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Thermodynamics of relaxed magnetized plasmas for magneto-inertial fusion applications

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An experimental study for the determination of equations of state applicable to a compressible magnetized plasma is essential for realizing controlled nuclear fusion. Numerous laboratory experiments have been performed to achieve a highly compressed plasma to ultimately lead towards fusion such as inertial confinement fusion experiments on unmagnetized plasma, experiments on magnetically confined plasmas (in various tokamaks) and magnetized liner inertial-fusion experiments. However, little has been done to understand the thermodynamics of these magnetized plasmas.

This talk will present results from our experiments on the thermodynamics of compressed magnetized plasmas[1-3]. In these experiments, we generate parcels of magnetized plasma at one end of the linear SSX device using a magnetized coaxial plasma gun. Magnetized plasma relaxes to a twisted Taylor state, as shown in Figure 1, and drifts to the other end of the device, where it stagnates and gets compressed due to its own inertia. Plasma parameters are measured in the compression volume, and we observe ion heating. An axial scan of the ion temperature confirms that the heating arises due to the stagnation and compression of the magnetized plasma. A PV diagram is constructed using measured plasma parameters, as shown in Figure 2, to identify the compression events accompanied by heating. Theoretically predicted magneto-hydrodynamic (MHD) and double adiabatic EOS – known as Chew, Goldberger and Low (CGL) equations are compared to experimental measurements. Since our magnetized plasmas relax to an equilibrium described by MHD, one would expect their thermodynamics to be governed by the corresponding EOS. However, we find that our data do not support the MHD EOS. Our results show consistency with the CGL EOS, suggesting that the relaxed SSX plasmas possess a significant anisotropy in the ion distribution function.

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References

[1] Kaur *et al.*, Phys. Rev. E. 97, 011202 (2018).
[2] Kaur *et al.*, J. Plasma Phys. 84, 905840114 (2018).
[3] Kaur, *et al.*, Phys. Plasmas 26, 052506 (2019).

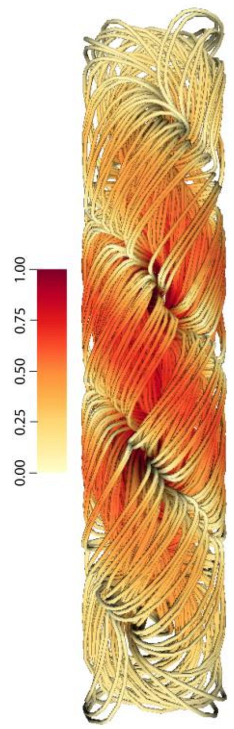

Figure 1. A 3D arrangement of the magnetic field lines in a twisted Taylor state, plotted using VisIt. The relative magnitude of |B| at any location is plotted using the colorbar at the top.

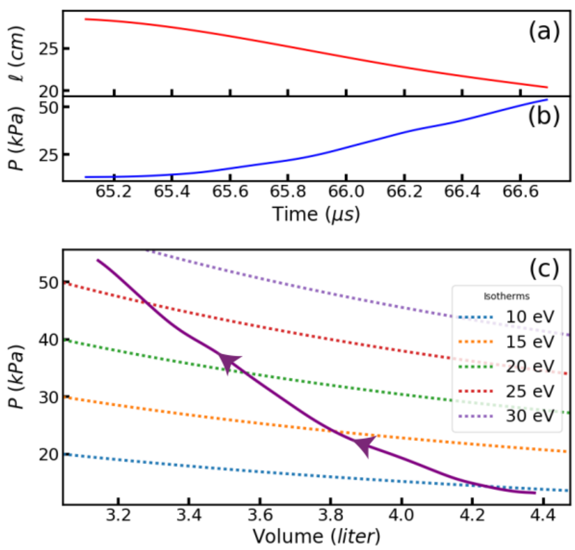

Figure 2. Typical time trace of Taylor state length (showing 30% compression) is shown in (a). Second panel (b) shows an increase in the thermal pressure of the plasma for the same time. The third panel (c) contains a graph of pressure versus volume with different isotherms plotted using the dotted lines in the background, showing plasma heating during compression.