

EIR Science & Technology

The truth comes out about the x-ray laser

Charles B. Stevens reports the declassification breakthrough that allowed Edward Teller to reveal the facts on a defensive super-weapon, on which, until now, only EIR has given accurate reports.

If any analyst after 1945 had seriously proposed to discuss strategic military capabilities without taking nuclear technology into consideration, one would have recommended that this analyst have his head examined. If the same analyst simultaneously proposed shutting down U.S. nuclear weapon capabilities and turning them over to the Soviet Union, it would have been said that this analyst was a traitor. But that is precisely what Michael Dukakis is proposing from the standpoint of contemporary technology.

This has been demonstrated by the release of a U.S. General Accounting Office report, *Strategic Defense Initiative Program: Accuracy of Statements Concerning DOE's X-Ray Laser Research Program*, and associated, previously top-secret letters by Dr. Edward Teller and his critics, with clarifying statements by Dr. Teller on CBS-TV national news on Aug. 10. These show that the United States is developing a nuclear-powered x-ray laser, a single module of which could destroy the entire inventory of Soviet missiles.

These startling revelations not only completely justify President Reagan's prediction that nuclear-tipped ballistic missiles could be rendered "impotent and obsolete," but also demonstrate that only *Executive Intelligence Review* and other publications associated with Lyndon H. LaRouche have accurately reported on the status of developing missile defense science and technology. Or, to put the matter more bluntly, Dr. Teller's public statements and this most recent GAO report categorically demonstrate that all other non-governmental public pronouncements and analyses have been "whistling in the dark" compared to *EIR*.

Despite some technical underestimates and flaws, which, it has been learned, leading defense scientists will shortly correct with further public revelations, the GAO report and

these other materials essentially provide complete documentation of the situation. Therefore, *EIR* will publish the GAO report and related materials in future issues.

The Teller interview

During his interview on CBS on Aug. 10—a fuller version of which will appear in October on the "60 Minutes" show—Teller states that he is now in a position for the first time to publicly defend the SDI and the x-ray laser with the scientific facts. This is an historic first. For more than four decades, Teller has complained that overly stringent secrecy rules have prevented him and other scientists from telling the American people the truth about Soviet capabilities and developments. Teller has argued these many years, quite cogently in the opinion of this reporter, that secrecy rules generally keep little secret from the prying Soviets and everything secret from the American people, particularly the great dangers that we actually face. Teller now says that, suddenly, he is free to talk. What happened? Dr. Teller and his close colleague Dr. Lowell Wood met with President Reagan at the beginning of August.

Dr. Teller and his closest collaborators have been attacked for supposedly misrepresenting the success of x-ray laser research. This, for example, was the subject of a major piece in the *Los Angeles Times* on July 17, 1988, by Robert Scheer. Actually, the *Los Angeles Times* has been trying to prop up this story for the past three years.

Previously, Teller was in a no-win situation. He couldn't reply in any detail to these critics. The information was being kept top secret. It didn't matter that the Soviets already had all of this information. (In fact, the Soviets pioneered much of the science of the x-ray laser; U.S. researchers were shocked

to find out how well the Soviet projections actually worked.) The rules say that this material must be kept top secret. But the issues involved in judging the status of the x-ray laser are complicated. It is literally on the frontiers of science and technology. But how could it be otherwise, if the x-ray laser were to have any substantial impact on the existing arsenal of weapons, those monsters of mass destruction, nuclear-tipped intercontinental ballistic missiles?

Teller's antagonists thought they were protected from any substantial counterattack by the impenetrable shield of classification. And then Teller met with President Reagan.

'As many as you wish'

What Teller said during the interview was really quite simple. Based on experiments through 1984, Dr. Teller and his leading collaborators at Lawrence Livermore National Laboratory in California had concluded that it was possible to realize an x-ray laser which would have a firing range greater than several thousand miles. Furthermore, this hydrogen bomb-powered x-ray laser could develop virtually as many beams as desired, and fire each of them at a separate target over thousands of miles. That is, a single weapon could produce more than 100,000 separate beams and destroy all Soviet missiles; all Soviet warheads, and all Soviet decoys over a range of several thousand miles.

This is quite an astounding claim. Teller was directly asked if he stood by his 1984 projection. He replied with an adamant, "Yes!" And it should be emphasized again, that Teller began by stating that, for the first time, he is in a position to publicly defend his assessment of the x-ray laser.

One does not have to be a general or a leading nuclear physicist to recognize that if the United States has a weapon so powerful that a single module costing less than a few million dollars can readily destroy every missile, every warhead, and every decoy in the Soviet inventory in one shot, that Soviet ballistic missiles are well on the road to being "impotent and obsolete."

Dukakis's petard

When skating on ice, always make sure it is firm. Anti-SDI Reps. Edward J. Markey (D-Mass.) and George E. Brown (D-Calif.) have just discovered that they have been skating on the thinnest ice. It was at the request of these congressmen that the latest GAO report and associated documents were issued.

In carrying out their campaign of slander against Teller and the SDI, Markey and Brown thought that they were safe from serious retaliation, given the way security classification had muzzled Dr. Teller and his friends. Their most recent effort against Dr. Teller and the x-ray laser was supposed to be the spearhead of the Dukakis campaign's mobilization to bury President Reagan's SDI missile defense program. The secondary flank was being taken up by Sen. Sam Nunn (D-Ga.), who is proposing a so-called Accidental Launch Pro-

tection System (ALPS) to replace the SDI with what, in effect, would be a limited missile defense for Washington, D.C.

From the beginning, the critics of the SDI have zeroed in on the most secret element of the effort, the nuclear bomb-powered x-ray laser, and Dr. Teller, because they believed that the administration would never release sufficient hard data on this secret program; that is, sufficient data to categorically rebuff their attacks. Without explaining in any substantial way the actual potentials of the nuclear-powered x-ray laser, or the fact that the Soviets had almost a decade's lead in developing the system, these critics thought that the x-ray laser would make the perfect target—obscure and mysterious—a mad project associated with that mad-looking Hungarian physicist



Edward Teller

with the Bela Lugosi accent.

Their line of attack was to say that the x-ray laser didn't work at all; it was a pure fantasy conjured up in the mad scientist's imagination. With the demonstration of unclassified laboratory versions of the x-ray laser, this became difficult to maintain. But then, a turncoat appeared. Roy Woodruff was a leading program manager working on x-ray lasers at the Lawrence Livermore National Laboratory, who began providing "hard information" on how Dr. Teller and his colleagues had "misrepresented" the x-ray laser: "The Man Who Blew the Whistle on Star Wars," to quote the *Los Angeles Times*.

The Woodruff tragedy

Teller's leading internal critic was Roy Woodruff, a relatively competent technician and weapons designer who was able to rise to the highest management ranks at Lawrence Livermore based on his clever design work since 1968. But, when he found that a job title did not necessarily equal scientific stature, he let himself become jealous of the influence which Dr. Teller and other leading scientists exerted, without imposing job titles. This small flaw was manipulated by the anti-SDI forces associated with the *Los Angeles Times*, to convert Woodruff into an opponent of the entire program.

It may be that a key role was played by Woodruff's wife Mary, who was a top assistant to former Secretary of Defense James R. Schlesinger. Schlesinger is a science-hater, a malthusian nut, and a notorious advocate of using psychological, as opposed to technical, means in military affairs—"aura of power." He was one of the chief architects of the entire MAD (Mutually Assured Destruction) policy. Schlesinger will always be remembered as the Secretary of Energy who tried to destroy the magnetic fusion energy program in 1977, pre-

cisely because it was on the verge of major breakthroughs.

Woodruff himself, when he saw that Teller was serious about replacing this "traditional" MAD policy with the SDI's mutually assured survival concept, reports, "That's where everything . . . turned sour."

Did Teller misrepresent the potential of the x-ray laser to the President and other American leaders, as Woodruff claimed? Both the declassified Teller and Woodruff memoranda reveal that the x-ray laser was indeed demonstrated. And that with sufficient resources, starting in 1985, a system with tremendous firepower capabilities could be realized within 5 to 10 years, and that the Soviets were as much as 7 years ahead of the United States in developing this capability.

From a military standpoint, the x-ray laser would appear to fulfill President Reagan's objective of making ballistic missiles "impotent and obsolete." In any case, even the existence of the x-ray laser as a *viable potential* undermines the military certainty of success with a massive ICBM first strike. Given that the West has no interest in such a first-strike policy, possession of x-ray laser capabilities by both the United States and Soviet Union would not be undesirable.

In this context, who, or what, is Rep. George Brown (D-Calif.)? When announcing the release of these materials, he bragged of the success that he and other Dukak-eyed Democrats have had in emasculating the x-ray laser budget, "with the SDI program this year requesting less than half as much for continued x-ray laser research as it projected two years ago. Funded through the Department of Energy's Nuclear Directed Energy Weapons (NDEWs) program, the lion's share of which is for the x-ray laser, the request for FY 1989 was \$285 million. This compares to a projected request two years ago of \$707 million for fiscal 1989. Congress has cut the request to \$255 million, putting it below the 1986 level of support."

Within the highly technical and frontier scientific areas involved in x-ray lasers, there is certainly a lot of room for debate and differing analysis. But with regard to competence in the field of nuclear weapons, making rational projections of capabilities and time-frames when these capabilities will become practicable, it should be noted that Dr. Edward Teller has a rather good track record. His critics have cited the Manhattan Project of World War II as a framework in which to compare the x-ray laser program, citing attacks on his H-bomb work at that time as allegedly "incompetent." They should be warned that there are still many crucial aspects to that effort which have remained secret even today. And Teller's critics have, for the most part, only read about the Manhattan Project in history books. Teller initiated the Manhattan Project when he helped get Albert Einstein to send a letter to President Roosevelt in 1939.

Fusion and the potential of the xraser

The fusion-powered x-ray laser, otherwise known as the xraser, is not a solitary capability, but rather, is characteristic

Teller, EIR record on the x-ray laser

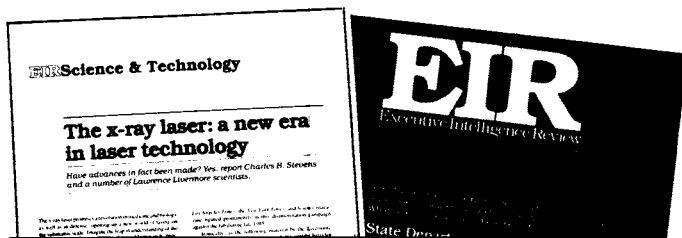
1982

Teller

"In the fall of 1982 . . . he wanted the lab to go to a meeting in La Jolla [probably the super secret defense science organization called JASON] and say that within five years we could produce an x-ray laser that would . . . defend against submarine-launched missile attack." (*Los Angeles Times*, July 17, 1988.)

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"These scientists have privately called for an accelerated research program in x-ray laser defense systems. . . . Such a program could prove the feasibility of an x-ray laser defense system in two to three years, and lead to a deployable ballistic missile defense . . . within five to eight years." (August)



1983

Teller

"I agree that science cannot be sped up by throwing money at it. But we are now entering the engineering phase of x-ray lasers. . . . We have also developed the diagnostics by which to judge every stage of engineering progress. . . . Since there is evidence that the Soviets have started sooner and in fact may have anticipated the President's speech of March 23 by a few years, it seems to me that we are facing a potentially dangerous situation." (Letter to Dr. George A. Keyworth, Dec. 22)

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"X-ray lasers: Current information indicates that the United States is months to a few years away from perfecting the nuclear-bomb-pumped x-ray laser. . . . The first-generation x-ray laser could be quite effective against short-range missiles." (April)

1984

Teller

"The technology employed in this demonstration appeared to be capable of generating a beam of x-rays which, at great distances, would be as much as [deleted] Bright as the bomb itself. One example of its utility would be the ability to kill a target at a distance of 10,000 km which would not be killed unless it were no more than 10 km from the bomb itself; another would be the ability to kill 100 such targets at distances of 1,000 km. This advance is thus comparable in magnitude to that involved in moving from chemical to nuclear explosives. . . . As a result of work done by Lowell's team during the past two years, there appears to be a real prospect of increasing the brightness . . . of x-ray lasers relative to the hydrogen bombs which energize them, which may thus be as large as a trillion, when directed against sharply defined targets. . . . This technology might be devastatingly effective in the mid-course and terminal phases of strategic defense, as it might be possible to generate as many as 100,000 independently aimable beams from a single x-ray laser module, each of which could be quite lethal even to a distant hardened object in flight." (Letter to Ambassador Paul Nitze, Dec. 28)

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"This means that anything within the cone defined by the laser beam will be hit by a beam that is a trillion times brighter than the H-bomb. . . . An x-ray laser beam of this brightness could destroy a missile booster from as far away as the Moon, and much harder targets, such as warheads within reentry vehicles, could be destroyed within a range of 10,000 miles. In fact, it is well known in directed-energy theory that the number of targets a laser weapon can kill increases as the inverse square of the ratio of different ranges. For example, if one x-ray laser module could kill a booster from 100,000-mile range, theoretically it could destroy 10,000 boosters within a range of 1,000 miles. And as was demonstrated in the case of mobile cannons with grapeshot against infantry two centuries ago, targeting problems rapidly disappear in the face of such gigantic firepower potentials." (May)

1985

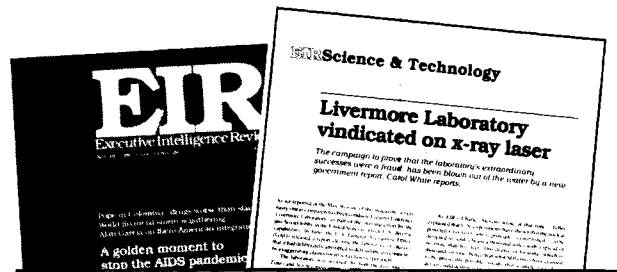
Lowell Wood

"Dr. Wood's April 23, 1985, briefing to William Casey, Director of the Central Intelligence Agency (CIA), and Stanley Sporkin, CIA's General Counsel. . . .

"In one part of his briefing, Dr. Wood stated the x-ray laser can have 'as many as [specific number of] independently aimable beams.'" (GAO Report, June 1988)

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"1) Firepower. The x-ray laser is extraordinarily energy-dense; The first x-ray laser weapon deployed will have the capability of destroying more than a score of offensive missiles. But even today, the scientific basis for far greater firepower potentials is being developed. The basis for projecting the development of a single x-ray laser weapon with the firepower to destroy the entire Soviet missile fleet with a single shot already exists." (December)



1986

EIR

"Given sufficient resources, the U.S. x-ray laser could now be developed within two years.

"The tremendous potential firepower of the nuclear bomb-energized x-ray laser, underscores the insanity of focusing U.S. missile defense efforts on obsolete systems. As Dr. Lowell Wood of Lawrence Livermore stated in testimony to Congress in early 1985, 'One contemplates the functional (and perhaps physical) destruction of entire fleets of ICBMs, with a single weapon module lofted by a single defensive missile. Each of these primary prospects has significant, albeit early, experimental results behind them at the present time. They are not dreams, nor are the corresponding applications studies naive.'

"With the plasma lens utilized to focus x-ray laser beams, a single x-ray laser bomb, in the megaton total output range, popped into space on a single missile could generate enough beams to destroy 10,000-100,000 hardened warheads over ranges of several thousand kilometers. In other words, one x-ray laser bomb could destroy all of the Soviet ICBM warhead and decoy capability, and do it during the 20 minutes of flight through space which the reentry vehicles, carrying the warheads, traverse on their way to the United States.

"Alternatively, Soviet x-ray lasers could easily destroy High Frontier's kinetic energy weapons and anti-missiles." (April)

of an entire range of new, directed energy technologies which combine the inherently large energy densities of thermonuclear fusion processes with the coherence manifested by relativistic, high energy particle and laser beams. In fact, this combination provides the means for an entirely new capability for mastering the spectrum of electrodynamic action.

Nuclear-explosive directed energy weapons (NDEW) are only the first, apparently crude and overly cumbersome working models for this new frontier of technology. For example, U.S. scientists have already been able to "miniaturize" the H-bomb by igniting thermonuclear reactions in microscopic quantities of fusion fuel. Thus, the scientific principles for harnessing the virtually unlimited potentials of inertial confinement, or so-called laser pellet fusion, have been demonstrated. In this case, a micro-pellet of fusion fuel is irradiated by either intense laser or particle beams. The action of the incident beams causes the fusion pellet to be compressed to the super densities and temperatures otherwise only found in the cores of stars. This generates the conditions for igniting thermonuclear fusion.

The resulting microscopic explosions can be readily contained and transformed into either useful mechanical or electrical impulses. The process has been described as the internal combustion engine of the 21st century. But instead of burning gallons of oil, laser fusion burns micrograms of readily available hydrogen. Instead of generating carbon dioxide and other potential pollutants, laser fusion generates the valuable element helium.

But inertial confinement fusion (ICF) is not limited to simply generating a cleaner and cheaper gross substitute for prevailing forms of energy consumption. The inherently high energy density of fusion processes also makes it possible to directly transform the output to useful forms, such as electricity, at very high efficiencies—in some cases approaching 99% and better.

But as the xraser demonstrates, this inherently high quality of energy deriving from high energy densities is not limited to existing forms of coherent energy, such as high voltage electricity. The xraser and other NDEWs demonstrate that coherent pulses capable of being focused to even higher energy densities than those originally found in the generating thermonuclear process can be achieved. And, as Leibniz first showed, energy density correlates with productivity.

How the xraser works

In principle, the workings of the xraser are quite simple. A primary H-bomb generates a burst of intense, incoherent x-rays. If this intense x-ray output is properly tailored, then it will generate x-ray lasing action when incident upon material containing the appropriate chemical elements. The appropriate chemical elements are contained in rods or cylinders which are geometrically placed to properly receive the pulse of x-rays deriving from the detonation of the primary fusion fuel of the H-bomb.

Within a few trillionths of a second, the incident x-rays convert the rods into plasmas. That is, the incident x-rays ionize the rod atoms. The x-ray output from the H-bomb thermonuclear plasma is not totally incoherent. It is possible to tailor this x-ray output both in terms of intensity and wavelength through the proper placement of intervening jackets (what are technically called "tamper") around the thermonuclear fuel. The essential requirements are that the incident x-ray pulse be tailored such that it generates a uniform plasma column and uniform distribution of the desired ionization states in the atoms making up the plasma.

To put the problem in more descriptive terms, a plasma has to be generated in which its atomic and electron elements are as well organized as those found in a perfect crystal. This must be done while the energy-flux of a hydrogen bomb explosion passes through the plasma. The time spans involved, though, are very short; the configuration must be achieved for durations lasting from only trillionths of a second to possibly a billionth of a second. But all of the conditions must match up during this short time span. If not, the plasma will not generate the desired xraser pulse. Furthermore, any nonuniformities could prevent the pulse, if generated, from escaping or being directed along the path desired.

Such tailoring calls for a very advanced comprehension of energy-dense plasmas and their nonlinear interaction with electrodynamic radiation.

A more detailed analysis shows that most other laser defense systems must deliver millions of joules of energy if they are to assure the destruction of hardened warheads. Because of its high energy density, the xraser can achieve the same result with as little as a couple of joules of incident energy. When a sufficiently intense xraser pulse hits the surface of a target, the interaction generates highly focused particle beams. The resulting high-energy particle beam will then penetrate to the interior of the target and will further focus the energy pulse during the process of absorption within the interior of the target.

This internal, high-energy particle energy deposition is of such a form that it guarantees the destruction of all electronic elements and circuits when a deposition level of greater than a few joules per gram of target is achieved. Furthermore, the nuclear explosive-powered xraser can generate laser pulses in excess of billions of joules. This provides a more accurate picture of the ultimate potential firepower of the xraser against nuclear warheads. It can kill billions of warheads, in principle. The essential determinant in this example is our ability to achieve the required initial level of xraser beam focusing.

It is clear in stark military terms that the xraser and other NDEWs represent a general transformation in the meaning and performance of firepower. This was the central method of the SDI policy presented by Lyndon H. LaRouche in 1982. Furthermore, this LaRouche criterion asks, "What level of productivity increases would result from applying this tech-

nology to the economy as a whole?"

The same self-focusing properties of the x-raser and other NDEWs which make them such powerful potential weapons, also give some indication of the vast increases in productivity which will accrue from applying these techniques to "civilian" pursuits. The x-raser, for example, is currently being perfected at Livermore for making *in vivo* atomic-scale microholograms—three dimensional pictures—of living cells. These microholograms promise to revolutionize every aspect of biological, medical, and chemical science and technology.

In the simplest case, atomic-scale microholograms taken with a time resolution measured in billionths through trillionths of a second could provide a "motion picture" of the way catalysis works in living biochemical processes. Insight gained from this alone could increase the productivity of the chemical industry many orders of magnitude.

On the broader horizon, the mastering of the microscopic plasma and electrodynamic processes implicit in the technology of x-raser development can provide the essential means for revolutionizing science itself. Some x-raser experimental results on the interaction of intense x-raser beams with "perfect" crystals indicates that we may be directly observing the relative curvature of space-time, in the sense that Bernhard Riemann first called for making such measurements in his 1854 paper, "The Hypotheses which Underlie Geometry."

Mastering of these measurements could lead to a new comprehension of what "matter" represents in terms of electrodynamic-physical processes—an understanding of the electrodynamic processes of subnuclear processes, for example. Mastery of such processes could enable us to construct new types of "crystalline" states of matter, such that controlled thermonuclear fusion between the lattice nuclei could be provoked by the simple introduction of the appropriate sound wave. The resulting fusion energy output appears as a pulse of electricity or other desired coherent energy form. In principle, we would have a new type of battery, as small or as large as desired, which would be millions of times more powerful, thousands of times cheaper, and capable of operating for years or decades, depending on the application.

Research and development

The first unambiguous demonstration of an x-raser took place in 1980 in an underground Nevada nuclear test. The experiment's design was highly speculative at the time, and surprised most scientists—including Dr. Teller—with its success. The initial weapon specifications deriving from this first-generation theoretical demonstration of x-rasing, projected a crude device developing a few x-raser beams whose poor optical quality and low efficiency in converting H-bomb energy into x-raser beam energy limited them to relatively short ranges of less than 500 kilometers against relatively soft targets, such as thin-skinned rockets during their boost phase, or satellites.

But then, further tests demonstrated that scientists had

underestimated the rate at which the nuclear x-raser could be improved. This developed along two lines. First, the dynamics of the x-raser lasing medium proved to be highly nonlinear. Much higher efficiencies and optical quality levels were achieved than were originally expected. Second, innovative techniques were uncovered for developing x-raser optics. Many scientifically esteemed critics of the SDI made the projection that optics, such as mirrors and lenses which direct and focus ordinary light, would be technically impossible to realize for intense x-ray laser beams. Experiments quickly demonstrated that to be false.

With the development of insight into the potential for improvements, as the GAO report and Teller's CBS-TV interview document, Dr. Teller and his colleagues began to radically increase their projections for the firepower of the

X-ray laser: reality comes out

The letters of Lawrence Livermore National Laboratory official Roy Woodruff were ballyhooed by the press as "debunking Edward Teller" about the x-ray laser and the Strategic Defense Initiative; claims about these letters led to congressional investigation, scandalized Livermore, and unleashed blundering FBI agents upon laboratory personnel. Now finally revealed, the Woodruff letters, written in 1984, state that:

- 1) "The production of strong x-ray energy beams that are unmistakably the result of lasing action, is an accomplished fact";
- 2) "I fully expect that these . . . experiments will establish that the x-ray laser could be an effective weapon";
- 3) "With the successful completion of the [experiments] outlined above, the development of a full x-ray laser weapon system would require an additional 5-10 years and would cost several billion dollars, depending on the number of weapons required. Of course the schedule could be accelerated if, in parallel to the x-ray laser research, we were to execute a weapon engineering development program."
- 4) "We are also working on several other methods for directing the energy of a nuclear explosion. It is only prudent to assume the Soviets also are actively pursuing other methods for directing the energy of a nuclear weapon, and it could be very dangerous if they are successful first."

X-ray laser funding has, since 1984-85, been cut to \$250 million per year.

xraser and reduce the estimated time it would take to perfect the system.

Then, in 1985, a Nevada test demonstrated the effectiveness of a plasma lens for focusing and directing xraser beams. This test blew the lid off even the most optimistic previous projection. While there is still a significant scientific debate on the interpretation of the 1985 results, Dr. Teller stands by the projections he made at that time. Moreover, there are indications that new information on these results will shortly be released.

In any case, the projection for the xraser improved, such that instead of envisaging the development of a system only capable of intercepting slower, submarine-launched ballistic and intermediate-range missiles in their boost phase, the accepted estimate was that a single xraser module could generate upward of 100,000 individual beams, each capable of functionally disabling, if not physically destroying, the hardest targets, such as reentry vehicles and warheads.

Vindication: the GAO report

The June 1988 GAO report, "Accuracy of Statements Concerning DOE's X-Ray Laser Research Program," presented the following "Summary of Findings":

"We found that the LLNL official channel, which included Mr. Woodruff, had made statements about the status and potential of the x-ray laser, which were similar to most of the statements identified by Mr. Woodruff as being 'overly optimistic and technically incorrect.'

"Mr. Woodruff prepared letters to send to [presidential science adviser] Dr. Keyworth and [arms negotiation] Ambassador Nitze clarifying the statements made by Dr. Teller. However, Dr. Batzel said that he preferred that Mr. Woodruff's clarifying letters not be sent [because Woodruff's letters included funding projections which Batzel did not think it proper to present to Keyworth and Nitze before sending these funding proposals through proper channels, as later detailed in the GAO report], and they were not. We found that Mr. Woodruff presented his opinions on information that had been provided by Dr. Teller to Dr. Keyworth and Ambassador Nitze. Mr. Woodruff told us he did not have opportunities to present his views to Mr. McFarlane and Mr. Casey.

"In addition, we asked selected LLNL scientists, who had specific knowledge about the x-ray laser program, for their opinions as to the accuracy of the statements challenged by Mr. Woodruff. From these interviews, we concluded there was no general agreement among these scientists regarding the accuracy of the statements. . . ."

The GAO report also quoted a Department of Energy (DOE) review of the statements of Drs. Teller and Wood:

". . . In summary, they found that Drs. Teller and Wood were optimistic about the potential of the x-ray laser. They concluded that the views of Drs. Teller and Wood were presented as views of individual scientists and not represented as the official position of LLNL."

Book Reviews

NATO is into chaos

by Warren J. Hamerman

Chaos in Biological Systems

ed. by H. Degn, A. Holden, and L. Olsen

Plenum Press, New York, N.Y. 1987

323 pages with index, \$62.50 hardbound

For four days in December 1986, the NATO military alliance sponsored an "Advanced Research Workshop" at Dyffryn House, Cardiff, Wales on the seemingly unlikely theme of "chaos" in biological systems. In this volume of the proceedings of the NATO seminar, one can read papers of some 75 scientists which prove, among other things, that:

- the dynamics of a healthy heart beating is pure chaos, while disease and arrhythmias are orderly;
- the oscillatory water transpiration in plants is governed by pure chaos;
- platelet production in the healthy person is random and chaotic;
- "chaos" runs everything from cell behavior and nerve impulses to the ecology and epidemics.

At the workshop, NATO reviewed "chaos models" in the following organisms: man, rabbits, plants, squids, and mollusks.

While the reader will have no trouble accepting that "chaos" took over our foreign policy and economy, he or she may be startled to learn that scientists around the world in every conceivable discipline are trying to elevate "chaos" to the level of a full-scale universal theory of all natural processes.

Recently, science journals in every field—from physics and meteorology to mathematics and biology—have been flooded with articles and reports which claim to prove that "chaos" explains everything.

Teams of computer programmers are racing to outdo each other in showing "chaos" on the screen in full-color graphics. A newspaper reporter has written a popular nonfiction best-seller which explains to the ordinary man just how important chaos is, and how, in a few years, it grew from being the pet project of a few crankish computer scientists to the fastest-spreading religion since Islam.

The chaos model promotes itself *falsely* as the *only* alternative to static, equilibrium systems characterized by linear dynamics. It maps complex physiological structures and pro-