AD-A063 774 FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OHIO F/G 20/5
X-RAY LASER MAY BECOME A REALITY,(U)
OCT 78 R VLAICU
UNCLASSIFIED FTD-ID(RS)T-1030-78 NL

| OF |
AD
A063774

END
DATE
FILMED
3-79
DDC

FTD-ID(RS)T-1030-78

AD-A063774

FOREIGN TECHNOLOGY DIVISION

X-RAY LASER MAY BECOME A REALITY

By

Radu Vlaicu

78 12 26 430

EDITED TRANSLATION

FTD-ID(RS)T-1030-78 2 October 1978

MICROFICHE NR: FTD-78-C-001343

X-RAY LASER MAY BECOME A REALITY

By: Radu Vlaicu

English pages: 4

Source: Stiinta si Tehnica, Nr. 6, 1977, pp. 7

Country of Origin: Romania
Translated by: LINGUISTIC SYSTEMS, INC.
F33657-76-D-0389
Bernath Tibor
Requester: FTD/TQTD
Approved for public release; distribution unlimited .

X-RAY LASER MAY BECOME A REALITY

by Radu Vlaicu

At the beginning of this decade research toward building an X-Ray laser was both subject to doubt and under theoretical speculation. Today, hopes of building it stand on firmer ground. Firstly, theoretical estimations for accomplishing a population inversion for soft X-Rays are realized and the most promising technique is the pumping of neutral atoms through photoionization. Secondly, intensive efforts are made in the experimental field, with many laboratories building powerful lasers in the visible or near X-Ray wavelengths.

Certainly the technique of the X-Ray lasers is different from the one producing usual lasers (infrared, visible and ultraviolet). It is known that to obtain a laser effect one needs a population inversion, namely to obtain an atom population with the majority of their nuclei in a certain excited state. Once this condition is reached, the next step is a cascade process by choosing adequate physical parameters, i.e. spontaneous emission of a photon by a nuclei returning to its ground state. The emitted photon interacts with another excited nuclei; the latter, being excited, emits a photon identical to the first photon (same energy, phase and vector movement).

For the X-Ray laser with wavelengths between 1 Angstrom (Hard X-Ray) and several hundred Angstrom (Soft X-Ray) the fundamental problem is the one of the amplifying medium. The most transparent medium to the X-Ray radiations is the strongly ~~inoized~~ ionized plasma (all other "cold" materials being opaque). The transitions between the atomic or ionic energy levels can produce corresponding high energy X-Ray emissions; the lifetime of these levels is short. Therefore, one would need energies at levels too high to produce these population inversions. Presumably the first X-Ray lasers will be built with amplifying mediums such as very thin cylinders to prevent the stimulated radial emissions. Since the length of the cylinders will be longer than the X-Ray trajectory, the exciting impulse should be propagated with the light velocity along the cylinder so as to maximize the amplifying properties of the medium.

Therefore, the efforts are actually aimed at accomplishing a population inversion between levels conveniently selected. For example, one has two options: either pumping neutral atoms through photoinoization or using plasmas produced by very powerful lasers. With either alternative the experimental results are far from satisfactory. With the first alternative, that of the photoionization, the necessary power requirement to accomplish the population inversion is considerable. A simple calculation indicates that to keep a copper atom in an excited state (K-shell) one needs 3 watts. Extrapolated to a one micron cube, the pumping system would require several gigawatts. Today these experiments are impossible since the most powerful laser (corked glass) has an output of 10^9 watts per cm^2 (in a 0.3 picosecond impulse) versus a 10^{17} watts per cm^2 (in a 0.1 picosecond impulse) as required by the emission K proportional to 1 of the copper atom (Lambda = 1.54 Angstrom, hard X-Ray).

One can see that the photoionization method cannot be taken into account in the area of hard X-Rays.

A more promising alternative is the use of soft X-Rays. M.A. Duquay (Sandia Laboratories, Alburquerque, New Mexico) investigated, with good results, the 372 Angstrom transition in sodium vapors. The necessary power for pumping has been estimated to 16 watts per cm^2. Moreover, a team led by P.J. Malloz (Battelle Institute, Columbus, Ohio) succeeded in converting, with an energy yield of 20%, impulses of 50 joules, released in impulses of one nanosecond by an infrared laser, to a flash of X-Rays with an approximate wavelength of 10 Angstrom. Similar performances with ruby soft X-Rays were accomplished by other investigators.

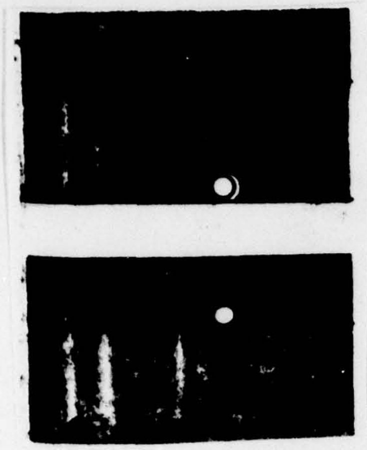
The second method for a population inversion in the soft X-Ray, namely the one using hot and thick plasma produced by focusing strong laser impulses on a solid target, has also been investigated around the world(Lebedev Institute, Moscow, Battelle Institute and Naval Research Laboratories, Washington). Promising results were also announced by investigators at Orsay laboratories in France. They observed that the spectral irradiation at 117.4 Angstrom due to triple ionized aluminum can be amplified by an average of 17% to a 0.1 mm. thick plasma.

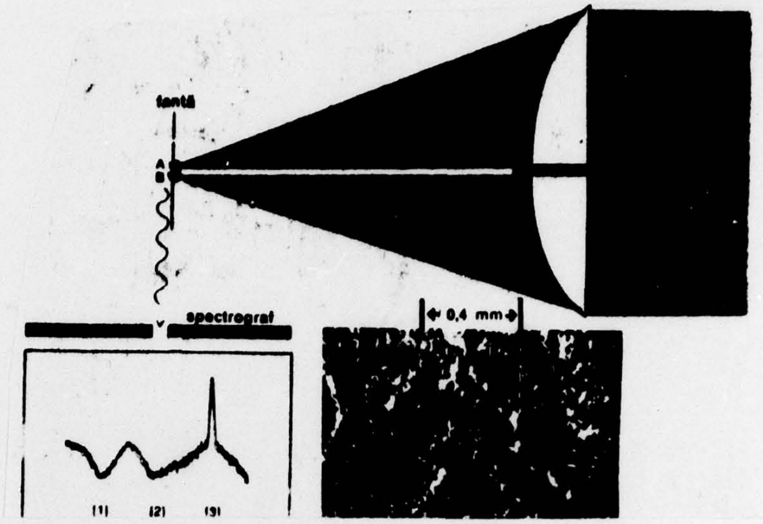
Why is there such an interest in building lasers which emit radiations close to X-Ray wavelengths? Undoubtedly the pride attched to scientific curiosity does not justify the expense and efforts. The reality is that these modern devices are impatiently expected by physicists, chemists and biologists. With a coherent bundle of X-Rays one would be able to successfully investigate macromolecules deep inside the living tissues, presently impossible with actual capabilities of electronic microscopes.

In solid state physics an X-Ray laser would allow research in crystal deslocations by strong and short impulses and changes in crystal structure due to propagation of an impact wave. Similarly, the electronic and optical technology could benefit from these lasers by the creation of thin masks leading to new components working at high frequencies.

Practically speaking, the opinion is that the research leading to nuclear fusion by lasers is strongly correlated with the construction of the X-Ray laser. The reasons are twofold. Firstly, the equipment in both cases is identical; lasers in infrared emit a high energy level through short impulses. Secondly, the mechanistic studies involved in very dense plasma, used in the fusion, would be greatly eased.

The interest arroused by the X-Ray lasers will certainly increase. One can be fairly confident that the first instruments of this kind will irradiate in the soft X-Ray region with wavelengths on the order of 100 Angstrom. In any event, the research leading to the construction of these lasers presents a major interest on a fundamental basis as well.





Exoposing an atom to X-ray irradiations one can create "deficiencies" on certain electronic shells (1A). That is the principle of the photo-ionization. This "deficiency" has a very short lifetime (0.45×10^{-15} sec. for the K-Shell of copper) and the "gap" will be filled by an electron comming from a higher energy level. The phenomena is accompanied with an X-ray emission. To obtain a laser effect it is necessary that at least 0.1% of the atoms to be in the 1A state. However, for this effect one needs an enormous "pumping energy.

The experiment which permitted the Orsay investigators to demonstrate the existence of an amplification of the 117.4Å irradiation with a laser initiated aluminum plasma. The very short impulses (40 nsec) of a neodymium laser pass through a cylindrical lens cut in two halves; the halves will converge the fasicule through A and B situated on an aluminum target at 0.4 mm of each other; the ejected material creates two hot thick plasmas with minimal volume near the target; a spectrograph permitted the analysis of plasma absorption of B and the irradiation from the plasma A. The 117.4 Å irradiation is amplified by the second plasma (the curve peak).

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

ORGANIZATION		MICROFICHE
A205	DMATC	1
A210	DMAAC	2
B344	DIA/RDS-3C	9
C043	USAMIIA	1
C509	BALLISTIC RES LABS	1
C510	AIR MOBILITY R&D LAB/FIO	1
C513	PICATINNY ARSENAL	1
C535	AVIATION SYS COMD	1
C591	FSTC	5
C619	MIA REDSTONE	1
D008	NISC	1
H300	USAICE (USAREUR)	1
P005	DOE	1
P050	CIA/CRB/ADD/SD	1
NAVORDSTA (50L)		1
NASA/KSI		1
AFIT/LD		1
LLL/Code L-389		1

ORGANIZATION		MICROFICHE
E053	AF/INAKA	1
E017	AF/RDXTR-W	1
E403	AFSC/INA	1
E404	AEDC	1
E408	AFWL	1
E410	ADTC	1
E413	ESD	2
	FTD	
	CCN	1
	ASD/FTD/NIIS	3
	NIA/PHS	1
	NIIS	2