Path to an efficient x-ray laser beam weapon has been found

Breakthroughs are imminent in work being done at the University of Chicago. By Charles B. Stevens.

Researchers working under the direction of Dr. Charles K. Rhodes at the University of Illinois in Chicago are on the verge of demonstrating that efficient, non-nuclear x-ray lasers are feasible. Word of this pending breakthrough is presented in a paper by Dr. Rhodes, appearing in the Sept. 27, 1985 issue of *Science*. This development will revolutionize every field of scientific research and industrial technology and immediately catapult beam weapon missile defense capabilities decades ahead of previous projections.

The experimental basis for this new approach to x-ray lasing, as detailed by Dr. Rhodes in his *Science* presentation, is already quite extensive. Experiments now in process could provide full feasibility demonstration in the immediate future, according to leading scientists at the Pentagon's Strategic Defense Initiative Office (SDIO). One result will be the realization of x-ray lasers (xrasers for short) with operating efficiencies millions to billions of times greater than that seen in existing models. Combined with the recent breakthroughs at Lawrence Livermore National Laboratory in California on the development of plasma refractive optics for focusing powerful xraser beams, the Rhodes work can lead directly to a non-nuclear xraser, multi-burst beam weapon capable of causing the nuclear disintegration of offensive missiles. If used in conjunction with nuclear explosives, the new approach could lead to the realization of single burst nuclear powered xraser devices capable of producing tens of thousands of simultaneous xraser pulses, each capable of destroying an offensive nuclear-tipped missile.

'Multiphoton ionization of atoms'

In his *Science* report with the above title, Dr. Rhodes notes that: "Historically, the initial discussions of coherent generation in the x-ray range and nonlinear atomic emission and absorption all appeared more than 20 years ago in entirely independent circumstances. Recently, however, these two areas of inquiry have become strongly linked, and it now appears that the achievement of the former may depend, at least in one possible representation, on certain basic properties of the latter."

Dr. Rhodes goes on to to review scores of experiments in which an unexpected, multiphoton (a photon is a quantum of light energy) process of radiation absorption was demonstrated.

Most lasers are based on pumping energy into a gas or solid medium with the result that some of the atoms or molecules of this medium are driven into an excited state. Lasing occurs when these excited atoms are stimulated to relax to an unexcited ground state. Each excited atom will emit a light photon of the same wavelength and, since it is precisely the nearby passage of such a wavelength of light which will stimulate an excited atom to emit, the net result is that the excited medium will emit photons all in step—coherently.

The atomic excitation process involves raising the energy of a specific atomic electron. The outer atomic electrons have the lowest energy levels and produce the longest light wavelengths. Therefore, to proceed to shorter wavelengths, such as those of x-rays, higher energy inner electrons must be pumped up. But the problem with this is that any energy input which would pump up inner electrons, would generally first be parasitically absorbed by the outer electrons. Therefore, any xraser pumping scheme would have to be extremely inefficient, if possible at all.

Rhodes reports on experiments in which the pump energy input is indeed absorbed by the outer atomic electrons. But, these pumped up outer electrons then proceed to collectively excite a much higher energy inner electron. As Rhodes emphasizes, his experimental results contradict all existing theoretical models of atomic processes on two counts: 1) the efficient way in which the outer electrons absorb large amounts of input radiation; 2) the efficient manner in which these outer electrons collectively transfer their energy to a single inner electron.

The Rhodes experiments appear to be producing a new state of matter which is similar in some regards to what is currently only found in collisions between high energy accelerated particles.

Dr. Rhodes has found in his experiments that high power incident optical laser light is non-linearly absorbed by atoms. The atom, in effect, acts like an electron accelerator. The intense electric field of the incident optical laser beam causes the electrons in the outer shell of the atom to become highly accelerated. This is similar to the action of the transformer on the plasma in a tokamak. The transformer induces a large electrical current in the donut shaped tokamak plasma. Rhodes is getting the same result, but on an atomic scale with resulting gigantic electric current densities.

In point of fact the Rhodes research may be unlocking the connection between non-linear processes seen in high density plasma pinches and those found within the atom. In a word, the dawn of the "atomic pinch" may be at hand. Indications of this development have already been seen in plasma focus experiments carried out at the Stevens Institute in New Jersey and the MAN company in West Germany, and in the theoretical work of the Soviet scientist Meieovich. Besides revolutionizing every aspect of basic physics, such a development could have immense technological applications. For example, the ability to produce nuclear densities and therefore nuclear energy at will with miniscule and crude energy inputs; the ability to produce particle accelerators which measure only a few centimeters in length, but which produce the same outputs as those currently projected as needing 100 mile dimensions.

Immediate applications

The practical implications of the Rhodes experiments are immense. First of all, as Rhodes notes, a one kilovolt x-ray laser with a 1% pump efficiency could be immediately developed. Furthermore, the pump input could be as little as a few joule excimer laser, making the total cost of the xraser quite small. As Rhodes notes: "A spectrally bright source of radiation in the x-ray region would be unsurpassed in its ability to microvisualize condensed matter. There is little doubt that major areas of application would include basic materials research, microelectronics, biology, and, indeed, any field that requires structural information of solid matter on an atomic scale." Rhodes's approach could make the xraser accessible to every university and major private research facility.

With regard to these scientific and industrial applications of xrasers, the Rhodes approach is particularly exciting since it could lead to xrasers over a wide range of x-ray wavelengths with a high quality optical output, given the "control on the energy transfer."

Among the more immediate specific applications would be xraser microholography in which moving pictures of biological and chemical processes could be made on a subatomic scale within a temporal resolution of one trillionth of a second or less. Besides leading to the development of entirely new materials for computing chips, xrasers could immediately increase the computing power of chips a million-fold with no increase in cost. A million fold increase in productivity in this one industry! (The greater resolution of xraser "printing" would immediately reduce the scale of existing types of electronic elements by as much as a factor of 10—since greater coherence of xrasers reduces the scale of shadow [*umbra*] effects sufficient to permit the use of printing-resists with a substantial physical standoff. This would increase production per resist by factors of 100 or more. And this in turn, because of the increase in reliability, could be translated into increase of chip size by the same factor. The net result is an increase in chip linear dimension by a factor of 1000, or a computing capacity increase of one million, since this varies with the area of the chip.)

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Weapon applications

In the first place, the Rhodes approach leads to an increase in laser efficiency over existing ones by a factor of one million to one billion. Theoretically, this means that if a xraser device could produce 20 lethal beams before, it could now develop 20 million such pulses in a single burst. Actually, other considerations, such as optics and geometry of laser distribution around the energy source, delimit this improvement to the range of 100 to 10,000. But still, the potential improvement represents an astounding increase in firepower. A single device, launched on a single missile and costing a few million dollars, theoretically has the potential of destroying the entire inventory of Soviet missiles and warheads costing hundreds of billions of dollars!

Most significantly, the Rhodes breakthrough means that efficient xrasers can be built to virtually any scale and wavelength up to a kilovolt. This immediately means that effective xrasers no longer have to be based on explosives of any kind. And systems that can be easily refired are quite feasible. For example, high repetition rate xrasers could be powered by existing types of excimer lasers, which have demonstrated refire rates of a thousand single pulse bursts per second. Other single burst varieties could be powered by small chemical explosive charges.

The net result is that xrasers could be deployed on the battlefield to provide a robust defense against the entire range of offensive munitions—missiles, aircraft, rockets, artillary shells etc.

Contrary to the claims of missile defense critics, it is not impossible to utilize xraser beams within the atmosphere. In the first place, the physics of high power-density xraser beams is only just now beginning to be explored in great secrecy. Indications, though, do exist that concepts have been developed for achieving atmospheric propagation of xraser beams. And it should be remembered that it was only a few months ago that SDI critics claimed that it was fundamentally impossible to shoot charged particle beams on a straight path through any part of the atmosphere. Now, scientists at both Los Alamos and Livermore have experimentally demonstrated that this can be done through the upper part of the atmosphere—the point being that methods could be developed for basing xrasers on the ground for defense against anything that moves.

As a weapon the xraser has a virtually unlimited firepower capability, though at the same time it is highly selective and not a weapon capable of mass destruction. To be utilized effectively the xraser must be focused down to very small areas—a few square meters at most and millimeters in most cases. Therefore it is only capable of destroying specific targets. But within that limitation the xraser is all-powerful.

The primary means of target destruction with the xraser is that of shock kill where the powerful x-ray pulse produces a shock wave on the surface of the target which punches a hole through it. But the xraser pulse is also capable of producing more complicated types of electronic kills at even very low power levels of beam deposition, such as system generated electromagnetic pulses. At the other end of the scale, highly focused xraser beams can produce nuclear disintegration of the target, even before the shock wave has time to punch a hole through it.

In this case the high power beam is deposited within an extremely thin micron layer of the target surface. Because the x-rays knock out electrons from this layer, this leads to the generation of huge electric fields within this layer. And the electric field accelerates ions within the layer to energies otherwise only produced in charged particle accelerators several miles long. (There already exist designs for miniature high energy particle accelerators based on xrasers.) These charged particles are capable of penetrating deep within the target and generating showers of nuclear reactions. Electronics, nuclear fuels and chemical explosives are particularly vulnerable to high energy charged particles. As a result, nuclear disintegration can be the most efficient and effective means to disable military hardware and weapons.

Japan moves to fusion forefront

by Charles B. Stevens

As I reported in *EIR*'s Oct. 4 issue, there is no barrier to achieving fusion power as an industrial source of energy, except money. The Reagan administration has cut the budget for inertial confinement fusion by 50%, despite criticism by the National Academy of Sciences.

Despite the excellent record of the program in achieving its technical goals, the program suffers under the restriction of being classified top secret; and, because of congressional chiseling on the budget for the Strategic Defense Initiative, funds are being vacuumed into that program from every other ongoing program.

This has also affected the magnetic fusion program, which is on the verge of significant breakthrough. Over the past two years, magnetic fusion has seen the initiation of reactor-scale experiments, such as the Princeton TFTR, the Japanese JT-60, and the European JET. The Alcator C at MIT has demonstrated the plasma-density/energy-confinement product needed for net energy generation. Confinements of hot fusion plasmas by magnetic fields has been improved by a factor of 10.

This notwithstanding, an adequately funded laser (inertial-confinement) fusion program probably offers the greatest chance for breakthrough at this time.

Laser fusion energy

Ironically, the other great handicap of the program identified by the National Academy of Sciences, the restrictions due to top-secret classification, appear to have little point, since the Japanese inertial-confinement program is a parallel program that is entirely open.

In laser, or inertial confinement fusion, the laser focuses intense pulses of radiation upon minute target-pellets of hydrogen. There are two basic approaches to depositing energy on the target. One deposits the beam energy directly upon the target surface. This leads to what is called an ablative implosion, which compresses the target.

In the other, the energy is deposited within a chamber, where it is converted into higher frequency forms of energy such as x-rays. The target is then caused to implode, indirectly, by the emission of these x-rays. While possibly necessitating greater amounts of total beam energy, the indi-