Dynamic HED Experiments and Theory at the Sandia Z Facility

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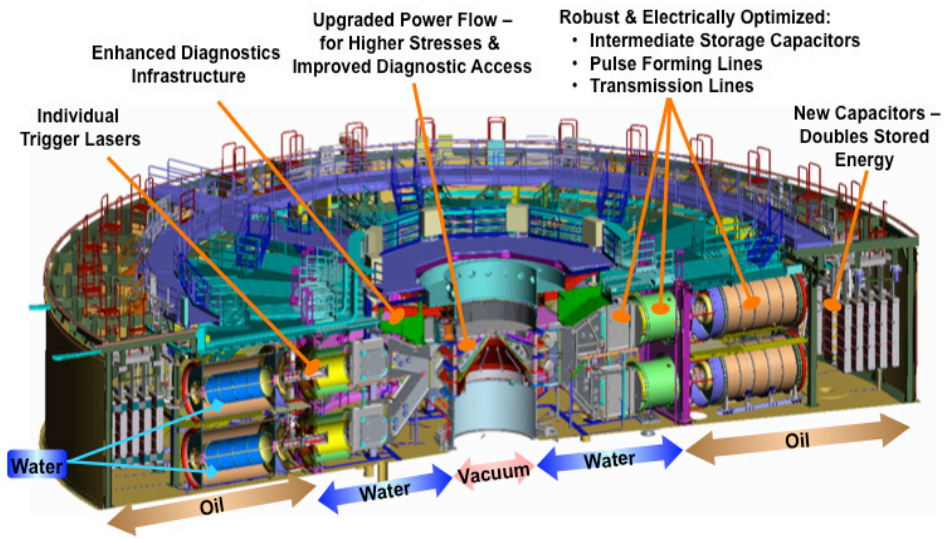
Summary: Overview of HED science at Z, including theory, modeling, simulation, and experiments in dynamic materials, inertial fusion, x-ray production, and fundamental science.

Introduction

After refurbishment and re-commissioning in 2007, the Z facility has made many advances in capabilities and science. Daily Z shots routinely deliver up to 26 MA currents, 1000 Tesla magnetic fields, and 10s of Mbars pressure to targets. Many developments in pulsed power technology have made this possible, such as the 6 MV laser triggered gas switch with pre-fire rates of 0.1% and 5 ns jitter [1]. A 100 TW facility, Z compresses in time and space as much as 22 MJ of wall plug energy at 30 m diameter to cm sized loads in 100-600 ns pulses. Loads on Z can be imploding or exploding. Imploding loads, such as cylindrical liners [2] and wire-arrays [3], are compressed onto the z-axis by magnetic pressure. The implosions may produce radiation used in an HED science experiment, such as an opacity measurement, or for inertial confinement fusion research. Exploding loads (loads pushed outward by magnetic pressure instead of imploded) are typically used for dynamic materials experiments, such as shock loading by magnetically accelerated solid flyer plates or by direct shock-less ramp-wave compression of samples.



HED Theory, Modeling, and Simulation

Experiments on Z would not be successful without many scales of predictive science modeling. Ab-initio QMD/DFT/QMC calculations are not only used to model experiments, such as the 1.6 TPa shock compression of the impedance standard quartz [4] or the 350 GPa compression of polymers [5], but also to tune electrical conductivity models [6,7] for predictive multi-dimensional experiment design calculations [8,9] using continuum and MHD codes such as ALEGRA [10]. The 36 module Z-machine, including laser triggered gas switches, self-breaking water switches, magnetically insulated vacuum transmission lines, and a post-hole convoluted feed to the load is modeled using a variety of tools, from very detailed 3D electrostatic, electromagnetic, and PIC [11,12] models of modules and components, to whole machine transmission line [13] and lumped circuit [14,15] models.

Conclusions

Z is pushing the boundary of HED science with experiments in dynamic materials, inertial fusion, and fundamental science. We will highlight recent experiments in dynamic materials, magnetized liner fusion, and fundamental science, with discussion of modeling and simulation techniques used to design and analyze experiments.

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