

1 Summary of Lindhard's derivation

For Lindhard's derivation, we can start with two variations on the Maxwell's equations:

$$\left(k^2 - \frac{\omega^2}{c^2}\epsilon^{tr}(\mathbf{k}, \omega)\right) \mathbf{A}^{tr}(\mathbf{k}, \omega) = \frac{4\pi}{c} \mathbf{j}_f^{tr}(\mathbf{k}, \omega), \quad (1)$$

$$\epsilon^{lo}(\mathbf{k}, \omega) k^2 V(\mathbf{k}, \omega) = 4\pi \rho_f(\mathbf{k}, \omega). \quad (2)$$

Here, ρ_f and j_f are the free charge density and current. The longitudinal and transverse dielectric functions, ϵ^{lo} and ϵ^{tr} , contain the same information as the traditional ϵ and μ .