Comparison to Metals

The Drude conducting model

$$\frac{\partial^2 \boldsymbol{P}}{\partial t^2} + \Gamma \frac{\partial \boldsymbol{P}}{\partial t} = \frac{ne^2}{m_e} \boldsymbol{E_0} e^{-i\omega t}$$

Substitute in the susceptibility $P = \chi(\omega)\varepsilon_0 E$

$$\varepsilon_0 \chi(\omega)\left(-\omega^2 - i\omega\Gamma\right)\boldsymbol{E_0} e^{-i\omega t} = \frac{ne^2}{m_e} \boldsymbol{E_0} e^{-i\omega t}$$

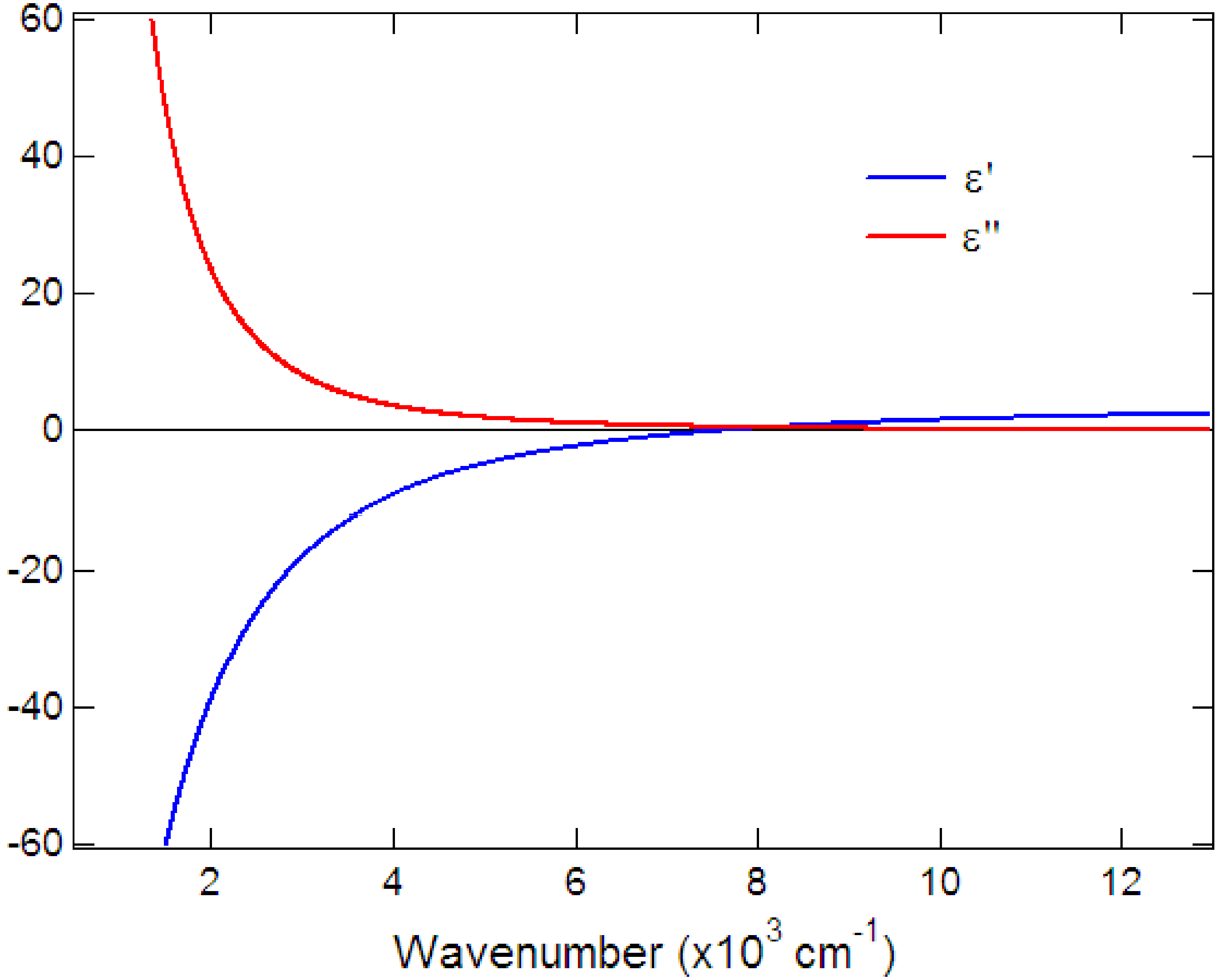
From the definition $\chi(\omega) = \varepsilon(\omega) - 1$ and the definition of the Drude plasmon resonance frequency

$$\varepsilon(\omega) = 1 - \frac{\omega_p^2}{\omega^2 + \Gamma^2} + i \frac{\Gamma\, \omega_p^2}{\omega\left(\omega^2 + \Gamma^2\right)}$$

The relaxation constant Γ can be related to the electron mean free path λ and the Fermi velocity v_F by $\Gamma = v_F/\lambda$

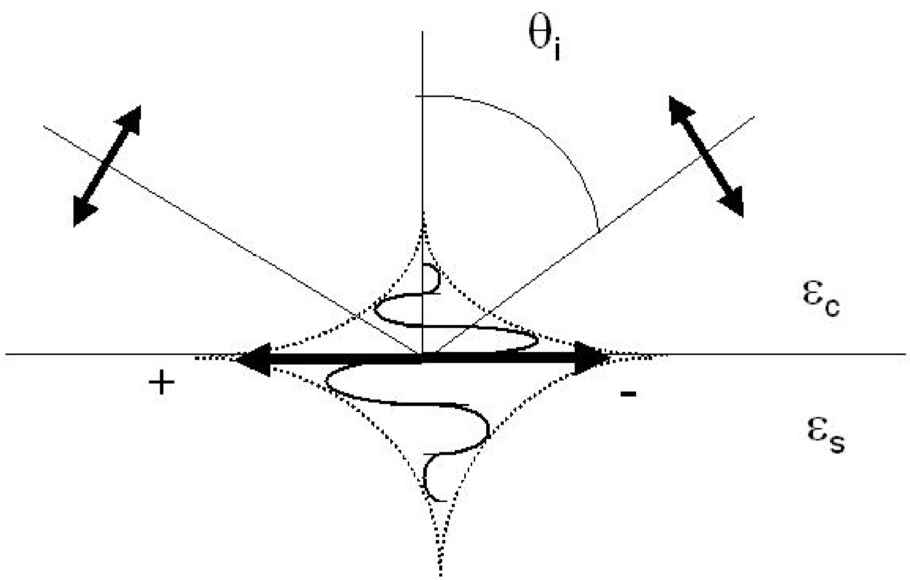
$$\varepsilon_1(\omega) = 1 - \frac{\omega_p^2}{\omega^2 + \Gamma^2} \quad , \quad \varepsilon_2(\omega) = \frac{\Gamma\, \omega_p^2}{\omega\left(\omega^2 + \Gamma^2\right)}$$

Dielectric function for ITO



Dispersion relations from Drude

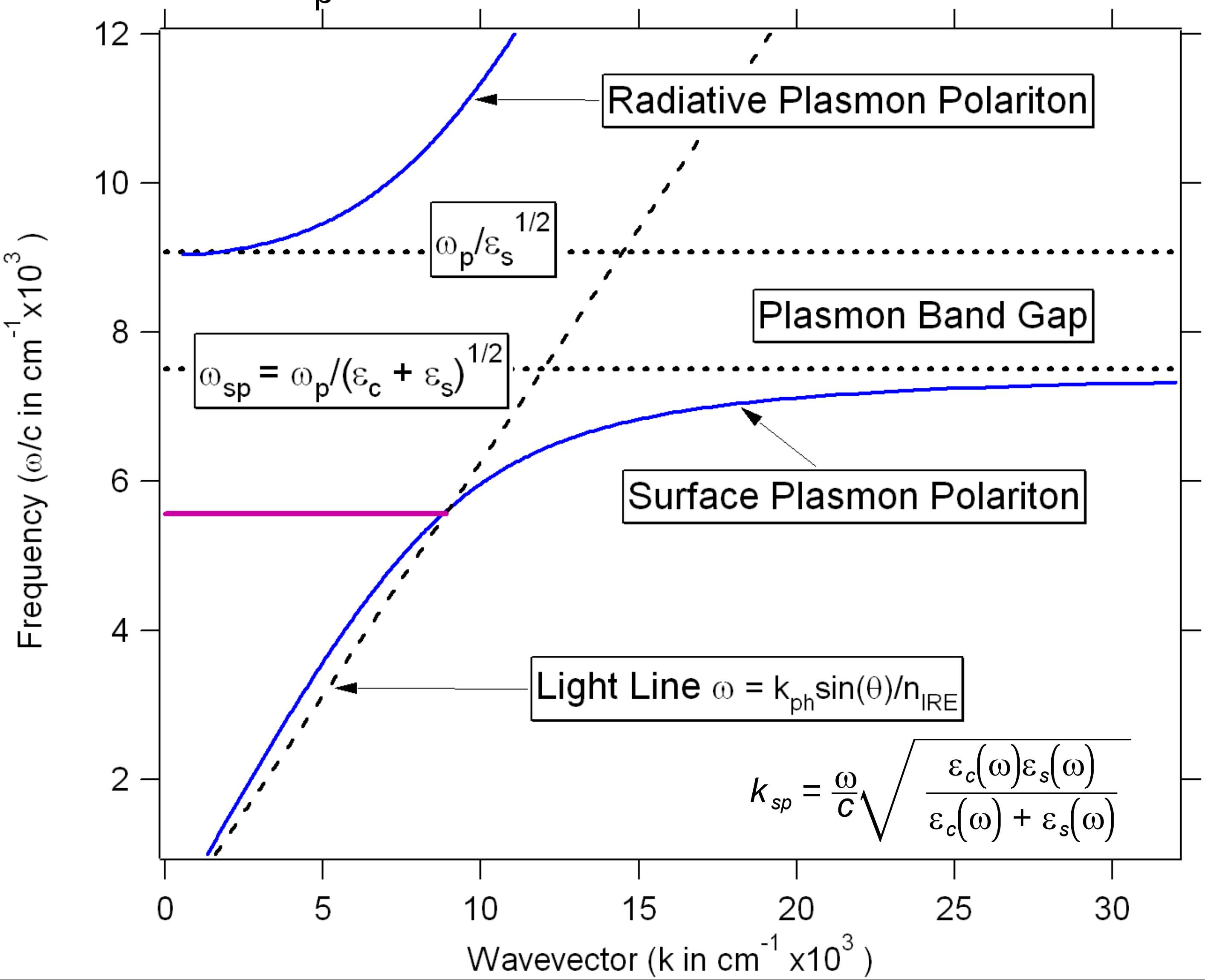
$$n_{cz} = \sqrt{\frac{-\varepsilon_c^2}{\varepsilon_c + \varepsilon_s}} \quad , \quad n_{sz} = \sqrt{\frac{-\varepsilon_s^2}{\varepsilon_s + \varepsilon_c}} \quad , \quad n_x = \sqrt{\frac{\varepsilon_c \varepsilon_s}{\varepsilon_s + \varepsilon_c}}$$



Surface plasmon polariton (SPP)

Predicted Plasmonics (Real)

$\omega_p = 17700\ cm^{-1} \quad \Gamma = 500\ cm^{-1}$



Predicted Plasmonics