

$$1.4A \quad E_{\omega} = \frac{E_0 \sqrt{\pi}}{\sigma_{\omega}} \sum_{a=1}^{N_e} \exp \left[\frac{-(\omega - \omega_a)^2}{4\sigma_{\omega}^2} + i\omega t_a \right]$$

$$N_{ph} = \frac{4\pi\epsilon_0 C \lambda^2}{\hbar \omega} \int d\omega |E_{\omega}|^2 = \frac{4\pi\epsilon_0 C \lambda^2}{\hbar \omega} \int d\omega (E_{\omega} \cdot E_{\omega}^*)$$

$$E_{\omega} \cdot E_{\omega}^* = \frac{\pi E_0^2}{\sigma_{\omega}^2} \sum_{a,b=1}^{N_e} \exp \left[\frac{-(\omega - \omega_a)^2}{2\sigma_{\omega}^2} + i\omega(t_a - t_b) \right]$$

$$N_{ph} = \frac{4\pi^2 \epsilon_0^3 C \lambda^2}{\hbar \omega \sigma_{\omega}^2} \sum_{a,b=1}^{N_e} \int d\omega \exp \left[\frac{-(\omega - \omega_a)^2}{2\sigma_{\omega}^2} + i\omega(t_a - t_b) \right]$$

$$\bar{\omega} = \omega - \omega_a$$

$$N_{ph} = \frac{4\pi^2 \epsilon_0^3 C \lambda^2}{\hbar \omega \sigma_{\omega}^2} \sum_{a,b=1}^{N_e} \exp[i\omega(t_a - t_b)] \int d\bar{\omega} \exp\left(\frac{-\bar{\omega}^2}{2\sigma_{\omega}^2}\right)$$

$$\int \exp(-ax^2 - 2bx) dx = \sqrt{\frac{\pi}{a}} \exp\left(\frac{b^2}{a}\right) \quad a = \frac{1}{2\sigma_{\omega}^2} \quad b = i\omega(t_a - t_b)$$

$$N_{ph} = \frac{4\pi^2 \epsilon_0^3 C \lambda^2}{\hbar \omega \sigma_{\omega}^2} \sqrt{2\sigma_{\omega}^2 \pi} \sum_{a,b=1}^{N_e} \exp[i\omega(t_a - t_b)] \exp\left[\frac{-\sigma_{\omega}^2(t_a - t_b)^2}{2}\right]$$

$$N_{ph} = \frac{4\pi^2 \epsilon_0^3 C \lambda^2 \sqrt{2\pi}}{\hbar \omega \sigma_{\omega}} \sum_{a,b=1}^{N_e} \exp\left[i\omega(t_a - t_b) - \frac{\sigma_{\omega}^2}{2}(t_a - t_b)^2\right]$$

$$N_{ph} = \frac{4\pi^2 \epsilon_0^3 C \lambda^2 \sqrt{2\pi}}{\hbar \omega \sigma_{\omega}} \sum_{a=1}^{N_e} \sum_{b=1}^{N_e} 1$$

$$N_{ph} = \frac{4\pi^2 \epsilon_0^3 C \lambda^2 \sqrt{2\pi}}{\hbar \omega \sigma_{\omega}} \sum_{a=1}^{N_e} N_e$$

$$N_{ph} = \frac{4\pi^2 \epsilon_0^3 C \lambda^2 \sqrt{2\pi}}{\hbar \omega \sigma_{\omega}} N_e^2 = \frac{T \sqrt{2\pi}}{\sigma_{\omega}} N_e^2$$

$$\langle N_{ph} \rangle = \frac{1}{N_e} N_{ph} = \frac{4\pi^2 \epsilon_0^3 C \lambda^2 \sqrt{2\pi}}{\hbar \omega \sigma_{\omega}} N_e$$

$$T = \frac{4\pi\epsilon_0 C \lambda^2}{\hbar \omega}$$

$$\langle N_{ph} \rangle = \frac{T \sqrt{2\pi}}{\sigma_{\omega}} N_e$$

$$\langle N_{ph} \rangle^2 = (2\pi) \frac{N_e^2 T^2}{\sigma_{\omega}^2}$$