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(I) Flow-Through Z-Pinch Research at Fuse

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Flow-through Z-pinches were first discovered over 50 years ago, manifesting themselves as a stable, pinch-like structure that persisted for 100 us in the Newton-Marshal gun experiments at LANL in the late 1960's. Linear stability analysis performed by Uri Shumlak in the 1990's showed that when dV_z/dr > 0.1 k V_A the kink mode could be stabilized in a Z-pinch plasma. Experimental work over the last couple of decades have shown that Z-pinches can be stabilized when the sheared axial flow exceeds this threshold. Quasi-steady-state Z-pinches existed near the axis of the assembly region for 20-80 us. The instability growth time from these Z-pinches was about 10 ns. Recent results from the sheared-flow Z-pinch experiment at the University of Washington, FuZE, have shown it may be possible to achieve a thermonuclear fusion burn. The FuZE device achieved 10 us long fusion burns along 30 cm of the Z-pinch plasma. Using adiabatic scaling relationships, it may be possible to build a Q=6 fusion reactor using the traditional Marshall gun approach. The formation and sustainment method relies on creating a neutral gas reserve that can be continuously ionized, supplying the stabilizing plasma flow to the Z-pinch throughout the current pulse. Creating the optimized neutral gas fill profile requires tedious experimentation. Fuse Energy Technologies will be studying the scaling towards a reactor by forming and sustaining flow-through Z-pinches using a new technique. The deflagration ionization process will be replaced with an array of plasma injectors. This novel technique will allow better control of the mass flow into the Z pinch. This process may allow for better comparisons with the scaling relationships. Previous work, recent simulation and experimental results from the Fuse devices will be presented.

Primary author: Dr GOLINGO, Raymond (Fuse)

Co-authors: MCDONALD, Alex (Fuse); Dr LIAO, Andy (Fuse); CHOUDHURY, Ayan (Fuse); Dr CHAMBERLAIN, Carter (Fuse); SEIFOLLAHI, Zahra (Fuse)

Presenter: Dr GOLINGO, Raymond (Fuse)

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