Flow Dynamics of Spheromaks in SSX

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Introduction

-The Swarthmore Spheromak Experiment (SSX) is designed to study both basic plasma physics (reconnection) and fusion-related science (spheromaks and FRCs). Plasma flow is a central theme in both cases. Reconnection generates Alfvenic plasma outflow and our formation scheme can generate strong flows in spheromaks and FRCs.

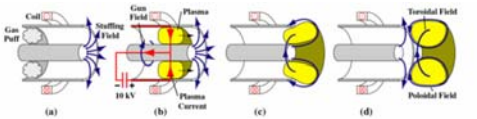


Figure 1. Schematic of spheromak formation in SSX. Spheromaks are ejected at 100 km/s.

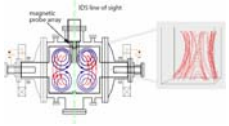


Figure 2. Spheromak merging in SSX. Measured 3D reconnection structure (right).

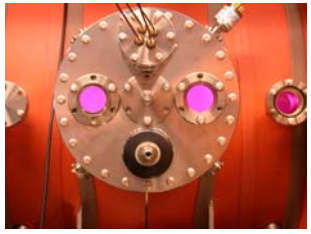


Figure 3. Plasma discharge in SSX (H plasma). Soft x-ray array is depicted (top).

Ion Doppler Spectroscopy (IDS)

-Our primary diagnostic to measure line averaged flow is IDS. The SSX IDS instrument measures with 1 μs time resolution the width and Doppler shift of CIII impurity (H plasma) 229.7 nm line to determine Ti and line- averaged flow velocity.

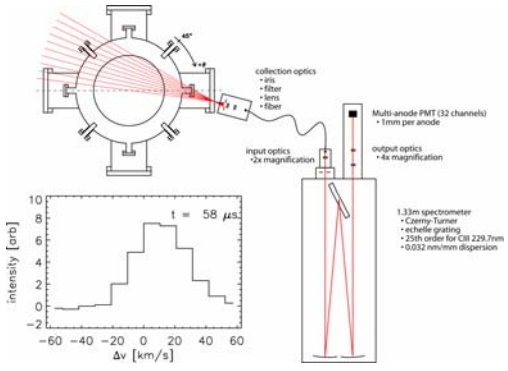
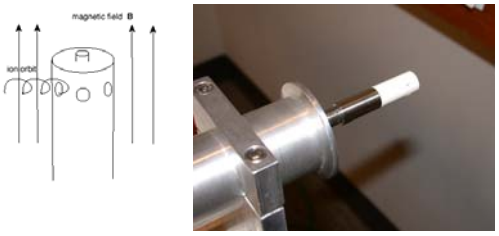


Figure 4. The SSX IDS setup. Typical low flow data.

Mach Probe Studies



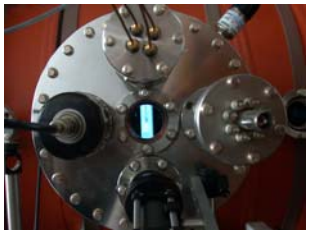


Figure 5. Mach probe schematic. Larger Mach II (top), smaller Mach I in He GDC plasma (bottom).

Vacuum Ultraviolet and Soft X-ray

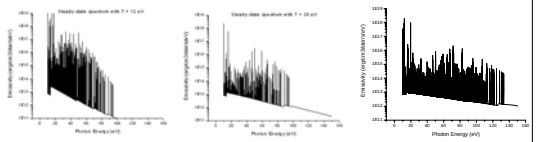


Figure 6. Calculated spectra with T = 12, 28, and 44 eV. 0.1% C, N, and O impurities. Calculations performed with PrismSpect.

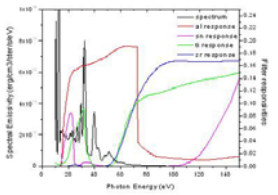


Figure 7. SXR filter response functions for photodiodes filtered by thin films of Al, Ti, Sn, and Zr

Figure 8. 0.2 m VUV monochrometer on SSX.

Figure 9. SXR filtered diode array.

Mach Probe Results

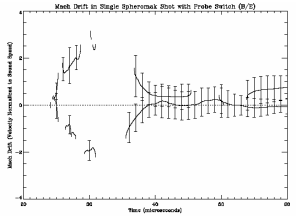


Figure 10a. "Flip" test with single spheromak using Mach II (J. Horwitz, JP1.37).

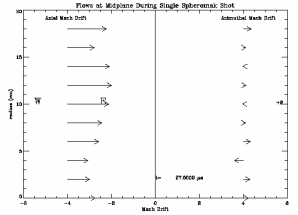


Figure 10b. High velocity axial flow with single spheromak (v = 100 km/s)

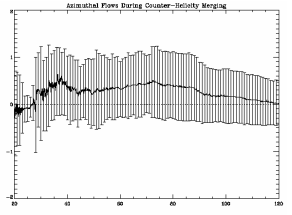


Figure 11a. Mean reconnection outflow for merging spheromaks, azimuthal flow, one side of the bidirectional jet

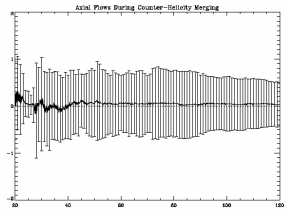


Figure 11b. Mean axial flow at the midplane for merging spheromaks, consistent with stagnation (v = 0).

Optical Diagnostic Results (IDS, VUV, SXR)

Figure 12. IDS output optics and multi-anode PMT array (bottom).

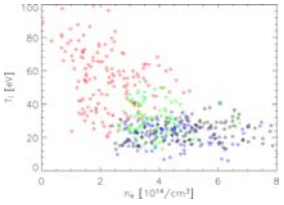


Figure 13. Scaling of Ti (measured with IDS) with density (measured with HeNe interferometer).

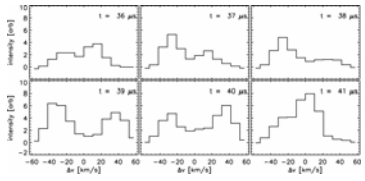


Figure 14. Bidirectional reconnection jets during counter-helicity merging (C. Cothran).

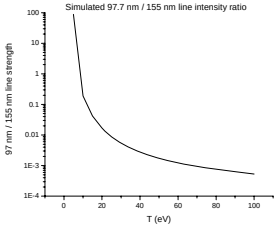


Figure 15. Te from CIII (97.7 nm) to CIV (155 nm) ratio (V. Chaplin, JP1.38).

Acknowledgements

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