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Magnetic Dynamics in Z-pinch Experiments

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The results of measurements from magnetic diagnostics (also called a "bdot" probes) in devices oriented towards fusion energy, such as the z-pinch and tokamak can be interpreted in terms of magneto-hydrodynamic (MHD) phenomena from time-of-arrival measurements and Fourier analysis.

A class of z-pinch devices operate using a coaxial gas puff, with the dense plasma focus (DPF) receiving the bulk of attention. Breakdown occurs between two coaxial electrodes in a thin layer known as a "snow-plow" or "umbrella" current sheet, which is accelerated via the Lorentz force into the pinch region of the device.

A new generation of gas puffed z-pinch devices (ZaP[1,2], FuZE[3,4], and the now defunct M.U. from Fuse Energy Technologies in Canada) exhibit long stabilization times (3 orders of magnitude longer than the DPF, and 1-2 orders of magnitude longer than the theoretical Alfven transit time) renewing the possibility that z-pinch devices may be viable for fusion energy production.

Previous experiments have detected a radial sheared flow profile via spectroscopic measurements[2-6] while previous theoretical studies have correlated radial sheared flow in a cylindrical column with stabilization of the m=0 "sausage" modes but not the m=1 "kink" mode[7] leaving unanswered questions as to the cause of stabilization.

An analysis of magnetic data in the new M.U. z-pinch device illustrates three previously unreported features/plasma behaviors; a conductive wake detected behind the "snow-plow" current sheet, a an ionization/breakdown pattern in the pinch region which occurs in a direction opposite to current flow immediately after the snow plow current sheet hits the end wall, and the "snap-back" motion of several axially propagating m=1 kink modes. The new results appear to compliment the previous findings[1-6] from the University of Washington's Zap and FuZE "SFS" Z-pinch devices and may point to new dynamics which explain stabilization of the m=1 kink mode.

As well, a new poloidal array of 24 bdot probes has been designed, built, and installed on the University of Saskatchewan STOR-M tokamak to improve on the resolution of the previous magnetic diagnostic system.[8]

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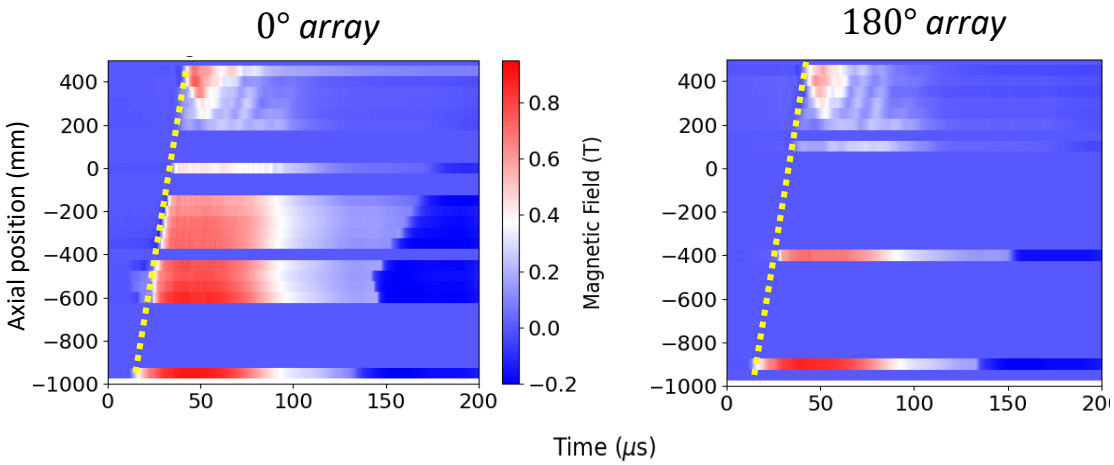

Figure 1. Plot of magnetic field strength vs time and position from two axial sensor arrays on the M.U. z-pinch device. The dotted yellow line with a positive slope represents the incoming "snow-plow" current "sheet". A magnetic signal in the pinch region detected as a negative slope suggests ionization/breakdown occurs in a direction opposite to the incoming current sheet.