

(5)

$$\begin{aligned}
 \langle \hat{p}_x^2(t) \rangle &= \langle \psi(t) | \hat{p}_x^2 | \psi(t) \rangle \\
 &= \frac{1}{3} \langle \psi_0 | \hat{p}_x^2 | \psi_0 \rangle + \frac{2}{3} \langle \psi_1 | \hat{p}_x^2 | \psi_1 \rangle \\
 &\quad + 2 \frac{\sqrt{2}}{3} \operatorname{Im} \left(e^{\frac{i}{\hbar}(\epsilon_1 - \epsilon_0)t} \langle \psi_1 | \hat{p}_x^2 | \psi_0 \rangle \right)
 \end{aligned}$$

Wando:

$$\begin{aligned}
 \langle \psi_m | \hat{p}_x^2 | \psi_m \rangle &= -\frac{m\hbar\Omega}{2} \left(\sqrt{(m+1)(m+2)} \delta_{m',m+2} \right. \\
 &\quad \left. + \sqrt{(m-1)(m-2)} \delta_{m',m-2} - (2m+1) \delta_{m',m} \right)
 \end{aligned}$$

$$\Rightarrow \langle \psi_0 | \hat{p}_x^2 | \psi_0 \rangle = \frac{m\hbar\Omega}{2}, \quad \langle \psi_1 | \hat{p}_x^2 | \psi_0 \rangle = 0$$

$$\langle \psi_1 | \hat{p}_x^2 | \psi_1 \rangle = \frac{3}{2} m\hbar\Omega$$

$$\langle \hat{p}_x^2(t) \rangle = \frac{1}{3} \frac{m\hbar\Omega}{2} + \frac{2}{3} \cdot \frac{3}{2} m\hbar\Omega = \frac{7}{6} m\hbar\Omega$$

$$\begin{aligned}
 \Delta p_x(t) &= \sqrt{\langle \hat{p}_x^2(t) \rangle - \langle \hat{p}_x(t) \rangle^2} \\
 &= \sqrt{\frac{7}{6} m\hbar\Omega - \frac{8}{9} m\hbar\Omega \cos^2(\Omega t)}
 \end{aligned}$$