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EXPERIMENTAL TEST OF RESONANT ABSORPTION THEORY

Progress Report
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Eli Yablonovitch

Harvard University
Cambridge, Massachusetts 02138

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Abstract

We report the initial progress in studying the interaction of an ultrashort CO_2 laser pulse with an overdense shock front.

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Our efforts in the first phase of this experiment are directed at the reliable production and detection of a strong (Mach number ca. 10) shock wave in D_2 gas. For ease of operation and electronic synchronization, we use a capacitive-discharge electrothermal shock tube rather than the diaphragm type. We have measured the dependence of shock speed on such parameters as charging voltage and fill pressure.

Shock waves have been detected by two means. In the first the moving shock front reflects a HeNe laser beam (λ = .633 μm) into a photomultiplier tube as it passes through a section of the shock tube. This method has rather small signals, since the reflection coefficient of the shock front is typically on the order of 10^{-3}. Nevertheless, the reflectivity as a function of angle gives important information about the density profile of the shock.

The most vital technical constraint of this experiment is the need to synchronize the 500 psec CO_2 laser pulse with the fast-moving shock. In order to provide a strong and fast synchronization signal, a second method is used. It relies on the fact that light rays in a probe laser beam are deflected towards regions of higher optical density behind the shock front, and thus may strike a photomultiplier as the shock front passes through the probe beam. This technique produces a strong signal, since it happens that a significant fraction of the laser beam intensity is deflected into the photomultiplier by the passing shock front. In fact, the signal is so strong that it appears that all shock waves that we might contemplate producing in this experiment will be detectable. This method is also rather insensitive to angular misalignments of the laser beam with respect to the shock tube, and to displacements of the knife edge.

Displaying a pair of probe beams a fixed distance apart on an oscilloscope, we have measured the Mach numbers of shocks in argon, nitrogen, helium and hydrogen.

Very shortly the engineering of shock wave production and detection will be finished, and we will move on to the real business of studying the interaction of the shock front and an intense pulse of infrared laser light.