Langmuir probe analysis of Plasma

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So what is our thought about Plasma?

Fourth state of matter

Ionized Gas

Apply high temperature on gas
or
high electric field etc.

Did you know all ionized gases are not Plasma!?

- A plasma is a *quasineutral* gas of charged and neutral particles
- It exhibits *collective* behaviour
- Behaves classically, follows maxwell equations

Criteria to be plasma

Debye length << dimension of the plasma

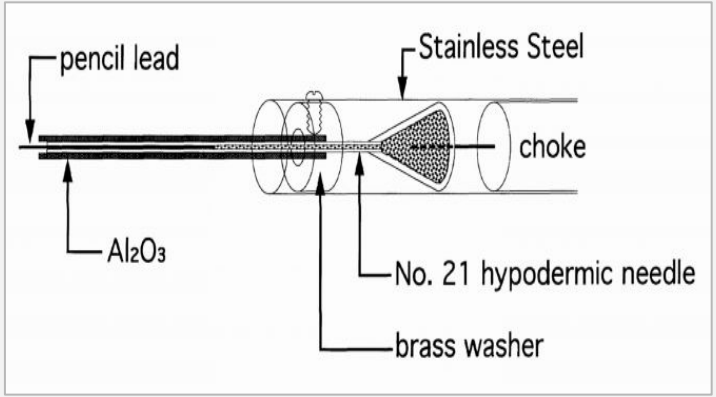
number N of particles in a Debye sphere >>>1

$\omega\tau > 1$

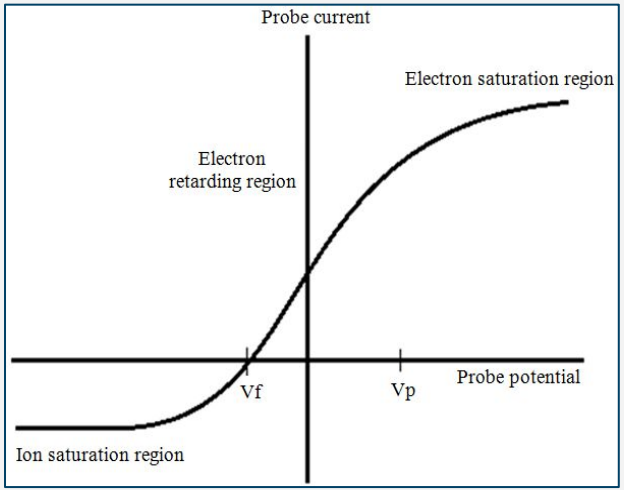
Langmuir probe

This following properties are measured

- electron temperature
- electron density
- electric potential of a plasma



Characteristics of Langmuir probe



Typical I-V curve of single langmuir probe, sometimes potential is taken as the difference between the probe and the plasma

- V_{φ} = Bias voltage (V_{β}) - Plasma voltage (V□)
- $V_{\beta} < V$□ : Ion saturation current
- $V_{\beta} > V$□ : Electron saturation current

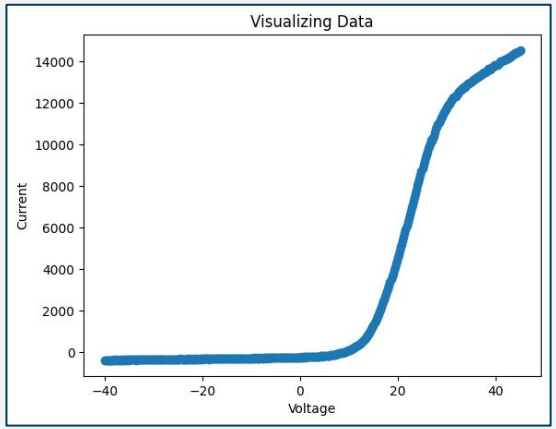
Floating potential : I = 0 [linear fit intersection/compared]

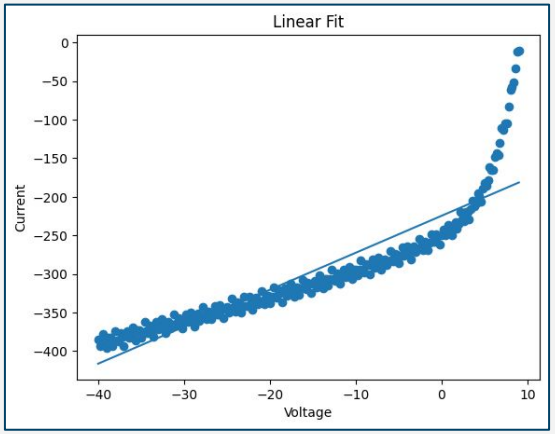
$I = I_o \exp\{-qV_{\varphi}/ K_{\beta}T\}$ [lnI vs V_{φ} - linear fit to get I_o for both electron and Ion saturation current]

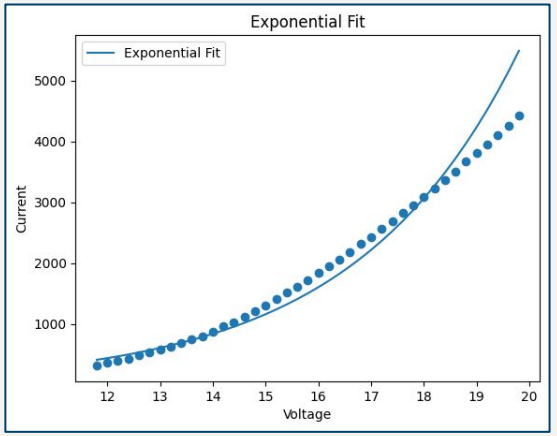
T is extracted from slope.

Plasma potential = Electron current is 0

Data Analysis





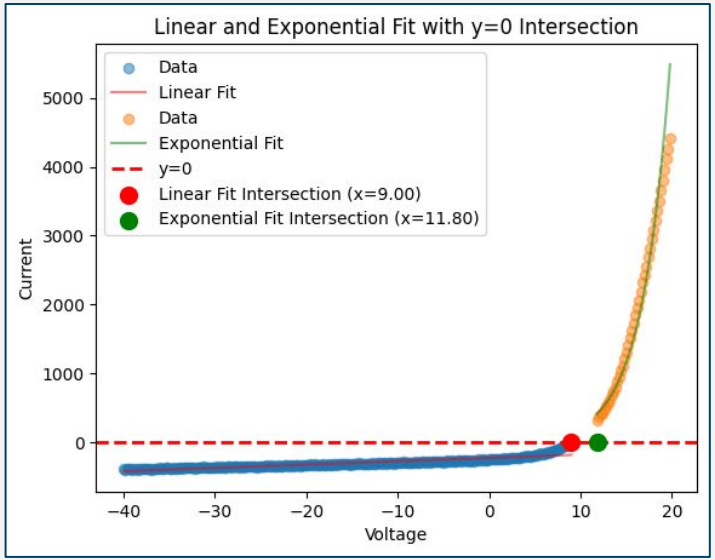


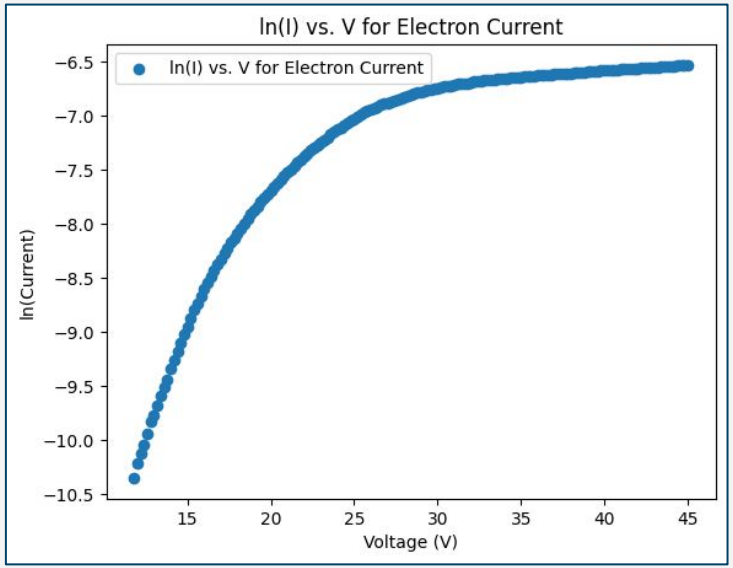
These two fit are for the region where V_φ is -ve

Linear fit slope, intercept: [4.79379916, -224.61074718] -> Temperature of electron, Ion saturation current

Electron Temperature (T) in eV: 11.54161232073355

Ion Saturation Current (Iis): -2.768795366795369e-05 A



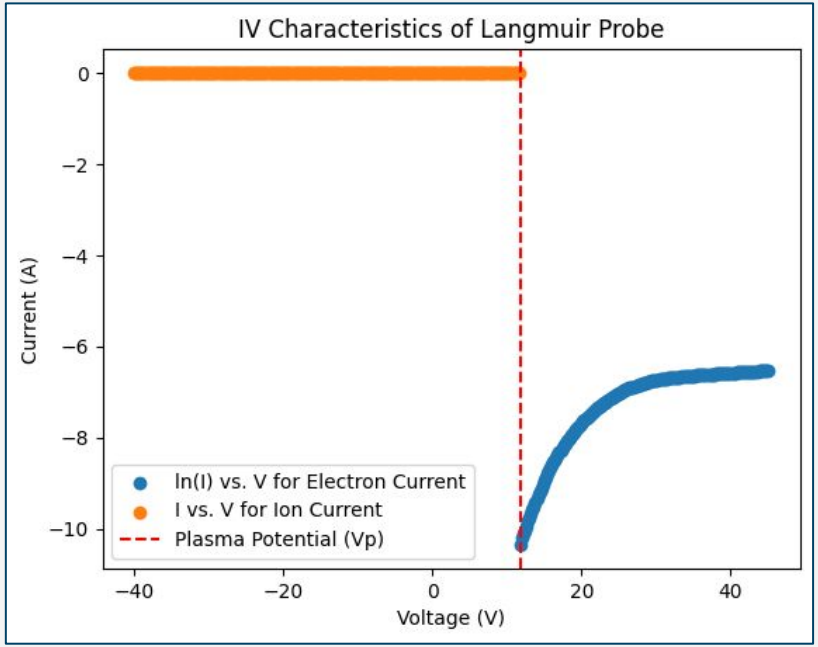


Linear Fit R2: 0.8107224623334592

Exponential Fit R2: 0.9416891696900579

Linear fit intersection = floating potential = 9 V

Electron Saturation Current: 5.770943314143221e-05 A



Plasma Potential (Vp): 11.8V

Probe Surface Area (A): 5707963267948965e-06

Plasma Density (n): 2.1052090080498222e+18

Electron Density (n_e):2.1052090080498222e+18

Results

A	B	C	D
Sheet no.	Electron Saturation Current (A)	Floating Potential (V)	Temperature of Electron (eV)
1	4.79E-06	7	12.86666641
2	4.79E-06	7	12.86724811
3	3.76E-06	6	12.34162516
4	3.66E-06	4.5	13.46663515

A	B	C	D	E	F
Sheet No.	Electron Saturation Current (A)	Floating Potential (V)	Temperature of Electron (eV)	Plasma Potential (V)	Ion Saturation Current (A)
5	5.77E-05	9	11.54161232	11.8	-2.77E-05

So What!

- Plasma physics reveals insights into cosmic phenomena like star formation and interstellar processes.
- It drives the quest for nuclear fusion as a sustainable energy source by replicating the processes of the sun.
- Plasma is integral to various high-tech applications, including semiconductor manufacturing and medical treatments.
- Research in plasma physics advances space exploration through efficient propulsion systems for spacecraft.
- It contributes to innovative solutions in environmental and material sciences, shaping modern technology and sustainable development.

Current usage other than the above

- Medical Treatments: Cold plasma technology is applied in sterilizing surgical instruments and operating rooms, treating skin diseases, promoting wound healing, and even targeting cancer cells without harming surrounding healthy tissues.

- Environmental Applications: Plasma technology is employed in the treatment of hazardous wastes and the purification of water

- Agriculture: Plasma-activated water and surfaces can enhance seed germination, plant growth etc.

- Weather Modification: Research into using plasma to influence weather patterns, such as cloud seeding to induce rain, is ongoing, though it's a more speculative application at this stage.

Future researches

- High-Power Lasers and Particle Accelerators
- Quantum Plasmas
- Magnetic Reconnection Research
- Ultrafast Plasma Dynamics
- Astrochemistry and Exoplanetary Science

Thank you!