Direct comparison of velocity distribution measurements and simulations in the vicinity of an absorbing boundary oblique to a magnetic field

**SUMMARY**

Plasma boundary interactions are strongly affected by the sheath and presheath structures that form near the boundary surface. Recent measurements have observed ion transport across magnetic field lines in regions where the surface is oblique to the background magnetic field ($\theta > 74^\circ$). In these boundary regions, charge exchange collisions may provide a mechanism through which neutral particles interact with the long distance presheath electric field. We report efforts to directly compare Boltzmann and particle-in-cell simulations with 3D neutral velocity distributions (NVDs) using laser induced fluorescence (LIF) in a magnetoplasma boundary region. We present a novel LIF method for measuring Axial-Maxwellian velocity distributions, in which we observe the 785 nm I$_3$ fluorescence that results from absorption of the 782 nm pump laser, providing neutral temperatures and flows. We additionally describe electrostatic probe measurements in the same region.

**PROPER STUDY OF THE PRESHREAT AND BOUNDARY REGION REQUIRES 3D OPTICAL ACCESS**

A 316 stainless steel grounded boundary (left) is oriented at magnetic angle $\theta > 74$ degrees between the plane normal (X) and the background field. The X-B direction is parallel to the plane normal axis of the experiment.

**MAPPING IN 3D REQUIRES SEVERAL DIAGNOSTIC INNOVATIONS**

3D translatable Langmuir probe produces EEPFs

**3D LANGMUIR PROBE MAPS SHOW RADIALY DEPENDENT n, T**

A map of $n_x$ (right) shows uniformity along the magnetic axis of HELIX with the characteristic, centrally peaked radial density profile of helium plasmas observed.

**SINAR 3D DEPENDENCY**

**ION FLOW MAPS REVEAL 3D NATURE OF BOUNDARY REGION**

Flows normal to the surface increase with proximity to the boundary. Ions are accelerated in the $E \times B$ direction. Background axial flows of 1,500–2,000 m/s are observed.

**ÉLECTRON ENERGY PROBABILITY FUNCTIONS (EEPFS) SHOW BI-MAXWELLIAN POPULATIONS, WITH THE RELATIVE DENSITY OF THE ENERGETIC POPULATION INCREASING AT LARGER RADIUS**

Electron kinetic energy is available for simulating collision rates.

**LIF MEASUREMENTS REVEAL ACCELERATION IN THE E X B DIRECTION WITHIN SEVERAL Z**

(right) A plasma potential gradient of 125 V/m is observed parallel to the surface, predicting drift $\mathbf{v}_D = 2000$ m/s.

**NEUTRAL VDFs PROVIDE T_X, U_Z, AND REVEAL ANY NON-MAXWELLIAN FEATURES**

No neutral flow observed in the experimental domain for either direction perpendicular to the background field.

**3D-3V MEASUREMENTS PROVIDE A DIRECT TEST OF THE CHODURA MAGNETIC PRESHREAT MODEL**

Volumetric representations of $U_z$ (above left) and $U_x$ (above right) with surface indicating the Bohm-Chodura transition location.

This surface occurs a factor of approximately 2 closer than predicted by the Bohm magnetic presheath model.

**Funding Source:** U.S. National Science Foundation Grant No. PHY-1362278 NSF Louis Stokes Alliance for Minority Participation