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Increasing Plasma Parameters using Sheared Flow Stabilization of a Z-Pinch[1]

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Recent experiments on the ZaP Flow Z-Pinch at the University of Washington have been successful in compressing the plasma column to smaller radii, producing the predicted increases in plasma density (10^{18} cm^{-3}), temperature (200 eV), and magnetic fields (4 T), while maintaining plasma stability for many Alfven times (over 40 μs) using sheared plasma flows. These results indicate the suitability of the device as a discovery science platform for astrophysical and high energy density plasma research, and keeps open a possible path to achieving burning plasma conditions in a compact fusion device. Long-lived Z-pinch plasmas have been produced with dimensions of 1 cm radius and 100 cm long that are stabilized by sheared axial flows for over 1000 Alfven radial transit times. The observed plasma stability is coincident with the presence of a sheared flow as measured by time-resolved multi-chord ion Doppler spectroscopy applied to impurity ion radiation. These measurements yield insights into the evolution of the velocity profile and show that the stabilizing behavior of flow shear agrees with theoretical calculations and 2-D MHD computational simulations. The flow shear value, extent, and duration are shown to be consistent with theoretical models of the plasma viscosity, which places a design constraint on the maximum axial length of a sheared flow stabilized Z-pinch. Measurements of the magnetic field topology indicate simultaneous azimuthal symmetry and axial uniformity along the entire 100 cm length of the Z-pinch plasma. Separate control of plasma acceleration and compression have increased the accessible plasma parameters and have generated stable plasmas with radii below 0.5 cm, as measured with a high resolution digital holographic interferometer.

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