous operational advantages.

Dr. Giovanielli also revealed for the first time that short, high-intensity laser pulses provide new, more efficient means of killing missiles and other offensive nuclear systems. The intense laser pulses produce intense bursts of microwaves, x-rays and high energy electrons on the surface of the target. These energy forms readily penetrate the interior of the missile and destroy delicate electronic controls.

For both fusion and strategic defense, about 200 to 400 times more laser energy will be needed—that is, pulse outputs of 2 to 4 million joules. Dr. Reed Jensen, Los Alamos advanced laser program manager, is quoted in the April 19 press release: "We know how to do it."

As detailed in Dr. Hunter's presentation, KrF lasers are quite economical. Multimillion-joule KrFs can now be built at costs on the order of a $100 per joule. If the full power KrF attains the sort of rep rates now being demonstrated in small scale models—hundreds of shots per second—ground-based systems with both orbiting and pop-up mirrors could be built before the end of this decade to provide an economic and robust defense against nuclear armed missiles and planes.