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Megaamps, Megagauss, and Megabars: Using the Sandia Z Machine to perform extreme material dynamics experiments[1]

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Pulsed power devices are quite efficient at producing very large pulsed current and magnetic field densities. The corresponding Lorentz forces enable these devices to be used very effectively in material dynamics experiments. For the past decade, a large, interdisciplinary team at Sandia National Laboratories has been refining the Z Machine (20+ MA and 10+ MGauss) into a mature, robust, and precise platform for such studies in the multi-Mbar pressure regime. In particular, significant effort has gone into effectively coupling condensed matter theory, magneto-hydrodynamic simulation, and electromagnetic modeling to produce a fully self-consistent simulation capability able to very accurately predict the performance of the Z machine and various experimental load configurations. This capability has been instrumental in the ability to develop experimental platforms to routinely perform magnetic ramp compression experiments to over 4 Mbar, and magnetically accelerate flyer plates to over 40 km/s, creating over 20 Mbar impact pressures. Furthermore, a strong tie has been developed between the condensed matter theory and the experimental program. This coupling has been proven time and again to be extremely fruitful, with the capability of both theory and experiment being challenged and advanced through this close interrelationship. This talk will provide an overview of the material dynamics platform and discuss several examples of the use of Z to perform extreme material dynamics studies with unprecedented accuracy in support of basic science, planetary astrophysics, inertial confinement fusion, and the emerging field of high energy density laboratory physics.

[1]Sandia is a multiprogram laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Company, for the US Department of Energy's National Nuclear Security Administration under Contract No. DE-ACO4-94AL85000.