Observation of a Magneto-Rayleigh-Taylor instability in magnetically collimated plasma jets

S. Malko[1], V. Valenzuela-Villaseca[2], D. B. Schaeffer[3], W. Yao[4,5], C. Johnson[1,2], G. Fiksel[6], A. Ciardi[4,5] and W. Fox[1,2]

[1] Princeton Plasma Physics Laboratory, Princeton, NJ, USA

[2] Dept. of Astrophysical Sciences, Princeton University, Princeton, NJ, USA

[3] Dept. of Physics & Astronomy, University of California Los Angeles, Los Angeles, CA, USA

[4] LULI - CNRS, CEA, Ecole Polytechnique, Paris, France

[5]Sorbonne Universite, Observatoire de Paris, Universite PSL, CNRS, Paris, France

[6]Center for Ultrafast Optical Science, University of Michigan, Ann Arbor, USA.

The interaction between laser-produced high-energy-density (HED) plasma and a magnetic field is important in various contexts, including magnetized fusion schemes like MagLIF, laboratory astrophysics experiments such as magnetic reconnection and magnetized collisionless shocks, and prior space-plasma experiments such AMPTE. Direct laboratory measurements of magnetic field dynamics are required to understand physical processes in such systems and to benchmark magneto - hydrodynamic (MHD) simulations.

In this study, we directly observe the formation of a diamagnetic cavity and MRT instability in a HED plasma with a β close to unity. Employing an innovative proton radiography technique [**1,2**], we measure the two-dimensional path-integrated magnetic field in laser-produced plasma traveling parallel to an existing magnetic field. Flute-like structures, linked to the MRT instability, emerge at the cavity's surface, exhibiting a measured wavelength of 1.2 mm and a growth time of 4 ns [**3**]. These observations align with the predictions of three-dimensional MHD simulations conducted using the GORGON code.

[**1**] C. L. Johnson, et al., Proton deflectometry with in situ x-ray reference for absolute measurement of electromagnetic fields in high- energy-density plasmas, *Review of Scientific Instruments* **93** (2022).

[**2**] S. Malko, et al. Design of proton deflectometry with in situ x-ray fiducial for magnetized high-energy-density systems, *Applied Optics* **61**, C133 (2022).

[**3**] S. Malko, et al., Observation of a Magneto-Rayleigh-Taylor instability in magnetically collimated plasma jets, *submitted to Physical Review Letters* (2023).