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Exercises to the lecture Nano-Optics, WS 2022/23

Exercises (IV)
(Discussion is on Friday, 9.12.2022)

Problem 1:

We discussed the solution of Surface-Plasmon-Polaritons (SPPs) in the case of a free electron gas as a simple model for a metal. Another model often used in (nano-) optics is an ideally conducting medium (ICM), i.e., a metal with vanishing electrical resistance and thus infinite conductivity, $\sigma \to \infty$. Find first a relation of the conductivity σ to the permittivity ϵ at optical frequencies and then try to find a solution of SPPs at the air-ICM interface using the dispersion relation derived in the lecture.

Hint: Use Maxwell's equation curl $\vec{H} = \vec{j} + \dot{\vec{D}}$ and the harmonic Ansatz $\vec{E} = \vec{E}_0 \mathrm{e}^{i(\vec{k}\vec{r} - \omega t)}$ to identify $\sigma/\epsilon_0\omega$ as the imaginary part of the complex permittivity ϵ of the metal.

Problem 2:

A plane electromagnetic wave of angular frequency ω in vacuum is reflected back at normal incidence from the interface to a metal with given conductivity σ. Determine the reflection coefficient R and the penetration depth d of the wave into the metal. Assume that σ is a real quantity and that $\sigma/\omega \gg \epsilon_0\epsilon'$ in which ϵ' is the real part of the permittivity ϵ.