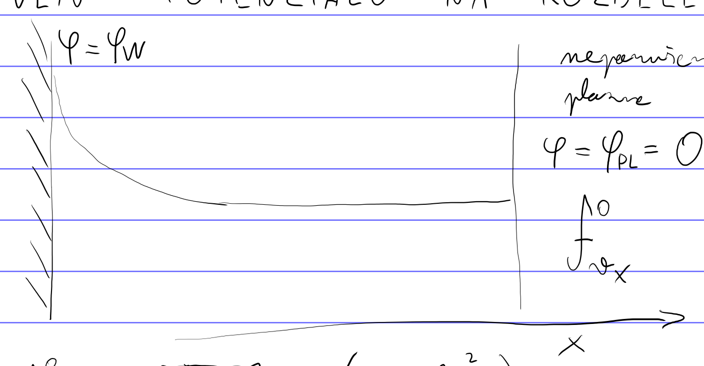
NEVF169 18.5.2021

INTERAKCE PLAZMATU SE STĚNOU

- VLIV POTENCIÁLU NA ROZDĚLENÍ ČÁSTIC



$$f^0_{v_x} dv_x = n\sqrt{\frac{m}{2\pi KT}}\exp\left(-\frac{m v_x^2}{2KT}\right)dv_x$$

tok z neporušeného plazmatu

$$\Gamma_{v_x} dv_x = f_{v_x} \cdot v_x \cdot dv_x$$

rovnice kontinuity

$$\Gamma_{v_x} dv_x = \Gamma_{v_x^0} dv_x^0$$

$$f_{v_x} v_x dv_x = f^0_{v_x} v_x^0 dv_x^0$$

transformace $v_x \leftrightarrow v_x^0$ - zachování E

$$\frac{1}{2} m v_x^2 + q\varphi = \frac{1}{2} m v_x^{0\,2}$$

$$\frac{1}{2} \cancel{m}\, 2 v_x dv_x + q\, d\varphi = \frac{1}{2}\cancel{m}\, 2 v_x^0 dv_x^0$$

$$\varphi = \varphi(x)$$
$$dx = 0$$
$$d\varphi = 0$$

$$v_x dv_x = v_x^0 dv_x^0$$

RK

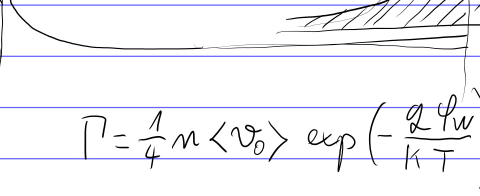
$$f_{v_x}(v_x) = f^0_{v_x}(v_x^0) =$$

$$= n\sqrt{\frac{m}{2\pi KT}}\exp\left(-\frac{m v_x^{0\,2}}{2KT}\right) =$$

$$= \underbrace{n\sqrt{\frac{m}{2\pi KT}}\exp\left(-\frac{m v_x^2}{2KT}\right)}_{\text{Maxwell, T}} \cdot \underbrace{\exp\left(-\frac{q\varphi}{KT}\right)}_{\text{Boltzmann}}$$

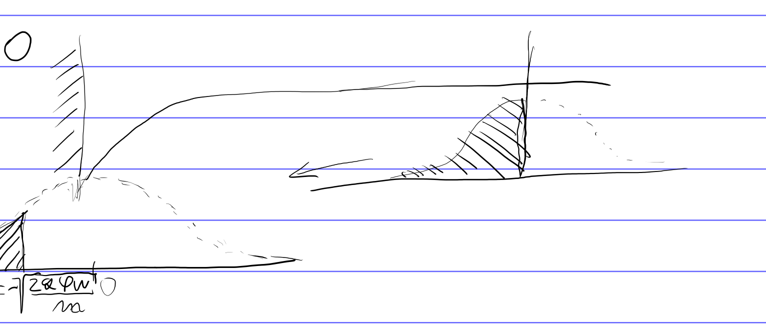
- rovnice $\frac{1}{2} m v_x^2 + q\varphi = \frac{1}{2} m v_x^{0\,2}$
  - nemá vždy řešení

1) $q\varphi = 0$



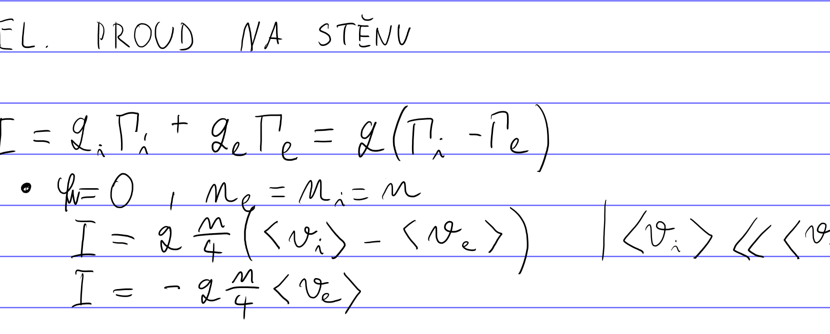
$$\Gamma = \frac{1}{4} n \langle v \rangle$$

2) $q\varphi > 0$



$$\Gamma = \frac{1}{4} n \langle v_0 \rangle \exp\left(-\frac{q\varphi_W}{KT}\right)$$

3) $q\varphi < 0$

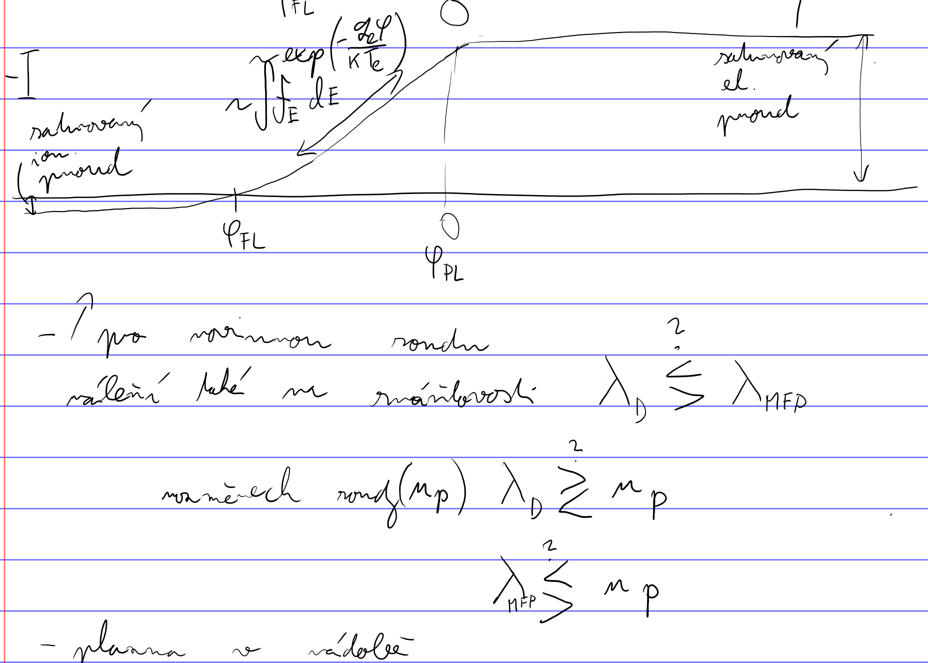


EL. PROUD NA STĚNU

$$I = q_i\Gamma_i + q_e\Gamma_e = q(\Gamma_i - \Gamma_e)$$

- $\varphi_W = 0$, $n_e = n_i = n$
  $$I = q\frac{n}{4}\left(\langle v_i \rangle - \langle v_e \rangle\right) \quad \Big|\ \langle v_i \rangle \ll \langle v_e \rangle$$
  $$I = -q\frac{n}{4}\langle v_e \rangle$$

- "PLOVOUCÍ" stěna
  - ustanoví se plovoucí potenciál, $I = 0$
    ~ několik KT_e

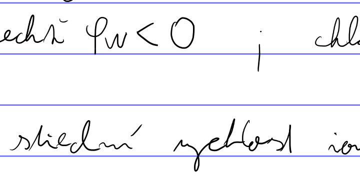


- pro vnitřní sondu
  záleží také na vzdálenosti $\lambda_D \overset{?}{\lessgtr} \lambda_{MFP}$

  rozměrech sond (r_p) $\lambda_D \overset{?}{\gtrless} r_p$

  $\lambda_{MFP} \overset{?}{\lessgtr} r_p$

- plazma v nádobě

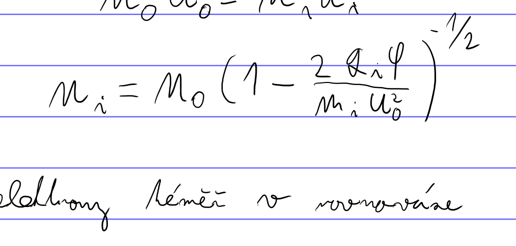


STĚNOVÁ (STÍNÍCÍ) VRSTVA

- průběh potenciálu
- plazma mimo rovnováhu
- nechť $\varphi_W < 0$; chladné ionty: $T_i \ll T_e$
  $KT_i \ll |q\varphi_W|$

- střední rychlost iontů

$$\frac{1}{2} m_i u^2 + q_i\varphi = \frac{1}{2} m_i u_0^2$$



$$u = \sqrt{u_0^2 - \frac{2q_i\varphi}{m_i}}$$

- kontinuita pro ionty
$$n_0 u_0 = n_i u_i$$
$$n_i = n_0\left(1 - \frac{2q_i\varphi}{m_i u_0^2}\right)^{-1/2}$$

- elektrony téměř v rovnováze

$$n_e = n_0 \exp\left(-\frac{q_e\varphi}{KT_e}\right)$$

- Poissonova rce

$$\frac{d^2\varphi}{dx^2} = \frac{q}{\varepsilon_0}(n_e - n_i) =$$

$$= \frac{q n_0}{\varepsilon_0}\left(\exp\left(\frac{q\varphi}{KT_e}\right) - \left(1 - \frac{2q\varphi}{m_i u_0^2}\right)^{-1/2}\right)$$

→ bezrozměrné proměnné

$$\chi = -\frac{q\varphi}{KT_e} \qquad \xi = \frac{x}{\lambda_D} = x\sqrt{\frac{n_0 q^2}{\varepsilon_0 KT_e}} \qquad M = \frac{u_0}{\sqrt{KT_e/m_i}}$$

- $$\frac{d^2\varphi(\xi)}{dx} = \frac{d}{dx}\left(\frac{d\varphi}{d\xi}\frac{d\xi}{dx}\right) = \frac{d^2\varphi}{d\xi^2}\frac{1}{\lambda_D^2} \quad \Big|\ \varphi = -\frac{KT_e}{q}\chi \Big|$$
$$= \left(-\frac{KT_e}{q}\right)\frac{1}{\lambda_D^2}\frac{d^2\chi}{d\xi^2}$$

- $$\frac{2q\varphi}{m_i u_0^2} = -\frac{2\cancel{KT_e}\chi\cancel{q}}{\cancel{q}\cancel{m_i} M^2 (\cancel{KT_e/m_i})} = -\frac{2\chi}{M^2}$$

$$-\frac{\cancel{KT_e}}{\cancel{q}}\frac{n_0 \cancel{q^2}}{\cancel{\varepsilon_0} \cancel{KT_e}}\frac{d^2\chi}{d\xi^2} = \frac{q \cancel{n_0}}{\cancel{\varepsilon_0}}\left(\exp(-\chi) - \left(1 + \frac{2\chi}{M^2}\right)^{-1/2}\right)$$

$$\frac{d^2\chi}{d\xi} = \left(1 + \frac{2\chi}{M}\right)^{-1/2} - \exp(-\chi)$$