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Investigation on the early stage plasma instabilities in magnetized cylindrical liners

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With the development of pulse power technology, the fast Z-pinch shows the potential of direct drive inertial confinement fusion, such as the magnetized liner inertial fusion (MagLIF) concept. The magneto Rayleigh-Taylor (MRT) instability is one of the most negative effects on the liner integrity and the implosion quality, and the level of MRT instability growth is significantly determined by the amplification of seed perturbations. The initial seed for MRT may be provided by the early time instability development during the plasma formation, such as the electrothermal instability (ETI) and the traditional sausage instability.

By using a two-dimensional MHD code (ZUES2D) we firstly study the early plasma formation in the initially solid aluminum liners driven with a 6.7 MA, 58 ns rise time (10%–90%) current pulse on the PTS facility. It is found that electrothermal instabilities characterized by the temperature perturbations immediately grow once the current pulse starts, and the stratified structures produced by ETIs can be seen obviously in both density and temperature contours. By analyzing instability spectrum, the dominant wavelengths of the perturbations are 8.33 μm–20.0 μm, which agree qualitatively with the theoretical predictions. It is also interesting to show that ETI provides a significant seed to the subsequent MRT instability.

Then, we also theoretically investigate the effect of external axial magnetic field on the early plasma instabilities. The dispersion relation is based on the resistive MHD model, where both the uniform axial magnetic field and the electrothermal effect are taken into account. For small wavelength, the instabilities are caused primarily by the electrothermal mechanism. For large wavelength, the axial magnetic field effect becomes dominant, especially the modes with wavelength larger than the gradient scale length of magnetic field tend to destabilize more easily.

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