Dispersion

$$\begin{cases} \varepsilon = \varepsilon(\omega) \\ \mu = \mu(\omega) \end{cases}$$

How to introduce ω?

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0} \qquad \vec{\nabla} \cdot \vec{B} = 0$$

$$\vec{\nabla} \times \vec{E} = -\dot{\vec{B}} \qquad \vec{\nabla} \times \vec{B} = \frac{1}{c^2} \dot{\vec{E}} + \mu_0 \vec{J}$$

Assume that all quantities oscillate with the frequency ω

$$\begin{cases} \vec{E}(\vec{r}, t) \rightarrow \vec{E}_\omega(\vec{r})\, e^{-i\omega t} \\ \vec{B}(\vec{r}, t) \rightarrow \vec{B}_\omega(\vec{r})\, e^{-i\omega t} \\ \rho(\vec{r}, t) \longrightarrow \rho_\omega(\vec{r})\, e^{-i\omega t} \\ \vec{J}(\vec{r}, t) \rightarrow \vec{J}_\omega(\vec{r})\, e^{-i\omega t} \end{cases} \qquad \frac{\partial}{\partial t} \rightarrow -i\omega$$

$$\begin{cases} \vec{\nabla}\cdot\vec{E}_\omega = \dfrac{\rho_\omega}{\varepsilon_0} & \vec{\nabla}\cdot\vec{B}_\omega = 0 \\[2ex] \vec{\nabla}\times\vec{E}_\omega = i\omega\vec{B}_\omega & \vec{\nabla}\times\vec{B}_\omega = -\dfrac{i\omega}{c^2}\vec{E}_\omega + \mu_0\vec{J}_\omega \end{cases}$$

$$\begin{cases} \vec{D}_\omega = \varepsilon_0\,\varepsilon(\omega)\,\vec{E}_\omega \\[2ex] \vec{B}_\omega = \mu_0\,\mu(\omega)\,\vec{H}_\omega \end{cases}$$

(Skip index ω)

$$\begin{cases} \vec{\nabla}\cdot\vec{D} = \rho_{ext} & \vec{\nabla}\cdot\vec{B} = 0 \\[2ex] \vec{\nabla}\times\vec{E} = i\omega\vec{B} & \vec{\nabla}\times\vec{H} = -i\omega\vec{D} + \vec{J}_{ext} \end{cases}$$

$$\vec{d} = \underbrace{\frac{Nq^2}{m} \sum_j \frac{f_j}{\omega_j^2 - \omega^2 - i\gamma_j \omega}}_{\varepsilon_0 \chi} \vec{E}$$

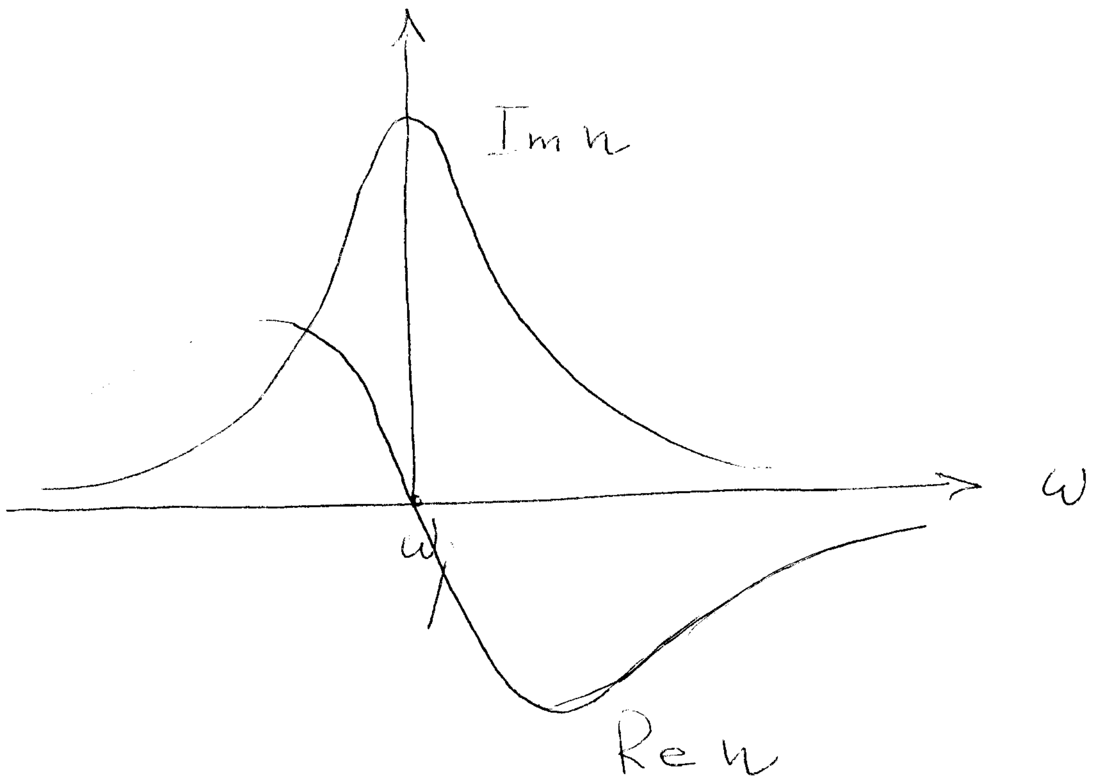
$$\varepsilon(\omega) = 1 + \frac{Nq^2}{m\varepsilon_0} \sum_j \frac{f_j}{\omega_j^2 - \omega^2 - i\gamma \omega_j}$$

$$n(\omega) = \sqrt{\varepsilon(\omega) \underbrace{\mu(\omega)}_{\to 1}} =$$

$$= \left[1 + \frac{Nq^2}{m\varepsilon_0} \sum_j \frac{f_j}{\omega_j^2 \omega^2 - i\gamma_j \omega_j} \right]^{1/2}$$

$$\cong 1 + \frac{Nq^2}{2m\varepsilon_0} \sum \frac{f_j}{\omega_j^2 - \omega^2 - 2\gamma_j \omega}$$

if not
in resonance


n
Im n
ω
ω_0
Re n