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# Growth of ablative Rayleigh-Taylor instability in a strong external magnetic field

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Although magnetohydrodynamics (MHD) of a high-energy-density plasma (HEDP) in an external magnetic field involve fundamental physics relevant to the fields of astronomy and solar physics and to inertial confinement fusion, few fundamental experiments in this research area have been performed, mainly due to the lack of a strong magnetic field source. Recent significant progress of generation in laboratory of a strong(> 100 T) magnetic field enables us to investigate experimentally unexplored MHD phenomena of a HEDP.

Especially in the magnetic field assisted fast ignition scheme, laser-driven implosion under several hundreds Tesla magnetic field is necessary to apply this guiding scheme to the actual fast ignition experiment. Nagatomo *et al*. found that the significant perturbation growth of an imploding shell under 100 T of the external magnetic field [1]. Well characterized basic experiments are required to validate such complex HEDP-MHD phenomena related to the magnetically assisted laser fusion research.

A well-characterized basic experiment in a simple geometry can be performed with a spatially uniform strong magnetic field generated by using a pair of laser-driven capacitor coil targets [2]. For simplicity, the experiments were performed with a planar target in magnetic field geometry: $B_{\parallel}$ the external magnetic fields with directions parallel to the plasma motion.

The magnetic flux density was characterized using a three-axis B-dot probe. The B-dot probe was placed 70 mm away from the coil center. The magnetic flux densities were reconstructed using the RADIA code to evaluate the current inside the coil and the magnetic field structure around the target position. The average flux density of $B_{\parallel}$ at the midpoint between the coils were 215+/-21 T. A 16-μm-thick polystyrene ($C_8H_8$) foil was irradiated by the laser beams midway between the two coils. Three 351-nm beams of the GEKKO-XII laser were used to drive the foil.

We performed two dimensional hydrodynamic simulations with and without an external magnetic field. The thermal conductivity becomes anisotropic in the $B_{\parallel}$ cases. Because anisotropic thermal diffusion reduces the thermal energy loss from the ablated plasma to its cold peripheral region that is transverse to the $B_{\parallel}$ field lines, the temperature and pressure of the ablated plasma increase significantly [3].

The hydrodynamic perturbation growth is affected by the external magnetic field as a result of the anisotropic thermal conductivity. A 30, 60 or 100 μm wavelength sinusoidal perturbation with initial amplitude $a_0$ = 1.0 μm was imposed on polystyrene planar foils, whose initial thickness $l_0$ = 16 μm. Face-on X-ray backlighting coupled with an X-ray streak camera was used to measure the temporal evolution of the areal density modulations.

In our experiment, perturbation growth is enhanced at a 30, 60 or 100 μm wavelength in the magnetic field. This trend was seen also in the simulation, as shown in Fig.1. The magnetic field lines move together with the ablated plasma due to its large magnetic Reynolds number. The direction of the ablated plasma flow is normal to the target surface, and ablated plasma accumulates at the valley of the sinusoidal perturbation. Therefore, the external magnetic field is compressed (decompressed) at the valley (peak) of the sinusoidal perturbation. The thermal conductivity across the magnetic field lines is reduced at the valley compared to that at the peak. The temperature increases at the valley due to the anisotropic thermal conduction in the perturbed magnetic field structure. The pressure distribution becomes spatially non-uniform, and lead to enhancement of the perturbation growth.

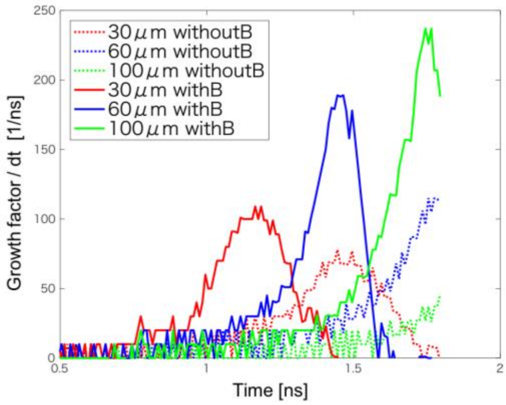


Fig.1: Solid and dashed lines are MHD calculations with and without consideration of the external magnetic. field, respectively.

References

[1] H.Nagatomo *et al*, Nucl. Fusion **53**, 063018 (2013).
[2] S.Fujioka *et al*, Sci. Rep. **3**, 1170 (2013).
[3] K.Matsuo *et al*, Phys.Rev.E. **95**.053204 (2017).