

$\vec{E}(\vec{r})$

$$\vec{E}(\vec{r}) = \vec{g}(\vec{r}, \vec{r}', \omega) \cdot \vec{p}$$

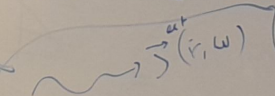
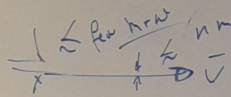
$$\vec{g}(\vec{r}, \vec{r}', \omega) = \vec{g}^T(\vec{r}', \vec{r}, \omega)$$

$$\left[ \nabla \times \nabla \times - k^2 \epsilon(\vec{r}, \omega) \right] \vec{g}(\vec{r}, \vec{r}', \omega) = 4\pi k^2 \delta(\vec{r} - \vec{r}') \\ (\nabla \times \nabla \times - k^2 \epsilon) \vec{E} = \frac{4\pi i k}{c} \vec{j} \text{ at } t$$

$$\vec{j}(\vec{r}, \omega) = -e \hat{x} \frac{v}{m} e^{i\omega x/v} \delta(y) \delta(z - z_0)$$

$$\Gamma_{EELS} = \Gamma_{EELS}'' + \frac{1}{\pi \hbar} \text{Re} \left\{ i \left( \alpha_{xx}^{\text{eff}} \left( \frac{E_x^{\text{ext}}}{y} - E_x^{\text{ind}} \right)^2 + \alpha_{zz}^{\text{eff}} (E_z^{\text{ext}})^2 \right) \right\} \vec{p}$$

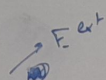
0.1 - 0.7 c



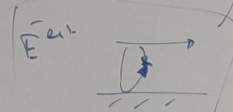
$$\vec{E}^{\text{ext}}(\vec{r}, \omega) = \frac{i}{\omega} \int d\vec{r}' \vec{g}(\vec{r}, \vec{r}', \omega) \cdot \vec{j}(\vec{r}', \omega)$$

$$\int d\vec{r}' \vec{g}(\vec{r}, \vec{r}', \omega) \cdot \left( \frac{-ie}{\omega} \frac{v}{m} e^{i\omega x/v} \right) = \vec{E}^{\text{ext}}(\vec{r}, \omega) = E_x^{\text{ext}} \hat{x} + E_y^{\text{ext}} \hat{y} + E_z^{\text{ext}} \hat{z}$$

$$\Gamma_{EELS}^{\text{ind}} = \text{Re} \left\{ \left[ E_x^{\text{ind}}(x) = \hat{x} \cdot \vec{g}(\vec{r}, \vec{r}', \omega) \cdot \vec{p} \right] \frac{e}{\pi \hbar \omega} e^{-i\omega x/v} \right\} \\ = \text{Re} \left\{ \frac{i \vec{p}}{\pi \hbar} \cdot \int d\vec{r}' \vec{g}(\vec{r}, \vec{r}', \omega) \left( \frac{-ie}{\omega} \hat{x} \right) e^{-i\omega x/v} \right\} \\ = -E_x^{\text{ext}} \hat{x} + E_y^{\text{ext}} \hat{y} + E_z^{\text{ext}} \hat{z}$$

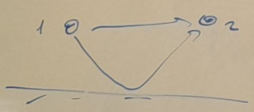


$$\vec{p} = \frac{1}{1/\alpha - g} E^{\text{ext}}$$

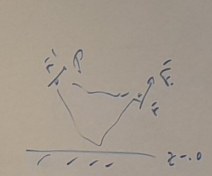
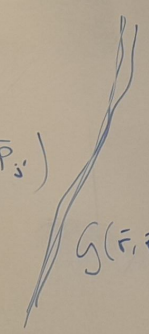


$$\vec{E}^{\text{ind}} = \dots$$





$$\bar{P}_j = \alpha^{eff} (\bar{E}_j^{ext} + \sum_{j' \neq j} G_{jj'} \bar{P}_{j'})$$



$z, z' > 0$

$\kappa^2 = \frac{\omega^2}{v^2}$

$$\frac{e^{i\kappa|\bar{r}-\bar{r}'|}}{|\bar{r}-\bar{r}'|}$$

$$G(\bar{r}, \bar{r}', \omega) = \kappa^2 \int \frac{d^2 \bar{Q}}{(2\pi)^2} \frac{2\pi i}{\kappa_z} e^{i\bar{Q} \cdot (\bar{r} - \bar{r}')} + \int_{z > z'}^{\downarrow z < z'} \frac{e^{i\kappa_z(z-z')}}{\kappa_z}$$

$$\left( \kappa^2 + \bar{Q} \otimes \bar{Q} \right) \frac{e^{i\kappa|\bar{r}-\bar{r}'|}}{|\bar{r}-\bar{r}'|} = \int d\bar{r}' \left\{ \left( \hat{\epsilon}_p^+ \otimes \hat{\epsilon}_p^+ + \hat{\epsilon}_s \otimes \hat{\epsilon}_s \right) e^{i\kappa_z(z-z')} + \left( r_p \hat{\epsilon}_p^+ \otimes \hat{\epsilon}_p^- + r_s \hat{\epsilon}_s \otimes \hat{\epsilon}_s \right) e^{i\kappa_z(z+z')} \right\}$$

$$\frac{e^{i\kappa R}}{R^3} \left[ (\kappa^2 R^2 + i\kappa R - 1) \hat{R} \otimes \hat{R} - (\kappa^2 R^2 + 3i\kappa R - 3) \hat{R} \otimes \hat{R} \right] \quad (\bar{R} = \bar{r} - \bar{r}')$$

$$L \rightarrow 0 \rightarrow \frac{3\hat{R} \otimes \hat{R} - \mathbb{I}}{R^3}$$

$$\bar{E}^{ext}(\bar{r}, \omega) = \frac{i}{\omega} \int d\bar{r}' G(\bar{r}, \bar{r}', \omega) \cdot \bar{J}^{ext}(\bar{r}', \omega) = -\frac{ev\omega}{|\omega| c^2} \int d\bar{Q}_y$$

$\rightarrow S_{surf}$

$$\frac{e^{i\bar{Q} \cdot \bar{r}}}{\kappa_z} \left[ e^{i\kappa_z(z_0-z)} \left( \hat{\epsilon}_p^+ \frac{\partial_x \kappa_z}{\kappa Q} + \hat{\epsilon}_s \frac{\partial_y}{Q} \right) + e^{i\kappa_z(z_0+z)} \left( r_p \hat{\epsilon}_p^+ \frac{\partial_x \kappa_z}{\kappa Q} + \hat{\epsilon}_s \frac{\partial_y}{Q} \right) \right]$$

$y=0 \rightarrow E_y=0$

$$\bar{J}^{ext}(\bar{r}', \omega) = \frac{-e\hat{x}v}{|\omega|} \delta(y') \delta(z-z_0) \cdot e^{i\omega x'/v}$$

$$\int d\bar{r}' e^{i\omega x'/v - iQ_x x'}$$

$$Q_x = \frac{\omega}{v}, \quad z < z_0 \quad \left( \bar{E}^{ext} \cdot \hat{E}_{q, \omega} \right)$$