Planned Emissive Probe Measurements on LDX

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ABSTRACT

The Levitated Dipole Experiment (LDX) investigates equilibrium and stability of a high-beta plasma confined to a dipolar magnetic field. Because of its closed field line geometry, LDX may be subject to convective cell formation. As a principal objective we would like to understand the relationship of convective cell formation as it relates to plasma equilibrium and stability for our dipole geometry. Their nature and role will be explored using emissive probes that function both as a diagnostic of the outer electrostatic potential but also as a low-impedance electrode for charging flux tubes and exciting or controlling convective cells. When biasing a given magnetic flux tube, we plan to interact with convective cells in a controlled manner and possibly amplify or suppress the level of electrostatic perturbation. The current progress of the diagnostics and setup will be presented together with results from a glow discharge plasma.

Outline

- What's New?
- Probe Interface Mounting
- Convective Cells
- Emissive Langmuir Probe
  - Goals
  - Design & Properties
  - Construction
- Other Probes
- Glow Discharge Cleaning (GDC) Anode
- Summary & Future Work

Electric Probes – Progress

* Images taken by Eugenio Ortiz. November 10, 2002.

- Probe Housing
  - Assembled : Oct 2002
- Emissive Langmuir Probe
  - Assemble : Nov 2002
- GDC Anode
  - Assemble : Dec 2002
- PLC – Data Acquisition
  - Assemble : Dec 2002
- Triple Langmuir Probe
  - Assemble : Jan 2003
- †Motorize Probes
  - Assemble : Jan 2003

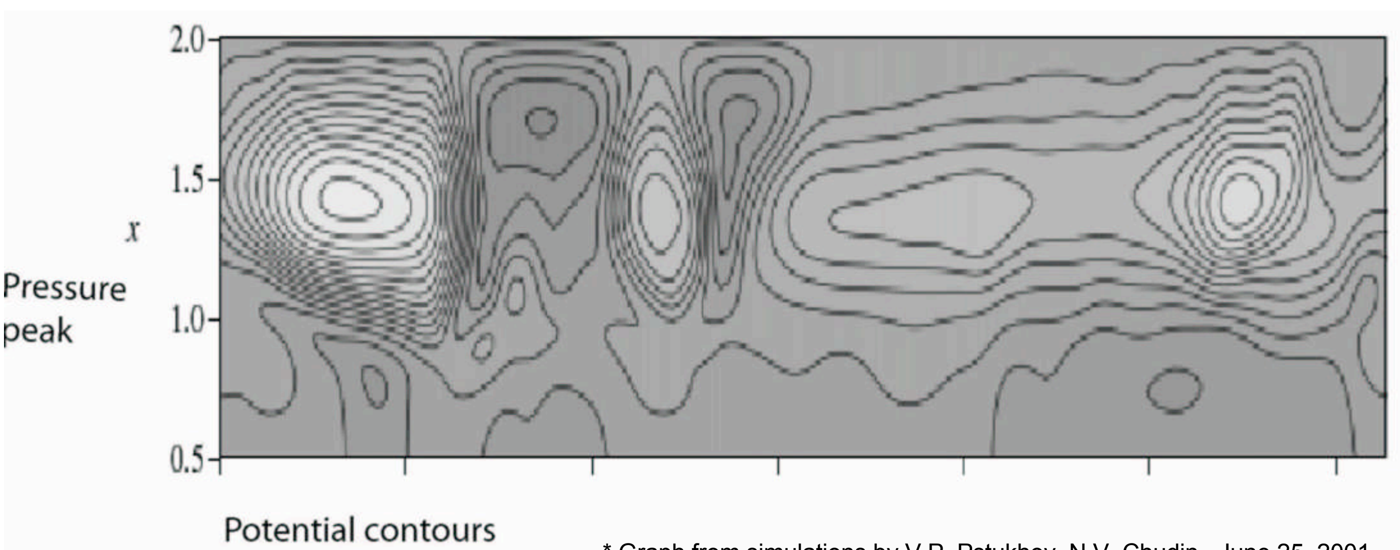
Probe Interface Mounting

- Easy access via platform
  - Actual height ~ 4.5’ (137 cm) from base flange
  - Four ports available
- Bellow stroke ~ 32.5” (83 cm)
  - Max length ~ 42.25” (108 cm)
  - Min length ~ 9.75” (25 cm)
- Removal of probe without breaking main vacuum
- Motorized version† allows remotely controllable motion
- Quick release shaft collars
  - No tools necessary

* Image taken by Eugenio Ortiz. November 10, 2002.

Convective Cell Questions

- Do convective cells exist in LDX?
  - Are they the nonlinear saturation of interchange modes?
- What do they do to energy confinement?
  - Can we have high energy confinement with low particle confinement?
- Can we drive and/or limit existing convective cells?
  - Use an emissive probe to ‘stir’ plasma?

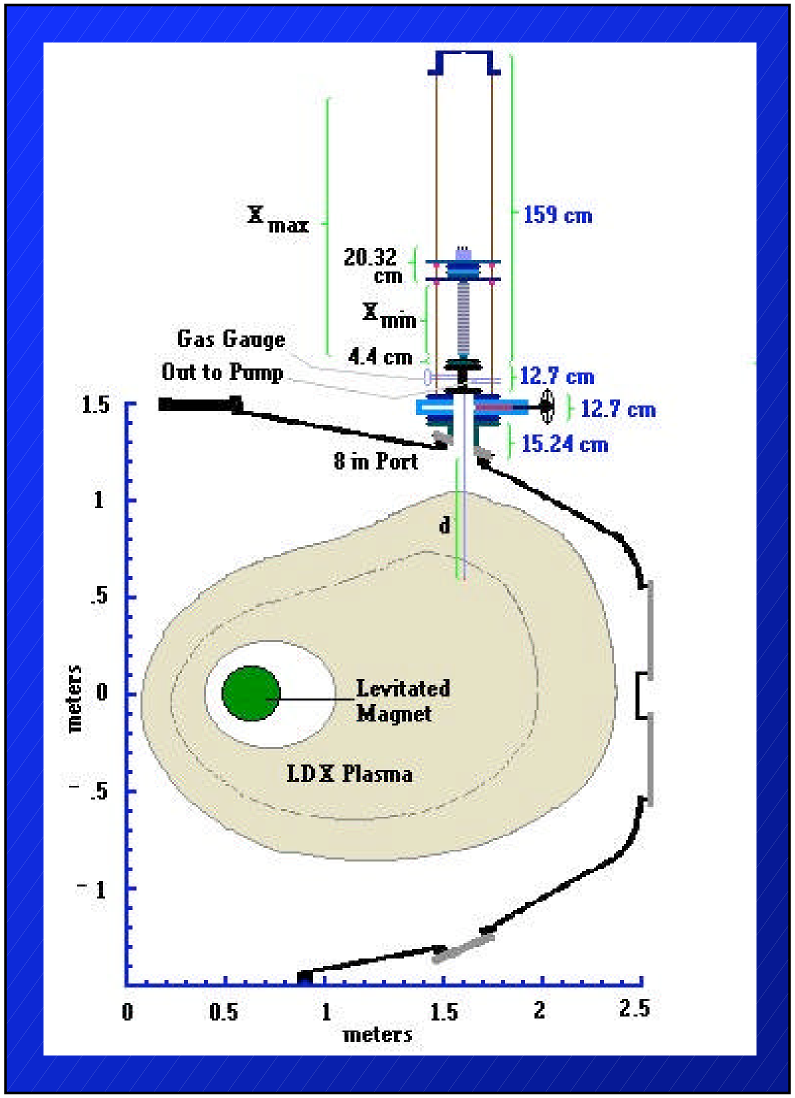


* Graph from simulations by V.P. Pstukhov, N.V. Chudin. June 25, 2001.

Convective Cell Interaction

- Emissive probe design
  - Bias field lines & charge flux tubes
  - Create small **E**-field fluctuations
- Explore emissive probe ability to control cells
  - Attempt to drive new convective cells or suppress existing cells
- Study dynamics with multiple probes
  - Track large scale vortices
  - Time dependent polarity?
  - Plasma flow dominated by vortices?
  - Convective flow measurements via Mach probes

Emissive Probe Goals

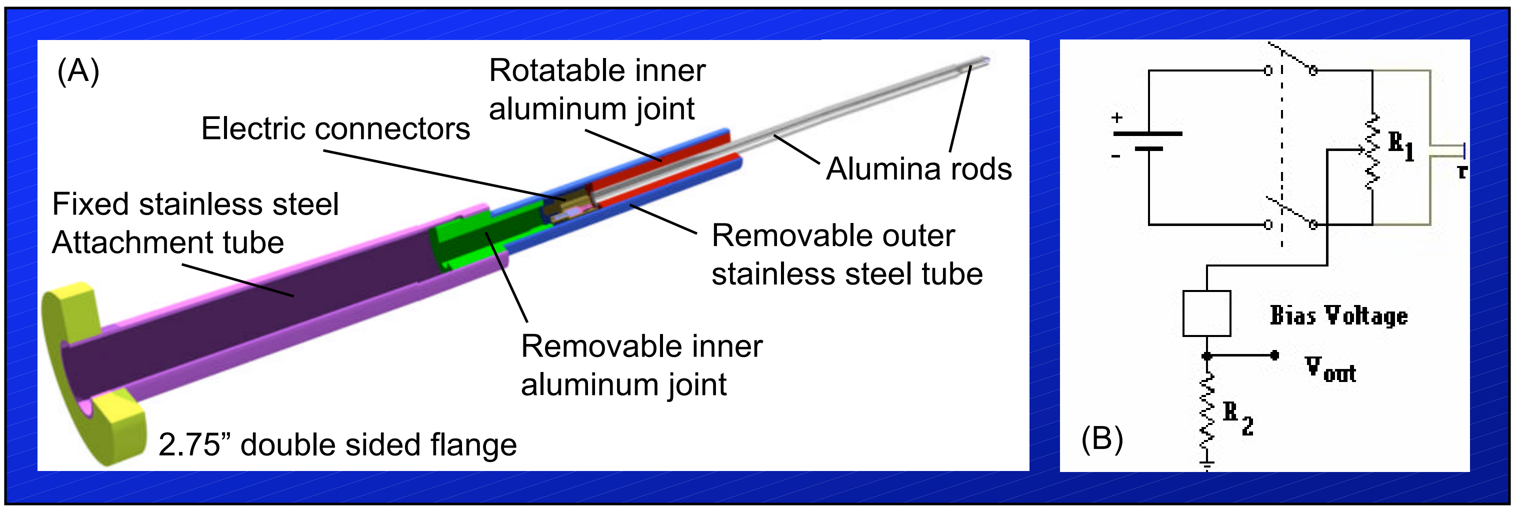


* Drawing by Eugenio Ortiz. May 15, 2001.

- Linear motion vacuum interface
  - Probe incursion depth of 23.5" (60 cm)
- Allow for easy probe replacement w/out breaking vacuum
- Ideal for measuring edge plasma phenomena
- Ability to bias single magnetic field line via emissive probe
- Measure fluctuations in local potential, ie. **E**-field

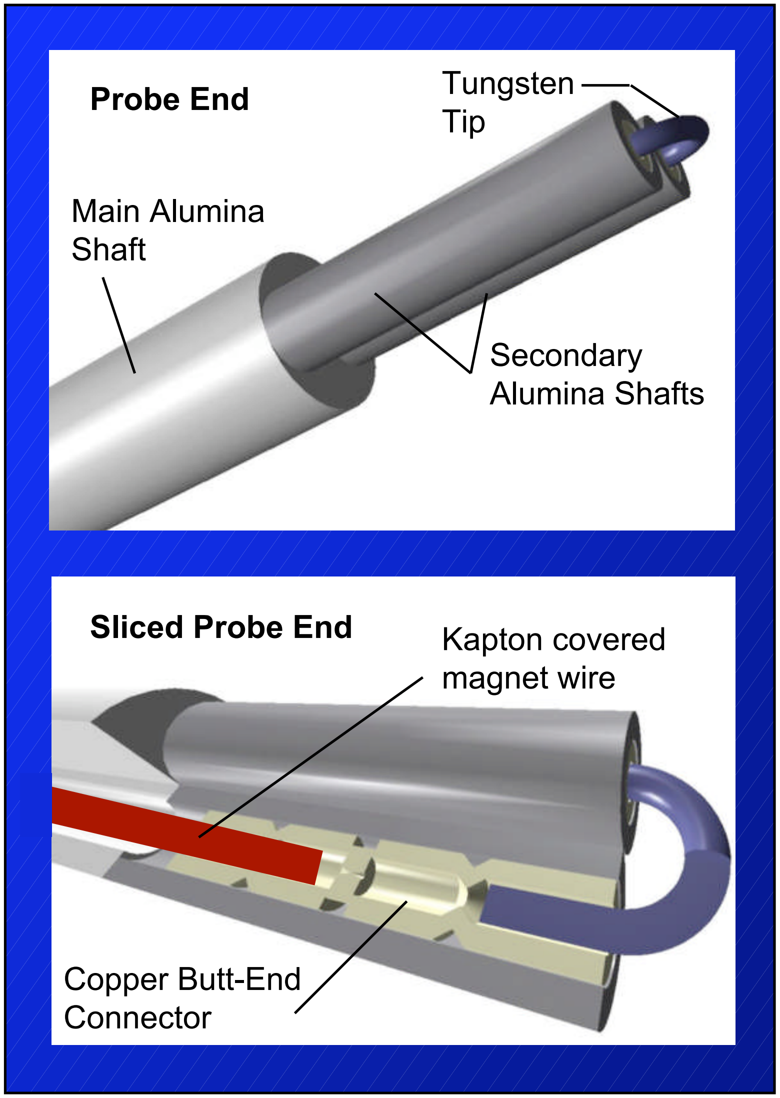
Emissive Probe Outline

- Thoriated Tungsten tip
  - Lower Work Function ~ 2.63 eV
  - Emission at lower temperatures 1700 degrees K
- Simple electrical circuit
  - R_2 used to measure resistivity of Tungsten, ie. temperature
  - Compare with ARIES chart (chart of Tungsten Temperature vs. Resistivity)
- Data acquisition via MDS-Plus, analysis using IDL



* Drawings by Eugenio Ortiz. Drawing (A) November 10, 2002. Drawing (B) May 15, 2001.

Final Probe Design



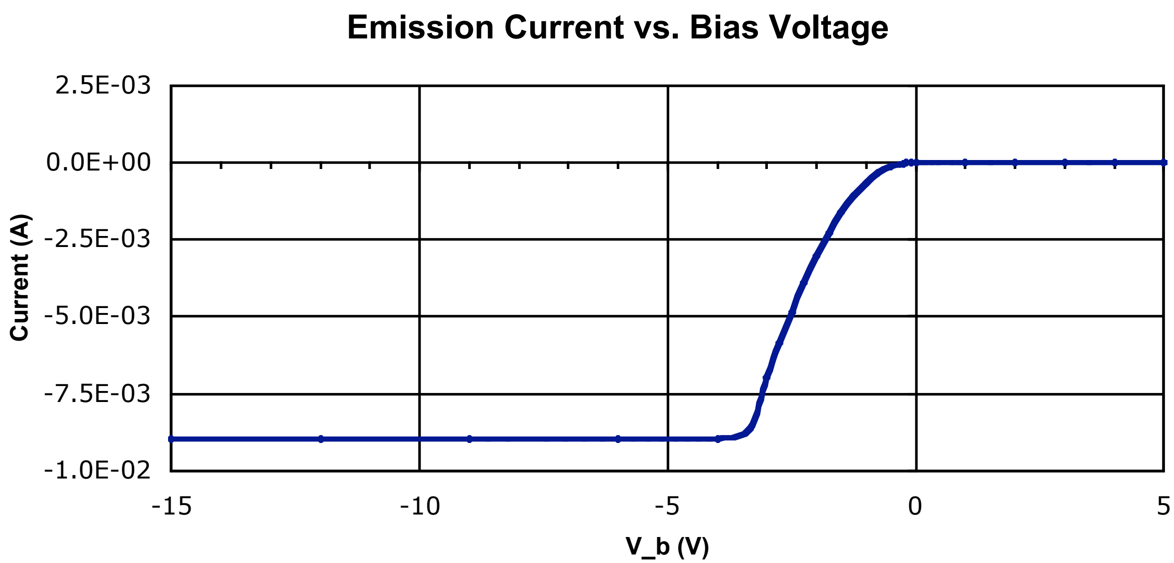
* Drawings by Eugenio Ortiz. November 10, 2002.

- Probe End Details
  - Diameter ~ 1 mm
  - Length ~ 6 mm
  - Enclosed in Alumina tubes
  - 14 AWG kapton covered magnet wire
  - Copper butt-end connectors
- Sealed with Respond 904 ceramic adhesive from Cotronics
- Filament diameter can vary in size ~ .5 mm to 1.5 mm

Probe Specifications & Parameters

Expected Edge Plasma Parameters

Electron Temperature	10	eV
Electron Density	10^{17}	m^-3
Ion Saturation Current	-4.7	mAmps
Ion Acoustic Velocity (He +2)	15.5	km/s
Debye Length	7.4 $\times 10^{-5}$	m
Edge Plasma Pressure	0.5	Pascal



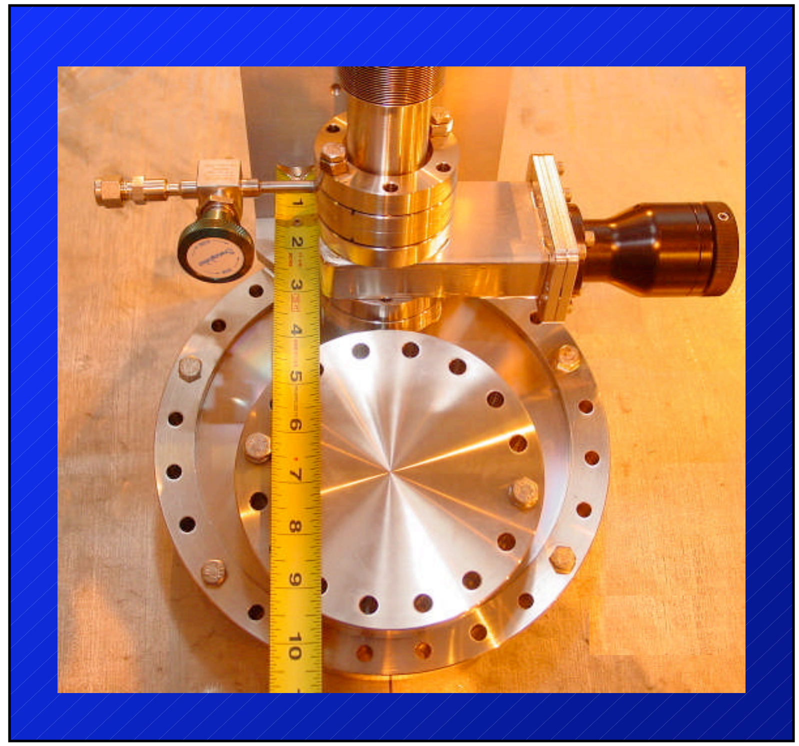
* Chart based on model derived by M. Y. Ye and S. Takamura. August 2000.

Emissive Probe Analysis Technique

- Heated Langmuir Probe
  - More accurate plasma potential measurement
  - Reduces contamination of electrode surface
- Two ways to determine V_p
  - Floating potential = V_p of strongly emitting probe
    - Can lead to plasma perturbations
  - Inflection Point method in limit of zero emission
- Differential Emissive Probe
  - Two identical probes
    - One heated no emission, another made hotter for emission
    - Operates at higher collecting currents
  - I-V characteristics resemble a step function
    - V_p to accuracy of T_{wire}/e

Other Probes

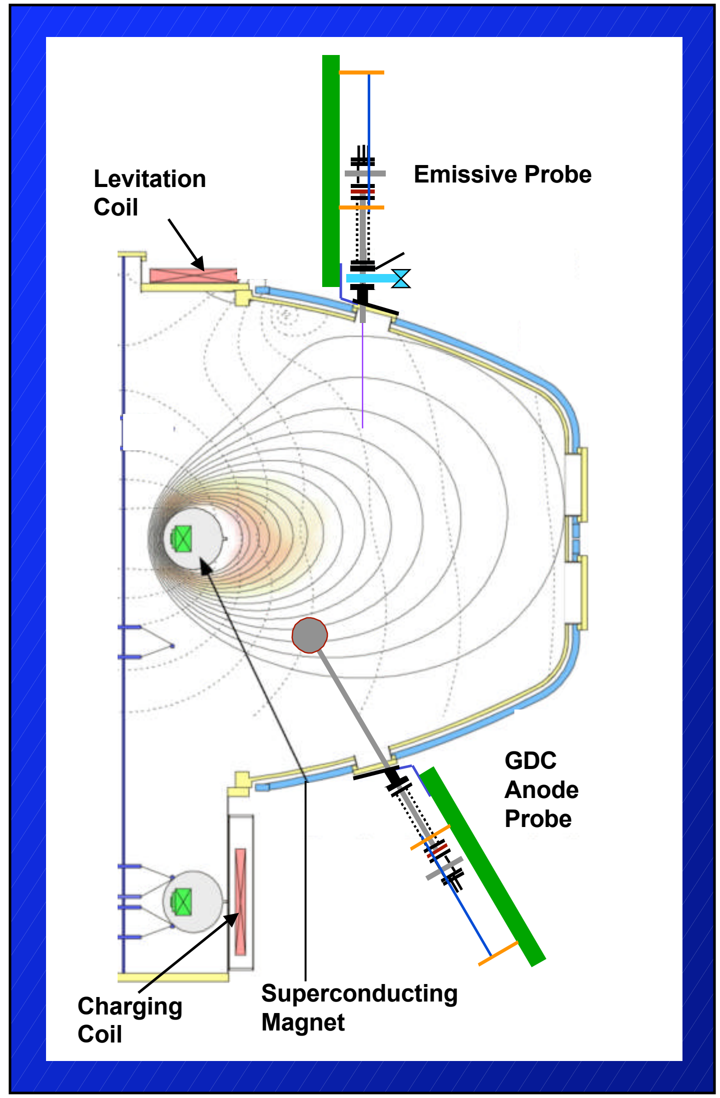
- Triple probe
  - Obtain instantaneously T_e and n_e
  - No Voltage and Frequency sweeping required
- Mach Probe
  - Measure plasma flow velocity
  - Use multiple probes to track convective cells in 2-D
- Rotatable lower interface flange allows for 48 distinct probing angles



* Image taken by Eugenio Ortiz. November 10, 2002.

Glow Discharge

- GD created by movable anode via flange portal
- Used before first thermal plasma in LDX
  - Eliminate impurities in vacuum vessel and probes
  - Initially no magnetic field
  - Anode biased up to 800 Volts and 12 kW DC
- Implemented with Deutrium gas followed by short helium periods
- Plasma created for calibration of electric probes



* Drawing by Eugenio Ortiz. November 10, 2002.

Summary & Future Work

- Three probe interface systems have been assembled
- One houses an emissive Langmuir probe, another the GDC system and the third will have a triple probe
- We will explore the nature of convective cells in dipole devices using emissive probes
  - Attempt to control and/or suppress their existence
  - Create new ones
- We will have the ability to determine instantaneously the outer plasma electron temperature and densities via a triple probe
- We would like to construct more probe interface systems to add Mach probes to track convective cell dynamics