# DOMAČE NALOGE

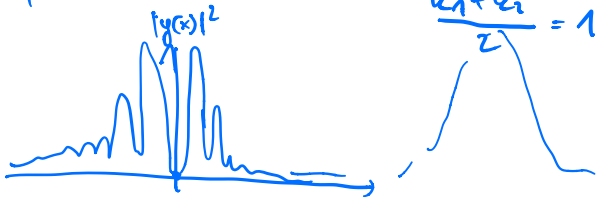
1) $y(x) = \sum_{i=1}^{n} A_i \sin(k_i x)$ $\quad \bar{k} = \sum_{i=1}^{n} k_i / n = 1$

$\int_0^{2n} |y(x)|^2 dx = 1$

$n=1$ $\begin{cases} y(x) = A_1 \sin x \\ y(x) = \frac{1}{\sqrt{\pi}} \sin x \end{cases}$ $\quad \frac{2\pi}{2} = \pi$

$n=2$ $\begin{cases} y(x) = A_1 \sin k_1 x + A_2 \sin k_2 x \end{cases}$ $\quad \frac{k_1 + k_2}{2} = 1$ $\quad k_1 = 0{,}9$ $\quad k_2 = 1{,}1$

$n = 10, 100 \ldots$




$\min \int_0^{2\pi} |y(x)|^2 \cdot x \, dx = \bar{x}$

{ Metropolis, Monte Carlo, simulirano popuščanje (annealing)

metoda konjugiranih gradientov

$\begin{cases} k_1, \ldots, k_{n-1} \to k_n \\ A_1, \ldots, A_{n-1} \to A_n \end{cases}$

2) $-K(\psi_n - \psi_{n-1}) - K(\psi_n - \psi_{n+1}) = m_n \ddot{\psi}_n$ $\quad \psi_{N+1} = 0$ $\quad \psi_0 = A \sin \omega t$

$t = 0$ $\quad \psi_n(t=0) = 0$ $\quad n = 1, \ldots, N$ $\quad N = 1000$

$\Delta t = 0{,}001$ $\quad 1000$ $\quad t = 1$ $\quad$ $t_{max}$

$\Delta t = 0{,}01$ $\quad 100$ $\quad t = 1$

a) $K = 1$ $\quad m = 1$

$A$ $\quad \omega$ $\quad \leftrightarrow$ $\quad \Delta t$

b) $m_n = 1 + \delta m_n$ $\quad \delta m_n \in [-a; a]$ $\quad a = 0{,}001$ ; $a = 0{,}01$ ; $a = 0{,}1$

$\to a \ll 1$

3) $\uparrow B$ $\quad \uparrow z$ $\quad$ precesija

$\psi(0) = \frac{1}{\sqrt{2}} (|\uparrow\rangle + |\downarrow\rangle)$ $\quad \sigma_x$ $\quad \psi(t)$ $\quad \to x$

$\psi(t) = \frac{1}{\sqrt{2}} \left( e^{-i\omega t/2} |\uparrow\rangle + e^{+i\omega t/2} |\downarrow\rangle \right)$ $\quad \pm i \; \sigma_y$

da T: $\sigma_x$ $+1$ ali $-1$ $\rightarrow$ $\psi(t') = |+\rangle = \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$

ali $|-\rangle = \frac{1}{\sqrt{2}}(|1\rangle - |0\rangle)$

2T $\omega_0 = 2\pi$

a) $+++-++-+++$

b) $T = 0{,}5$ $T = 0{,}25$

c) $T \to 0$ $\rightarrow$ kvantni Zenov paradoks

4) $|\psi\rangle = \sum_{ij} \beta_{ij} |e_i\rangle \otimes |e_j\rangle$

ali $|00\rangle + |11\rangle$ $(|0\rangle + |1\rangle) \otimes |0\rangle$

$|\psi\rangle = \sum_{i=1}^{n} \alpha_i |u_i\rangle \otimes |v_i\rangle$ Schmidtov razcep

1) $\alpha_1 = 1$ $\alpha_2 = 0$ $\rightarrow$ $|\psi\rangle = |u_1\rangle \otimes |v_1\rangle$ separabilno

2) $\alpha_1 = 1/\sqrt{2} = \alpha_2$ $= |u_1\rangle \otimes |v_1\rangle + |u_2\rangle \otimes |v_2\rangle$ prepleteno

$S = -\sum_{i=1}^{n} |\alpha_i|^2 \log_2(|\alpha_i|^2)$ entropija prepletenosti

$2^{-1} = \frac{1}{2}$

1) $S = 0$

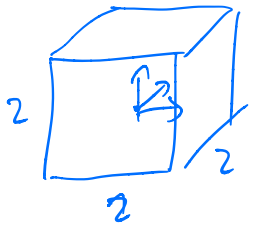
2) $S = -2 \frac{1}{2} \log_2\left(\frac{1}{2}\right)$ $-1$

$S = +1$

$\psi = \sum c_{ij} |e_i\rangle \otimes |e_j\rangle$

SVD : singular value decomposition $\begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \end{bmatrix}$

5) 1) $x, y, z \qquad x^2+y^2+z^2 = 1$




$x, y, z \in [-1:1]$

$x^2+y^2+z^2 > 1$

$0 < x^2+y^2+z^2 \leq 1$

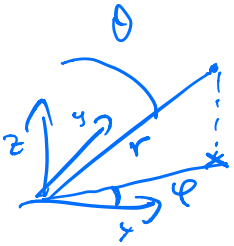
$x^2+y^2+z^2 = 0$

$\frac{x}{\sqrt{x^2+y^2+z^2}}, \frac{y}{r}, \frac{z}{r}$

2) $x, y, z$

3) $x, y, z \rightarrow r, \theta, \varphi$

$x = r\cos\varphi\sin\theta$
$y = r\sin\varphi\sin\theta$
$z = r\cos\theta$




$r = 1 \qquad \varphi \qquad u \in [0,1] \qquad \varphi = 2\pi u$

$\theta \qquad v \in [0,1] \qquad \theta = \arccos(2v-1)$

$\cos\theta \in [-1:1]$ $\qquad \theta = \pi v$ ?

$dV = dx\,dy\,dz = r^2 dr\,d\varphi\,d\cos\theta = r^2\sin\theta\,dr d\varphi d\theta$

6)

7) 3.21 $\qquad |\psi(T)\rangle = \frac{1}{\sqrt{2}}\left(e^{-i\omega_0 T/2}|\uparrow\rangle + e^{+i\omega_0 T}|\downarrow\rangle\right)$

$B = \text{konst.}$

$B \sim \text{konst.} \qquad T \sim \Delta t$

$\Delta t: \quad B(t_i) \rightarrow \psi(t) \rightarrow \psi(t+\Delta t)$

a) $B = B_0\cos(\omega t) \qquad \theta(t=0),\ \varphi(t=0) = 0$

b) $B_0 = 1 \qquad \omega < \omega_0,\ \omega = \omega_0,\ \omega > \omega_0$

8) $i\hbar\dot{\psi} = \hat{H}\psi \qquad \psi = \psi(x) \qquad L^2 \qquad e^{ikx} \rightarrow ik \qquad (ik)^2 = -k^2$

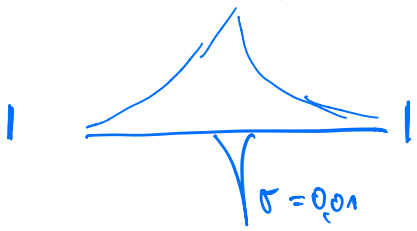
$\hat{H} = \hat{H}_{kin} + V \qquad H_{kin} = -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$

$V =$  $V = \frac{-V_0}{\sigma\sqrt{2\pi}} \exp\left(-\frac{x^2}{2\sigma^2}\right)$

$\sigma$ čedalje manjši

$\psi = \varphi\, e^{-i\omega t}$ $\quad i\hbar\dot{\psi} = i\hbar(-i\omega)\varphi(x)e^{-i\omega t} = \hat{H}\varphi\, e^{-i\omega t}$

$\hat{H}\varphi(x) = \hbar\omega\,\varphi(x)$



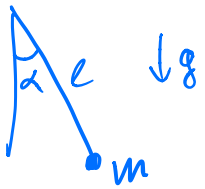

$\Delta x = \sigma/10$ $\quad [x_{min}; x_{max}]$ $\quad 100\sigma$

$n = 1000$

$\frac{\partial}{\partial x} \to \frac{\Delta f}{\Delta x} = \frac{f(x+\Delta x) - f(x)}{\Delta x}$

$\hbar = 1 \quad m_e = 1 \quad \sigma = 1$

9) $V = mgl(1-\cos\alpha)$ $\quad \psi(\alpha)$




$\alpha \in [0, 2\pi]$

$m = 1 \quad l = 1$ $\quad g$ poenostavimo!

10) $i\hbar\frac{\partial}{\partial t}\psi(x,t) = \hat{H}\psi(x,t)$ $\quad \hat{V} = 0$

$\Delta x = 0{,}01$


$\psi(x_i) \in \int_0^1 |\psi(t=0)|^2 dx = 1$

11) $H \quad m_{ij} \quad [-1;1]$ $\quad i \le j$ $\quad m_{ji} = m_{ij}$


$n \to 10000$