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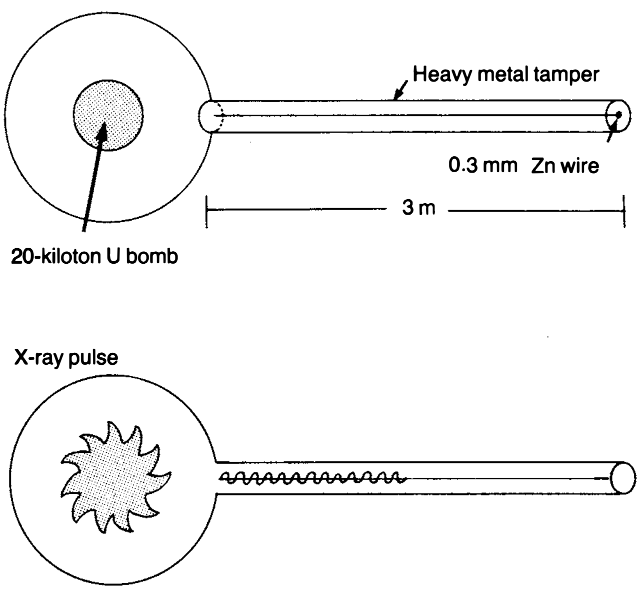
X-ray lasers could mean deployable ABM systems within three years

by Steven Bardwell

President Reagan's science adviser George Keyworth has said of the ballistic missile defense system proposed by the President: "These programs are a lot closer than people think. . . . All the components already exist—we simply have to assemble them." This striking assessment, reported in a June 14 *Washington Times* interview, is confirmed by a new analysis of x-ray laser technologies recently completed by the Fusion Energy Foundation. Based on extensive discussions with leaders in the American physics community and experimentalists in several foreign countries, FEF researchers have concluded that the "state of the art" in x-ray lasers is far advanced, not only justifying Keyworth's statement, but making development and initial deployment possible within the next three years.

Figure 1
X-ray laser configuration



Zn plasma, 10^6 degrees, 10^9 Å/cm² photo current along axis of rod

For discussion of such a device, F. V. Bunkin, et al., "Specification for Pumping X-Ray Laser with Ionizing Radiation," *Soviet Journal of Quantum Electronics,* 11:7 (July 1981), p. 971.

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Three independent indications point to a near-term x-ray laser ABM system.

1) Scientists at Lawrence Livermore Laboratory in charge of the x-ray laser system have repeatedly hinted that the scientific and engineering progress is so rapid that they expect to "present the next President" with a working system for ABM defense. In several conversations they have emphasized that chemical laser-mirror systems are *irrelevant* because the x-ray laser will be deployable *sooner* than a chemical laser system. This confidence has been, apparently, conveyed to Congress as well, since it has, for two years, redirected the U.S. program increasingly toward "short wavelength"—a code phrase for x-ray laser systems.

2) Three independent reports of successful tests of different x-ray laser components have circulated. The first (the February 1981 *Aviation Week & Space Technology* article, corroborated by Soviet analysis) is known to have been based on detailed data from the Dauphin test. This is not a "leak" in the usual sense. This test demonstrated the scientific proof of principle of the x-ray laser. It was, reportedly, so successful at producing a monochromatic, collimated beam of x-rays that the diagnostic equipment installed for the experiment was vaporized by the pulse of x-rays. This report was followed by one on tests of sensing and pointing system for an x-ray laser, and another for other system components.

One of the great virtues of the x-ray laser is that its small size makes possible separate testing of the sensing and power technologies.

3) The significance of these tests has been misunderstood by the scientific community not privy to classified data because of the obvious engineering problems of the published designs of a nuclear-pumped x-ray laser. These problems, noted by critics of the x-ray laser, are the following:

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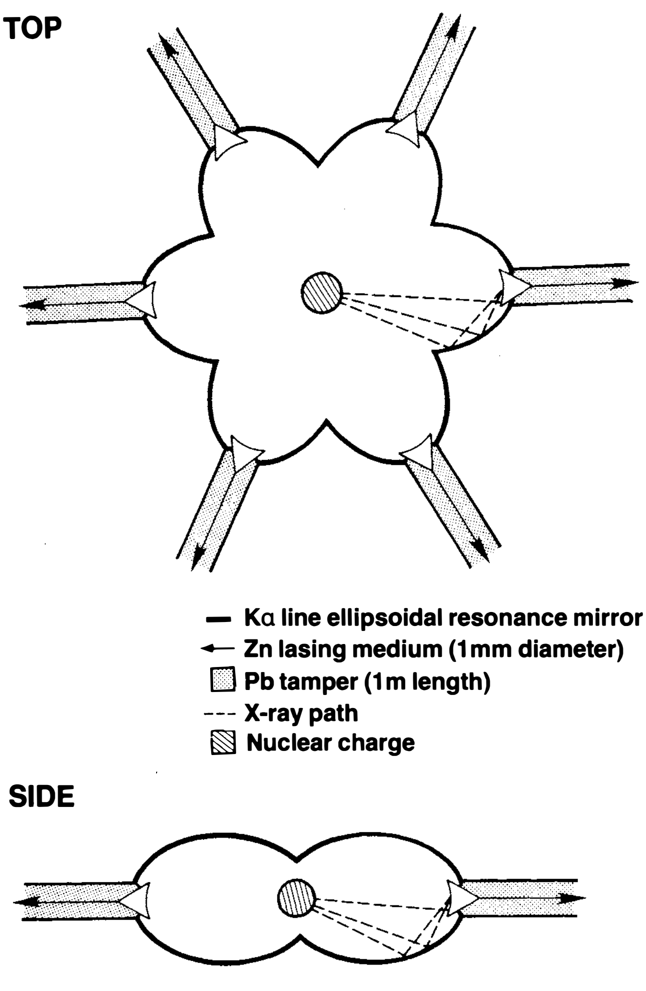
Energy output efficiency: The reported pulse energy of the first experiment was one megajoule. For a workable near-term system two or three orders of magnitude increase in energy would be necessary. The problem involved the inherent inefficiency of the designs described in speculative reports on the device. They all showed (see **Figure 1**) that only a small amount of the pumping energy released by the bomb energy could be used, imposing a geometrical limit on the efficiency of the device because of the small area that the lasing medium subtended at the active surface of the device.

Beam divergence: Since the only known focusing mechanism for collimating the beam was the geometric one—using a small diameter rod (really a wire) several meters long—increasing the area irradiation of the rod meant increasing the beam spread. The two requirements create a fatal trade-off: a brightly focused beam has low power and a high power one is spread over a large area.

Pointing: The pointing difficulty of the x-ray laser of pulse energy in the range of the first test is roughly the same as that of a chemical laser system. Overcoming this difficulty is a challenging task that itself would require about several years. However, if the power could be increased by 100 to 1,000 times, the pointing accuracies would be relaxed sufficiently so that the pointing would come within *present* technological capabilities. That is, there is a similar trade-off between pointing difficulty and energy. Low energy systems conceivable now require very severe pointing accuracies, but the high energies necessary to relax this accuracy seem unattainable with the design in **Figure 1**.

Figure 2
Hypothetical design for X-ray laser



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A hypothetical design

Based on discussions with a large number of physicists involved in weapons and inertial confinement work, FEF researchers have proposed a design which shows that each of these problems can be solved with technologies which are well known in the weapons field and which already form the basis for the current generation of "advanced" nuclear weapons. **Figure 2** shows a geometric configuration which uses present bomb technology to completely solve the inefficiency inherent in **Figure 1**. By using x-ray focusing mirrors, the whole pump energy is focused on the lasing medium. These ellipsoidal cavities are a standard component of small, efficient nuclear weapons. This design also removes the trade-off between accuracy and efficiency, by using two physicial principles to focus the beam, with reasonable rod dimensions. The result is a beam 20 microradians in divergence, giving dramatically lower requirements for pointing accuracies.

The configuration of lasing medium shown uses a hyperbolic horn at the inside surface of the rod, which focuses the x-rays reaching the rod into a one-dimensional flux of radiation. This radiation in turn produces a zinc plasma and an intense photocurrent. The combination of the photocurrent, its magnetic field, and the inertial effects of the heavy metal tamp, give focusing beyond that provided by the geometric one of the lasing medium itself. Thus, a rod with larger diameter (hence more stable and able to contain more energy) can be used. The technologies involved in the construction of these focusing horns, the tailoring (or filtering) of x-radiation, and the use of intense photocurrents are all standard components of recent generations of nuclear weapons.

This design shows that once the scientific principle of the lasing principle has been demonstrated (which was two and a half years ago), it is only a question of known bomb technologies combined with communications and control capabilities that remain to be answered.

Two conclusions follow from these facts:

1) The United States is close to the deployment of an x-ray laser. First deployment would seem to be possible within two to three years.