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5D05-06

Overview of High Density FRC Research on FRX-L at Los Alamos National Laboratory[†]

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The Field Reversed Experiment - Liner (FRX-L) is a plasma injector for Magnetized Target Fusion (MTF) development at Los Alamos National Laboratory. The MTF project goal is to adiabatically compress a target plasma to achieve fusion conditions in a pulsed experiment in near future. FRX-L is designed to produce a field reversed configuration (FRC) plasma that will be translated and fast compressed in an imploding flux-conserving metal liner. It is predicted that the FRC plasma will maintain its equilibrium topology while being adiabatically heated during compression by the fast moving aluminum metal liner. To achieve this goal, it is required to produce a warm and dense FRC plasma of $n \sim 10^{17} \text{ cm}^{-3}$ and $T_e \sim 300 \text{ eV}$, and sustain it for a lifetime of 10-20 μs . Theta pinch data from several different laboratories in the past demonstrate that it is possible to create an FRC with our initial desired parameters. We have so far successfully produced dense FRC plasmas of $\sim 5 \times 10^{16} \text{ cm}^{-3}$ with a lifetime up to 12 μs , and sub-100 eV temperatures. The present focus is to improve on field reversed theta pinch formation of FRC and increase the main capacitor bank fields to increase the magnetic fields and energy. In addition, new plasma diagnostics are being implemented including multi-point Thomson scattering system, an 8-chord visible interferometer, and an end-on bolometer array. These improvements will enable us to investigate the critical issues of plasma stability, cleanliness, and lifetime for high-density FRC plasmas relevant to MTF.

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5D07-08

Improved Spheromak Operation with Reduced Fluctuations in SSPX[†]

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We will report recent results from the Sustained Spheromak Physics Experiment (SSPX) in which we measure peak electron temperatures greater than 300eV in driven spheromak discharges. The SSPX spheromak plasma (0.31m major radius, 0.13m minor radius) is driven for up to 4msec by a DC coaxial source (a Marshall gun), which is powered by a 2MJ capacitor bank. The plasma is contained inside a tungsten-coated copper flux conserver which maintains stability against global tilting modes.

Plasma temperature and density are measured by a multi-point Nd:YAG Thomson scattering system and CO2 interferometer, respectively; a complete temperature profile is obtained during each discharge. We use a 2d Grad-Shafranov solver to reconstruct the MHD equilibrium current profile from edge magnetic field data. The reconstruction can be further constrained by using insertable magnetic probes to measure the magnetic field components inside the coaxial injector region.

Best operation of the spheromak is obtained after extensive pre-conditioning, which includes a high temperature bake, glow discharge cleaning, helium plasma scrubbing, and titanium getter. In this way, we obtain discharges with $Z_{eff} < 2.5$. Without such conditioning, the spheromak plasmas exhibit rapid decay of the magnetic field after the drive is turned off and central electron temperatures are 50eV or less.

Our results also show that magnetic fluctuations must be reduced in order to obtain high temperatures. We minimize the magnetic fluctuations by maintaining the gun current just above the ejection threshold of the gun for several msec following a large initial high-current formation pulse. As the plasma evolves, the magnetic fluctuations fall to $\delta B/B < 0.5\%$ and T_e rises from 100eV to more than 300eV. Peaked temperature profiles are observed with $T_e > V_{gun}$. Transport analysis yields a thermal diffusivity $\chi_e < 10 \text{ m}^2/\text{s}$ with peak $\beta_e > 10\%$.

We are now exploring ways to increase the spheromak magnetic field strength from the present peak of about 0.25T. Higher fields should allow higher plasma temperature at fixed density. While many discharges exhibit a stiff relationship between gun current and spheromak magnetic field, we observe steadily rising magnetic field energy at constant gun current when we eliminate the large initial formation pulse and turn on the gun more slowly. These discharges exhibit large voltage fluctuations, which are the subject of present research. New gun designs are being developed which will help us understand the source of these voltage fluctuations.

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