[redacted]

DOC016324

[redacted]

SECY-1522

May 13, 1971

Redacted Copy Version

This document consists of 11 pages

Copy No. 19 of 40 Series A

DP-32FRS9ØF1086

LASER RESEARCH PROGRAM: SUMMARY REPORTS FOR JANUARY-MARCH, 1971

Note by the Secretary

The General Manager has requested that the attached memorandum of May 12, 1971 from the Assistant General Manager for Military Application, with enclosures, be circulated for the information of the Commission.

W. B. McCool

Secretary of the Commission

DISTRIBUTION	COPY NO.	DISTRIBUTION	COPY NO.
Secretary	1,26-37	Asst. GM for MA	14-15
Chairman Seaborg	2,38-40	Asst. GM for Reactors	16
Commissioner Ramey	3	Asst. GM for R&D	17
Commissioner Johnson	4	General Counsel	18
Commissioner Larson	5	Classification	19
Commissioner	6	Congressional Relations	20
General Manager	7-8	Controller	21
Deputy Gen. Mgr.	9	Inspection	22
Asst. Gen. Mgr.	10	Intelligence	23
Exec. Asst. to GM	11-12	Research	24
Asst. GM for Admin.	13	Space Nuclear Systems	25

~~RESTRICTED DATA~~
~~This document [illegible] restri[illegible] as defined in the Atom[illegible] of 1954. Its transmitt[illegible] disclos[illegible] its conte[illegible] any manner to an unauth[illegible] [illegible] is prohibited~~

~~GROUP 1~~
~~[illegible] downgrad[illegible] de[illegible]ication~~

~~7/31/09~~ [illegible]

[redacted]

Staff papers SECY Lasers

P9693

Acc 7816

[redacted]

[redacted]

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

MAY 12 1971

Chairman Seaborg
Commissioner Ramey
Commissioner Johnson
Commissioner Larson
Commissioner

THRU: General Manager

LASER RESEARCH PROGRAM

My April 19, 1971 memorandum* on laser research advised of plans to keep you current on this work through brief quarterly summary reports by LASL and LRL. Accordingly, enclosed for your information are summaries for the period January-March 1971. Should you desire additional information, I will be pleased to furnish it.

I am providing the JCAE copies of these summary reports.

Edward B. Giller
Major General, USAF
Assistant General Manager
for Military Application

Enclosures:
1. LASL Report, DLP-28
2. LRL Report, CPL 71-10

*Secretariat Note: In the Record, Secretariat.

[redacted]

When separated from enclosures, handle this document UNCLASSIFIED
(Insert proper classification)

[redacted]

[redacted]

April 29, 1971
DLP-28

LASL
LASER PROGRAM SUMMARY REPORT

[redacted]

During the period December 31, 1970 through March 31, 1971, a number of advances [illegible] been made and plans for future work placed on a firmer basis outlined below:

A. THEORETICAL WORK

1. Energy absorption predictions - Calculational methods of handling both oblique and normal incidence laser radiation in the collisionless ($> 10^{14}$ watts/cm^2) region are now working satisfactorily and predicts strong absorption in the normal incidence case due to the growth of two stream plasma instabilities, while oblique incidence radiation shows even stronger absorption due to a resonance absorption phenomena. Absorption lengths are now being calculated.

2. TN burn codes - Two dimensional codes with non-local deposition of alpha particle energy are operational. Our predictions of low break-even energies are now in agreement with the LRL results. More work is needed to account properly for self-absorption of radiation.

3. Calculations - Calculations of experimental results obtained by various workers in the field are in progress and give good agreement.

4.

DoE
b(3)

Deleted

B. [illegible]

1. [illegible] - The rod system has been moved to the new location and [illegible] with fair beam quality and high pulse to background ratios [illegible] joule level. The energy is being focused on targets without pre-[illegible] but energy feedback from the target is causing some diffi-[illegible]. A Faraday rotator designed to correct this problem

[redacted]STRICTED DATA [redacted]

[redacted]

is being installed to decouple the target feedback from the laser. Design is proceeding on the disk laser and most components are on hand for its construction. It should permit operation at the 500 to 1000 joule level later this year.

2. CO_2 lasers - Mode-locking has been achieved for an atmospheric pressure CO_2 laser and a satisfactory pulse train obtained. Equipment to switch-out a single pulse from the pulse train for further amplification is being installed.

Electron beam ionization experiments for the electric discharge pumped CO_2 laser have progressed to the point where small signal gain of over 20 db/meter [illegible] and power densities of greater than 100 joules/liter appear achievable. This has prompted a decision to use this technique throughout the laser system. Three lasers 5 cm x 5 cm x 100 cm operating at one bar and one of the same size operating at pressures as high as ten bars have been designed and are being detailed for construction. These will be used to explore the practical power density achievable from the standpoint of window, mirror and self-focusing limitations and to provide further design parameters for the high powered systems. They will also provide components for the front end for a 10^3 joule system which is in the design stage at this time. We now believe that lasers having a pulse output of 10^5 to 10^6 joules in a nanosecond or less will be achievable in the next several years. We are studying the design of such a system with the intent of starting construction in FY-73.

3. Chemical lasers - Experiments on the HF laser system demonstrate deactivation of the population inversion in 300 collisions and superradiance (spontaneous emission into 4 π solid angle without resonant cavities) in a few centimeters. This confirms our original opinion that a traveling wave chemical laser would be required to obtain substantial energy in a short pulse output for HF. Several experiments are in progress to explore the feasibility of such a concept. Experiments are also underway on condensed explosive systems (liquid or solid explosives) as a possible way of obtaining a high energy laser pulse from a very lightweight compact system.

4. Experiments - A number of experimental setups to use the laser energy have been prepared and the focusing of laser energy on targets has just started.

[redacted]

[redacted]

May 4, 1971

LRL LASER THERMONUCLEAR PROGRAM SUMMARY **(C-RD)**

(JANUARY - MARCH 1971)

Lawrence Radiation Laboratory

Livermore, California

[redacted]

ORGANIZATION

Laser research has been in progress at the Lawrence Radiation Laboratory since 1962. Until FY 1971, since this was predominantly a research effort, it was part of the physics program. Recent advances in high-power lasers have led to an increased programmatic commitment in the laser area. Specifically, during FY 1971 a greatly increased effort directed at investigating the application of high energy, high power, lasers to the attainment of pure fusion explosions was begun. The Physics Department's Q Division continued to provide theoretical support and work on advanced laser concepts as well as pursue laser oriented Laboratory experiments of a long term programmatic character. Additional laser development was pursued under the direction of the small weapons program. Development of thermonuclear fuel capsules and associated hardware was carried on within the large weapons program and chemical lasers were investigated in the chemistry program. Because of the FY 1971 growth, and that anticipated for the future, all of the Laboratory's high power laser efforts have recently been consolidated into a single program under the direction of Carl Haussmann.

TRENDS

Current lasers are already powerful enough to begin studies of the properties of matter and the emission of x-rays from matter at high temperature. The Laboratory is attempting to develop high-power short-pulse lasers that are required to ignite thermonuclear fuel. This necessitates a considerable extension of current laser technology. To this end glass, chemical, and electrical-discharge-driven CO_2 lasers are being examined. In addition, miniature thermonuclear capsules that can be used to diagnose laser performance and which will provide a basis for the development of higher-yield thermonuclear capsules are being fabricated. A program of code development and research on basic laser phenomenology is being pursued in support of these efforts. A brief description of our recent work, and our near term expectation, is given below.

GLASS (NEODYMIUM)

Long Path Disk Lasers

The Long-Path Disk Laser was used in neutron-production experiments with CD_2 targets in vacuum. 25-30 joule 4 nanosecond pulses were focused on the targets, and on the order of 10^4 neutrons were observed (similar to the French results). The oscillator-preamplifier chain of the Long-Path laser was re-arranged to reduce the divergence of the beam injected into the disk amplifier. The dielectric reflectors used in the Long-Path laser will be replaced by prisms when they are received next month, and it should then be possible to increase the pulse energy from the present 25-30 joules to at least 400 joules. An expanded target area is being planned for this laser.

Picosecond Oscillator

An improved mode-locked picosecond pulse oscillator, similar to one that has been very successfully operated at Harvard University, has been built and is being tested. It is expected to provide single spatial-mode pulses of high reproducibility.

Amplifier Evaluations

The glass amplifier evaluation program was started in January. An expression for the figure of merit of a laser amplifier has been derived, and the gain/beam divergence tradeoff is being experimentally evaluated for the LRL-designed laser amplifiers. Thus far, gain and divergence in an amplifier have been measured with a CW probing beam as a function of time for various pumping parameters. This has enabled us to optimize the pumping methods on our rods. We are planning to acquire and test better amplifiers in hopes of achieving better performance. Pumping uniformity will be measured next quarter. We are setting up a picosecond oscillator to test amplifiers with short pulses. Because performance is thought to be sensitive to the time behavior of the short pulse, three methods of pulse diagnostics are under development:

1) two photon fluorescence;
2) Kerr cell camera;
3) electronic streaking camera.

[redacted]

[illegible] program has been set up in order to calculate rod [illegible] followed up later with computer programs to calculate [illegible] of laser pulses through amplifiers.

[illegible]

[illegible] overall review of the various options for future glass laser work [illegible] completed and a final report is in preparation.

GAS (CO_2)

Hot Cathode

The leading objective of the CO_2 program is the construction and [illegible] of an energetic short pulse CO_2 laser source for fusion research. [illegible] effort has gone into the development of an electron beam gun to be [illegible] for initiation in the laser amplifiers. A gun with an emitting area of [illegible] cm has been designed and is presently being assembled. After [illegible], four larger guns with emitting areas of 20x200 cm will be built and used to initiate four CO_2 amplifier stages.

Cold Cathode

This quarter we have built several Canadian and French CO_2 electrically [illegible] discharge lasers. We are in the process of measuring the gain and electrical discharge characteristics. The objective is to see if an efficient discharge can be achieved by suitable modifications of the input parameters. A small scale field emission cathode was built which produced [illegible] amp/cm^2 of 40 kev electrons. This concept is now being scaled up in size for use in a several kev electron gun source appropriate for an AVCO [illegible] discharge. We are also experimenting with other external electron [illegible] for our discharges.

Calculational Model

A computer program to calculate the behavior of CO_2 electrical discharge lasers has been developed. This past quarter most work has been done adjusting cross sections to agree with experiments. We now have fairly good agreement between the calculational model and our experiments and this has greatly improved our understanding of the discharge lasers.

[redacted]

[redacted]

Oscillator

Several mode locked CO_2 oscillators are under development. Some components have been procured or fabricated and others are on order. These oscillators will be used to drive the chain of amplifier stages.

CHEMICAL

HF

Laser action from vibrationally excited HF in the region of 2.7 microns has been achieved in mixtures of exploding NF_3+H_2, $N_2F_4 + B_2H_6$, $NF_3 + B_2H_6$ and $IF_7 + H_2$ in a transverse electric discharge tube similar to that used by Beaulieu for carbon dioxide. A maximum of laser energy (2 joules/liter) was obtained at pressures of about 40-60 torr with fluorine rich mixtures (e.g., five NF_3 to one H_2). The ratio of laser energy emitted to electrical energy delivered to the discharge were of the order of one percent. The $V_{2 \rightarrow 1}$ vibrational transition lased first followed by the $V_{1 \rightarrow 0}$ and $V_{3 \rightarrow 2}$ with no vibrations above the 3rd level observed.

Other Systems

Other chemical systems which have lased and are currently under investigation are $ClF_3 + H_2$, $BrF_5 + H_2$, $IF_7 + D_2$ and $F_2 + H_2$.

TARGET CALCULATION

DOE
b(3)

Deleted

[redacted]

DOE
b(3)

Deleted

X-Ray Generator

A scheme has been calculated which converts laser light to thermal x-rays with high efficiency. A laser pulse of short duration is focused through a small hole into a cavity with high Z walls are heated to temperatures of ∿ 1 kev and radiate x-rays of 1-10 kev energy. The radiated spectrum can be varied by changing the wall mass and the cavity volume. With a one kilojoule short pulse laser, it appears feasible to make a simulator which could irradiate several cm^2 of target with at least 10 cal/cm^2 of 1-10 kev x-rays. This would be a considerable improvement over existing simulators (< 1 cal/cm^2), and of interest to the AEC, the Services, and DASA.

MANPOWER

Allocations

Approximately forty scientific and one hundred support personnel are presently assigned to LRL's laser program. Of this total, glass and electrical discharge lasers (CO_2) consume one third each. Chemical lasers and theoretical work are each requiring about one sixth of the total manpower available.

Trends

The FY 1972 level of effort will remain at about the same total with a slight shift in favor of theoretical efforts and increased participation by senior scientists in the experimental and development phases of the program. This shift will necessitate a lower level of engineering, design, technician, and fabrication support than is now provided. LRL's laser effort will, to a large extent, shift in FY 1972 from laboratory type research to design, fabrication and assembly of larger laser systems which normally require even more engineering support. However, we feel that the

[redacted]

basic physics problems involved in developing such lasers in the picosecond regime warrant the increased emphasis in the scientific area. We will carefully monitor the discipline mix in FY 1972 to make certain that the laser systems will proceed at the maximum pace commensurate with a sound basic understanding of the physics involved.

FACILITIES

Near Term

At present, the experimental portions of the laser program are housed in seven separate buildings, six of which are metal sheathed. These facilities lack proper temperature, humidity, and dust control; and are marginal from a vibrational standpoint. In all cases, the buildings now occupied were constructed either for purposes other than high powered lasers or on a temporary basis and lack characteristics deemed suitable for long term laser occupancy. Plans are now underway to modify several of these structures in order to make them more suitable, so they can serve until such time as higher quality facilities can be procured. In addition to internal modifications, additions to three of the buildings are being considered as an interim solution to either a space inadequacy or a geometry problem. Both the glass lasers and larger CO_2 lasers require long, straight buildings to avoid turning mirrors or prisms in the laser beam. With a few exceptions, we have been able to accomplish our small scale experimental needs with short laser path lengths or reflected beams. However, our plans for the immediate future include beam power levels and intensities which will not permit operating in this manner. These interim additions are tentatively planned for FY 1972 using GPP funds.

Long Range

We are preparing criteria and a preliminary design for permanent housing of both the experimental and personnel requirements of the laser program. These preliminary plans will be completed this fiscal year.