MASTER

EXPERIMENTAL TEST OF RESONANT ABSORPTION THEORY

Progress Report
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Abstract

The scaling of the hot electron temperature, T_h , with laser intensity, I , has been studied with the laser-shockfront interaction apparatus. Our preliminary result for 500 psec laser pulses of intensity $I \sim 10^{14}$ W/cm² is $T_h \propto I^\alpha$, where $\alpha = .35-.40$.

Progress Report

In the last report of progress in the laser-shockfront interaction experiment, preliminary measurements of the hot electron energy spectrum produced by resonance absorption were described. These experiments use a novel, "temporally multiplexed", magnetic-focussing electron spectrometer which allows an absolute seven-channel electron energy spectrum to be recorded on a fast oscilloscope for each laser shot. We now regard the fundamental concept of this experiment as being proven: optical breakdown on a shockfront produces a target plasma which is optimized for resonance absorption and in which other effects are diminished. However, before proceeding with a full-scale parametric study of this mechanism, we have felt it important to assess various possible experimental artifacts by doing the following:

- (1) To assure that the observed signals are in fact due to hot electrons leaving the target, rather than other plasma radiations, we have:
 - (a) varied the spectrometer magnetic field, (b) applied a bias varying over ± 500 V to the spectrometer electrodes, and (c) placed foils of varying electron stopping powers in front of the electrodes. These alterations produced the expected changes in the spectrum.
- (2) To rule out artifacts due to electrode geometry, two different arrays

of charge collectors have been used in the spectrometer. The hot electron temperature is found to be reproducible.

(3) The effects of pre-ionization and space charge have been studied experimentally and theoretically. We conclude that the hot electron temperature is unaffected by space charge left on the target. The temperature observed in the spectrometer is the same as that produced in the target.

With these tests performed, it has become appropriate to acquire data on a larger scale. A significant experimental problem which could ruin this plan is the fact that, on most shots, the synchronization of the shockfront and the laser pulse is not correct. In the past, this has caused data to be collected very inefficiently. This problem has largely been solved by the construction of a digital timing discriminator, which displays the synchronization condition of the shockfront on each shot and prevents data acquisition if the shockfront is not properly synchronized. The fraction of good data collected, the time taken to collect it, and the expense involved have all been improved by factors of at least two.

As a preliminary parameter study, the hot electron temperature T_h has been measured as a function of laser pulse energy. For 500 psec laser pulses of intensity $I \sim 10^{14}$ W/cm², the experimentally observed behavior is $T_h \propto I^\alpha$, where $\alpha = .35-.40$. This is even slower than the $T_h \propto I^{.5}$ scaling predicted by the simplest model of resonance absorption, which ignores hydrodynamics. It will be fascinating to supplement this observation with experiments using 30 psec laser pulses of intensity $I \sim 10^{15}$ W/cm², which will become available shortly.

This work has been reported at the Gordon Research Conference on Laser Interaction with Matter, Tilton, New Hampshire, August 13-17, 1979.