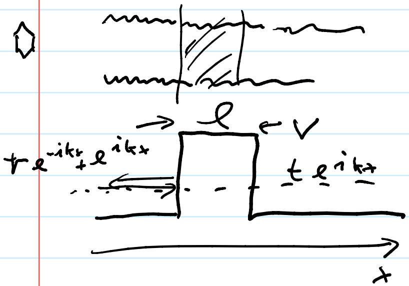
Grafen vaja

petek, 10. april 2020 08:16

Kleinovo tuneliranje



$$k = \sqrt{\frac{(V-E)2m}{\hbar^2}}$$

$$T = |t|^2 \sim e^{-k\ell}$$

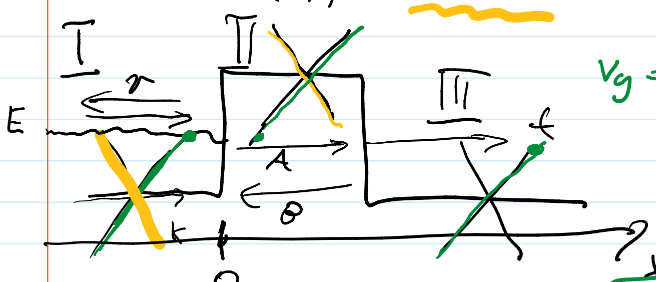
$$V\psi + c(\vec{p}\cdot\vec{\sigma})\psi = E\psi = H\psi$$

$$\psi = \begin{pmatrix}\psi_A(\vec{r})\\ \psi_B(\vec{r})\end{pmatrix} = \begin{pmatrix}\psi_A\\ \psi_B\end{pmatrix} e^{i\vec{k}\cdot\vec{r}} = \begin{pmatrix}\psi_A\\ \psi_B\end{pmatrix} e^{ikx}$$

$$V\psi + c\hbar k \sigma_x \psi = E\psi$$

$$c\hbar k \begin{pmatrix} & 1\\ 1 & \end{pmatrix}\begin{pmatrix}\psi_A\\ \psi_B\end{pmatrix} = \underbrace{(E-V)}_{\tilde{E}}\begin{pmatrix}\psi_A\\ \psi_B\end{pmatrix}$$

$$\begin{pmatrix}\psi_A\\ \psi_B\end{pmatrix} = \begin{cases}\begin{pmatrix}1\\ 1\end{pmatrix} \dots \tilde{E} = c\hbar k\\ \begin{pmatrix}1\\ -1\end{pmatrix} \dots \tilde{E} = -c\hbar k\end{cases}$$



$$v_g = \frac{d\varepsilon}{dk}$$

I $\begin{pmatrix}1\\ 1\end{pmatrix}e^{ikx} + r\begin{pmatrix}1\\ -1\end{pmatrix}e^{-ikx}$

II $Ae^{i\tilde{k}x}\begin{pmatrix}1\\ 1\end{pmatrix} + Be^{-i\tilde{k}x}\begin{pmatrix}1\\ -1\end{pmatrix}$

III $t\, e^{ik(x-\ell)}\begin{pmatrix}1\\ 1\end{pmatrix}$

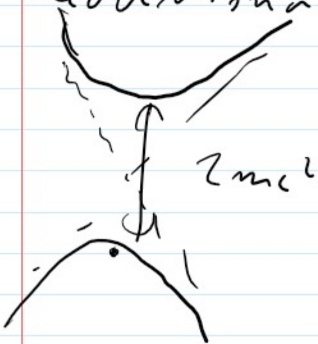
$$\boxed{\begin{pmatrix}1\\ 1\end{pmatrix} + r\begin{pmatrix}1\\ -1\end{pmatrix} = \begin{pmatrix}1+r\\ 1-r\end{pmatrix} = \begin{pmatrix}A+B\\ A-B\end{pmatrix}}$$

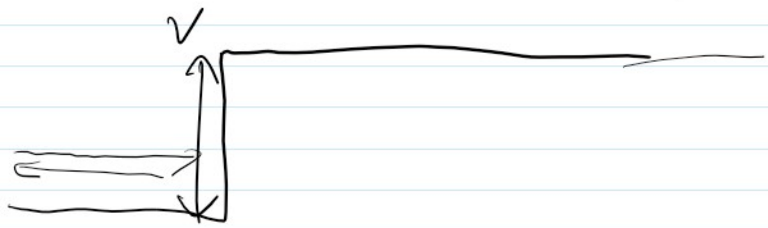
$$\boxed{\begin{pmatrix}Ae^{i\tilde{k}\ell} + Be^{-i\tilde{k}\ell}\\ Ae^{i\tilde{k}\ell} - Be^{-i\tilde{k}\ell}\end{pmatrix} = \begin{pmatrix}t\\ t\end{pmatrix}}$$

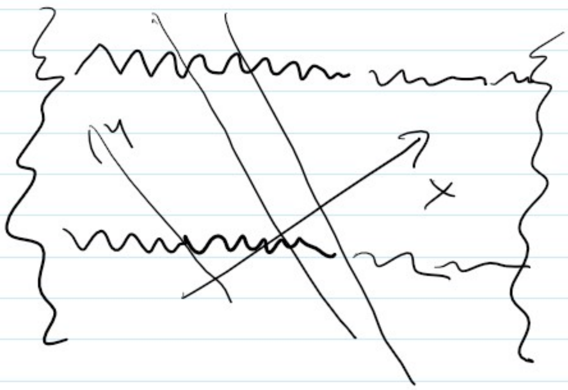
$$B = 0 \Rightarrow \boxed{r = 0\,!}$$

$B=0 \Rightarrow \boxed{r=0\,!}$

neodvisna od višine barriere odboja ni!



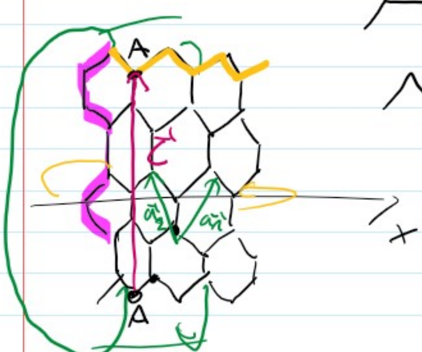


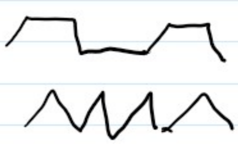


$e^{i k_x x + k_y y}$

$E = |k| c\hbar = \sqrt{k_x^2 + k_y^2}\; c\hbar$

Nanocevke



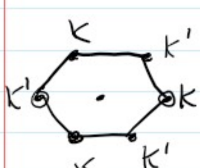


$\vec{a_1} = a\left(\tfrac{1}{2}, \tfrac{\sqrt{3}}{2}\right)$

$\vec{a_2} = a\left(-\tfrac{1}{2}, \tfrac{\sqrt{3}}{2}\right)$

$\vec{b_1} = \frac{2\pi}{a}\left(1, \tfrac{1}{\sqrt{3}}\right)$

$\vec{b_2} = \frac{2\pi}{a}\left(-1, \tfrac{1}{\sqrt{3}}\right)$



$\vec{K} = \tfrac{1}{3}\left(\vec{b_1} - \vec{b_2}\right) = \frac{2\pi}{a}\left(\tfrac{2}{3}, 0\right)$

$\vec{K}' = \tfrac{1}{3}\left(\vec{b_2} - b_1\right)$

kiralni vektor

$\vec{C} = m_1 \vec{a_1} + m_2 \vec{a_2}$ $\quad M \in \mathbb{N}$

$\vec{C} = \{ (\vec{a_1} + \vec{a_2}) M = a\left(0, \sqrt{3}\, M\right)$; armchair

$$\vec{C} = \begin{cases} (\vec{a}_1 + \vec{a}_2) M = a(0, \sqrt{3}) M ; \text{ archair} \\ (\vec{a}_1 - \vec{a}_2) M = a(1, 0) M ; \text{ zig-zag} \end{cases}$$

$$e^{i\vec{k}\vec{C}} = 1 \qquad \vec{k} \cdot \vec{C} = 2\pi N$$

$$\vec{k} = k_{\parallel} \hat{C} + k_{\perp} \hat{D} \qquad \vec{C} \cdot \vec{D} = 0 \qquad \hat{C} = \frac{\vec{C}}{|\vec{C}|}$$

$$k_{\parallel} C = 2\pi N$$

$$k_{\parallel} = \frac{2\pi N}{C} ; \begin{cases} \text{armchair } k_{\parallel} = \dfrac{2\pi N}{a\sqrt{3} M} ; \text{ pol kovinsta} \\ \text{zig-zag } k_{\parallel} = \dfrac{2\pi N}{a M} \end{cases}$$

$M \begin{cases} \text{polkovina} \\ \text{večkratnik } 3 \\ \text{polprevodnik ; žican} \end{cases}$

$$K = \frac{2\pi}{a} \frac{2}{3}$$

armchair