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Sheared flow stabilized Z-pinch plasma production on the FuZE experiment[1]

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Sheared-flow stabilization is reigniting interest in Z-pinches for thermonuclear fusion. Recent measurements of steady-state DD neutron production lasting up to 8 μs, coincident with keV impurity ion temperatures and quiescent MHD activity suggest that thermonuclear plasmas are produced on the FuZE experiment. FuZE studies how a column of axially-flowing plasma with radial velocity shear can be compressed and heated by electrical current. We summarize our understanding of plasma dynamics on FuZE and possible control schemes via tailored gas injection. FuZE consists of a 1 m coaxial plasma accelerator, followed by a 0.5 m assembly region, an extension of the outer electrode past the inner. Gas is supplied from 3 sets of fast valves with independent mass flow rates and delay times to generate diverse axial gas density profiles. The discharge begins with an initial current sheet propagating in a snowplow manner, injecting a slug of plasma into the assembly region where it collapses towards the axis. Maintaining the pinch requires continuous plasma injection that is provided by a second current sheet moving backwards through the neutral gas in the accelerator. Flexible gas injection allows for control of this process. Plasma dynamics is characterized with several diagnostics. A fast video camera films visible light emission. Space-and-time resolved spectroscopy shows the presence of keV-temperature C-V ions with sheared velocity profiles, coincident with neutron production. Correlating time resolved spectroscopy with video reveals key phenomena: the presence of high neutral densities in the initial slug ejected by the snowplow, stagnation of plasma near the endwall, and silicon lines near viewports from plasma impact. Models describing these phenomena, and their implications for the shear-flow stabilized Z-pinch concept, are discussed.

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