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Faraday Rotation Measurements on Z-Pinches Final Report

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Abstract

The Campus Executive Program sponsored this research at Cornell University. The research was directed toward the implementation of laser-based diagnostics for wire-array Z-pinches. Under this contract we were able to carry out all the necessary preparations to set up the laser diagnostics to complement our x-ray backlighting measurements of the early phase of exploding wire z-pinch plasma formation.

*The work described in this report was performed for Sandia National Laboratories under Contract No. AX2329.

Introduction

The Campus Executive Program sponsored this research at Cornell University. The work carried out under this contract from May 1998 through September 1998 was directed toward the implementation of laser-based diagnostics for wire-array Z-pinches. These new diagnostics will augment the capabilities of our present x-ray backlighting diagnostic to allow simultaneous laser illumination and x-ray backlighting of wire plasmas. Initially, schlieren imaging and interferometry with the laser will allow measurement of lower plasma densities than the x-ray backlighter. Eventually we hope to implement polarimetry ("Faraday rotation") to determine the magnetic field profile and therefore the current density profile flowing in the wire plasmas. This contract funded the initial steps toward these goals.

Diagnostic Development

We first determined the laser parameters needed for these laser-based techniques in combination. We next compared commercially available Nd-YAG lasers within our budget, and ordered a laser from Continuum Corp., model Surelite1, 400 mJ. Although the nominal minimum laser pulse width is 4 ns, we were able to arrange with the manufacturer for an operating procedure which permits a 2 ns pulse in frequency-tripled light to be included within the warranted operating conditions because of our low intended pulse repetition rate (1pps).

Beginning in June, the laboratory space around our z-pinch experimental system was reorganized to allow the laser diagnostics to be added. Optical tables were installed for the laser and several required optical trains. Laser safety requirements necessitated modification of the lab space to install a full light shield around the experimental area.

The Nd-YAG laser arrived in mid-July while the laboratory preparation was in progress. The laser was first pulsed before the end of July. It is set up to operate in either the fundamental, first or second harmonic modes, and we can also use any of them in combination. After satisfactory laser operation in the first harmonic was established, measurements of laser trigger throughput delay were made to determine possible approaches for the design of a system to trigger the laser with minimum possible time jitter with respect to the wire array current pulse and the x-ray backlighter. This design was not straightforward because this laser, which was the only one available within our budget constraint having the required optical parameter for our applications, is supplied only in a configuration which is intended to be used in a free-run, repetitive pulse mode of operation. However, we must synchronize a single laser pulse with the x-ray backlighter pulsed power system. A design for the trigger system was decided upon which selects a pulse from the free-running repetitive firing of the laser flashlamp to trigger the wire array current pulse and the x-ray backlighter driver when both are fully charged. The trigger for the laser Q-switch (Pockels cell) is then generated from a current monitor located after the main output switch of the x-ray backlighter driver, which minimizes jitter between the backlighter and the laser. We have determined that

the Pockels cell trigger throughput delay is just short enough to allow this ideal low-jitter mode of operation. This system was designed in September, and is presently being constructed. First testing of the integrated system will be done shortly.

Conclusion

Under this contract we were able to carry out all the necessary preparations to set up the laser diagnostics to complement our x-ray backlighting measurements of the early phase of exploding wire z-pinch plasma formation. We are now taking the initial steps to integrate the laser into the existing experimental system.

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