Tera-Pascal Shock Physics Experiment Using Pulsed Power Driver

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Summary: ALT-3 (Advanced Liner Technology) is a collaborative experiment between VNIIEF and LANL that aims to conduct high velocity material experiments and measure shockvelocities at pressures near 1 TPa. The DEMG (Disk Explosive Magnetic Generator) is used to drive a >60MA current that accelerates an aluminum liner to speeds in excess of 20 km/s. A simple circuit model is presented that models the DEMG to reasonable accuracy and is then coupled with 1-D MHD simulations of both the liner and target. 2-D hydrodynamic simulations of the target are also presented along with implications for measurement accuracy and expected results.

Discussion

In continuing collaboration with Russian scientists at VNIIEF, ALT-3 is a joint project designed to accelerate an aluminum liner to extremely high velocities and study the application of cylindrically imploded liners to shock physics and making highly accurate Hugoniot measurements. The Russian-made DEMG (Disk Explosive Magnetic Generator) will be able to achieve extremely high currents with as much as 70 MA usable for driving a z-pinch experiment. In this experiment, LANL will fabricate a high-precision liner and target and will field numerous diagnostics for the experiment that will be tentatively conducted in Russia during the spring or summer of 2012. The liner will be accelerated to near 20 km/s and impacted into a target where shock and free surface velocities will be measured in order to extract Hugoniot data at pressures near 1 TPa. Similar experiments have been proposed for the ATLAS pulsed power machine [1], and flyer experiments in an expanding geometry have been conducted on the Sandia Z Pulsed Power Machine [2].

The DEMG (Disk Explosive Magnetic Generator) is a flux compression generator utilizing modular disks of copper and HE that when detonated, compresses the flux between disks and then into a load. Currents in the DEMG can reach as much as 100 MA and through a foil-opening-switch (FOS), approximately 60 MA can be delivered to a load over a period of 3.5 μs. A schematic drawing of the DEMG is shown in Figure 1, but the design for the ALT-3 experiment will have the radial portion of the transmission line at the same axial position as the liner load.

The LANL-supplied aluminum liner, target, and CMU are shown in Figure 1b. PDV probes fielded by LANL will be used to collect velocimetry data from a central measurement unit (CMU) positioned along the axis of the experiment. The velocimetry data will be collected from 32 different PDV channels viewing the target itself and also the liner via holes in the target. Liner performance will be characterized by assessing uniformity of shock breakout along the target surface as well as azimuthal symmetry in the liner probes. The target will be partially stepped with steps 0.7 mm, 0.6 mm, and 0.4 mm thick recessed into the 0.8-mm thick target. Current profiles in the generator and load will be measured using a combination of Faraday rotation probes and B-dot induction coils. A preliminary drawing of the experimental setup is presented in Figure 1, showing a portion of the transmission line, liner, target, and CMU. The right side is a rotational axis of symmetry (Figure 1b is also rotated 90° counter-clockwise relative to Figure 1a).

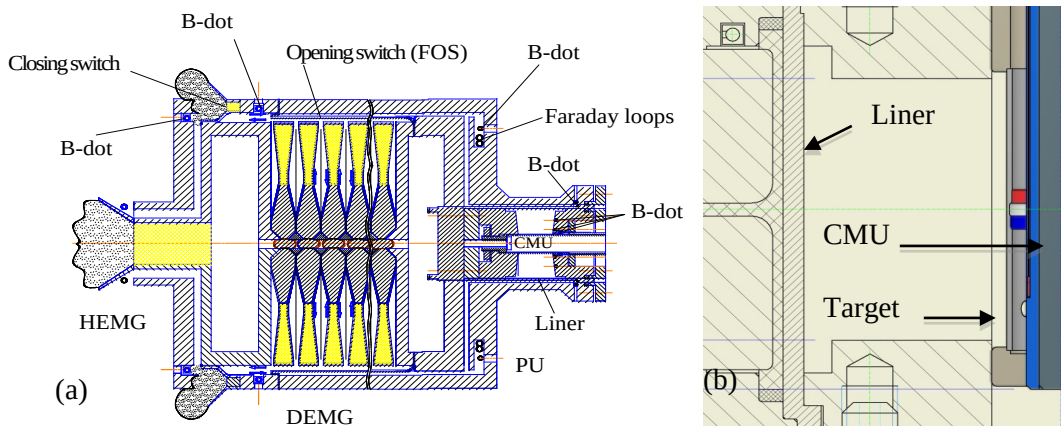

Figure 1. (a) Schematic diagram of DEMG[3] and (b) Current ALT-3 liner and target assembly (rotationally symmetric about the right side).

References

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[3] A.M. Buyko et al, "Explosive Magnetic Liner Devices to Produce Shock Pressures up to 3 TPa," in Proc. IEEE-PPC #17, (2009), p.215-220.

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