

1 Drude model σ and ϵ

Our ultimate goal will be to find the conductivity σ and the dielectric constant ϵ in the Drude model, with Drude relaxation time τ , electron density n and electron mass m . We'll find

$$\sigma_{\text{DC}} = \frac{ne^2\tau}{m} \quad (1)$$

$$\sigma_{\text{AC}} = \frac{ne^2\tau}{m} \frac{1}{1 - i\omega\tau} \quad (2)$$

$$\epsilon = 1 + i \frac{4\pi\sigma}{\omega} \quad (3)$$

Our dielectric constant can be rewritten to plug in for σ , giving us

$$\epsilon = 1 + i \frac{4\pi\sigma}{\omega} \quad (4)$$

$$= 1 + i \frac{4\pi\sigma_{\text{DC}}}{\omega} \frac{1}{1 - i\omega\tau} \quad (5)$$

$$= 1 + i \frac{4\pi\sigma_{\text{DC}}}{\omega} \frac{1}{1 - i\omega\tau} \frac{1 + i\omega\tau}{1 + i\omega\tau} \quad (6)$$

$$= 1 + i \frac{4\pi\sigma_{\text{DC}}}{\omega} \frac{1 + i\omega\tau}{1 + \omega^2\tau^2} \quad (7)$$

$$= \left(1 - \frac{4\pi\sigma_{\text{DC}}\omega\tau}{\omega(1 + \omega^2\tau^2)}\right) + i \left(\frac{4\pi\sigma_{\text{DC}}}{\omega(1 + \omega^2\tau^2)}\right) \quad (8)$$

$$= \left(1 - \frac{4\pi\sigma_{\text{DC}}\tau}{1 + \omega^2\tau^2}\right) + i \left(\frac{4\pi\sigma_{\text{DC}}}{\omega(1 + \omega^2\tau^2)}\right) \quad (9)$$