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The mitigating effect of self-generated magnetic field on Rayleigh-Taylor unstable inertial confinement fusion plasmas[1]

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It has long been expected that Rayleigh-Taylor instabilities (RTI) in ICF can generate magnetic fields at the gas-ice interface and at the ice-ablator interface during the deceleration phase of target implosion. The focus here is on the gas-ice interface where the temperature gradient is the largest. Nonlinear evolution of RTI leads to undesirable mixing of hot and cold plasmas and enhances target energy loss. RTI is also expected to generate magnetic fields via the Biermann battery effect, which is related to fluid vorticity generation by RTI. The magnetic field wraps around the bubbles and spikes and concentrates in flux bundles at the perturbed gas-ice interface where fluid vorticity is large. The generated magnetic field can then be further amplified via the MHD dynamo effect. While the planar 2-D simulations only generate out-of-plane magnetic fields, 3-D simulations will result in further amplification of the complex magnetic field structures via the MHD dynamo. This is studied by including a seed in-plane magnetic field in 2-D and examining the resulting magnetic field structure and magnitude. The self-generated out-of-plane magnetic fields depend on ICF parameters via the scaling law, $m_i\sqrt{Ag/\lambda}$ where m_i is the ion mass, A is the Atwood number, g is the acceleration, and λ is the wavelength. These magnetic fields grow to magnitudes of 10^2-10^3 T for ICF relevant parameter regimes. While this is dynamically insignificant due to the plasma pressure far exceeding the magnetic pressure, it can significantly reduce perpendicular electron thermal conductivity by a factor of 2-10. Such a reduction in thermal conductivity perpendicular to the magnetic field contributes to lowering of radial energy transport in the implosion target.

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