The 2005 Workshop on Nonlocal, Collisionless Electron Transport in Plasmas

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PPPL
PRINCETON PLASMA PHYSICS LABORATORY

Organizational Comments (1/3)

- **Open Public meeting. Visitors should stay in the open areas of the Laboratory (MBG Auditorium, Spitzer Lobby, Cafeteria).**
- **US citizens and foreigners who completed the UFNV&A form can be escorted elsewhere during the meeting.**
- **Visitors from sensitive countries (Israel, Russia, Ukraine) have to be escorted by US citizens.**

PPPL Cafeteria

- **Hours of Operation**
  - **Breakfast 7:00 - 10:00 AM**
  - **Continental Breakfast 10:00 -11:30 AM**
  - **Lunch 11:30 AM - 1:30 PM**
  - **Snack Service until 2:30 PM**

Organizational Comments (2/3)

Meeting is sponsored by volunteers of PS&T Department.

Please contribute $10 to cover the cost of refreshments.

US Universities are sponsored by PPPL-University collaboration program, special thanks to Stewart Zweben.

Organizational Comments (3/3)

- **The main goal of the workshop is to facilitate discussion on nonlocal, collisionless phenomena in low-pressure plasmas.**
  - **ask questions during talks.**
- **Many informal discussions are planned to bridge**
  - **high- and low-temperature plasma communities,**
  - **DOE lab and Universities.**

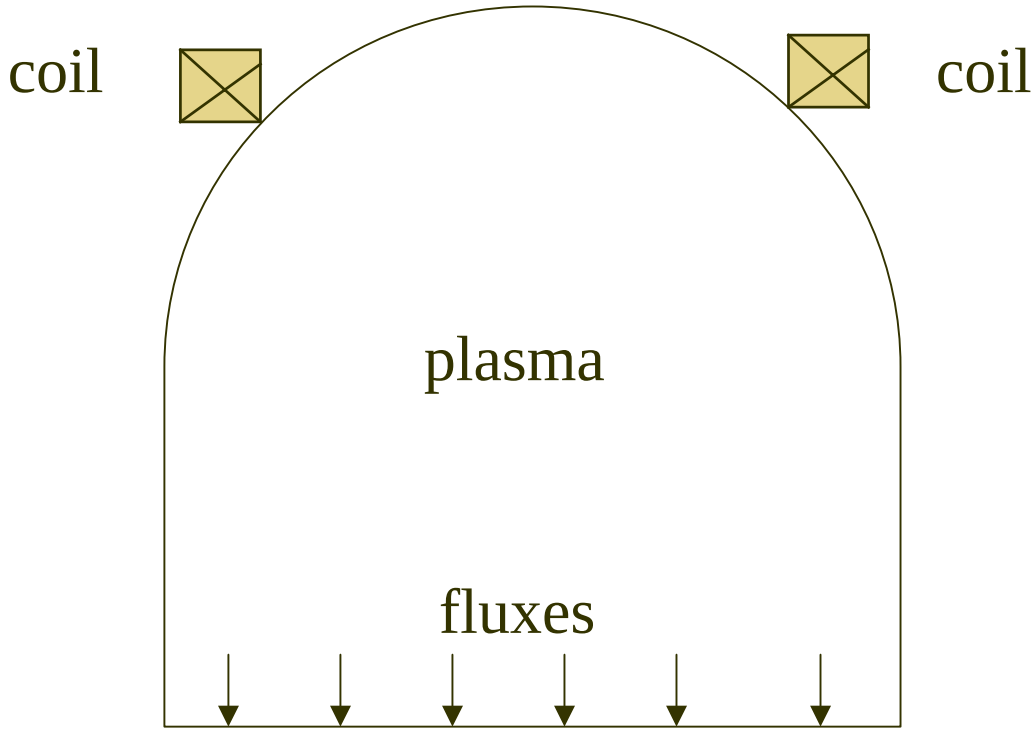
Introduction into the Workshop Topic

- **Nonlocal, Collisionless Electron Transport in Plasmas.**

- **What is nonlocal?**

What is Nonlocal?

- **Electron energy mean free path is large, this allows remote plasma handling via nonlocal electron energy distribution function.**



The treatment has to be kinetic!

- **Most remote from thermodynamic equilibrium:**
  - **T_e differs from T_i**

3eV	**$3\ 10^{-2}$ eV**	**glow discharges**
$3\ 10^{-3}$ eV	**$3\ 10^{-2}$ eV**	**afterglow**
10keV	**1eV**	**ECR ion sources**

- **Electron energy distribution functions are nonMaxwellian:**
  - **Parts of the EDF are very flexible and almost independent.**

50 Years of History

- **1954 - I. Bernstein and T. Holstein**
  - **Positive column of dc discharge**
    - **This results in higher specific ionization rate but effect is not so great….**
- **1974 - L. Tsendin**
  - **Positive column of dc discharge**
  - **Striations in dc discharge**
- **1990 - Germany, Italy, Russia, USA**
  - **RF discharges, anode and cathode regions of dc discharges**

Applications of Low-temperature Plasmas

- **Plasma processing of materials**
- **Lighting**
- **Gas discharge lasers**
- **Plasmas for electric propulsion**
- **Plasmas for pollution control and reduction**
- **Plasma isotope separation**

Diagnostic and Simulation Advances

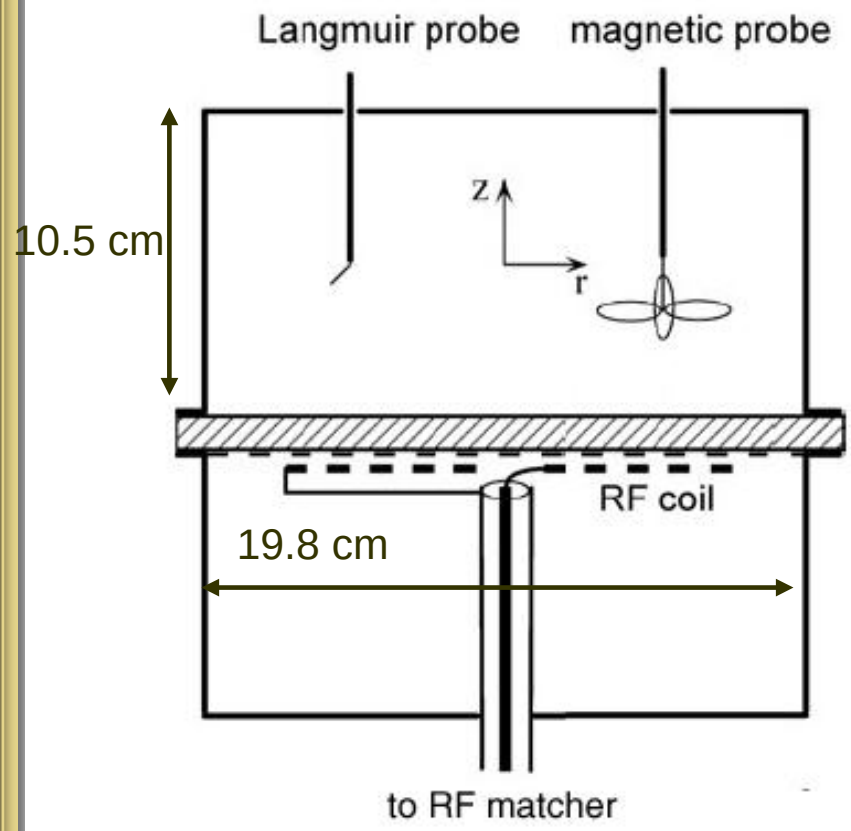


Figure 1. Experimental discharge chamber.

Measurements:

- EDF, n_e, T_e, E, B, ϕ, u_i, Γ_e, Γ_i, LIF/spectroscopy

Simulations:

- PIC
- Boltzmann

Is it challenging/ interesting/ well-understood?

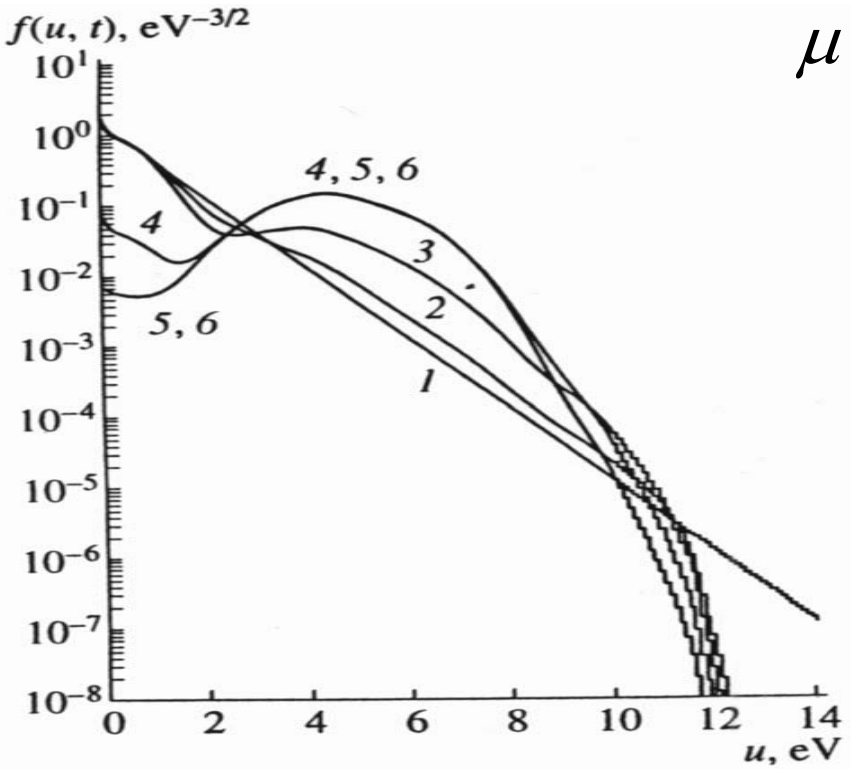
Is it challenging / interesting/ well-understood?

- **Plasma is highly**
  - **Nonlinear**
  - **Nonlocal**
  - **Collisionless**
- **Results are often unexpected and surprising**

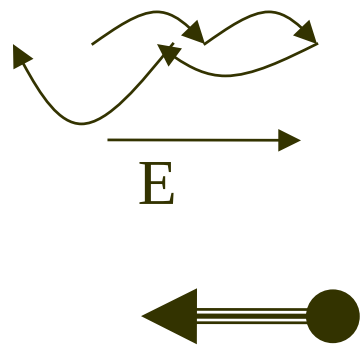
Non-monotonic EEDF yields Negative Plasma Conductivity!

EDF afterglow Ar:NF_3. E/N=2 10^{-17} Vcm^2 0, 0.25, 1, 3, 5, 10 ns.

N.A. Dyatko, *et al.,* Plasma Phys. Rep. 1998



$$\mu = -\frac{2e}{3m}\int u^{1/2}\lambda\frac{df(u)}{du}du < 0$$



Total electron flux is directed opposite to the electric field

Workshop Program Logic: informal discussion on experiments, theory, simulations:

August 2	August 3	August 4
Link to high-temperature plasmas	Diagnostics	Simulations
Magnetized low-temperature plasmas	Theory	Theory, Link to laser plasmas
Poster session	Modeling Dinner	High- pressure discharges