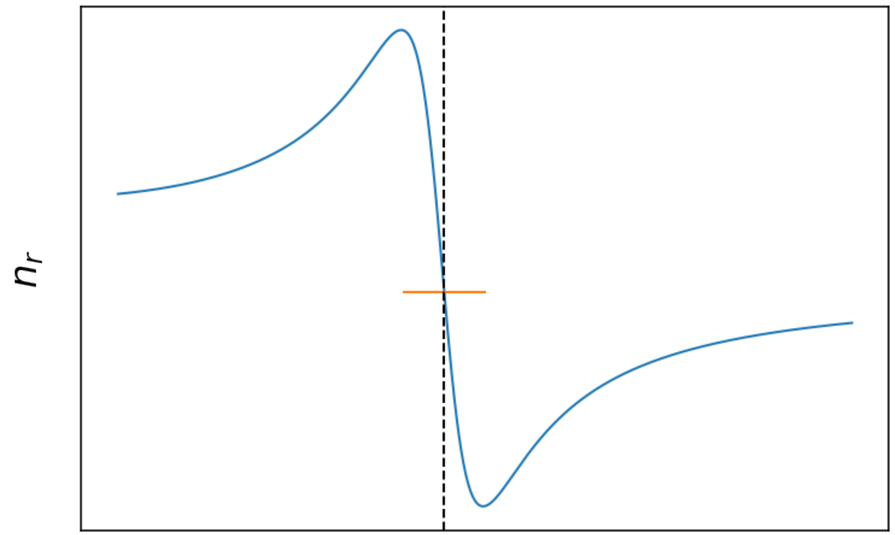
Experimental Physics 3 - Em-Waves,Optics, Quantum mechanics

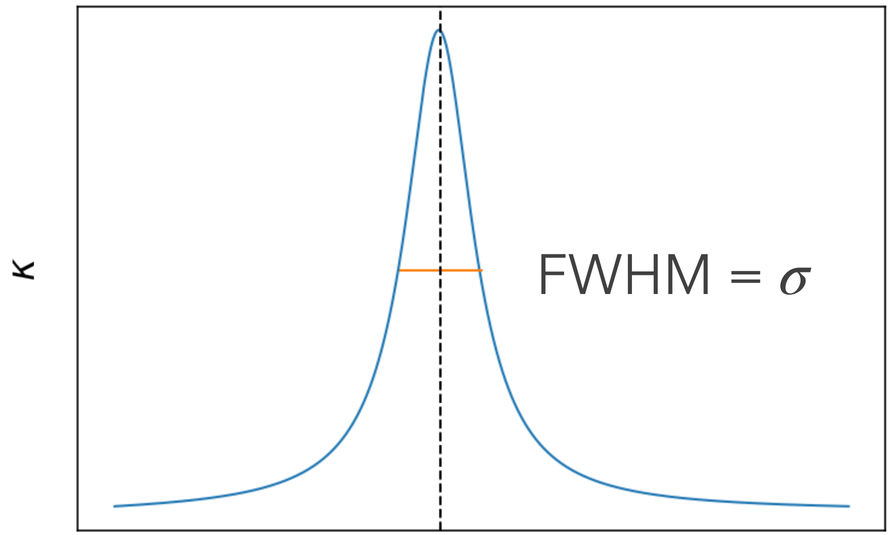
Lecture 14

Prof. Dr. Frank Cichos
WS 2022/23

Electric fields in Materials

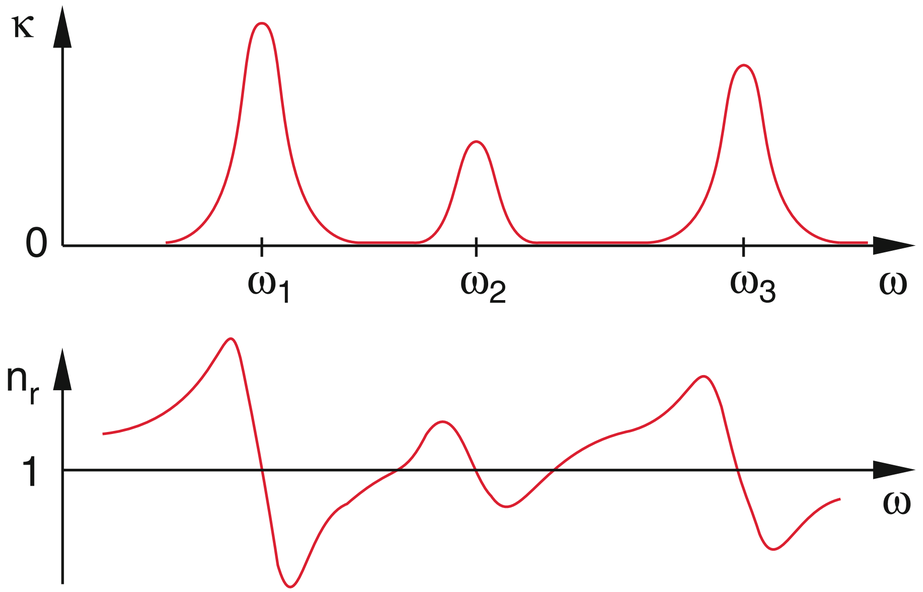
Dispersion and Absorption

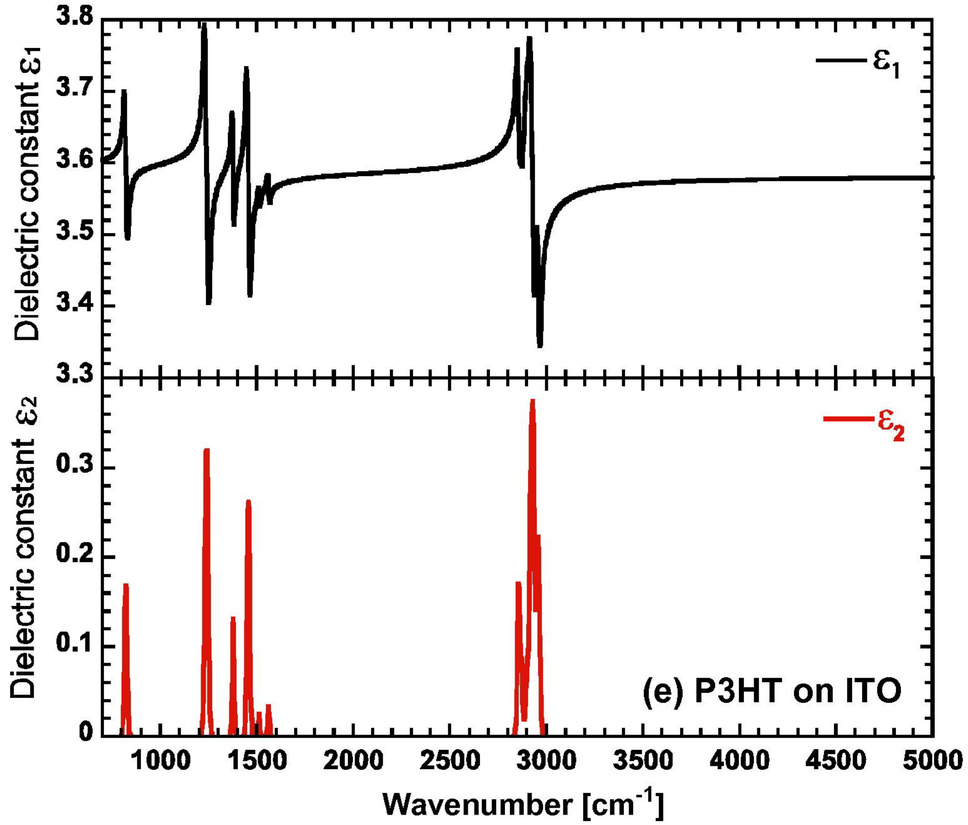




$$n = 1 + \frac{Nq^2}{2\epsilon_0 m} \cdot \frac{\left(\omega_0^2 - \omega^2\right) - i\sigma\omega}{\left(\omega_0^2 - \omega^2\right)^2 + \sigma^2\omega^2} = n_r - i\kappa$$

Dispersion and Absorption

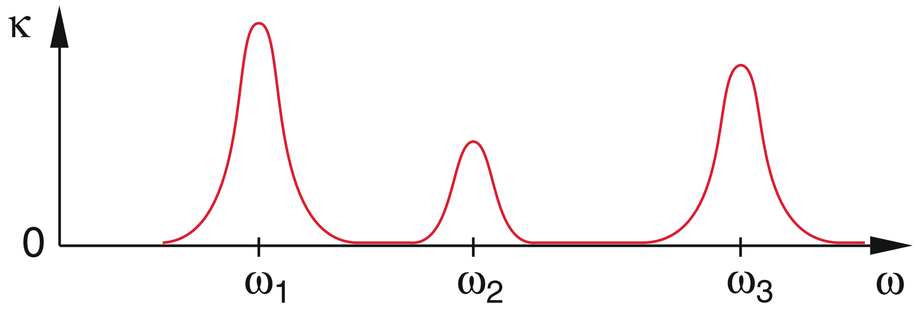




(c) Demtröder: Electrodynamics and Optics

Tamanai et al., Display 34 (2013) 399-405

Dispersion and Absorption - Absorption

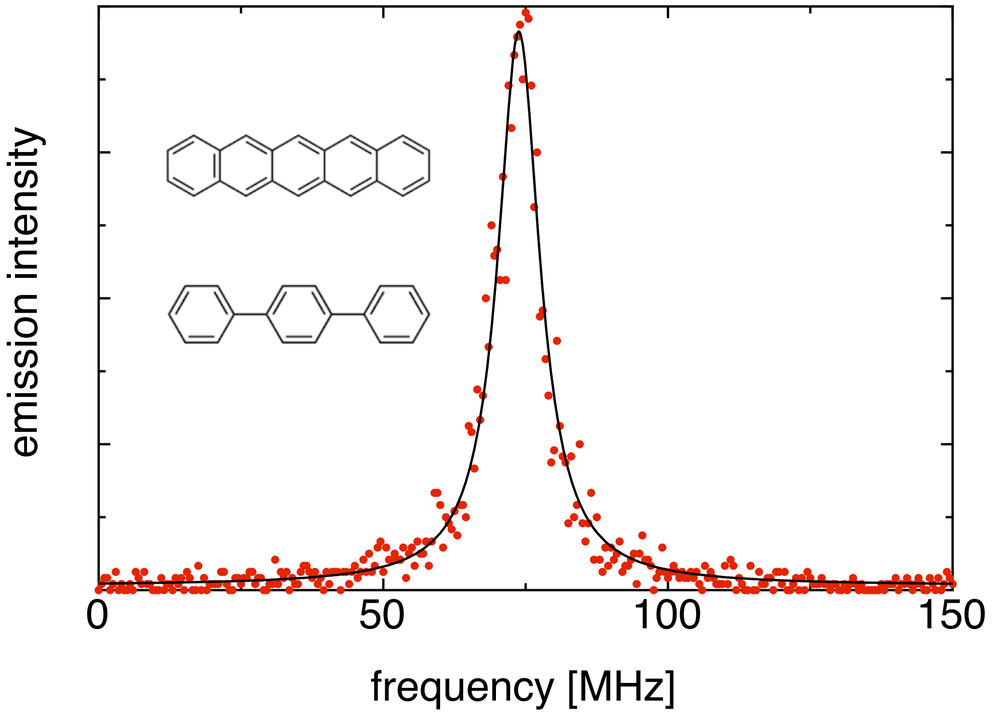


Intensity:

$$I = \epsilon_0 c \, |E_0 \, \mathrm{e}^{-i n_r k_0 z} \, \mathrm{e}^{-\kappa k_0 z}|^2$$
$$= I_0 \mathrm{e}^{-2\kappa k_0 z}$$
$$= I_0 \mathrm{e}^{-\alpha z}$$

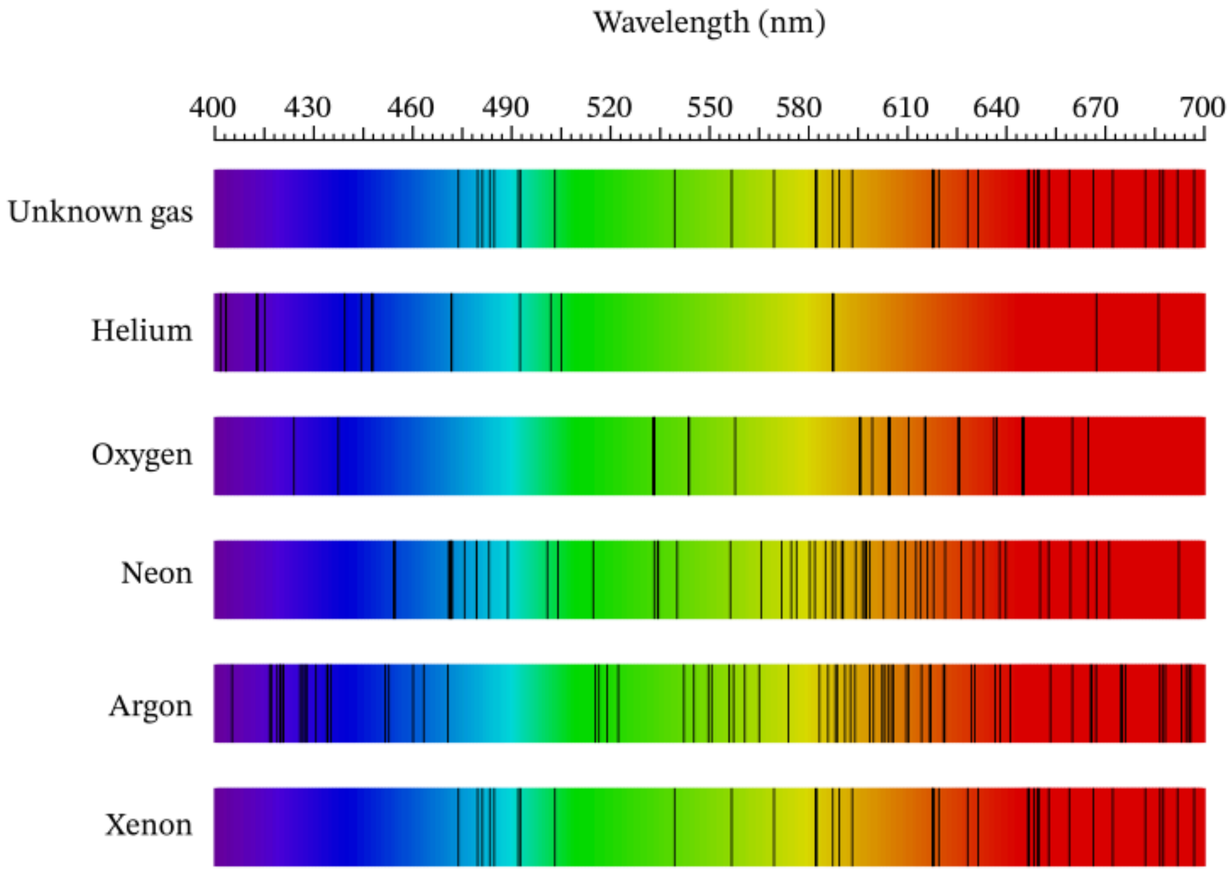
- Absorption coefficient $\alpha(\omega) = 2\kappa(\omega) k_0$
- Lambert-Beer law

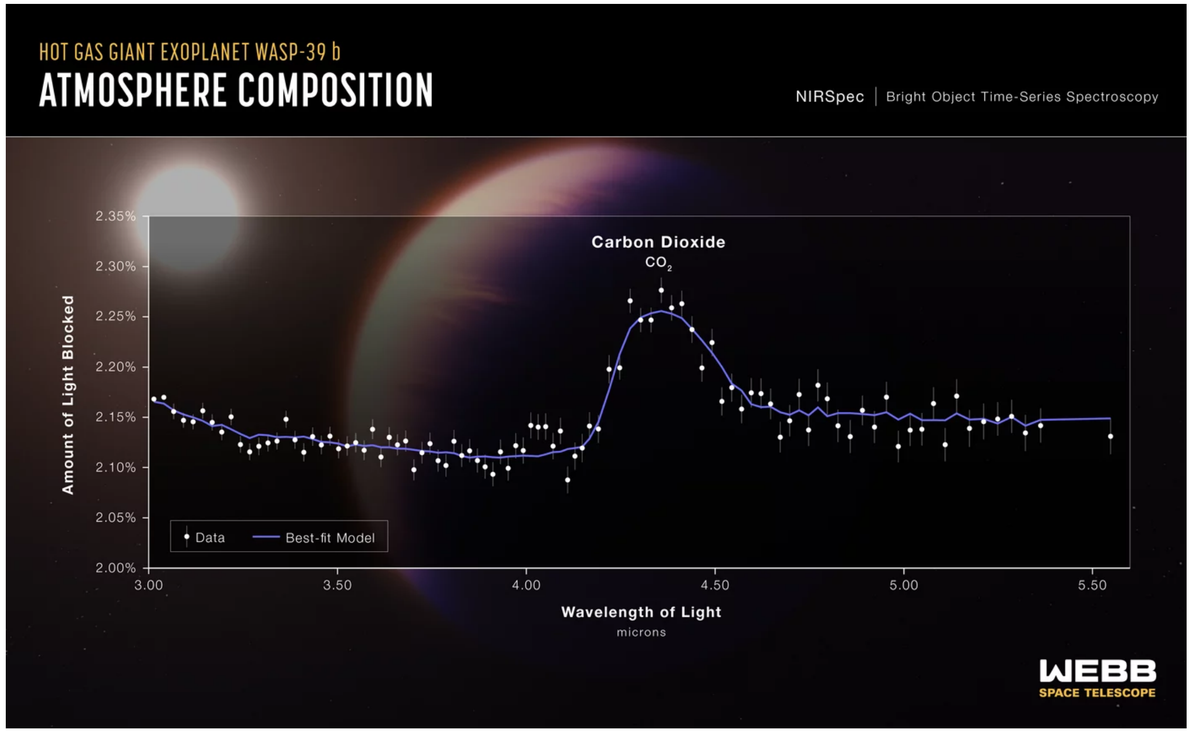
Dispersion and Absorption - Single Molecule Absorption Line



Excitation spectrum single pentacene molecule
in p-terphenyl ($T = 1.8\mathrm{K}$)

Dispersion and Absorption - Absorption Spectra





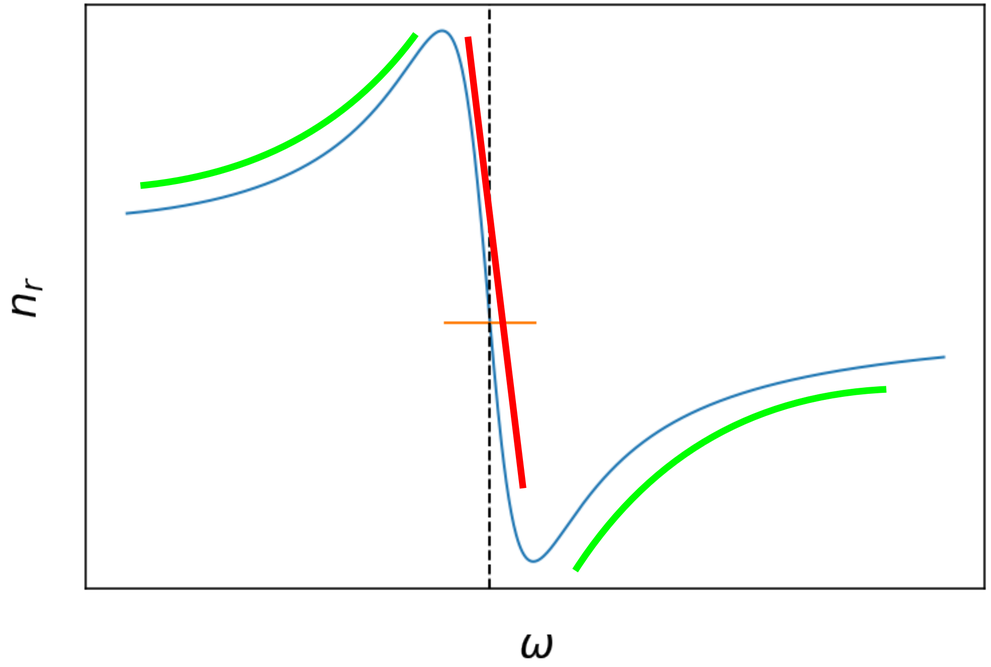
Proof of carbon dioxide in exoplanet WASP-39 b's atmosphere (James Webb space telescope, Press release: https://www.mpg.de/19114683/0822-astr-jwst-co2-exoplanet-150980-x)

Dispersion and Absorption - Group Velocity and Dispersion

$$v_g = \frac{\mathrm{d}\omega}{\mathrm{d}k} = \frac{c}{n_r + \omega \frac{\mathrm{d}n_r}{\mathrm{d}\omega}}$$

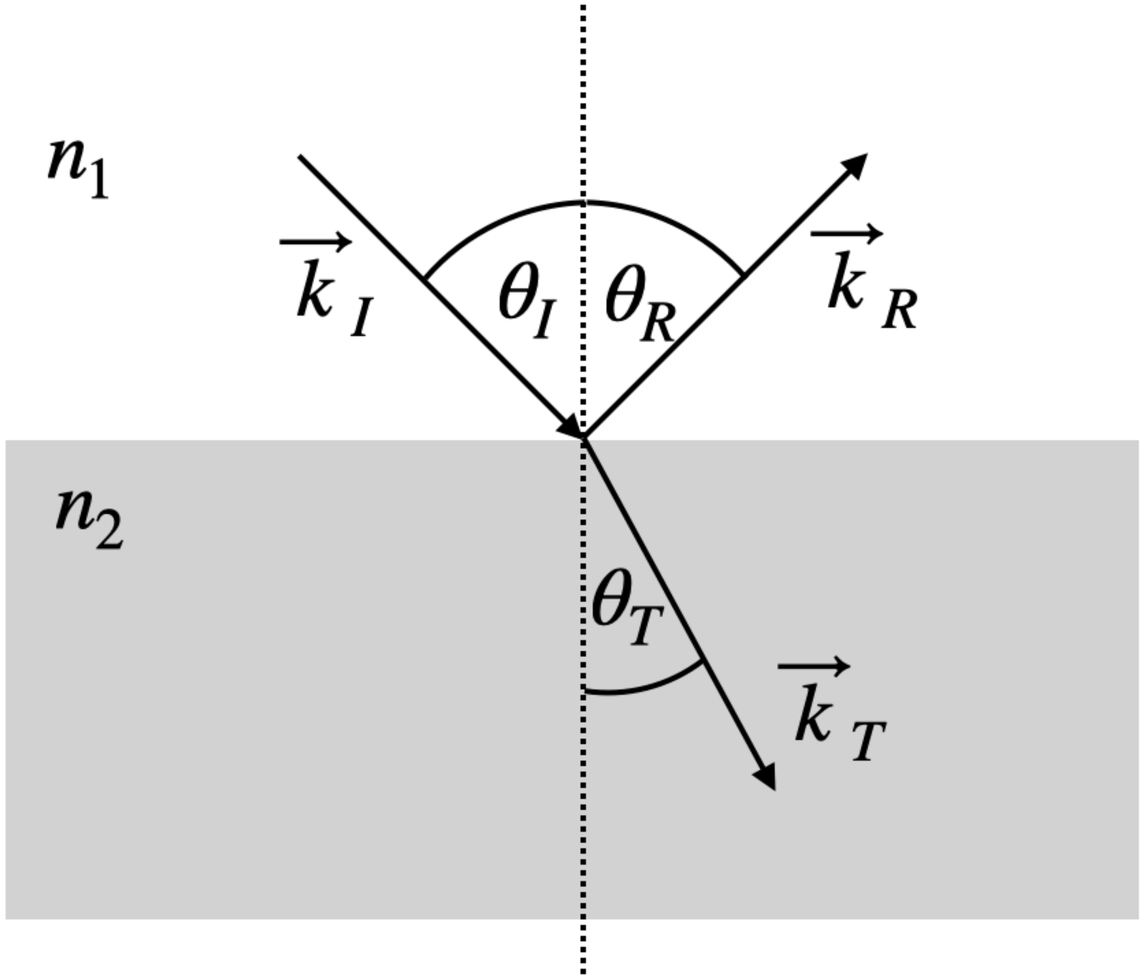
$\frac{\mathrm{d}n_r}{\mathrm{d}\omega} > 0$ normal dispersion –

$\frac{\mathrm{d}n_r}{\mathrm{d}\omega} < 0$ anomalous dispersion –



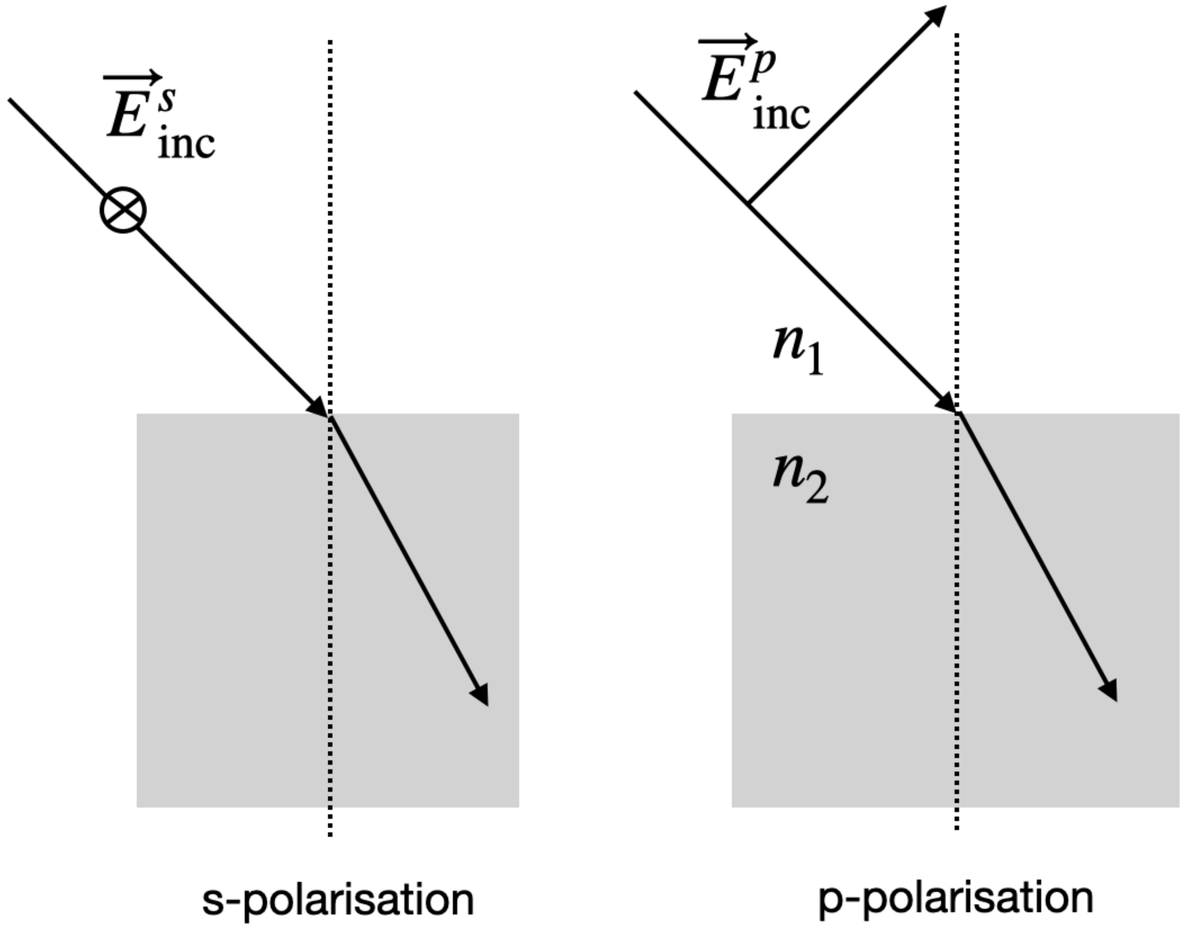
Institute of Sound and Vibration Research,
University of Southampton,
https://resource.isvr.soton.ac.uk/spcg/tutorial/tutorial/Tutorial_files/Web-further-dispersive.htm

Fresnel Equations - Geometry

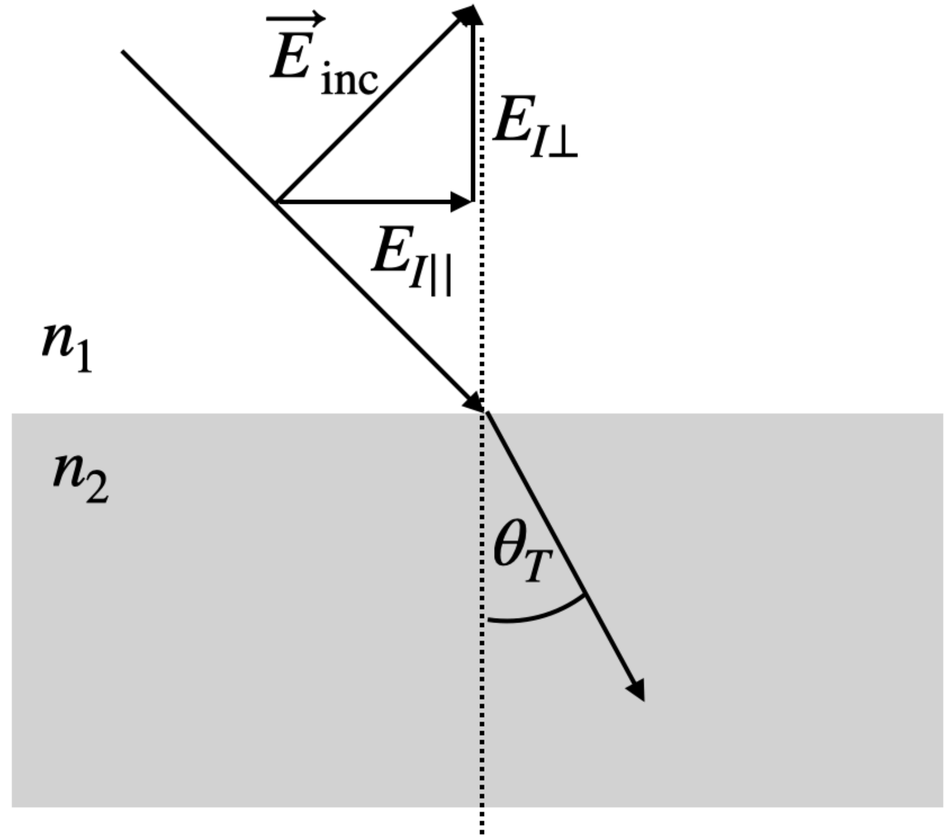


Fresnel Equations - Polarization

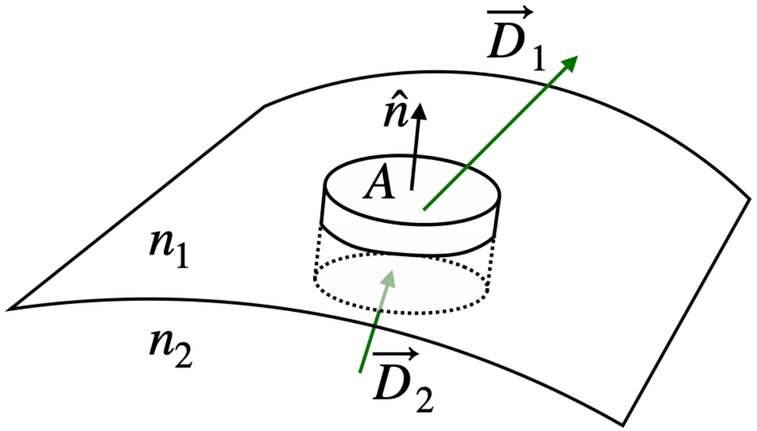
Polarization

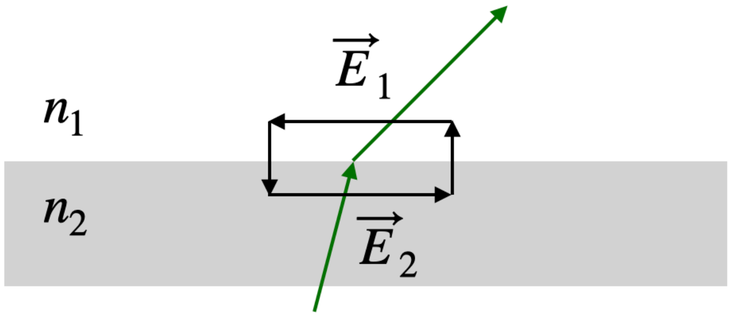


Decomposition of p-pol. light



Fresnel Equations - Boundary Conditions



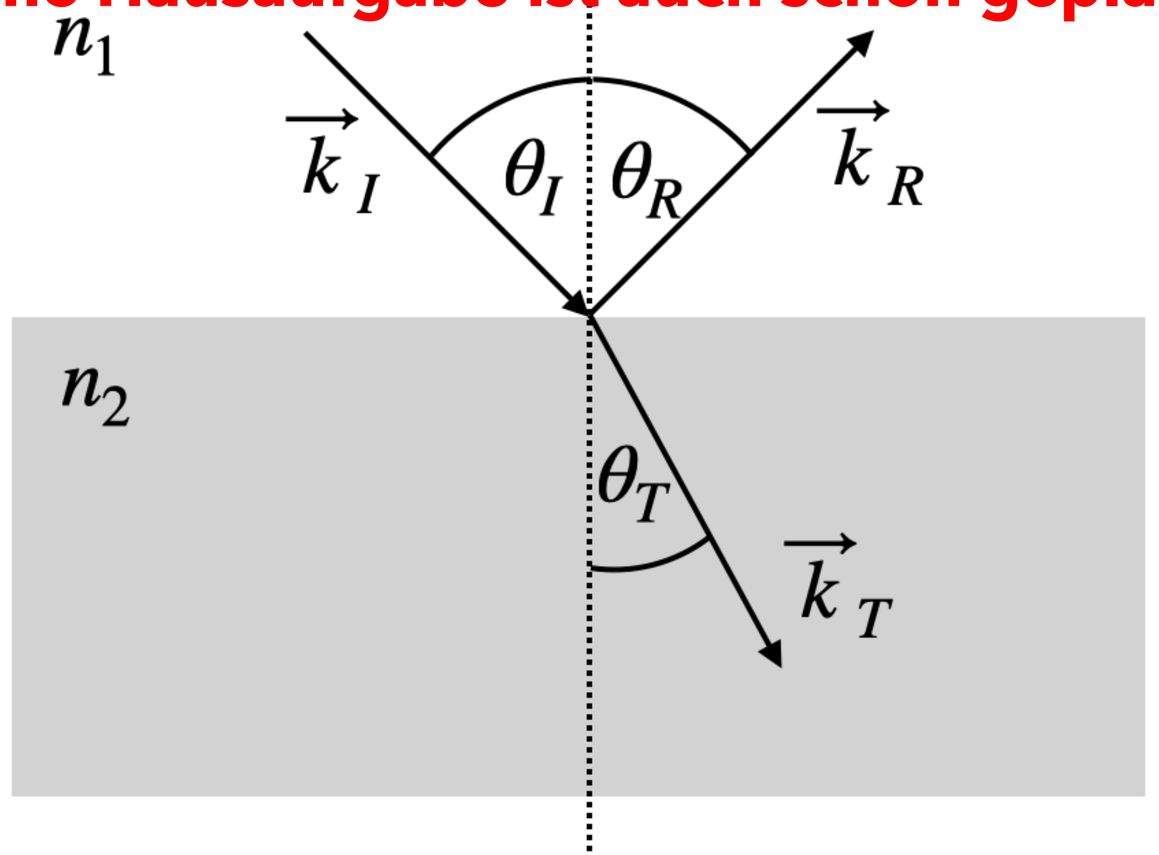


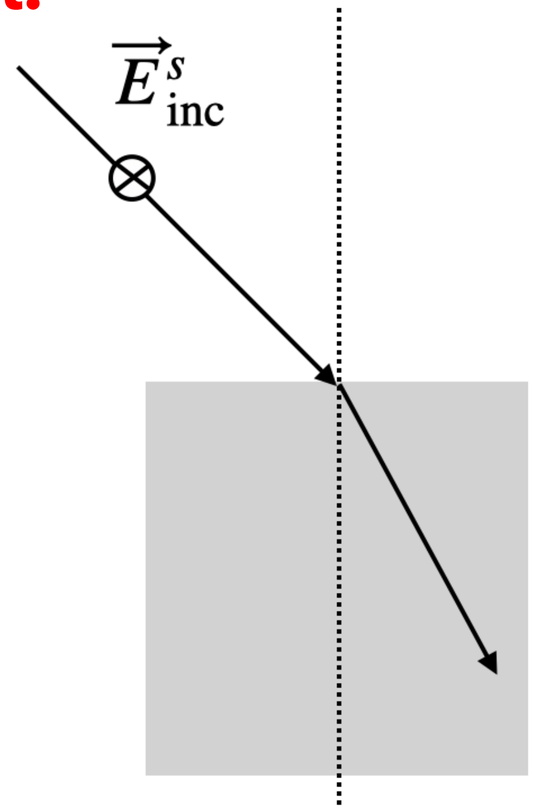
$$D_{1,\perp} = D_{2,\perp}$$
$$B_{1,\perp} = B_{2,\perp}$$

$$E_{1,\parallel} = D_{2,\parallel}$$
$$H_{1,\parallel} = H_{2,\parallel}$$

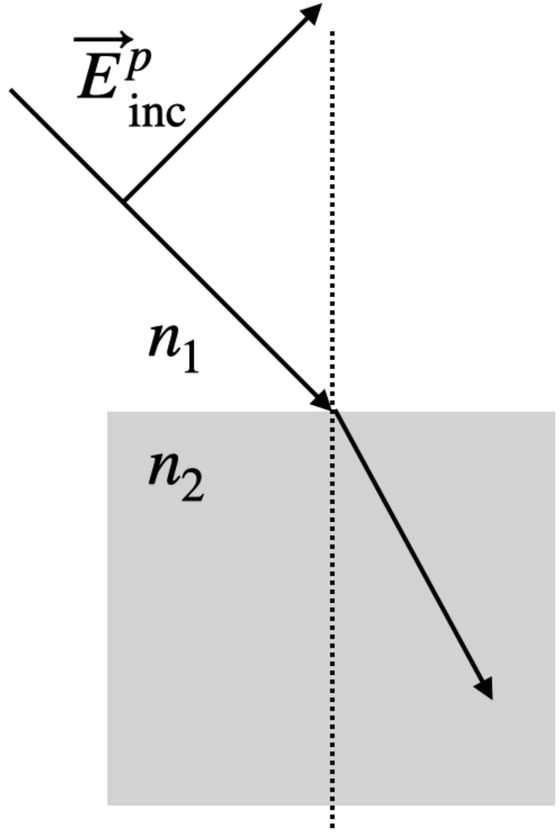
Fresnel Equations - Geometry and Polarization

Das war die letzte Folie. Fresnel-Gln. (r_s, t_s, r_p, t_p) sind hergeleitet und eingeführt.
Die Diskussion der einzelnen Übergänge (Luft-Glas etc.) ist nicht angefangen.
Eine Hausaufgabe ist auch schon geplant.





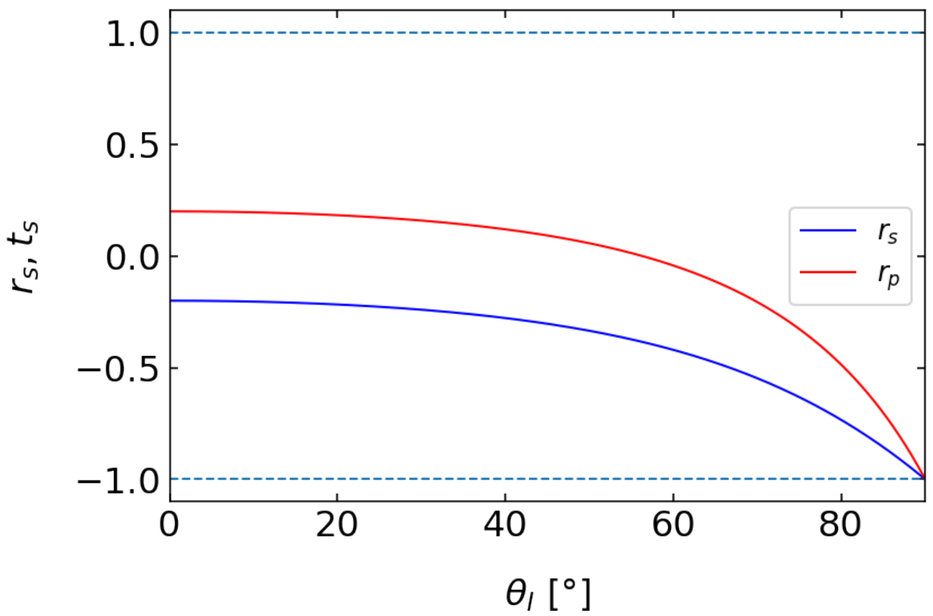
s-polarisation

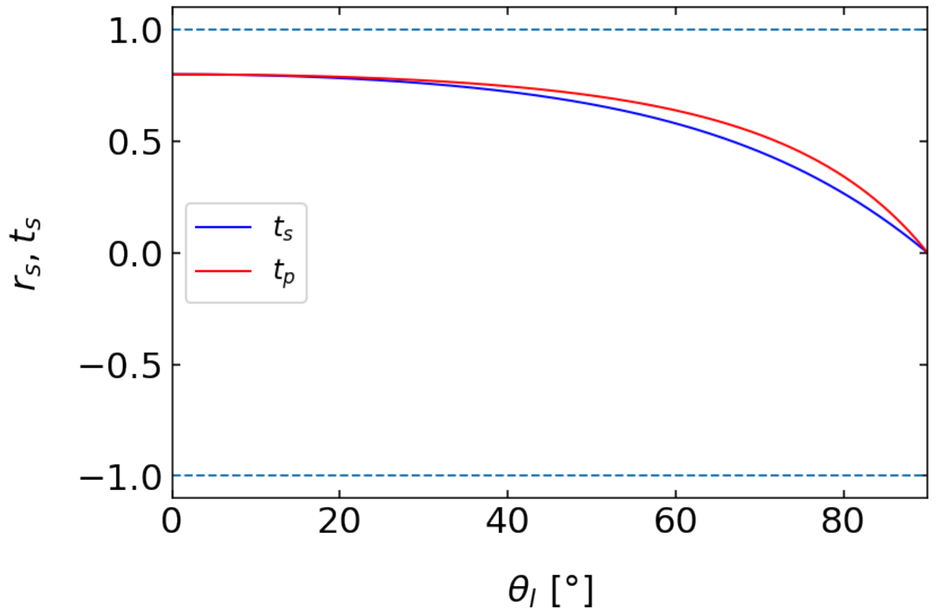


p-polarisation

Fresnel Equations

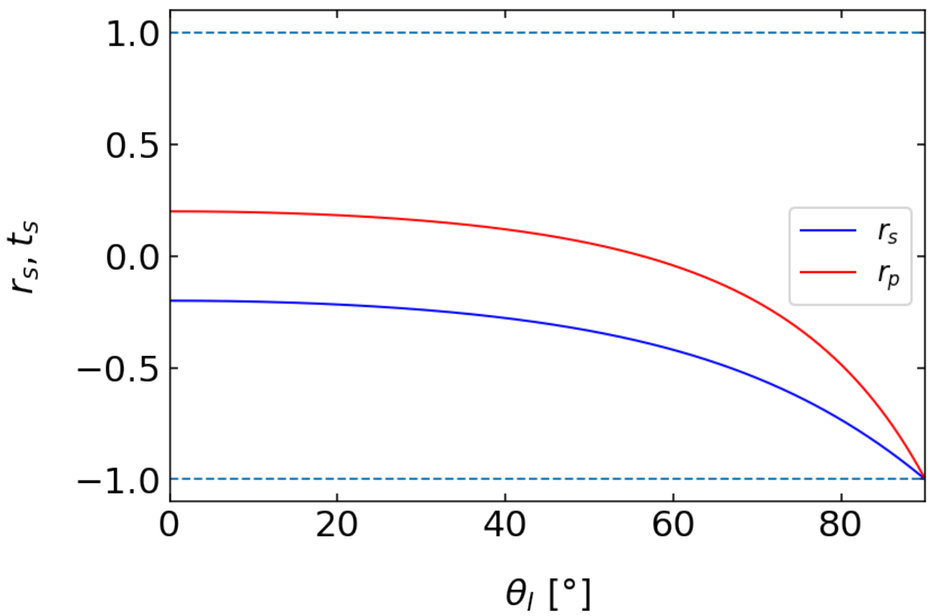
Air to Glass

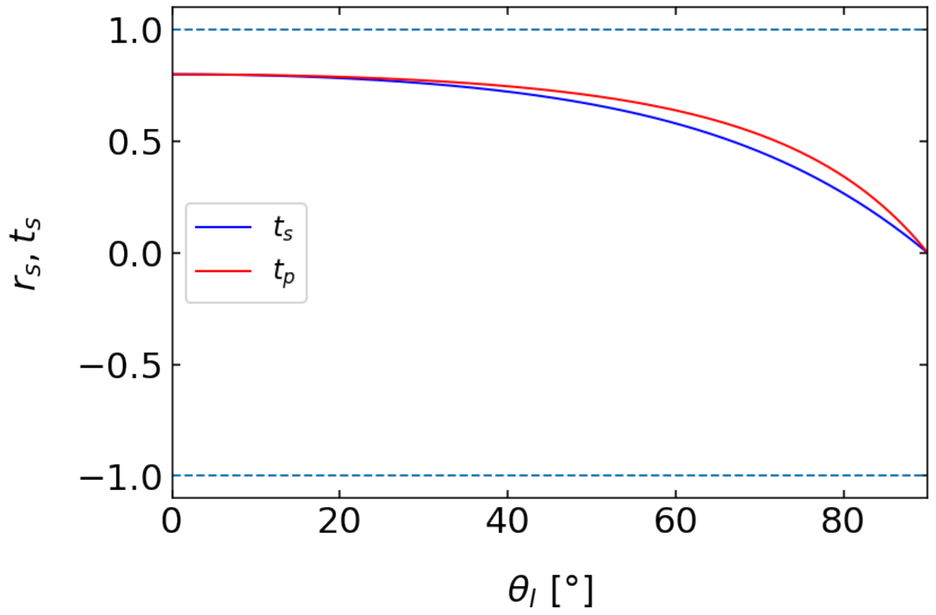




Fresnel Equations

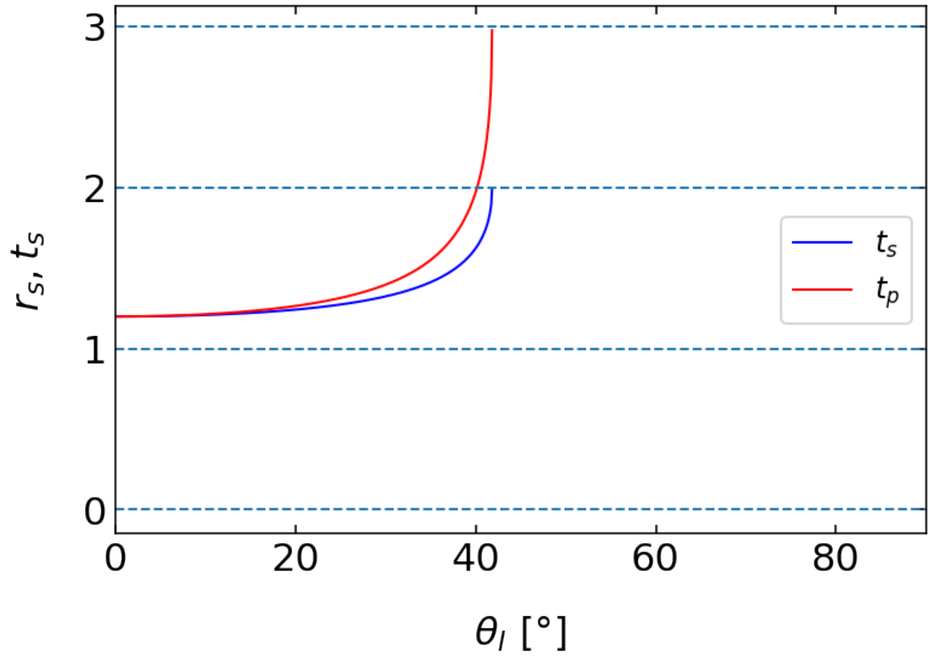
Air to Glass

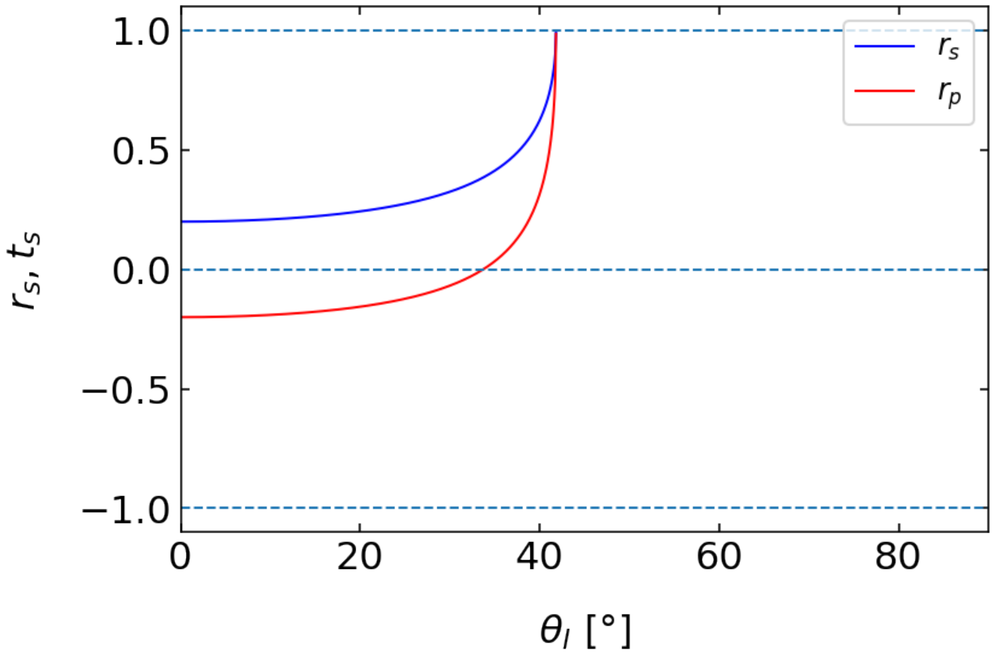




Fresnel Equations

Glass to Air





Experiment Fresnel Equations