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Laser-driven quasi-static magnetic fields for magnetized high energy-density experiments

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The use of seed magnetic-fields (B-fields) in laser-driven compression experiments of pellet targets may lead to > 10kT B-fields across the compressed core due to advection of the in-flow plasma. This constitutes a test bed for exploring extreme plasma magnetization phenomena. Such B-fields are comparable to the strongest observable in the Universe, and are promising for a magneto-inertial fusion since they are sufficient to confine fusion alpha-particles.

We designed such magnetized compression experiments in a cylindrical geometry, using seed B-fields between 5 and 50 T and for both 15 kJ and 300 kJ laser drive (respectively, for OMEGA and LMJ irradiation conditions). Our extended-MHD simulations show that the compressed B-fields contain a significant proportion of the implosion energy and induce large electrical currents in the plasma's hot core.

One important challenge is to provide the needed strong seed B-fields for magneto-inertial fusion. We use coil-targets (CT) to explore laser interactions and B-fields in a geometry that gives easy access for diagnostics and does not produce a significant quantity of debris. At the LULI2000 and OMEGA facilities we used ns laser pulses of ~10^{15} -10^{16} W/cm^2 intensity (relevant for LMJ conditions) and generated discharge currents of ~20 kA and ~8 kA yielding B-fields of ~50 T and 6 T respectively. The fields were characterized using proton deflectometry. Data analysis with particle test simulations reveal features that can be linked to the looping current and static charging of the wire surface. The characterized discharge currents are consistent with predictions from a plasma diode model which has been continuously improved and validated through benchmarking experiments over the past years.

References:

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