UFSC

Federal University of Santa Catarina
Graduate Program in Engineering and Mechanical Sciences

Plasmas and electrical discharges in gases

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Diego Alexandre Duarte
Laboratory of Surface Treatments

SUMMARY
Plasmas and electrical discharge in gases

- Kinetic theory of gases
- Atomic structure
- Ionization
- Deionization
- Electron emission
- Behavior of charged particles in a gas in electric fields of low E/p
- Behavior of charged particles in a gas in electric fields of high E/p
- Glow discharges
- Plasmas

ELECTRON EMISSION
Photoelectric emission

- In 1887, the photoelectric effect was discovered by Heinrich Hertz while he was experimenting with electromagnetic waves.
- In 1905, Einstein formulated his explanation if this effect and showed that a threshold frequency exists below which no emission can take place.
- Energy conservation:

$$h\nu = \frac{1}{2}mv^2 + W$$

where W is the work done to separate one electron by an incident photon of energy $h\nu$. Setting $W_{\mathrm{min}} = e\phi$ as the **material work function** we get:

$$h\nu = \frac{1}{2}mv_{max}^2 + e\phi$$

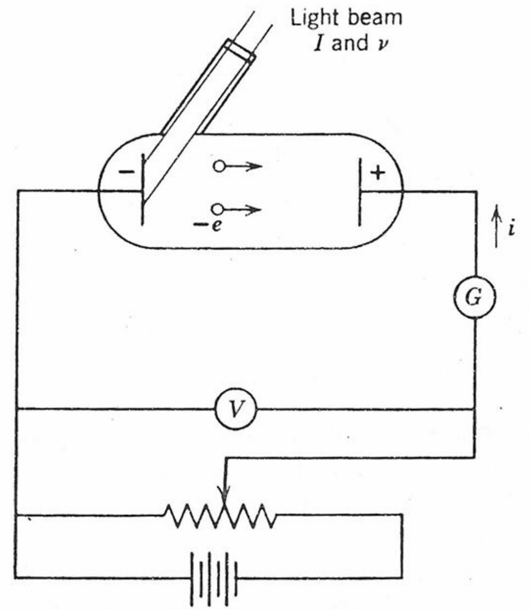
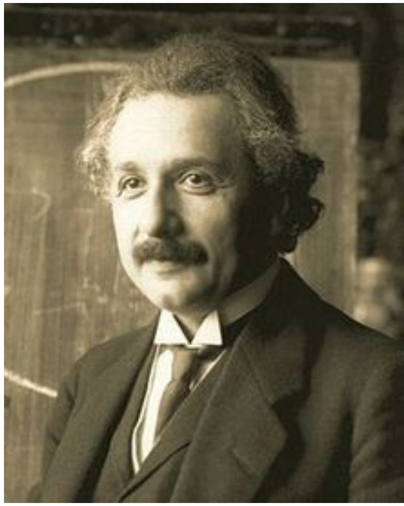


Fig. 5.2 Schematic diagram of an experimental arrangement for the study of photo-emission

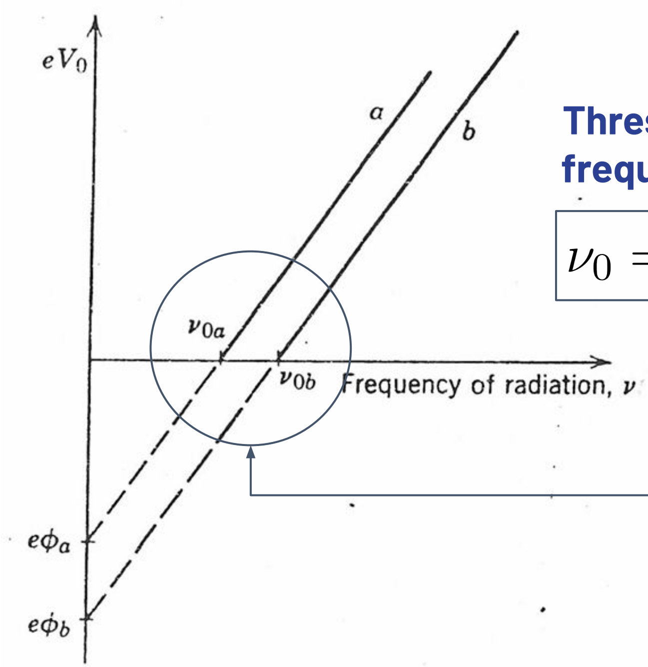

https://pt.wikipedia.org/wiki/Heinrich_He


https://pt.wikipedia.org/wiki/Albert_Einstein

ELECTRON EMISSION
Photoelectric emission

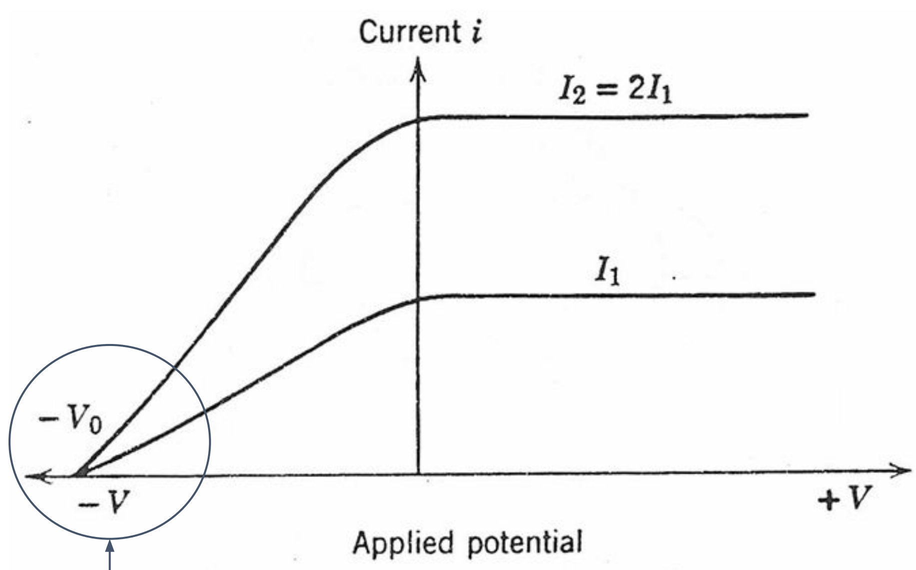
- If the acceleration potential is set up so that the photocurrent i just ceases to flow, this stopping voltage V_0 equals the maximum kinetic energy an electron can possess at emission:

$$h\nu = \tfrac{1}{2}mv_{max}^2 + e\phi \quad \text{where} \quad \tfrac{1}{2}mv_{max}^2 = eV_0 \quad \therefore \quad \boxed{V_0 = \tfrac{1}{e}(h\nu - e\phi)}$$



Threshold frequency

$$\boxed{\nu_0 = \frac{e\phi}{h}}$$



E. Nasser, Fundamentals of Gaseous Ionization and Plasma Electronics, New York: Wiley, 1971.

ELECTRON EMISSION
Photoelectric emission

- The increase of the light frequency increases the number of emitted photoelectrons.

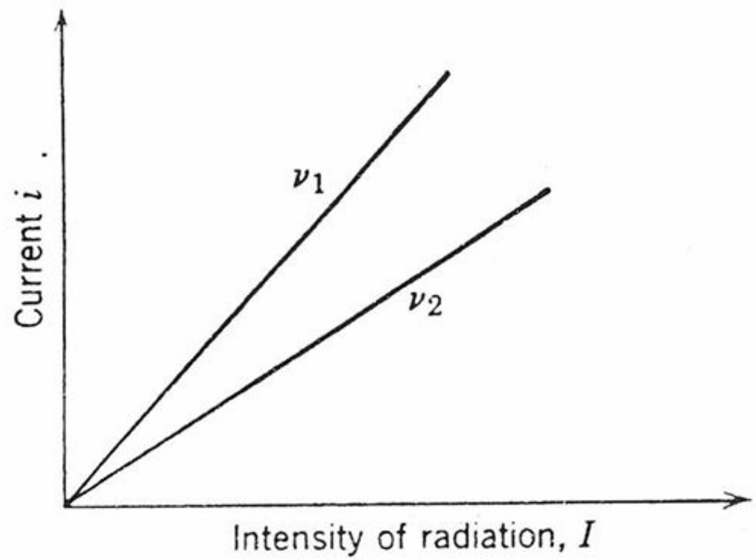


Fig. 5.4 The current i as a function of the intensity of the monochromatic radiation I for two frequencies ν_1 and ν_2, where $\nu_1 > \nu_2$.

Table 5.1 Work Functions ($e\phi$) of Some Elements in eV as Measured Photoelectrically and Thermionically [3]

Element	Photoelectric Work Function, eV	Thermionic Work Function, eV
Ag	4.74	3.08–3.56
Al	2.98–4.43	
Au	3.9–4.92	4.0–4.58
Ba	1.9–2.49	2.11
C	4.81	4.39
Ca	2.42–3.21	2.24
Cs	1.38–1.9	1.81
Cu	4.07–4.8	3.85–4.38
Fe	3.91–4.7	4.04–4.77
Li	2.28–2.42	
Mg	2.15–3.75	
Ni	4.06–5.2	4.61–5.24
Rb	2.9–2.16	
Ta	4.05–4.16	4.07–4.19
U	3.63	3.27
W	4.35–4.6	4.52

ELECTRON EMISSION
Thermionic emission

- The thermionic emission is described by Richardson equation:

$$j = AT^2 \exp\left(-\frac{e\phi}{\kappa T}\right) \text{ where } A = 1.2 \times 10^6 \text{ A/m}^2\text{K}^2$$

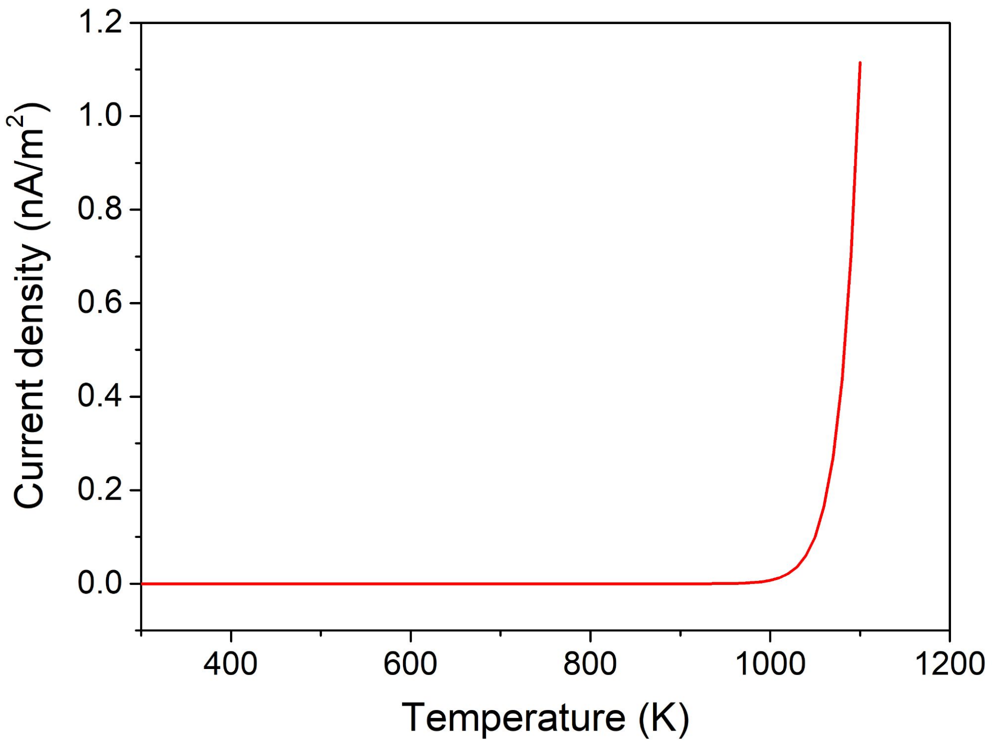
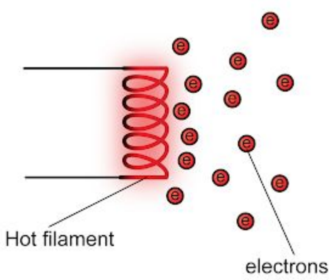


Table 5.2 Emperical Constants of Thermionic Emission

Metal	Cr	Fe	Mo	Ni	Pt	Ta	V
$e\phi$ eV	4.6	4.48	4.20	4.61	5.32	4.19	4.
A 10^6A/m^2-deg^2	0.48	0.26	0.55	0.30	0.32	0.55	0.



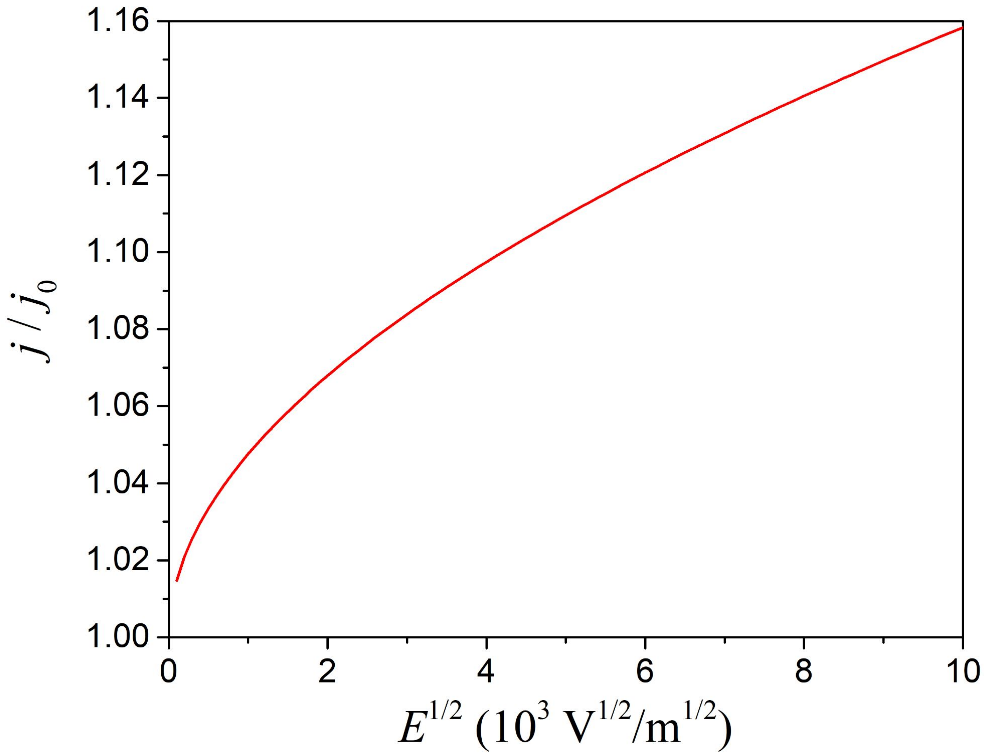
https://spmphysics.blog.onlinetuition.com.my/electronic/thermionic-emission/

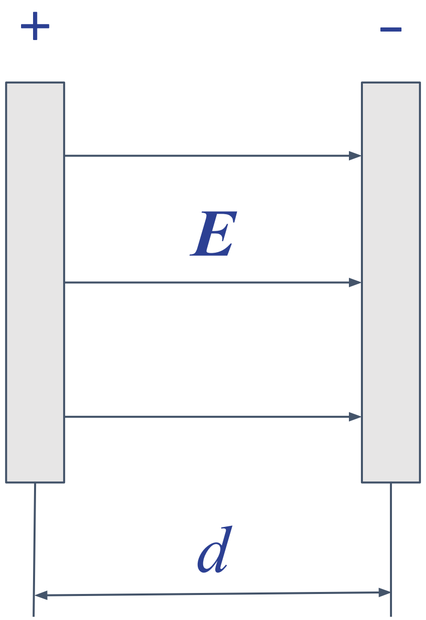
E. Nasser, Fundamentals of Gaseous Ionization and Plasma Electronics, New York: Wiley, 1971.

ELECTRON EMISSION
Field emission

- The current density produced by field emission is given by:

$$j = j_0 \exp\left(\frac{B\sqrt{E}}{T}\right) \text{ where } B = 0.441\ \mathrm{K}\cdot\mathrm{m}^{1/2}\mathrm{V}^{-1/2}$$





ELECTRON EMISSION
Reading

- Chapter 5 - E. Nasser, Fundamentals of Gaseous Ionization and Plasma Electronics (pages 140-154).

See you next topic!

Diego A. Duarte
diego.duarte@ufsc.br
https://lats.ufsc.br