EXPERIMENTAL TEST OF RESONANT ABSORPTION THEORY.

Annual Progress Report,
for Period January 1, 1978 - December 31, 1978

92-0900
Eli Yablonovitch
Harvard University
Cambridge, Massachusetts 02138

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed or represents that its use would not infringe privately owned rights.

There is no objection from the patent
point of view to the publication of August 1978
dissemination of the document(s)
listed in this report

BROCKHOLLEN PATENT GROUP
10/9/1978 by *ell*

Prepared For

THE U. S. DEPARTMENT OF ENERGY
UNDER CONTRACT NO. ED-78-S-02-4631

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED *gb*

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Abstract

In this progress report we discuss the current and anticipated progress for the first year of our research on the interaction of an ultrashort CO_2 laser pulse with an overdense shock front.

Progress Report

Although the funding for this research program started only seven months ago, we have already made good progress toward our goal. The objective of this work is to make a quantitative experimental test of resonant absorption theory by means of the interaction of an ultrashort CO_2 laser pulse with the preformed density gradient of an overdense shock front. While the qualitative aspects of resonant absorption have been demonstrated, our work is concentrating on detailed quantitative experiments which will provide a severe test of numerical simulation results.

It is not as widely recognized as it should be that the first and most direct result of resonant absorption is the acceleration of electrons from the critical layer down the plasma density gradient. The absorption effect is an expression of the fact that the laser energy is being converted to particle kinetic energy of the accelerated electrons. As a space charge sheath builds up, the electrons turn around and heat the target. Any attempt to understand the electron thermal transport should take account of the process of acceleration of the electrons and the fact that they are initially directed outward.

In this experiment we are directly measuring the initial velocity spectrum of the electrons as accelerated by the resonant absorption

process. Space charge deceleration effects are eliminated by the presence of a background plasma in the underdense gas region. (This background plasma density can actually be controlled to monitor its effects.) The direct measurements of the velocity distribution and angular distributions of resonant accelerated electrons is essential for dealing with the question of the electron thermal transport.

The shock front target offers a unique opportunity for doing experiments where the initial density profile of the plasma can be controlled. The density scale lengths can be in the interesting range of the order of one wavelength. A key requirement, then, is the synchronization of the rapidly moving shock front with the picosecond CO_2 laser pulse. We have developed a Schlieren-type system to trigger the laser which directly detects the density gradient associated with the shock wave. The Schlieren system is illustrated below, and its performance capabilities were fully listed in the April-June 1978 quarterly progress report.

We anticipate firing our first laser pulses at the shock front before the end of the current quarter. As indicated in our introduction, we feel that the electron velocity spectrum and its angular distribution is our most direct and important diagnostic. We will be constructing a miniature β -ray spectrometer to measure these properties.

The system has outstanding flexibility for answering scientific questions. It pulses every three seconds, which is unheard of in a laser-plasma experiment. The shock-front conditions are easily varied, as is the space-charge neutralizing background plasma. Once the system is up, a huge amount of valuable data can be gathered as the knobs are all systematically varied. This experiment should bring an unprecedented degree of experimental exactness to a field where the results have been primarily qualitative until now.

We are including with this annual progress report a conference abstract which we recently submitted to the APS Plasma Physics divisional meeting to be held this fall. It is entitled "Resonant Absorption and the Thermal Emissivity of Plasmas".

Abstract Submitted
For the Twentieth Annual Meeting
Division of Plasma Physics
American Physical Society
October 30 to November 3, 1978

5

Subject Category Number 1.14

Resonant Absorption and the Thermal Emissivity of Plasmas.* ELI YABLONOVITCH, Harvard U.--The resonant absorption mechanism contributes significantly to the absorptivity of laser-produced plasmas. Likewise it should make a significant contribution to the thermal emissivity, which should exhibit the standard angular and polarization dependence. The optimum angle of emission as a function of wavelength should be a powerful diagnostic on the plasma density profile, $n(z)$. We will report experiments on the polarization of the broadband infrared emission.

*Supported by U.S. DOE Contract ED-78-S-02-4631 A000

☐ Prefer Poster Session

☒ Prefer Oral Session

☐ No preference

☒ Special Requests for placement of this abstract: Please schedule this abstract on Monday, Oct. 30, or Tuesday, Oct. 31, 1978.

Submitted by:

El. Yablonovitch
(signature of APS member)

Eli Yablonovitch

(same name typewritten)
Division of Applied Sciences
Harvard University

(address) Cambridge, MA 02138

This form, or a reasonable facsimile, plus two Xerox copies must be received NOT LATER THAN FRIDAY, AUGUST 4, 1978 at the following address.

Burton D. Fried
P. O. Box F
Sherman Oaks, California 91413