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Convergence Ratio Effects on Ultra-thin Foil Liner Implosion and Explosion Stability

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Ultrathin foil liners, with thicknesses on the order of 400 nm, are used in university-scale Z-pinch experiments (˜1 MA) to study physics relevant to inertial confinement fusion efforts on larger-scale facilities (e.g. the MagLIF efforts on the 25 MA Z facility at Sandia National Laboratories). In university-scale experiments, these ultrathin foils have required a central support rod to maintain structural integrity prior to implosion. The radius of this support rod sets a limit to the maximum convergence ratio achievable. In recent experiments with a support rod and pre-imposed axial magnetic field, helical instability structures in the imploding foil plasma were found to persist as the plasma stagnated on the rod and subsequently expanded away from the rod [1]. We have now used 3D MHD simulation code PERSEUS (which includes Hall physics) [2] to study these experiments. The results suggest that it is the support rod which enables the helical structures to persist beyond stagnation. Furthermore, we find that as the radius of the support rod decreases (i.e., as the convergence ratio increases), the integrity and persistence of the helical modes diminishes. In the limit with no support rod, we find that the structure of the final stagnation column is governed by the structure of the central precursor plasma column. These simulation results and their comparisons to experiment will be presented.

[1] Yager-Elorriaga, D. A., Zhang, P., Steiner, A. M., Jordan, N. M., Campbell, P. C., Lau, Y. Y., & Gilgenbach, R. M. (2016). Discrete helical modes in imploding and exploding cylindrical, magnetized liners. Physics of Plasmas, 23(12), 124502. https://doi.org/10.1063/1.4969082
[2] Seyler, C. E., & Martin, M. R. (2011). Relaxation model for extended magnetohydrodynamics: Comparison to magnetohydrodynamics for dense Z-pinches. Physics of Plasmas, 18(1). https://doi.org/10.1063/1.3543799
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Authors: WOOLSTRUM, Jeff (University of Michigan); Dr YAGER-ELORRIAGA, David (Sandia National Laboratories); CAMPBELL, Paul (University of Michigan); MILLER, Stephanie (University of Michigan); Dr JORDAN, N. M. (University of Michigan, Ann Arbor, MI 48109, USA); Prof. SEYLER, Charles (Cornell University); Prof. MCBRIDE, Ryan (University of Michigan)

Presenter: WOOLSTRUM, Jeff (University of Michigan)

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