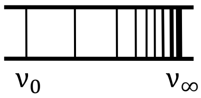


– frekvenční spektrum plynu

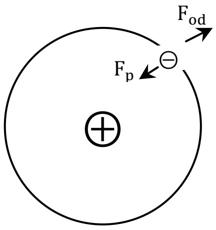
$\nu = cR.\left(\frac{1}{S^2} - \frac{1}{h^2}\right)$

S=1… Lymanova

S=2… Bolmanova

Borův model atomu

$m.v.r = n.\frac{h}{2\pi} -$ dráhy této podmínce vyhovují



$$\frac{mv^2}{r} = \frac{1}{4\pi\varepsilon_0}.\frac{e^2}{r^2}$$

$$v = \frac{n.h}{m.r.2\pi}$$

$$m.\frac{n^2h^2}{4\pi^2m^2r^3} = \frac{1}{4\pi\varepsilon_0}.\frac{e^2}{r^2}$$

$$r = \frac{n^2h^2\varepsilon_0}{\pi e^2 m} \Rightarrow v = \frac{1}{n}.\frac{e^2}{2\varepsilon_0 h}$$

$$W = E_k + E_p = \frac{1}{2}mv^2 + \frac{1}{4\pi\varepsilon_0}.\int \frac{e^2}{r^2}.dr = \frac{1}{2}m.\frac{1}{n^2}.\frac{e^4}{4\varepsilon_0^2h^2} + \frac{e^2}{4\pi\varepsilon_0}.\left[-\frac{1}{r}\right]_\infty^r =$$

$$= \frac{1}{n^2}.\frac{me^4}{8\varepsilon_0^2h^2} - \frac{1}{n^2}.\frac{me^4}{4\varepsilon_0^2h^2} = -\frac{1}{n^2}.\frac{me^4}{8h^2\varepsilon_0^2} -$$ celková energie elektronu

$$h\nu = \Delta E = W_n - W_1 = -\frac{1}{n^2}.\frac{me^4}{8h^2\varepsilon_0^2} + \frac{1}{1^2}.\frac{me^4}{8h^2\varepsilon_0^2} = \underbrace{\frac{e^4m}{8\varepsilon_0^2h^2}}_{cR}.\left(\frac{1}{\underbrace{n^2}_{\frac{1}{S^2}}} - \frac{1}{h^2}\right)$$

Vlnová funkce

$$\lambda = \frac{h}{p}$$

$$\psi = C.\exp\left(j\left(\overset{(x;y;z)}{\vec{k}}\ \vec{r} - \omega t\right)\right) \qquad y = A.\sin\big(\omega(t - t')\big), t' = \frac{x}{c} \qquad e^{jx} = \cos x + j.\sin x$$

C … amplituda, $k = \frac{2\pi}{\lambda} -$ vlnové číslo

$\psi.\psi^* = |\psi|^2$ – pravděpodobnost výskytu částice (hustota pravděpodobnosti)

$dW = \psi.\psi^* dV \qquad \int_{(V)} \psi.\psi^*.dV = 1 -$ pravděpodobnost

$$E = \frac{1}{2}mv^2 = \frac{1}{2}.\frac{p^2}{m} = \frac{p^2}{2m} + U \ \ (p = mv) \qquad \bar{h} = \frac{h}{2\pi}; \omega = 2\pi r \Rightarrow \nu = \frac{\omega}{2\pi}; E = h\nu = h.\frac{\omega}{2\pi}$$

$$\vec{p} = (p_x; p_y; p_z)$$

$$E = \frac{p_x^2 + p_y^2 + p_z^2}{2m}$$

$$E = h\nu = \bar{h}\omega \Rightarrow \omega = \frac{E}{\bar{h}}$$

$$\frac{2\pi}{\lambda} = \frac{\vec{p}}{\bar{h}} = \vec{k}$$

$$\frac{\partial\psi}{\partial t} = \psi(-j\omega) = -j.\frac{E}{\bar{h}}\psi \Rightarrow -\frac{1}{j\bar{h}}.\frac{1}{\psi}.\frac{\partial\psi}{\partial t} = E = j\bar{h}.\frac{1}{\psi}.\frac{\partial\psi}{\partial t} = -\frac{\bar{h}^2}{2m}.\frac{1}{\psi}.\left(\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2}\right) \Rightarrow$$

$$\Rightarrow j\bar{h}.\frac{\partial\psi}{\partial t} = -\frac{\bar{h}^2}{2m}.\Delta\psi$$ – **Schredingerova rovnice**

$$\vec{k} = \frac{\vec{p}}{\bar{h}} = \frac{p_x}{\bar{h}}x + \frac{p_y}{\bar{h}}y + \frac{p_z}{\bar{h}}z$$

$$\frac{\partial^2\psi}{\partial x^2} = \psi\left(\frac{j}{\bar{h}}p_x\right)^2 \Rightarrow j^2\bar{h}^{-2}.\frac{1}{\psi}.\frac{\partial^2\psi}{\partial x^2} = p_x^2 \Rightarrow -1$$

$$\frac{\partial^2\psi}{\partial y^2} = \psi\left(\frac{j}{\bar{h}}p_y\right)^2 \Rightarrow \cdots$$

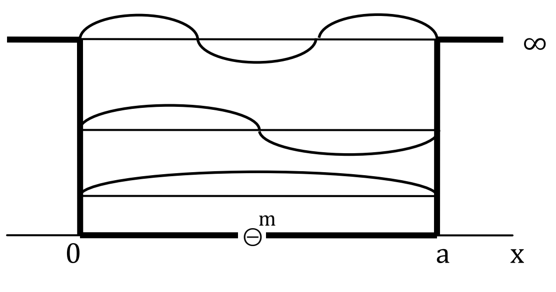
$$\frac{\partial^2\psi}{\partial z^2} = \psi\left(\frac{j}{\bar{h}}p_z\right)^2 \Rightarrow \cdots$$

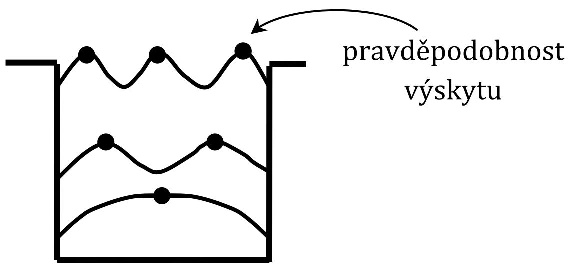
$$\psi(\vec{r}; t) = \psi(\vec{r}).\Omega(t)$$

$$\boxed{jh.\frac{\partial\psi}{\partial t} = -\frac{\bar{h}}{2m}\Delta\psi + U\psi}$$

$$\Delta\psi + \frac{2m}{\bar{h}^2}(E - U)\psi = 0$$

Potenciálová jáma





$$\Delta\psi + \frac{2m}{\bar{h}^2}(W_c - U)\psi = 0$$

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\bar{h}}(W_c - U)\psi = 0$$

$\psi = C.e^{\alpha x}$

$\alpha^2 + \frac{2mW_c}{\hbar^2} = 0$

$\alpha^2 = -\frac{2mW_c}{\hbar^2}$

$\alpha = \pm j\sqrt{\frac{2mW_C}{\hbar^2}}$

$\psi = C_1 e^{\alpha_1 x} + C_2 e^{\alpha_2 x} = \cdots = A.\sin\alpha_1 x + B.\sin\alpha_2 x \qquad \psi(0) = \psi(a) = 0$

$A.\sin 0 + B.\cos 0 = 0 \Rightarrow B = 0$

$A.\sin(\alpha_1 a) = 0$

$\alpha_1 a = n\pi \qquad \sqrt{\frac{2mW_c}{\hbar^2}}a = n\pi \Rightarrow W_c = n^2.\frac{\hbar^2\pi^2}{2ma^2}$

$\psi = A.\sin\sqrt{\frac{2mW_c}{\hbar^2}}x$

$\psi = A.\sin\frac{n\pi x}{a}$

$\int_0^a \psi.\psi^*.dx = 1 = A^2.\sin^2\frac{n\pi x}{a} \Rightarrow A = \sqrt{\frac{1}{\int \ldots}} = \sqrt{\frac{2}{a}}$

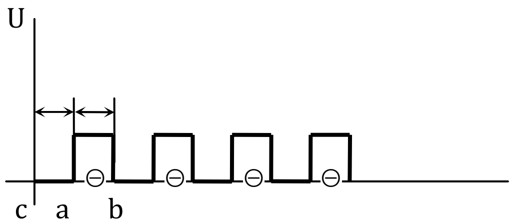
$\underline{\psi = \sqrt{\frac{2}{a}}.\sin\frac{n\pi x}{a}}$

$\underbrace{\left(-\frac{\hbar^2}{2m}\Delta + U\right)}_{\hat{H}}\psi = j\hbar\frac{\partial\psi}{\partial t}$

$\hat{H}$ – Hamiltonův operátor → celková energie elektronu

$\hat{H}\psi = \hat{E}\psi$

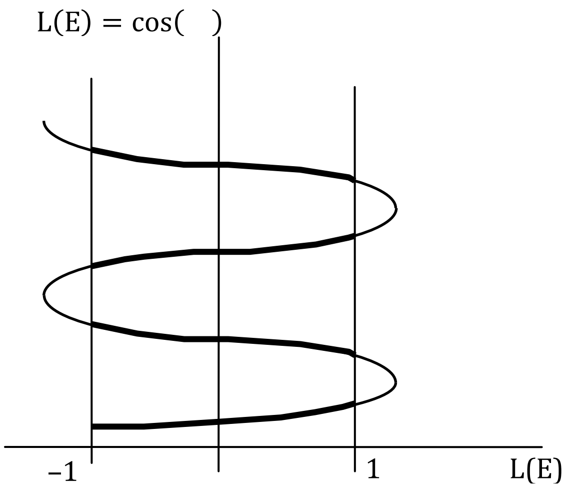
$\hat{H} = -\frac{\hbar^2}{2m} + U$

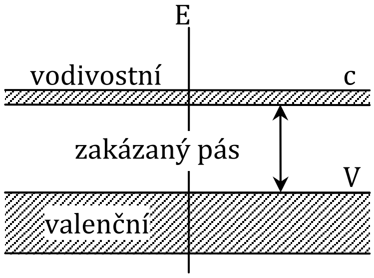


– funkce „cimbuří“

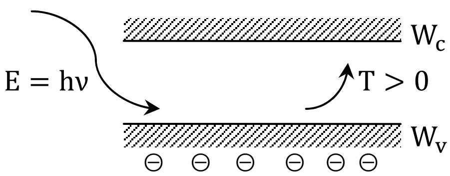
$\psi_1^2(a) = \psi_2^2(b)$

$\psi_1^2(b) = \psi_2^2(c)$





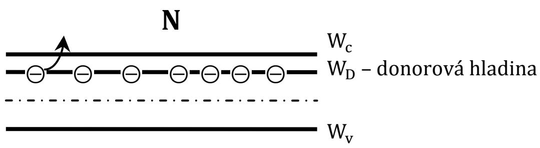
- izolanty – zakázaný pás > $3eV$
- polovodiče – zakázaný pás cca 0,1 – 3eV
- vodiče – pásy se překrývají

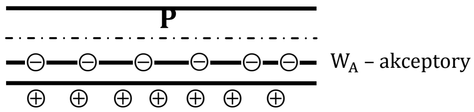


Polovodiče

při T=0 jsou všechny ⊖ dole, při T>0 může ⊖ přeskočit do W_c

Vlastní polovodič

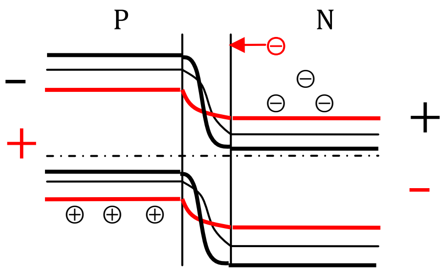


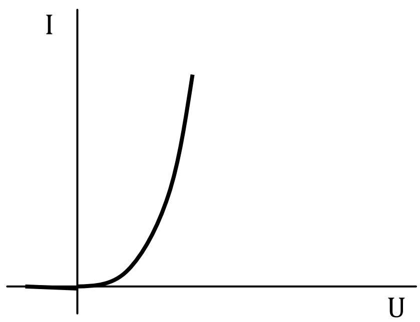


Nevlastní polovodič

Fermiho hladina – vždy je mezi W_A nebo W_D

Dioda





Tranzistor

NPN