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Strong Laser-Driven Magnetostatic Fields for Magnetized High Energy-Density Physics

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We present experimental studies and optimization prospects of a robust open-geometry platform for generation of ultra-strong magneto-static fields.
The all-optical principle is based on a ns-laser pulse of several hundred Joule at 10**17 W/cm2 driving a target-discharge. The laser is tightly focused into a Capacitor Coil Target [1] comprising two parallel plates connected by a coil-shaped wire. The subsequently rising return current of up to hundreds of kA is guided by the target geometry and induces a strong magnetic field up to the order of kT.
We will review the main results and physical understanding in driving such strong discharge currents and B-fields, obtained over the last 5 years in experiments carried out at the LULI2000, Gekko-XII, Vulcan and PALS laser facilities. At LULI2000 [2] and Gekko-XII [3] laser facilities, nanosecond-scale B-field pulses, above 500 T at the center of 500 µm-diameter coils were spatially and temporally characterized by ultra-high frequency B-dot probing and by proton deflectometry.
Modelling of the mechanisms yielding the looping discharge current [4] motivated more recent experimental efforts on a better understanding of the laser interaction processes giving rise to the discharge current. We show first results concerning the dependence of the generated B-field's strength to the laser-target parameters, employing complex interferometry measurements of the plasma density and self-generated B-field profiles in the laser driven diode plasma [5].
The distance of coil and laser interaction region is on the scale of mm. This proximity renders not only accurate measurements of the field strength difficult [6], it also means a possible threat to applications counting on employing the ultra-strong magnetic fields to secondary targets. Notably, future projects will focus on novel high energy-density physics (HEDP) investigations, e.g. i) exploring magnetized laser-plasma interactions at relativistic intensities in view of triggering phenomena relevant to astrophysics; ii) combining the magnetized liner fusion (MagLIF) approach to inertial confinement fusion (ICF) with a laser-driven seed B-field, so as to rise the magnetization level; iii) developing novel magnetized atomic physics simulation tools for improved characterization of complex plasma states in HED experiments. We present novel experimental results obtained at LULI2000 in September 2019 that show high performance of a modified target design with an improved shielding of the coil region.
We successfully applied B-fields of hundreds of Tesla to magnetize solid-density [7] or laser-compressed targets [8], and therein radially confine and guide relativistic electron beams (REB) over distances of the order of 100 µm.

References

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