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Magnetic Rayleigh-Taylor Instability Mitigation and Efficient Radiation Production in Gas Puff Z-Pinch Implosions[1]

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For a long time it was believed that tightness and uniformity of Z-pinch plasmas imploded from large radii are inherently low because the adverse effect of the magnetic Rayleigh-Taylor (RT) instability that distorts the imploding plasma column is stronger for a longer acceleration path. None of the wire-array implosions from a diameter exceeding 7 cm were successful; a significant decrease of the argon K-shell radiation yield was observed when a 2.5 cm diameter annular shell load was replaced with a 4 cm diameter one. We report how we solved the problem of imploding z-pinch plasmas from large initial radii, making it possible to efficiently produce x-ray radiation with z pinches driven by longer current pulses than previously thought possible. Our novel load design[1] that mitigates the RT instability and enhances energy coupling to the radiating plasma column consists of a "pusher," outer region plasma that carries the current and couples energy from the driver, a "stabilizer," inner region plasma that stabilizes the implosion and a "radiator," high-density center jet plasma that radiates. It increased the Ar K-shell yield at 3.46 MA in 200-ns implosions from 12-cm initial diameter by a factor of two, to 21 kJ, matching the yields obtained earlier on the same accelerator with 100-ns implosions. Test results of this load on all other major US accelerators will be presented [2]. Using laser shearing images, we illustrate the RT growth, its suppression and stabilization of an imploding plasma in a structured gas puff load that lead to a high compression, high yield z pinch. Similar images obtained for gas puff loads whose design does not ensure stabilization show the evolution of highly unstable z pinches which perform poorly as radiators. This research points the way to improved z-pinch implosions from large initial radii, either in the form of wire arrays or gas puffs.

[1] H. Sze *et al.*, Phys. Rev. Lett. **95**, 105001 (2005)
[2] J. Levine *et al.*, Phys. Plasma (August 2006)

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