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Results from the Sheared-Flow Stabilized Z-Pinch and Scaling to Fusion Conditions

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The sheared-flow stabilized Z-pinch has been experimentally demonstrated to produce long-lived plasmas that satisfy radial force balance and are stable for thousands of exponential growth times. The sheared-flow stabilized Z-pinch has the potential to lead to a compact plasma confinement device that scales to fusion conditions. The stabilizing effect of a sheared axial flow on the m=1 kink instability in Z-pinches has been studied using ideal MHD theory to reveal that a sheared axial flow stabilizes the kink mode when the shear exceeds a threshold value. Following these theoretical results, the ZaP Flow Z-Pinch group at the University of Washington has been experimentally investigating the connection between flow shear and gross plasma stability. Plasma stability is diagnosed with azimuthal arrays of magnetic probes that measure the plasma's magnetic structure. Large magnetic fluctuations occur during pinch assembly, after which the amplitude and frequency of the magnetic fluctuations diminish. This stable behavior continues for an extended quiescent period. Plasma flow profiles are measured from the Doppler shift of plasma impurity lines. The experimental flow shear exceeds the theoretical threshold during the quiescent period. Scaling relations suggest that high energy density plasma and fusion conditions are possible in a compact design. Recent experiments with the upgraded ZaP-HD device have demonstrated the ability to increase the plasma parameters by compressing the plasma radius to smaller values than achieved with the ZaP device. Based on the successful results of ZaP and ZaP-HD, a new experiment FuZE is designed to scale the plasma parameters to fusion conditions. The project will focus on furthering our understanding of the physics with specific emphasis on the limitations of sheared flow stabilization and on the importance of kinetic effects at large drift speeds.

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