COO-2288-3

Calspan

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Absorption of Electromagnetic Rays Near the Critical Density

Contract No. AT(11-1)-2288
Calspan W/A W01

Quarterly Progress Report
1 June 1973 to 1 September 1973

Prepared For: Division of Controlled Thermonuclear Research
Atomic Energy Commission

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DISCLAIMER

ABSTRACT

The program is an experimental study of the interaction of high-intensity ruby laser radiation with hydrogen gas in a free-jet. In these experiments both laser intensity and the plasma frequency can be varied. By monitoring several parameters, including incident and reflected power, x-ray emission and the kinematics of plasma growth, the existence of an anomalous threshold for coupling radiation into plasma energy should be determinable. A discussion of the experiment, including a design drawing of the experimental arrangement and the diagnostic instrumentation, is included.

OBJECTIVE

This program is directed at studying the absorption of laser light by a plasma. The electron density is adjustable in the experiments so that studies can be made with plasma frequencies both above and below the laser frequency. The measurements are being made in the free-jet/ruby laser facility of Calspan. A theoretical modeling of the experiments is also being carried out.

PROGRESS

During this quarter, work has progressed on the design of the higher-pressure free-jet, and plasma diagnostic system. To achieve plasma densities greater than the critical density it has been necessary to redesign both the free-jet reservoir and the fast-acting gas valve connecting this reservoir to the vacuum tank. In our present operational free-jet we have the reservior connected to a vacuum tank through a fast-acting valve. The valve opens allowing gas to enter the evacuated chamber through the orifice and establishing the free-jet. However, this free-jet system was designed for relatively low reservoir pressures and has been operated only up to about ten atmospheres in the reservoir. The new system has been designed to accomodate 150

atmospheres in the reservoir. (About 45 atmospheres pressure at room temperature will produce an electron density of 2.3×10^{21} cm^{-3}, which is the critical electron density for ruby-laser radiation, when the gas is doubly ionized.) The design work has been completed, most of the components have been ordered and assembly is anticipated in late October.

The fast responding solenoid valve for the new high pressure free jet has been received. This valve was specified for 2500 psi helium service with an opening time of less than 20 msec. We are presently assembling the valve on a 1 liter gas bottle for initial tests of its opening time and leakage rate.

Our present free-jet apparatus has been limited to pressures of 135 psi absolute due to leakage of the solenoid valve. With the new solenoid valve the limitation of our present apparatus will be the side viewing windows used for obtaining streak records. They are calculated to withstand a pressure of 300 psia or about one tenth of the capability of the new, high pressure free jet design.

In addition, the new free-jet system is being designed to allow measurement of soft x-ray emission for electron temperature determination. As discussed in the previous quarterly progress report, these modifications are being made under AFOSR contract. (The new contract number under which this work is being carried out is F44620-74-C-0004.) The design and rebuilding of this complete, new free-jet and diagnostic system is being performed concurrently. Measurement of soft x-rays were not made in the previous free-jet experiments, and these measurements will provide a very valuable diagnostic tool.

The design of the new high-pressure gaseous free-jet system shown in Figure 1 has several features. The 2-mm diameter sonic orfice is located in a separate insert that can be removed and modified without affecting the allignment. The x-ray detectors employ light pipes to connect the 2-inch diameter photomultiplier tubes with the scintillator. This design is presently being reevaluated to try to reduce fabrication cost. The gas feed to the orfice is through a side port and not through the rear so that better measurements can be made of the transmitted spectrum.

The diagnostics which are in place or nearly so are shown in Figure 2. A Fabre-Perot interferometer is being used to measure mode patterns of the incident beam and the width of the reflected spectrum. This data will allow determination of the doppler shifts. A 0.75 meter spectrometer has been adapted with photomultiplier to record the time history of the reflected light at the laser frequency ω_o and at $2\omega_o$, $(3/2)\omega_o$ and soon at $(1/2)\omega_o$. Spectrograms can also be taken when desired. Transmitted, reflected and incident powers will also be measured. A relative calibration of these channels is also planned. The laser system is now operating routinely and data from these diagnostics will be soon forthcoming.

During this quarter, from August 20 through August 24, Drs. J.W. Daiber and R.G. Rehm attended the Gordon Research Conference on Laser Interaction with Matter in Tilton, New Hampshire. Anomalous absorption effects were discussed by many speakers at this meeting. Experiments using high-intensity laser radiation on solid targets were reported in which threshold phenomena are thought to be seen. However, plasma density in all of these experiments is fixed by the solid target. By contrast the free-jet experiments allow operation at both sub-critical and super-critical electron densities.

FINANCIAL

Research funds available*	$58,683
Funds expended this quarter*	$13,904
Total funds expended to end of this quarter*	$23,802
Funds remaining*	$34,881

Charges by individual:

Person	Percentage of Time
J.W. Daiber	4%
R.G. Rehm	12%
H.M. Thompson	4%
W.A. Lorich	7%

*exclusive of fee

The work on this program is due to be completed 30 November 1973; however, since the contract was not signed until March 1973, it is approximately one calendar quarter behind schedule. We believe that a no-cost time extension will be advantageous to complete the research on this program.

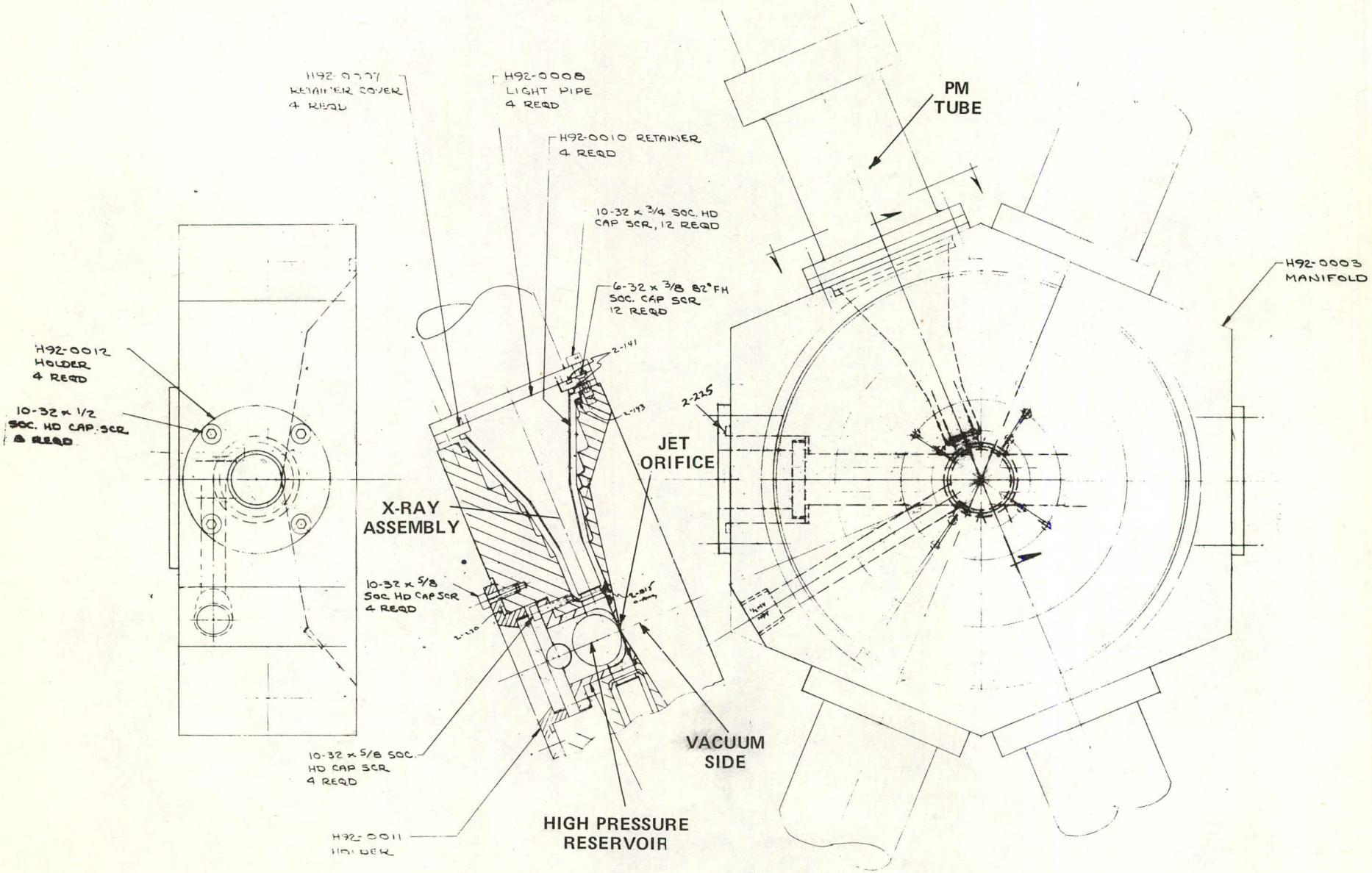

Figure 1 HIGH PRESSURE FREE JET DESIGN

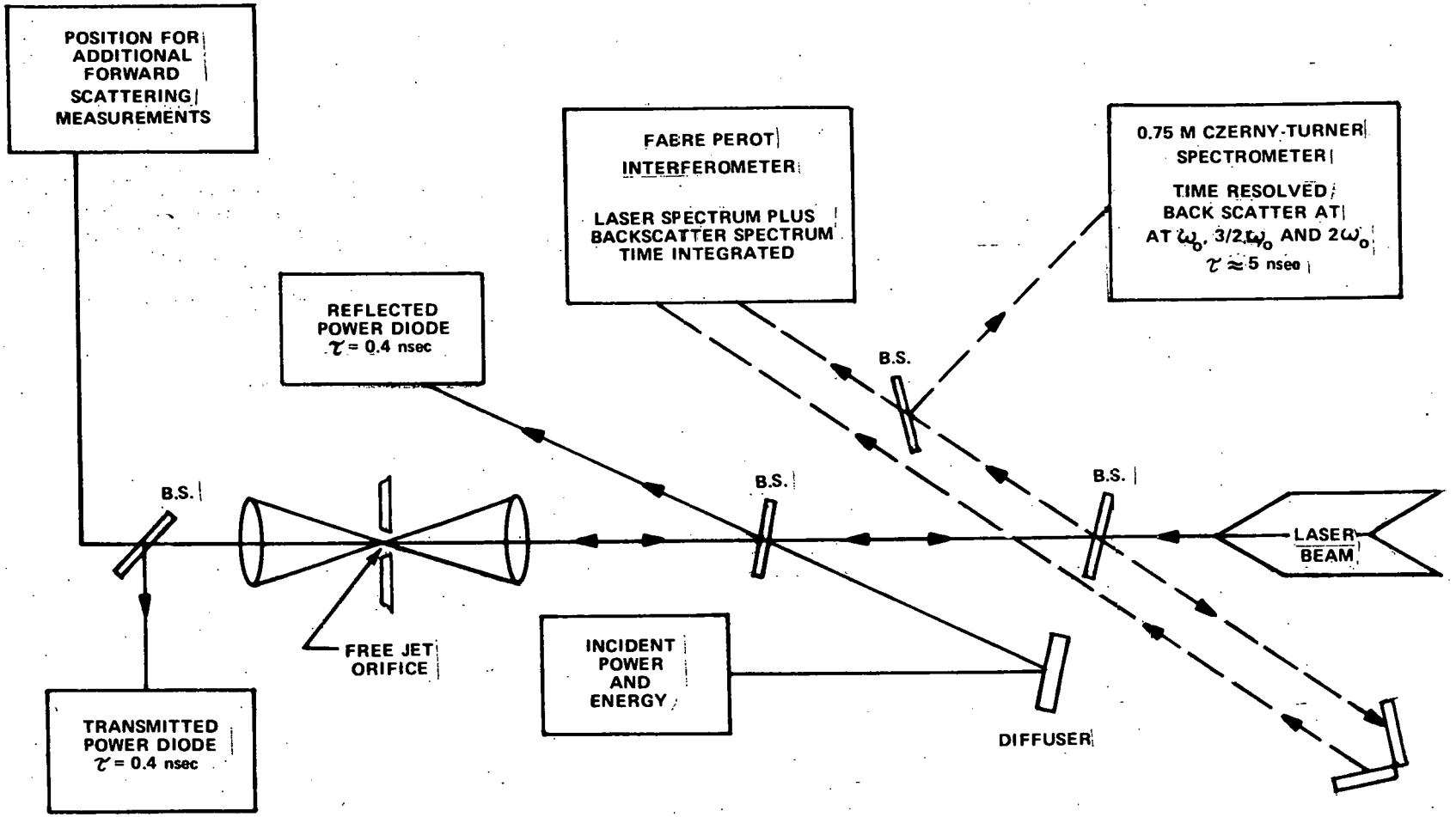

Figure 2 INSTRUMENTATION SCHEMATIC – LASER HEATING EXPERIMENTS