EPFL

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\varepsilon_0}$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

$$\nabla \times \mathbf{B} = \mu_0 \left( \mathbf{J} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right)$$

# Week 3

## (Material Properties and Optical Constants)

Stavros Athanasiou

Lausanne, 23 Sep 2025

# Course Timeline

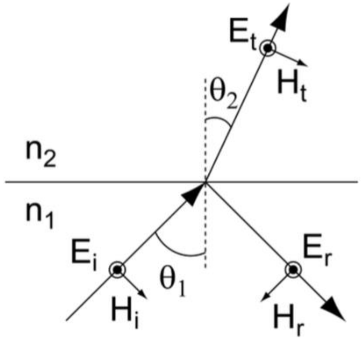


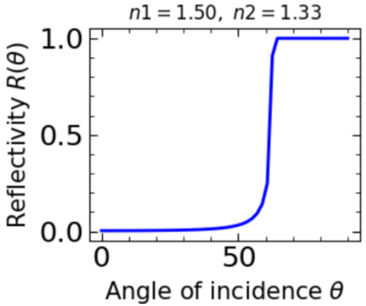


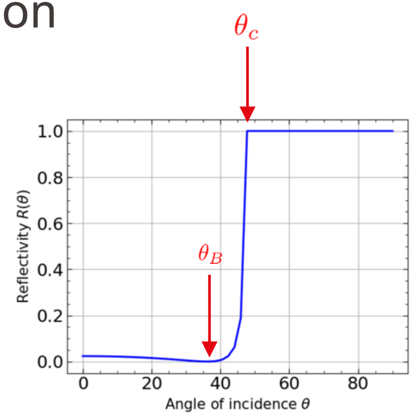
- Week 1
  - Introduction
  - Ray Optics
  - Wave Optics
- Week 2
  - EM Optics
- Week 3
  - Material Response
  - Optical Constants
- Week 4
  - Light Scattering
  - Mie Theory
- Week 5
  - Localized Surface Plasmons
- Week 6
  - Propagating Surface Plasmons
- Week 7
  - Plasmonic
  - Applications
- Week 8
  - Gratings
- Week 9
  - Stratified Media
  - Transfer Matrix
- Week 10
  - Photonic Crystals
- Week 11
  - Metamaterials
- Week 12
  - Metasurfaces
- Week 13
  - Applications of Metamaterials
- Week 14
  - Lab Tour
  - **No Exercise Session**

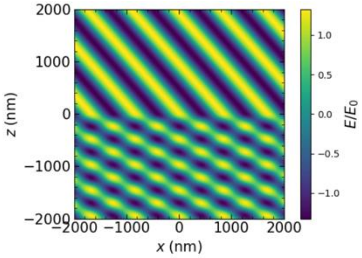
# Last Week : Electromagnetic Optics

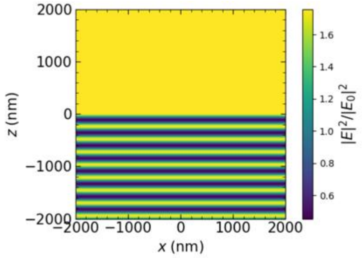
1. Derivation of the Fresnel Coefficients for TE-polarization
2. Total Internal Reflection
3. The Brewster Angle
4. Field Visualization





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# This Week : Material Properties and Optical Constants

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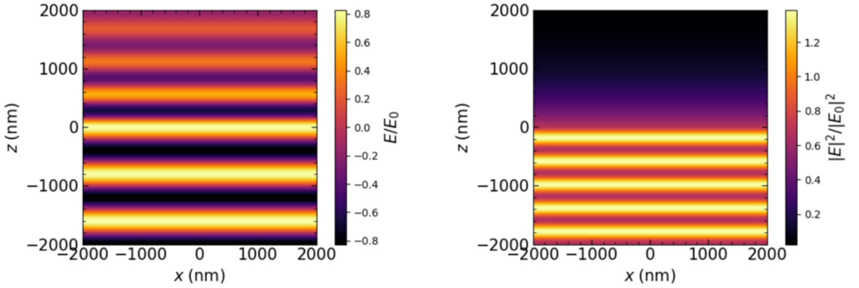
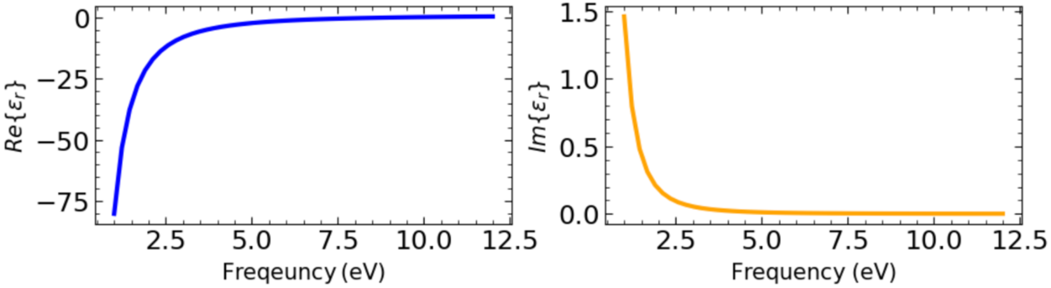
- Propagation in Lossy Media



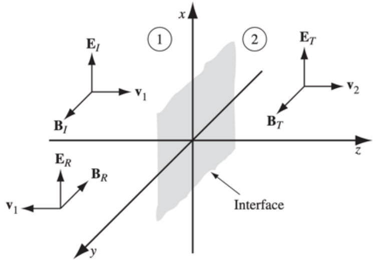

- The Drude Model

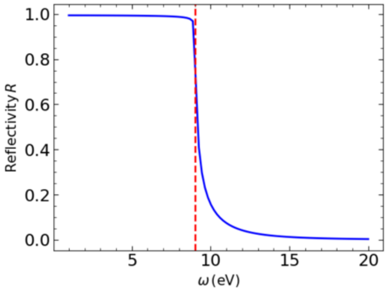
$$P = \varepsilon_r \varepsilon_0 E, \quad \varepsilon_r = 1 - \frac{\omega_p^2}{\omega^2 + i\gamma\omega},$$



# This Week : Material Properties and Optical Constants

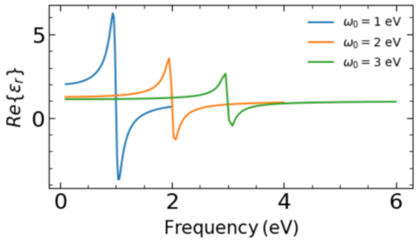
- Reflection from a Metal Planar Surface

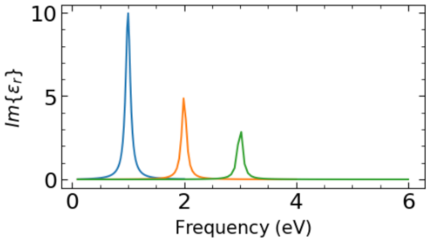


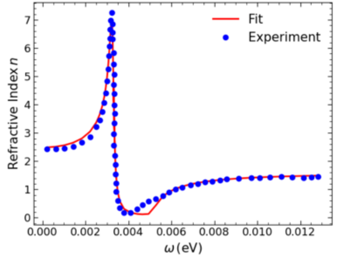




- The Lorentz Model in Action

$$\varepsilon_r(\omega; \varepsilon_\infty, \omega_p, \omega_0, \gamma) = \varepsilon_\infty + \frac{\omega_p^2}{\omega_0^2 - \omega^2 - i\omega\gamma} .$$



# Units

- Angular frequency ω, measured in rad/s (SI)
- Frequency f, measured in 1/s = Hz (SI)

$$f = \frac{\omega}{2\pi}$$

- Photon energy, measured in J (SI)

$$E = \hbar\omega = hf = \frac{hc}{\lambda}$$

$$\left( E\,[\text{eV}] = \frac{1239.8\,\text{eV nm}}{\lambda\,[\text{nm}]} \right)$$

In photonics, we deal with small magnitudes of energy

➔Use eV (electron-volt) instead of Joules.

$$1\ \text{eV} = 1.6 \cdot 10^{-19}\ \text{J}$$

In photonics, we usually express frequency in eV, just like energy!

(convenient when dealing with material band gaps or transition frequencies)