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Modeling, measuring, and mitigating instability growth in liner implosions on Z[1]

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Electro-thermal instabilities result from non-uniform heating due to temperature dependence in the conductivity of a material. In this talk, we will discuss the role of electro-thermal instabilities [1] on the dynamics of magnetically accelerated implosion systems. We present simulations that show electro-thermal instabilities form immediately after the surface material of a conductor melts and can act as a significant seed to subsequent magneto-Rayleigh-Taylor (MRT) instability growth. We discuss measurement results from experiments performed on Sandia National Laboratories Z accelerator to investigate signatures of electro-thermal instability growth on well-characterized initially solid aluminum or beryllium rods driven with a 20 MA, 100 ns risetime current pulse. These measurements show good agreement with electro-thermal instability simulations and exhibit larger instability growth than can be explained by MRT theory alone. Recent experiments have confirmed simulation predictions of dramatically reduced instability growth in solid metallic rods when thick dielectric coatings are used to mitigate density perturbations arising from the electro-thermal instability [2]. These results provide further evidence that the inherent surface roughness of the target is not the dominant seed for the MRT instability, in contrast with most inertial confinement fusion approaches. These results suggest a new technique for substantially reducing the integral MRT growth in magnetically driven implosions. Indeed, recent results on the Z facility with 100 km/s Al and Be liner implosions show substantially reduced growth. These new results include axially magnetized, CH-coated beryllium liner radiographs in which the inner liner surface is observed to be remarkably straight and uniform at a radius of about 120 microns (convergence ratio $\sim$20).

[1] K.J. Peterson, D. B. Sinars, et al., Phys. Plasmas 20, 056305 (2012)
[2] K.J. Peterson, T. J. Awe, et al., PRL 112, 135002 (2014)

[1]Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.