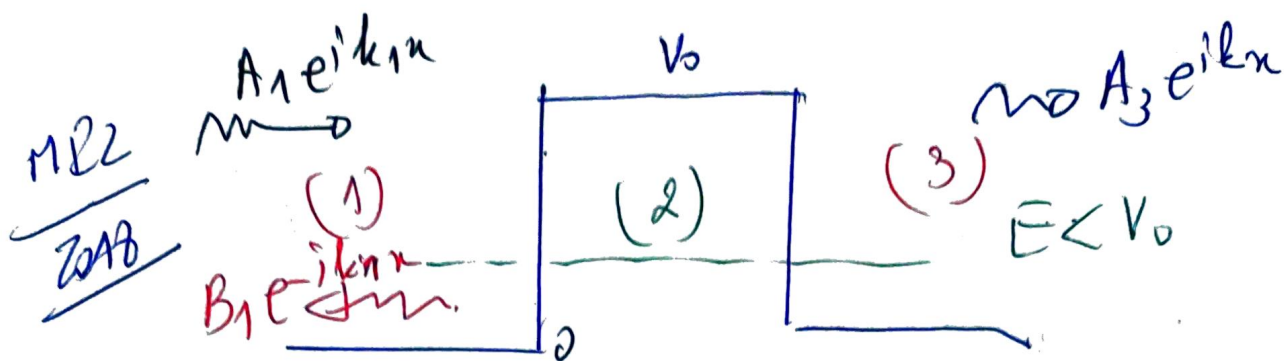




classique $E = \frac{1}{2} m v_2^2 + V_0, \quad v_2^2 < 0$

(1) et (3): $V(x) = 0$

(2): $V(x) = V_0; \quad k_2^2 = q^2 = -\frac{2m(V_0 - E)}{\hbar^2}$

$\frac{2mE}{\hbar^2} = k_1^2 = k_3^2 = k^2$

$\phi_1''(x) + k_1^2 \phi_1(x) = 0$

$\phi_2''(x) - q^2 \phi_2(x) = 0$

$\phi_3''(x) + k_3^2 \phi_3(x) = 0$

$\phi_1(x) = A_1 e^{ik_1 x} + B_1 e^{-ik_1 x}$

$\phi_2(x) = A_2 e^{qx} + B_2 e^{-qx}$

$\phi_3(x) = A_3 e^{ik_3 x} + B_3 e^{-ik_3 x}$

$B_3 = 0$, ~~barrière à l'is.~~

$$2) \psi_2(0^-) = \psi_2(0^+)$$

$$\psi_2'(0^-) = \psi_2'(0^+)$$

$$\psi_2(a^-) = \psi_3(a^+)$$

$$\psi_2'(a^-) = \psi_3'(a^+)$$

$$\int_{-\infty}^{+\infty} |\psi|^2 dx = 1$$

$$a) T = \frac{\|\vec{J}_t\|}{\|\vec{J}_i\|} = \frac{|A_3|^2}{|A_1|^2} \frac{v_{g3}}{v_{g1}} = \left| \frac{A_3}{A_1} \right|^2$$

$$\frac{1}{T} = \left| \cosh(ag) + \frac{i}{2} \left(\frac{q}{k} - \frac{k}{q} \right) \sinh(ag) \right|^2$$

$$= 1 + \sinh^2(ag) + \frac{1}{4} \left(\frac{q}{k} - \frac{k}{q} \right)^2 \sinh^2(ag)$$

$$= 1 + \frac{1}{4} \left(4 + \frac{q^2}{k^2} + \frac{k^2}{q^2} - 2 \right) \sinh^2(ag)$$

$$\Rightarrow T = \frac{1}{1 + \frac{1}{4} \left(\frac{q}{k} + \frac{k}{q} \right)^2 \sinh^2(ag)}$$

$$\left(\frac{q}{k} + \frac{k}{q}\right)^2 \leftarrow \frac{V_0^2}{(V_0 - E) E}$$

$$T = \frac{1}{1 + \frac{1}{4} \frac{V_0^2}{E(V_0 - E)} \sinh^2(ag)}$$

$$b) T(x) = \frac{1}{1 + \frac{1}{4} \frac{1}{x(1-x)} \frac{\sinh^2 \left(\frac{a \sqrt{2mV_0}}{\hbar} \sqrt{1-x} \right)}{\left(\frac{E}{\hbar} \right) \sqrt{1-x}}}$$

$$x \rightarrow 0 \quad T = 0$$

$$x \rightarrow 1 \quad T = \frac{1}{1 + \frac{1}{4} \frac{1}{x(1-x)} \frac{a^2 2mV_0}{\hbar^2} (1-x)}$$

$E \rightarrow V_0$

$$T \simeq \frac{1}{1 + \frac{1}{4x} \frac{a^2 2mV_0}{\hbar^2}}$$

$a \rightarrow$
 $V_0 \rightarrow$
 $m \rightarrow$

$(qa) \rightarrow$

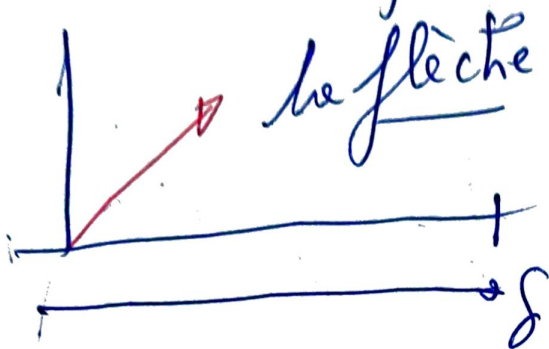
$T(x) \searrow$

$T(x) \searrow$

$$c) a \ll \frac{1}{q}, \quad (aq) \ll 1$$

$$\frac{1}{q} = \delta \quad \psi_2 = A_2 e^{q x} = A_2 e^{x/\delta}$$

↓ la portée de l'onde



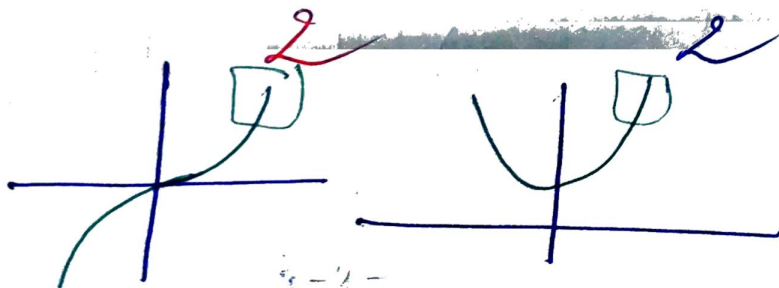
$$\underline{\text{Sh}(aq) \approx aq}$$

$$(aq) \gg 1; \quad a \gg \frac{1}{q} = \delta$$

$$T \approx \frac{1}{1 + \frac{1}{4} \frac{V_0^2}{(V_0 - E)E} \left(\frac{1}{2} e^{aq} \right)^2}$$

$$\lim_{\alpha \gg 1} \text{Sh } \alpha = \frac{e^{\alpha} - e^{-\alpha}}{2} \approx \frac{e^{\alpha}}{2}$$

$$\alpha \gg 1$$



$$T \approx \frac{16 E (V_0 - E)}{V_0^2} \exp(-2aq)$$

$$d) (aq) \gg 1, \lambda \gg a$$

$$k = \frac{2\pi}{\lambda} \ll \frac{1}{a} \ll q$$

$$\left(\frac{q}{k} + \frac{k}{q} \right)^2 \approx \frac{q^2}{k^2}; \quad T \approx \frac{16 k^2}{q^2} (e^{-2aq})$$

facteur d'atténuation

$$e) \underline{AN} \text{ me} \rightarrow T = 80\%$$

$$m_p = 1840 \text{ me} \rightarrow T = 10^{-13} \rightarrow 0,$$

$$f) T = T_0 \exp\left(-\frac{a}{\delta}\right)$$

$$\delta = \frac{1}{2\eta}; \quad (\Delta t) \cdot \Delta E \sim \frac{\hbar}{2}$$

$$\tau \approx \frac{\hbar}{2\Delta E} \quad \text{durée de vie.}$$

$$\delta = v \cdot \tau$$

$$\Delta E \rightarrow E = \frac{1}{2} m v^2 + V_0$$

$$\frac{1}{2} m v^2 = E + (\Delta E) - V_0$$

$$v = \sqrt{\frac{2}{m} (E + (\Delta E) - V_0)}$$

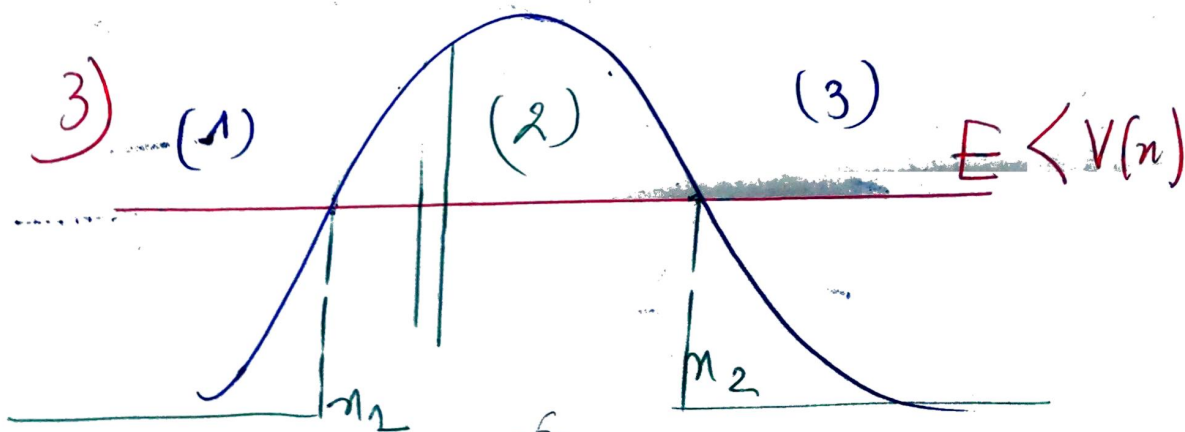
↪ fluckinh

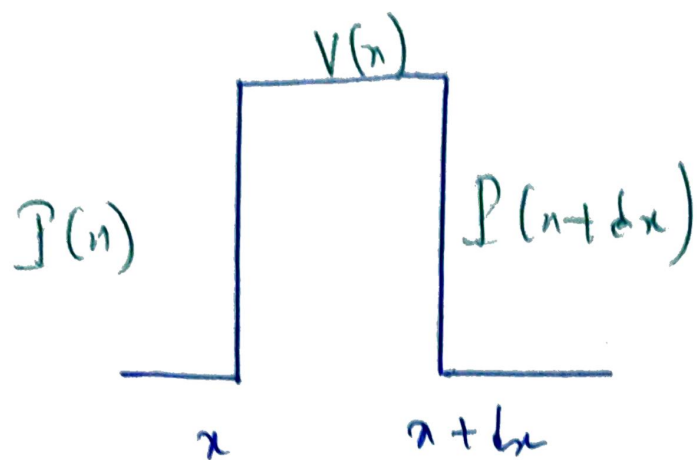
$$\delta = \sqrt{\frac{2}{m} (E + \Delta E - V_0)} \cdot \frac{\frac{h}{h}}{2 \Delta E}$$

$$\delta \delta r_{max} \quad \frac{d\delta}{d\Delta E} \rightarrow$$

$$\Delta E = - \frac{h}{2} (V_0 - E)$$

$$\delta = \frac{h}{2 \sqrt{2m(V_0 - E)}}$$





$$q(x) = \frac{\sqrt{2m(V(x) - E)}}{\hbar}$$

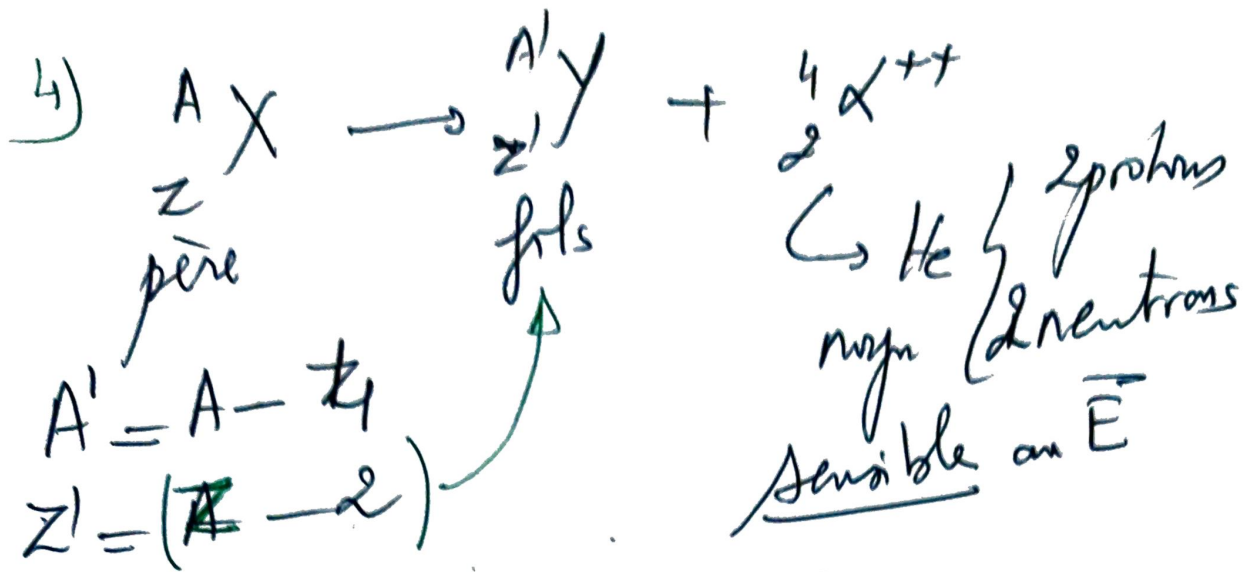
$$I(x+dx) = I(x) \exp(-2q(x) dx)$$

$$I(x+dx) \approx I(x) (1 - 2q(x) dx)$$

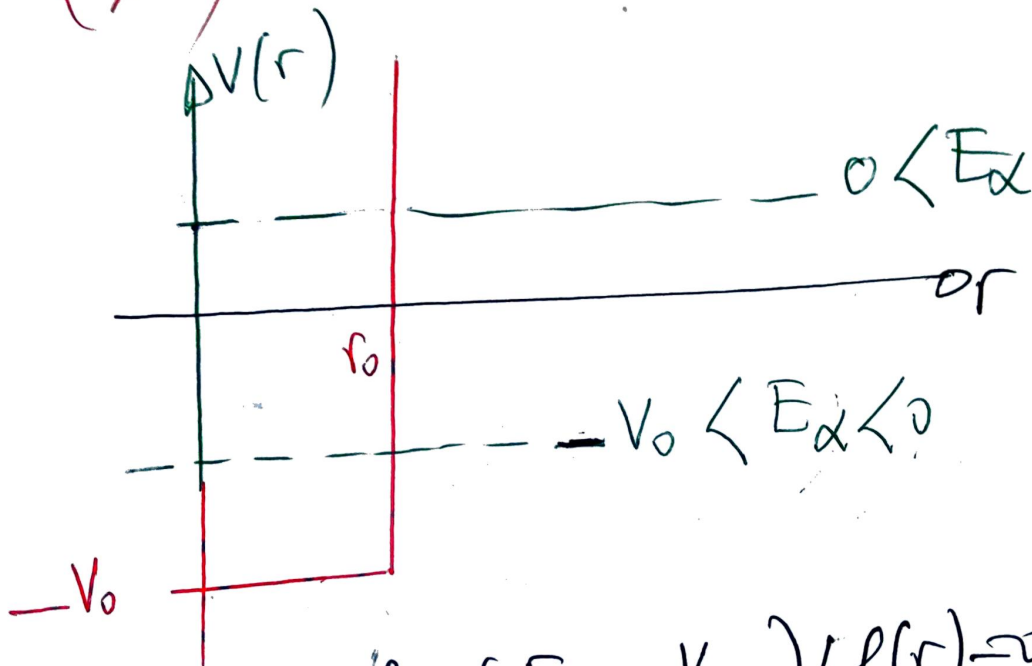
$$\frac{I(x+dx) - I(x)}{I(x)} = -2q(x) dx$$

$$\int_{x_1}^{x_2} \frac{dI(x)}{I(x)} = -2 \int_{x_1}^{x_2} q(x) dx$$

$$\ln \frac{I(x_2)}{I(x_1)} = \ln T = -2 \int_{x_1}^{x_2} \frac{\sqrt{2m}}{\hbar} \sqrt{V(x) - E} dx$$



$$g(\cancel{m_x} c^2) > m_y c^2 + m_{\alpha} c^2$$



$$\psi''(r) + \underbrace{\frac{2m}{\hbar^2} (E + V_0)}_{k^2} \psi(r) = 0$$

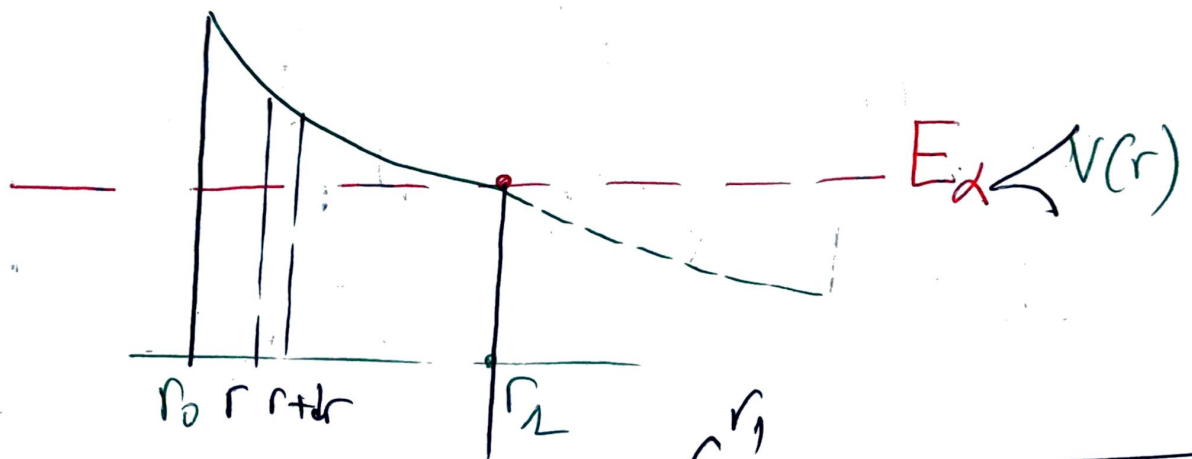
$$\psi(r) = C \sin(kr + \gamma)$$

soit $q_\alpha = +2e$ charge ${}^4\text{He}$

$$q_2 = (Z-2)e : \text{'' } {}^{\text{N}}\text{Y}$$

$$V(r) \text{ \u00e9nergie potentielle} = \frac{q_2 q_\alpha}{4\pi\epsilon r}$$

$$V(r) = \frac{2e(Z-2)}{4\pi\epsilon r} = \frac{K}{r}$$



$$d) \quad \text{Ln T} = -\frac{2}{K} \sqrt{2m} \left(\int_{r_0}^{r_1} \sqrt{\frac{K}{r} - E} \, dr \right)$$

$$= -\frac{2}{K} \sqrt{2mE} \int_{r_0}^{r_1} \sqrt{\frac{K}{rE} - 1} \, dr$$

$$\text{or } E = \frac{K}{r_1}$$

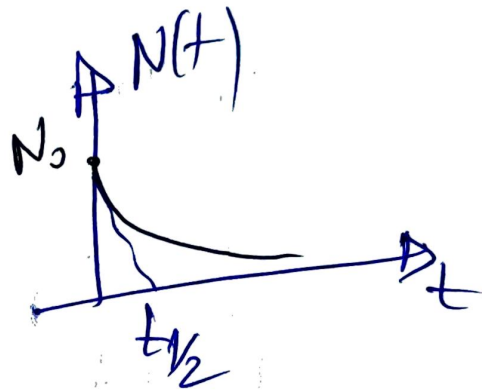
$$\ln T = -\frac{2}{\hbar} \sqrt{2mE} \left(\int_{r_0}^{r_1} \sqrt{\frac{r_1}{r} - 1} dr \right)$$

$$= -\frac{2}{\hbar} \sqrt{2mE} r_1 \left(\frac{1}{2} - 2\sqrt{\frac{r_0}{r_1}} \right)$$

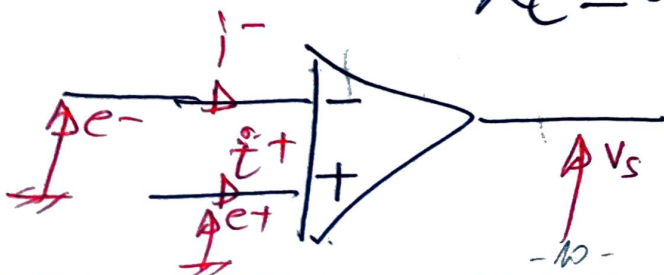
$$\ln T = C_1 - \frac{C_2}{\sqrt{E}}$$

Voir MP2 2018

$$N(t) = N_0 e^{-t/\tau}$$



AO idéal : $i^+ = i^- = 0$
 courts de polarisation
 $Z_e = \infty, Z_s = 0$

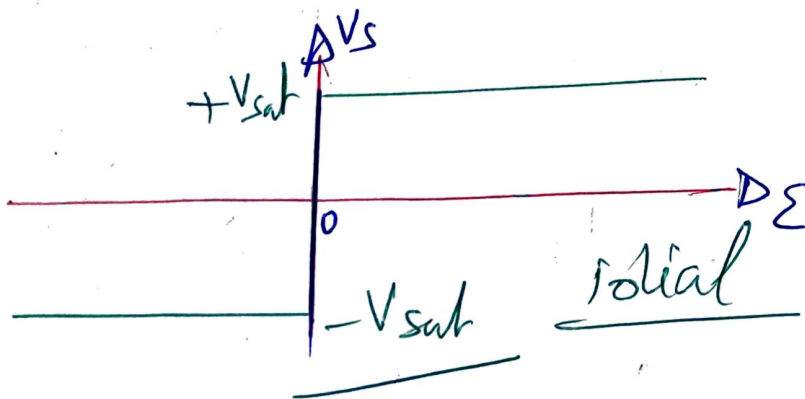
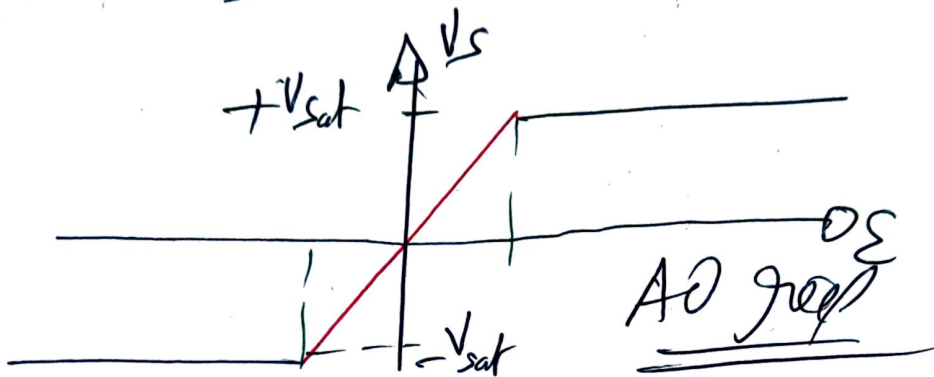


$$\varepsilon = e^+ - e^- = \text{tension différentielle}$$

$$\varepsilon = 0, \quad \underline{e^+ = e^-} \quad \underline{\text{linéaire}}$$

$$\varepsilon > 0 \quad v_s = +V_{\text{sat}} \quad \text{satiné}$$

$$\varepsilon < 0 \quad v_s = -V_{\text{sat}}$$



montage : convertisseur courant/tension

$$\underline{Z} = \frac{V_T}{I_T} (\Omega)$$

$$e^- = \frac{V_T \left(\frac{1}{R_p} + \frac{1}{Z_p} \right) + I_T}{\frac{1}{R_p} + \frac{1}{Z_p}} = e^+ = 0$$

$$\boxed{V_T = -Z_{||} I_T} = - \frac{R_p I_T}{1 + j R_p C_p \omega}$$

$$\underline{Z} = - \frac{R_p}{1 + j \frac{\omega}{\omega_c}}, \quad \omega_c = \frac{1}{C_p R_p} = \frac{1}{R_p C_p}$$

$$\omega \ll \omega_c ; \underline{Z} \simeq - R_p$$

$$\omega \gg \omega_c \quad \underline{Z} \simeq - \frac{R_p \omega_c}{j \omega} = \frac{V_T}{I_T}$$

$$\underline{V_T} = - R_p \omega_c \int I_T dt$$

Intégrateur en haute Fréq

filtre passe-bas, 1^{er} ordre, actif

Inversum

$$Q = \frac{\omega_0}{\Delta \omega} = \frac{f_0}{\Delta f} \quad G_{max} \geq 1$$

$$c) V_A = \frac{\frac{0}{Z_C} + \frac{V_T}{R_C} + \frac{e^-}{Z_{||}}}{\frac{1}{Z_C} + \frac{1}{R_C} + \frac{1}{Z_{||}}}$$

$$V_A = \frac{V_T/R_C}{\left(\frac{1}{Z_C} + \frac{1}{R_C} + \frac{1}{Z_{||}}\right)} \quad \text{??}$$

$$e^- = \frac{I_T + V_A/Z_{||}}{\frac{1}{Z_{||}}} = e^+ = \underline{0}$$

$$V_A = -Z_{||} I_T$$

$$Z' = -\left(R_C + R_p \frac{1 + j\omega(R_C C_C)}{1 + j\omega(R_p C_p)}\right)$$

$$R_C C_C = \tau_C = \tau_p = R_p C_p$$

$$Z' \approx -(R_C + R_p)$$

$$\underline{H}(j\omega) = \frac{1 - j\omega/\omega_c}{1 + j\omega/\omega_c}$$



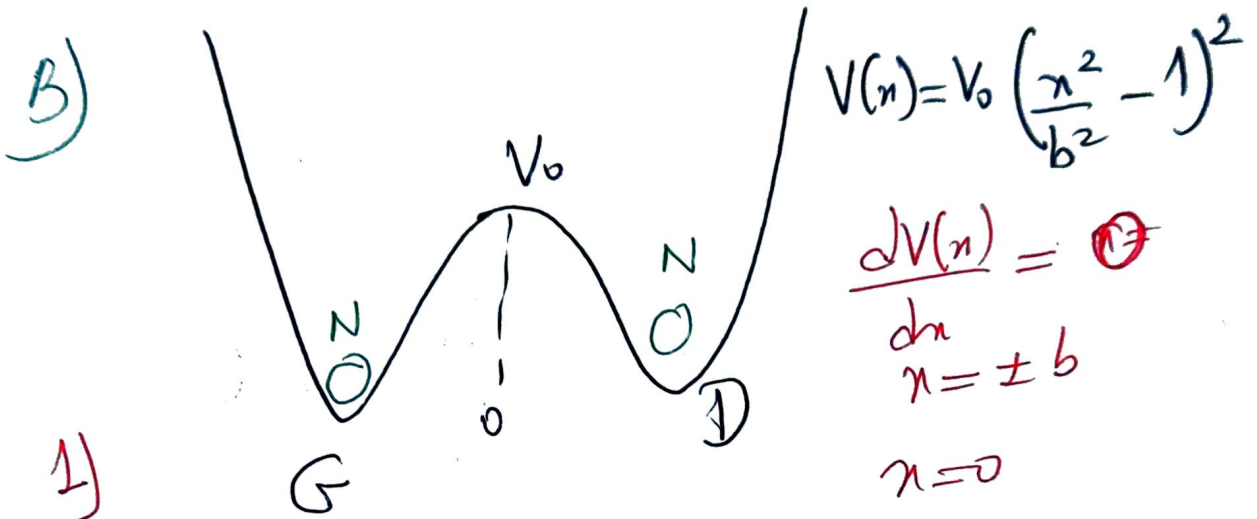
1) $dP = |4|^2 dn$, $[14] \rightarrow L^{-1/2}$

2) amplitude de normalisation = $\int_{-\infty}^{+\infty} (dP) = 1$

3) $S = |4(n4)|^2$

4) $\text{div } \vec{J} + \frac{\partial \rho}{\partial t} \rightarrow 0$; état stationnaire
 $\text{div } \vec{J} \rightarrow 0$

5) non relativiste $v \ll c$



1)

$$\frac{dV(n)}{dn} = 2V_0 \left(\frac{n^2}{b^2} - 1 \right) \left(\frac{2n}{b^2} \right)$$

$V(n) = \text{paire}$

$\left. \frac{d^2V}{dn^2} \right|_{n=\pm b} > 0$ stable

$\left. \frac{d^2V}{dn^2} \right|_{n=0} < 0$ instable

$$2) \vec{F} = m \vec{a} = -\vec{\nabla} V = -\vec{e}_r \frac{dV}{dr}$$

$$F(r) = -\frac{dV(r)}{dr} = -2V_0 \left(\frac{r^2}{b^2} - 1 \right) \frac{2r}{b^2}$$

$$F(r) = -\frac{4V_0}{b^2} r \left(\frac{r^2}{b^2} - 1 \right) = m \ddot{x}$$

$$x(t) = r_e + \xi(t) = b + \xi(t)$$

$$\ddot{x} = \ddot{\xi}(t)$$

$$m \ddot{\xi}(t) = -\frac{4V_0}{b^2} b \left(1 + \frac{\xi(t)}{b} \right) \left[\left(\frac{b + \xi(t)}{b} \right)^2 - 1 \right]$$

$$= -\frac{4V_0}{b} \left(1 + \frac{\xi(t)}{b} \right) \left[\left(1 + \frac{\xi}{b} \right) - 1 \right]$$

$$= -\frac{8V_0}{b^2} \left[\xi + \frac{\xi^2}{b} \right]$$

$$\ddot{\xi}(t) \approx -\frac{8V_0}{b^2 m} \xi$$

$$\ddot{\xi}(t) + \left(\frac{8V_0}{mb^2} \right) \xi(t) = 0.$$

$$\omega_1^2 = \frac{8V_0}{mb^2} = \frac{2V_0}{T_0} \quad \left| \begin{array}{l} \xi(0) = \xi_0 \\ \dot{\xi}(0) = 0 \end{array} \right.$$

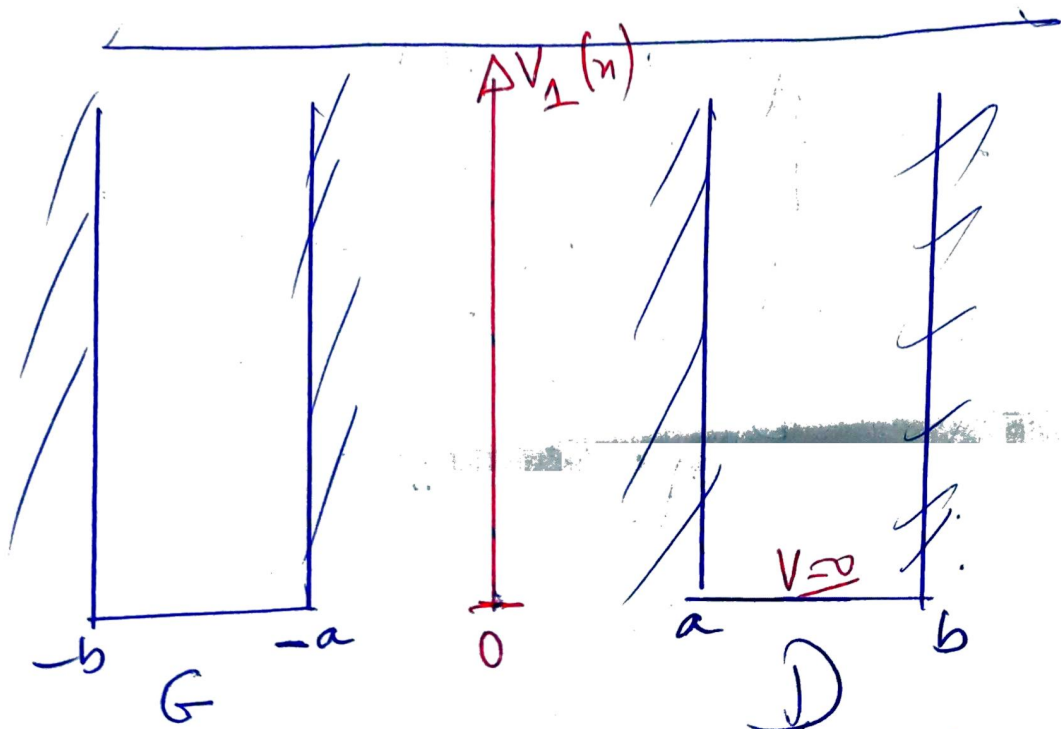
$$\xi(t) = \xi_0 \cos(\omega_1 t)$$

$$p = m \dot{\xi}(t) = -(m \xi_0 \omega_1) \sin(\omega_1 t)$$

$$5) A = S = p_{\max} \cdot \xi_{\max} = m \omega_1 \xi_0^2 = \frac{2}{\pi} \hbar$$

$$6) E > V_0 ; \quad k_B T > V_0$$

$$T > \frac{V_0}{k_B} = \underline{\underline{2200 K}}$$



$$a) \quad \psi_d''(n) + k_d^2 \psi_d(n) = 0 \quad . \quad k_d^2 = \frac{2mE}{\hbar^2}$$

$$\psi_d(x) = A \sin(k_d x + \gamma)$$

$x=a$ $\psi_d(a)=0 \Rightarrow (k_d a + \gamma) = 0$
 $\gamma = -k_d a$

$$\psi_d(x) = A \sin[k_d(x-a)]$$

$$\psi_d(b)=0 \Rightarrow k_d(b-a) = n\pi$$

$$k_d = \frac{n\pi}{(b-a)}; n \in \mathbb{N}^*$$

$$E_d = \frac{\hbar^2}{2m} k_d^2 = \frac{\hbar^2 \pi^2 n^2}{2m(b-a)^2}$$

b) degré de dégénérescence
 le nombre de micro états accessibles au système pour la même valeur d'énergie

$$g = \frac{n\pi}{(b-a)}$$

$g=2$
 droite ou gauche

$$E_{H_2} = -\frac{13.6}{n^2} \text{ (eV)}$$

$$(n, l, m_l, \mu, m_s)$$

$$(1, 0, 0, \frac{1}{2}; \pm \frac{1}{2})$$

$C_n^{n'}$

$\uparrow \downarrow$

$$g_{\text{spin}} = 2$$

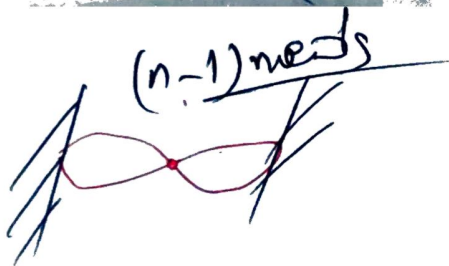
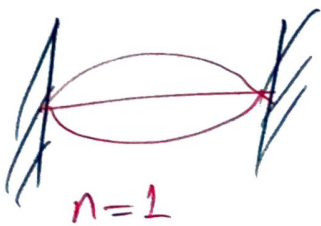
$$g_{\text{spin}} = (2s+1)$$

c) $\psi_d(n, t) = \psi_d(n) e^{-i\omega_d t}$

$$\int_a^b |\psi_d(n)|^2 dx = 1 = A^2 \int_a^b \sin^2 \left(\frac{n\pi(n-a)}{(b-a)} \right) dx$$

$$A^2 \frac{(b-a)}{2} = 1, \quad A = \sqrt{\frac{2}{b-a}}$$

$$\psi_d(n) = \sqrt{\frac{2}{b-a}} \sin \left(\frac{2\pi(n-a)}{(b-a)} \right)$$

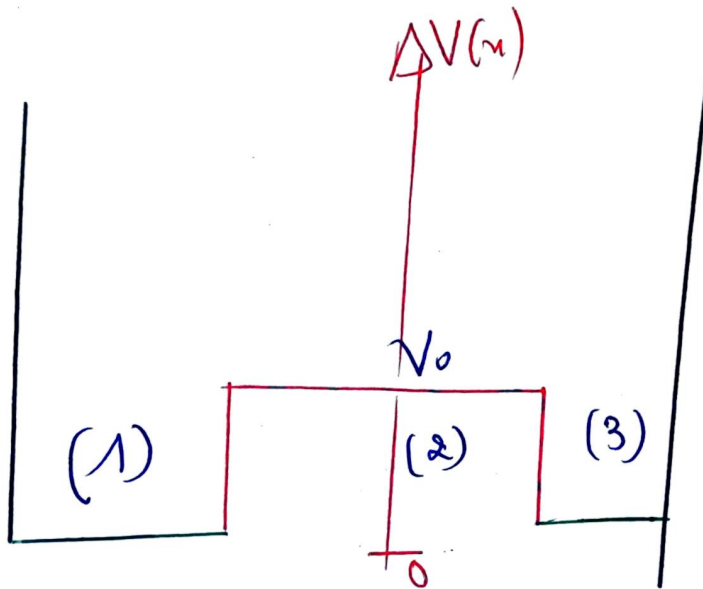


$n=2$

$$\psi(x, t) = \alpha \psi_g(x, t) + \beta \psi_d(x, t)$$

$$\int_{-\infty}^{+\infty} |\psi(x, t)|^2 dx = \int_{-b}^a |\alpha|^2 |\psi_g(x, t)|^2 dx + \int_a^b |\beta|^2 |\psi_d(x, t)|^2 dx$$

$$= |\alpha|^2 + |\beta|^2 = 1$$



~