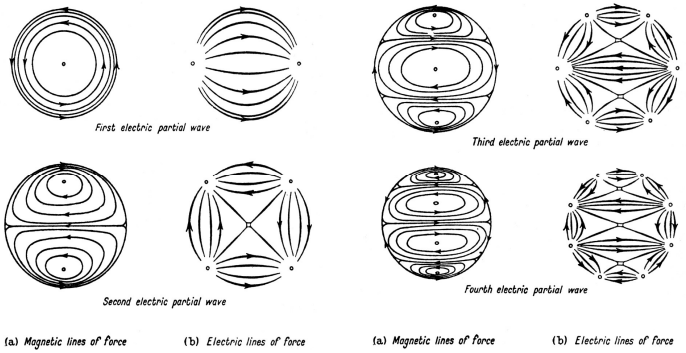
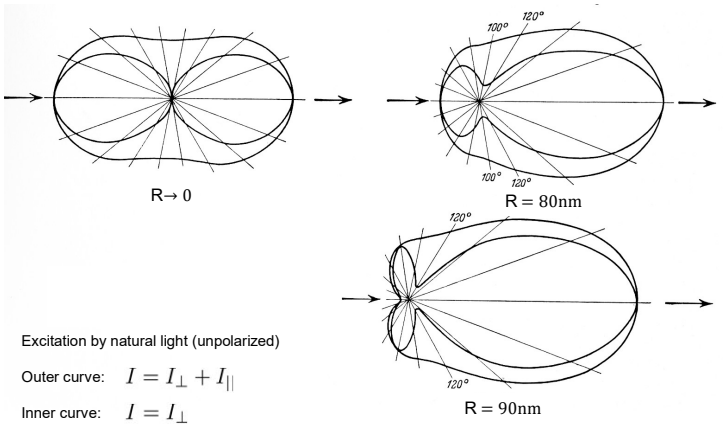
Mie scattering – partial waves

Multipole excitations. Resonances are at $\varepsilon_1(\omega) = -\varepsilon_2 \cdot \frac{l+1}{l}$; $l = 1,2,3...$



Born & Wolf, Principles of Optics

Radiation Pattern of a Au particle



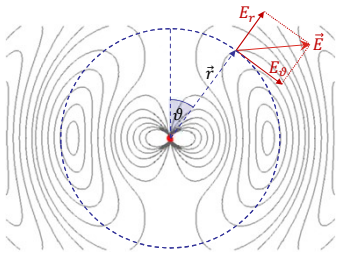
Excitation by natural light (unpolarized)

Outer curve: $I = I_\perp + I_{||}$

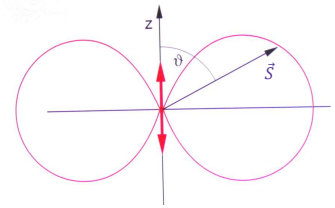
Inner curve: $I = I_\perp$

Born, Optik

Electric field



Emission to far-field (polar diagram)



Far- and Near-Field of a Point Dipole

Dipole moment

$$p(t) = p_0 \cos(\omega t)$$

Far-field

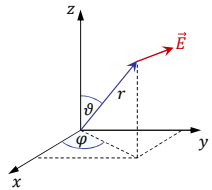
Near-field

creates time-dependent electric field (spherical coordinates!)

$$\vec{E}(r,\vartheta,\varphi,t) = \begin{pmatrix} E_r \\ E_\vartheta \\ E_\varphi \end{pmatrix} = \frac{p_0 k^3}{4\pi\varepsilon_0} \begin{pmatrix} \left(-\frac{2i}{(kr)^2} + \frac{2}{(kr)^3}\right)\cos\vartheta \\ \left(-\frac{1}{kr} - \frac{i}{(kr)^2} + \frac{1}{(kr)^3}\right)\sin\vartheta \\ 0 \end{pmatrix} \cos(kr - \omega t)$$

Emission to far-field

$$\langle|\vec{S}|\rangle = \frac{\omega^4 p_0^2}{32\pi^2\varepsilon_0 c^3}\frac{\sin^2\vartheta}{r^2}$$



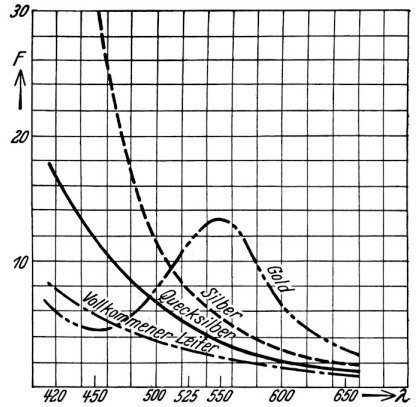
Near-fields

Comparison of far- and near-fields:

$$\left|\frac{E_{Nearfield}}{E_{Farfield}}\right|^2 \sim \left|\frac{kr}{(kr)^3}\right|^2 \sim \frac{1}{(kr)^4} \sim \left(\frac{\lambda}{r}\right)^4$$

The intensity in the near-field ($kr \ll 1 \Rightarrow r \ll \lambda$) of an antenna (or, e.g., a molecule) is very large as compared to the far-field!

Total scattering cross section



Translation

Gold = Gold

Silber = Silver

Quecksilber = Mercury

Vollkommener Leiter = Ideal Conductor

Born, Optik