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Liner Implosion Experiments Driven by a Dynamic Screw Pinch

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Magnetically driven implosions are susceptible to magnetohydrodynamic instabilities, including the magneto-Rayleigh-Taylor instability (MRTI). The use of a dynamic screw pinch (DSP) has been proposed [1], to control the MRTI growth in sold-metal liner implosions. In a DSP configuration a helical return-current structure surrounds the liner, resulting in a helical magnetic field that drives the implosion. Using the 1-MA, 100–200-ns COBRA pulsed-power driver at Cornell, we present experimental tests of three DSP cases (with peak axial magnetic fields of 2 T, 14 T, and 20 T) as well as a standard z-pinch (SZP) case [2]. The liners had an initial radius of 3.2 mm and were made from 650-nm-thick aluminum foil. Micro B-dot probes measured the axial magnetic fields produced by the return current structures. A probe placed inside the liner measured the axial field injected into the liner's interior prior to the implosion and the degree of flux compression during the implosion. Load current measurements made in COBRA's power feed suggest that the amount of low-density plasma flowing in the power feed after peak current is reduced in the DSP cases. Imaging revealed that helical MRTI modes developed in the DSP cases while azimuthally correlated MRTI modes developed in the SZP case and that the MRTI amplitudes for the 14-T and 20-T DSP cases were smaller than in the SZP case. Specifically, when the liner had imploded to half of its initial radius, the MRTI amplitudes for the SZP case and for the 14-T and 20-T DSP cases were, respectively, 1.10.3 mm, 0.70.2 mm, and 0.30.1 mm. Relative to the SZP, the stabilization obtained using the DSP agrees reasonably well with theoretical estimates. This work was conducted in collaboration with T. M. Jones, J. M. Woolstrum, N. M. Jordan, and R. D. McBride (U. Michigan), P. F. Schmit (Sandia), and J. B. Greenly, W. M. Potter, E. S. Lavine, B. R. Kusse, D. A. Hammer (Cornell). This work was supported by NSF Grant PHY-1705418 of the NSF-DOE Partnership in Basic Plasma Science and Engineering. COBRA support was provided by the NNSA SSAP under DOE Cooperative Agreement DE-NA0003764. [1] P. F. Schmit *et al.*, Phys. Rev. Lett. **117**, 205001 (2016). [2] P. C. Campbell *et al.*, "Stabilization of Liner Implosions via a Dynamic Screw Pinch", accepted in Phys. Rev. Lett. (2020).