$\hat V(t) = \hat V$ $\quad i\partial_t \psi = \hat H \psi$

$\hat H = \hat H_0 + \hat V(t)$ $\quad \sum_n c_n \psi_n = |n\rangle c_n e^{-iE_n t}$

$\hat H_0 |n\rangle = E_n |n\rangle$

$|n(t)\rangle = |n\rangle e^{-iE_n t}$

$\psi(t) = \sum_n \psi_n(t) e^{-iE_n t} |n\rangle$

$\sum_n i(\partial_t \psi_n) e^{-iE_n t}|n\rangle + E_n \psi_n |n\rangle = E_n \psi_n |n\rangle + \hat V e^{-iE_n t} \psi_n(t)|n\rangle$

$\langle m| \quad n=m \quad n \leftrightarrow m$

$i\partial_t \psi_n = e^{+iE_n t} \sum_m e^{-iE_m t} \langle n|\hat V|m\rangle \psi_m(t)$ $\quad E_n - E_m$

$i\partial_t \psi_n = \sum_m \hat V_{nm}(t) \psi_m(t)$

$V^I_{nm}(t) = \langle n|\hat V|m\rangle e^{i\omega_{nm} t}$

$\langle n(t)|\hat V|m(t)\rangle$

$\psi_m(-\infty) = \delta_{m,0}$ $\quad V_{n0}$

$\psi_n^{(1)}(t) = -i \int_{-\infty}^{t} dt \sum V_{nm}(t) \cdot \delta_{m,0}$

$|\psi_n(+\infty)|^2 = \left| \int_{-\infty}^{+\infty} V_{n0}(t) dt \right|^2$

(I) $|\psi(t)\rangle$ $\quad C_n(t)$

$C_n(+\infty)$?

$\hat V(t)$: $V=0$

(II) $V = \text{const}$ $\quad$ Unterman type

$\hat V =$ $\quad T$

$$H(t) = \frac{P_x^2}{2m} + \frac{m\omega^2 x^2}{2} - Fx \cdot e^{-t^2/\tau^2}$$

$|\psi(-\infty)\rangle = |0\rangle$

$$V_{nm} = \langle n|(-F)\hat x|m\rangle e^{-t^2/\tau^2} e^{i(n-m)\omega t}$$

$\hat x = \frac{(\hat a + \hat a^+)}{\sqrt{2m\omega}}$

$$\left\{ (-F) \frac{e^{-t^2/\tau^2 + i(n-m)\omega t}}{\sqrt{2m\omega}} \right\} \left[\delta_{m+1,n}\sqrt{n} + \delta_{m-1,n}\sqrt{n+1} \right]$$

$$\psi_1(+\infty) = \left| \int_{-\infty}^{+\infty} \frac{e^{-t^2/\tau^2 + i\omega t}}{\sqrt{2m\omega}} (-F) dt \right|^2$$

$1 \leftarrow 0$

$\psi_1 \leftarrow V_{10} \cdot \psi_0$

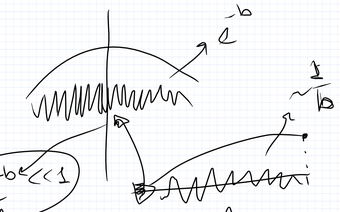
$$|\psi_1^{(1)}(+\infty)|^2 = \frac{F^2}{2m\omega} \left(\sqrt{\pi}\tau\right)^2 e^{-\frac{\omega^2\tau^2}{2}}$$

Dipole: $a e^{-b}$ $\quad b \ll 1$

$\frac{a}{b} \ll 1$ $\quad$ Fcc?

$V_{21} = \Omega_1 V_{10}$

F



$\frac{|\psi(t)| \ll 1}{|\psi(+\infty)|}$

$|\psi_2^{(1)}(+\infty)|^2 = 0$ $\quad V_{20} = 0$

$n = 1$

$$\psi_2^{(2)}(t) = -i \int_{-\infty}^{t} V_{2n}(t) dt \cdot \int_{-\infty}^{t_1} (-i) V_{n0}(t_2) dt_2 \Rightarrow |\psi_2^{(2)}(+\infty)|^2 = \frac{1}{4} \left| \int_{-\infty}^{+\infty} V_{21} dt \right|^2 \times \left| \int_{-\infty}^{+\infty} V_{10} dt \right|^2 = \frac{1}{2} |\psi_1^{(1)}(+\infty)|^2 \ll 1$$

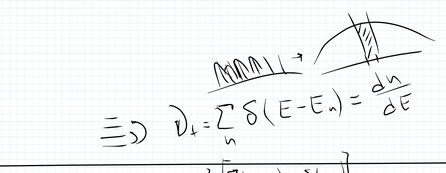
$e^{-\omega^2\tau^2/2}$ $\quad e^{-\omega^2\tau^2/2}$

$\frac{1}{4} \times \ldots e^{-\omega^2\tau^2}$

$\omega\tau \gg 1$

$$(-1) \iint_{-\infty}^{+\infty} V_{21} V_{10} dt_1 dt_2 = \frac{1}{2} \iint_{-\infty}^{+\infty} V_{21} V_{10} dt_1 dt_2$$

$t_1 < t_2$



$\Rightarrow \nu_f = \sum_n \delta(E - E_n) = \frac{dn}{dE}$

$$\hat V = \hat F e^{-i\omega t} + \hat F^+ e^{+i\omega t}$$

$E_i \to \omega_i$

$i \to f$ $\quad E_f \to \omega_f$

$t=0$ $\quad \psi_n(0) = \delta_{i,n}$

$F_{fi} = \langle f|\hat F|i\rangle$ $\quad \omega_{fi}$

$i\partial_t \psi_f(t) = F_{fi} e^{-i\omega t + i(\omega_f - \omega_i)t} + F^*_{if} e^{+i\omega t + i\omega_{fi} t}$

1 non-zero

$$\psi_f(t) = F_{fi} \frac{1 - e^{+i(\omega_{fi} - \omega)t}}{\omega_{fi} - \omega} + F^*_{if} \frac{1 - e^{i(\omega_{fi} + \omega)t}}{\omega_{fi} + \omega}$$

$t \gg \Delta\omega^{-1}$ $\quad \# \delta(\omega_{fi} - \omega)$

? $\gg t \gg (\omega_{fi}^{-1}, \omega_{if}^{-1})$;

$$\left| \frac{1 - e^{-i\omega t}}{\omega_{fi} - \omega} \right| = \left| \frac{2 \sin \frac{\omega_{fi} - \omega}{2} t}{\omega_{fi} - \omega} \right|$$

$t(\omega_{fi} - \omega) \sim \frac{1}{t}$

$\omega_{fi} - \omega$

$$|\psi_f(t)|^2 = \text{max} \left[|F_{fi}|^2 \left[\frac{\sin^2 \frac{\omega_{fi} - \omega}{2} t}{(\omega_{fi} - \omega)^2} + \frac{\sin^2(+)t}{(+)^2} \right] \right]$$

t^2 $\quad \sim \frac{1}{t}$

$\pi t \delta\left(\frac{\omega_{fi} - \omega}{2}\right)$

$2\pi t \delta(\omega_{fi} + \omega)$

$2\pi t \delta(\omega_{fi} - \omega)$

ω_{fi} $\quad t \gg$

f' $\quad +\omega$ $\quad i$ $\quad -\omega$ $\quad f'$

$$\int_{-\infty}^{+\infty} \frac{\sin^2 z t}{z^2} dz \mapsto \pi t$$

$$\frac{1}{\tau} = \frac{\Delta P}{\Delta t} = \frac{|\psi|^2}{t} = |F_{fi}|^2 \cdot 2\pi \left[\delta(\omega_{fi} - \omega) + \delta(- \to +) \right]$$

$$\frac{\partial P}{\partial t} = -\frac{1}{\tau} P \to P \propto e^{-t/\tau}$$

$$d\omega_{i\to f} = 2\pi |F_{if}|^2 \left[\delta(\ldots) + \delta(\ldots) \right]$$

$$\frac{1}{\tau} = \sum_f d\omega_{i\to f} = \int d\nu_f \, 2\pi |F_{if}|^2 \left[\delta(\ldots) + \delta(\ldots) \right]$$

f $\quad \omega$ $\quad -i$

$$H = \frac{P^2}{2m} - \frac{\hbar^2}{m}\delta(x) + f x \cos\omega t$$

$E_0 = -\frac{\hbar^2}{2m}$ $\quad \hat F = \frac{f \cdot \hat x}{2}$

$\psi_0(x) = \sqrt{\kappa} e^{-\kappa|x|}$

$$\psi_k = \begin{cases} \sin kx \\ \cos|kx + \varphi_k| \end{cases} \quad \int \sin kx \sin k'x \, dx = \pi \delta(k - k')$$

$\sqrt{\frac{2}{L}}$ $\quad \sum_k = \int \frac{dk}{\pi}$ $\quad k^2$ $\quad \kappa^2$

$$F_{if} = \int_{-\infty}^{+\infty} \frac{F x}{2} \sqrt{\kappa} e^{-\kappa|x|} \cdot \sin kx \, dx = \frac{2 F k \kappa^{3/2}}{(k^2 + \kappa^2)^2}$$

odd $\quad$ even $\quad$ cos $\quad$ $\mathrm{Im} + \partial_{k\kappa}$

$\hbar$ $\quad \hbar = 1$ $\quad E = \hbar\omega$

$$\frac{1}{\tau} = \sum_f \int \frac{dk}{\pi} \times \frac{(2F)(k)\kappa^2 k}{(k^2 + \kappa^2)^2 \frac{2m}{\hbar}} \delta\left(E_f - E_i - \omega\right) = \delta\left(\frac{k^2 + \kappa^2}{2m} - \omega\right)$$

$k dk = dE \, 2m$ $\quad k = \sqrt{2m\omega - \kappa^2}$

$\frac{1}{\tau} = \omega$

$$= \frac{m \, 4F^2 \kappa^3}{\hbar (2m\omega)^4} \sqrt{2m\omega - \kappa^2} = E_0^{3/2} \frac{\sqrt{\omega - E_0}}{\omega^4} \left(\frac{F^2}{m} \cdot 2 \right)$$

$\frac{\kappa - 1}{x^n}$ #

$\omega^E = x$

$\frac{\kappa^2}{2m} = E_0$

$\frac{(2m)^{3/2}}{(2m)^4 \kappa^2} \frac{\kappa F^2 m}{}$

$E_0 \omega$

$\frac{1}{\tau}$ $\quad \omega \propto E$ $\quad \omega^{-3/2}$ $\quad \omega$

$E_0/2$ $\quad E_0$

$n \gg 1$

Задача Кондаурова

$\sim e^{-\frac{|E_0 - \omega|}{E_0}}$ #

$\left(\frac{F^2}{E_0}\right)^n$