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Staged Z-pinch Experiments and Simulations Using Different Gas Shells

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Staged Z-pinch experiments at the Nevada Terawatt Facility at UNR show evidence of uniform compression of a deuterium plasma target compressed by a high-Z, Argon or Krypton gas-puffed liner. Pinch stability is improved by seeding the implosion with an axial magnetic field of 0.1 to 0.2T. Implosion dynamics and stagnation conditions are also studied computationally with the radiation-MHD code MACH2 and Hydra, by applying initial conditions similar to those in the experiment. Simulations show that magnetic field diffuses through the outer shell and piles up at the interface providing narrow profile, high intensity current that Ohmicly preheats the target. This secondary piston launches shock waves in the target plasma that heats the target to several 100 eV. Finally, the preheated target is compressed adiabatically to stagnation. Simulations show: (a) stronger shocks and more pronounced pre-heating with Kr than Ar, (b) the axial magnetic field is compressed preferentially in the liner plasma, providing greater magneto-Rayleigh-Taylor mitigation during run-in phase compared to the self-similar model. For typical Ar liner on D target experiments we measured neutron yield up to 2×10^9 and for Kr liner up to 2.5×10^{10}. Experimental observations limited to the liner exterior (plasma current, visible streak images, gated-XUV pinhole images, and laser shadowgraphs) are compared with simulations, and show general agreement. The experimentally measured neutron yield is also in good agreement with simulations. Scaling up for high current machines like 10 MA and 20MA providing scientific breakeven and beyond using both MACH2 will also be presented. Conceptual design of the next generation machine of 10 MA will also be presented.
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