mpre 321 lect 7

→ practicum on friday

→ at nuclear radiations lab.

↳ 2 groups, 30 mins

↳ listen to what he says for report

- arc discharge: voltage can be 10V, current > 1 A
  - ↳ fraction ionized 10^{-3} to 10^{-1} ⇒ T_e and T_i are 10^4 k
  - ↳ can happen when you plug something in to an outlet
- thermalize ⇒ $T_e \sim T_i$

  T_e ← electrons, T_i ← ions

- thermionic arc: emission of electrons due to cathode being heated up

  ↳ emission of electrons from hot surfaces:

  $$j = aT^2 \exp\left[-\frac{e\phi}{kT}\right]$$

  ↳ ϕ = work function

  $a = \lambda_R A_0$ → universal constant $(1.20173 \times 10^6\, A m^{-2} k^{-2})$

  λ_R ↓ correction factor

- thermionic arc → have to be heated → non-self sustaining
- field emission arc: emission of electrons due to very high electric field at the cathode
- metal arc: heating the cathode vaporizes metal
- high pressure arc: p > 1 atm
- low pressure arc: p < 1 atm

• process of deionization

→ dissociative recombination: $A_2^+ + e \rightarrow A^* + A$

↳ fastest recombination method

• plasma's will be able to shield out electric potentials

• poisson's equation : $-\nabla^2 \phi = \frac{\sigma}{\varepsilon_0}$

↳ consider a positive charge then potential: $\phi = \frac{q}{4\pi\varepsilon_0 r}$

↳ theory of charge sitting out in a plasma

↳ attracts electrons and repel ions

↳ probability factor: $f(v) = \exp\left[\frac{-\frac{1}{2}mv^2 + q\phi}{k_B T}\right] dv_x\, dv_y\, dv_z$

↳ particle density: $n = \int f(v)\, dv_x\, dv_y\, dv_z$

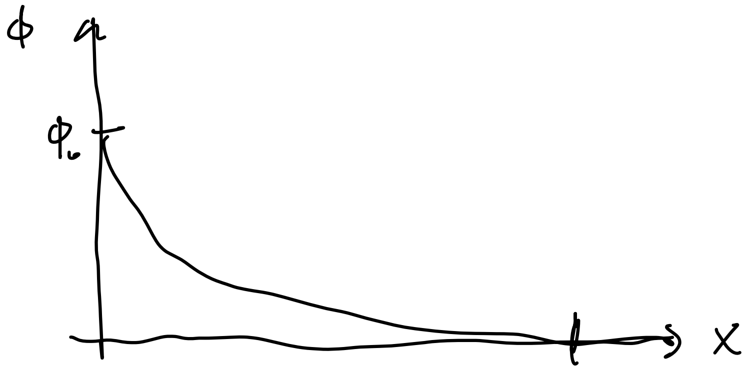
→ $n_e = n_0 \exp\left[\frac{-e\phi}{k_B T_e}\right]$; $n_i = n_0 \exp\left[\frac{-q\phi}{k_B T_i}\right]$

→ $\sigma = -\frac{2 n_0 e^2 \phi}{k_B T}$

→ $\phi = \frac{q}{4\pi\varepsilon_0 r} \exp\left[\frac{-r}{\sqrt{\frac{\varepsilon_0 k_B T}{2 n_0 e^2}}}\right]$; potential falls away exponentially

→ $\lambda_d = \sqrt{\frac{\varepsilon_0 k T}{n e^2}}$; $\phi = \frac{q}{4\pi\varepsilon_0 r} e^{-\frac{r\sqrt{2}}{\lambda_d}}$

↳ beyond about $4\lambda_d$, debye shielding is very effective, and this is called the sheath



$4\lambda_d$

→ need to be enough particles to happen

↳ Debye sphere: $N_D = n \frac{4}{3}\pi \lambda_D^3$

→ 2 requirements for plasma to occur:

- $\lambda_D \lll L$
  ↳ size of your plasma

- $N_D \ggg 1$, # of electrons in a debye sphere needs to be much greater than 1

→ 1 more:

- $n_e \approx n_i \approx n_0$; if local concentration of charge, at plasma dimension greater than λ_D

- if an electrode is put into plasma, then it will be shielded by a sheath of thickness $\approx \lambda_D$

  ↳ $\lambda_D = 69.0\sqrt{\frac{T}{n_e}}$; T in kelvin, n_e in m^{-3}

- plasma frequency: natural plasma will oscillate
  ↳ displacing electrons, electrostatic forces will pull them back in; however it will overshoot and create oscillations of plasma;

$$m = m_e n_e A L$$

- charge density: $\sigma = \frac{e \cdot n_e \cdot x \cdot A}{A}$

- plasma frequency: $\omega_{pe} = \sqrt{\frac{n_e e^2}{\varepsilon_0 m_e}}$

$$\omega_{pi} = \sqrt{\frac{n_i q^2}{\varepsilon_0 M_i}}$$

↳ rewrite this frequency to be: $f_{pe} = 8978\sqrt{n_e}$

- another requirement to be plasma.

$$\underbrace{\omega_{pe}}_{\text{plasma frequency}} \tau > 1$$

$\tau \rightarrow$ mean time it takes for a collision of a neutral atom to happen

- $\omega_{pe}\lambda_d = \sqrt{\frac{k_B T}{m}}$ } velocity that the electrons move in the bulk plasma