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Investigations of strongly magnetized HED plasmas via laser-driven magnetic flux compression

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We present investigations of plasma dynamics in laser-driven magnetised cylindrical implosions by time-resolved dopant spectroscopy. Our first experimental results were obtained at the OMEGA laser facility. The cylindrical targets were filled with Ar-doped D_2-gas and symmetrically imploded using a 40-beam, 14.5 kJ, 1.5 ns laser drive.
GORGON extended-MHD simulations conducted prior to the experiment suggested we could achieve 10 kT-level B-fields due to magnetic flux-compression of an externally-imposed 25 T seed B-field [1], as per our experimental conditions. Dopant-Ar emission spectra collected during the experiment show distinctive and reproducible spectral features corresponding to changes in the D_2 plasma conditions of the compressed core in the cases with and without the applied B-field, revealing changes in the implosion dynamics due to the B-field compression.
The MHD modelling output is being coupled to calculations of synthetic X-ray emission spectra performed with the Non-LTE atomic kinetics code ABAKO and detailed Stark-Zeeman broadening codes (MERL, PPP-B, and DinMol), which will provide a robust characterization of the core plasma conditions.
An extension of this technique has been accepted for beam time at the LMJ laser facility, using a 20 times greater laser drive and seed B-fields generated by laser-driven coil-targets. The predicted increase in compressed B-field is significant, which would allow us to reach more extreme regimes of magnetized HED plasmas.
Our experimental, theoretical and numerical efforts will improve the understanding and control of the transport, hydrodynamic and atomic physics processes in magnetized HED plasmas, including anisotropic conductivity, magnetized electron heat flow and magnetic-flux compression.
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References

[1] C.A. Walsh *et al.*, Plasma Phys. Control. Fusion **64**, 025007 (2022)