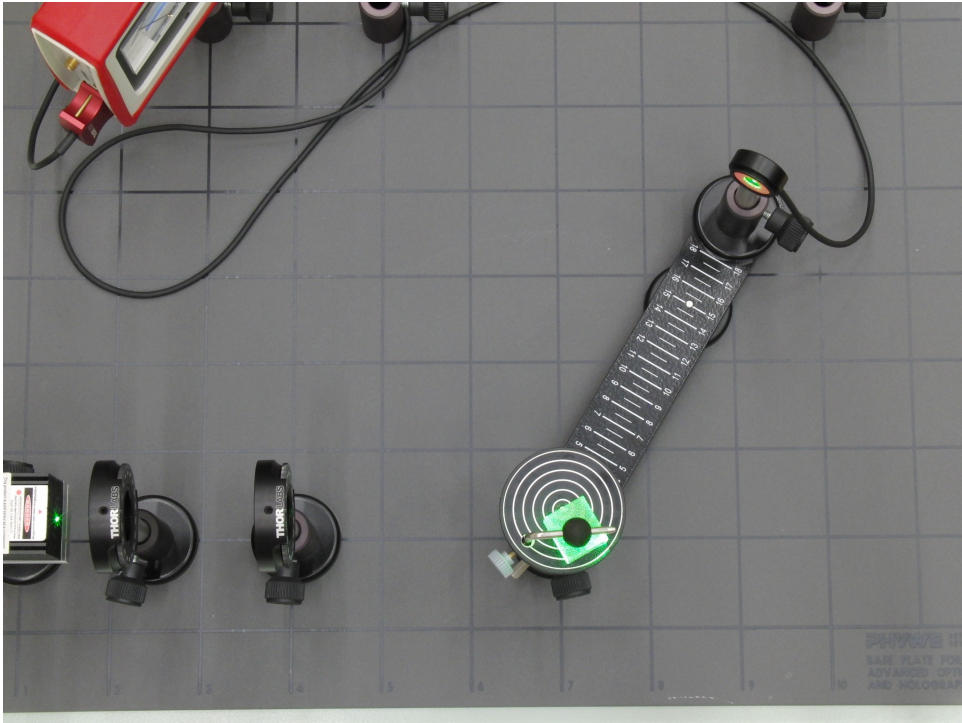
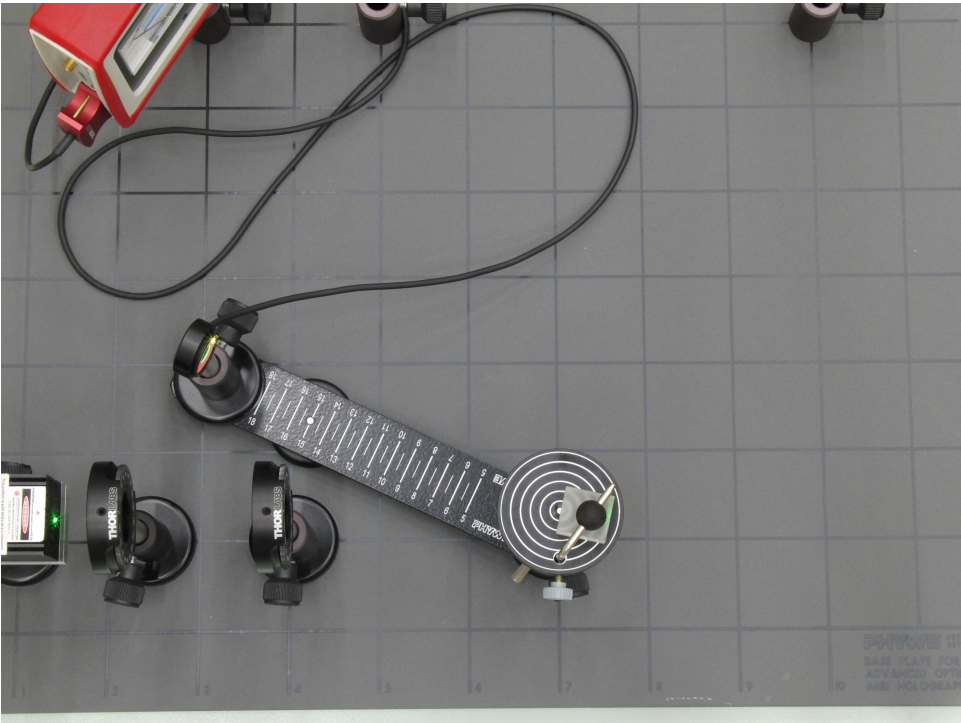


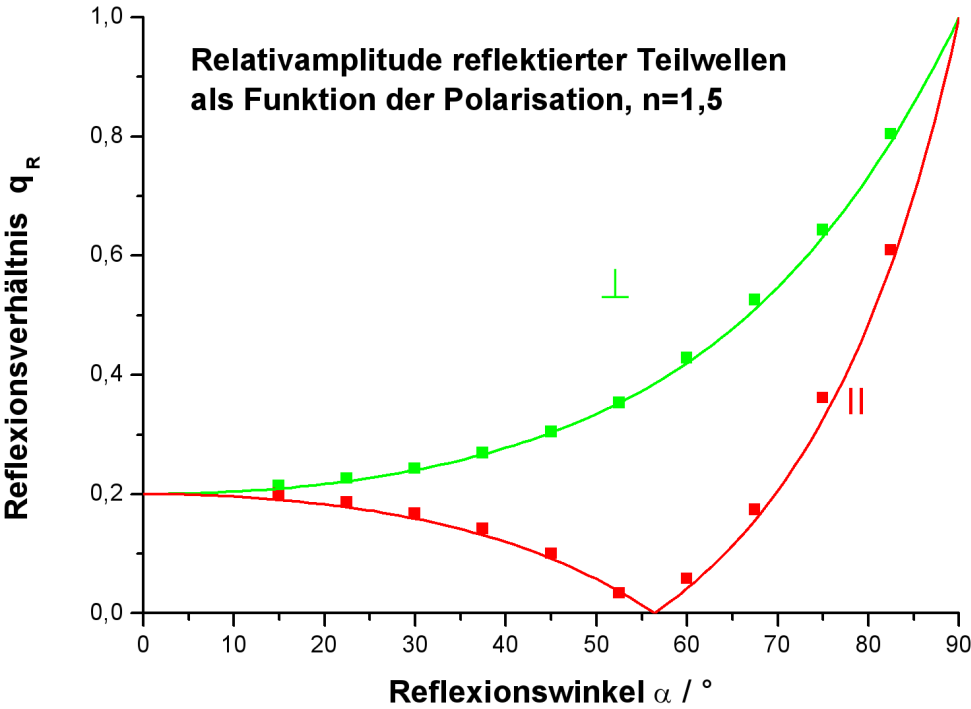
Experimental Physics 3 - Em-Waves, Optics, Quantum mechanics

Lecture 19

Experiment Fresnel Equations

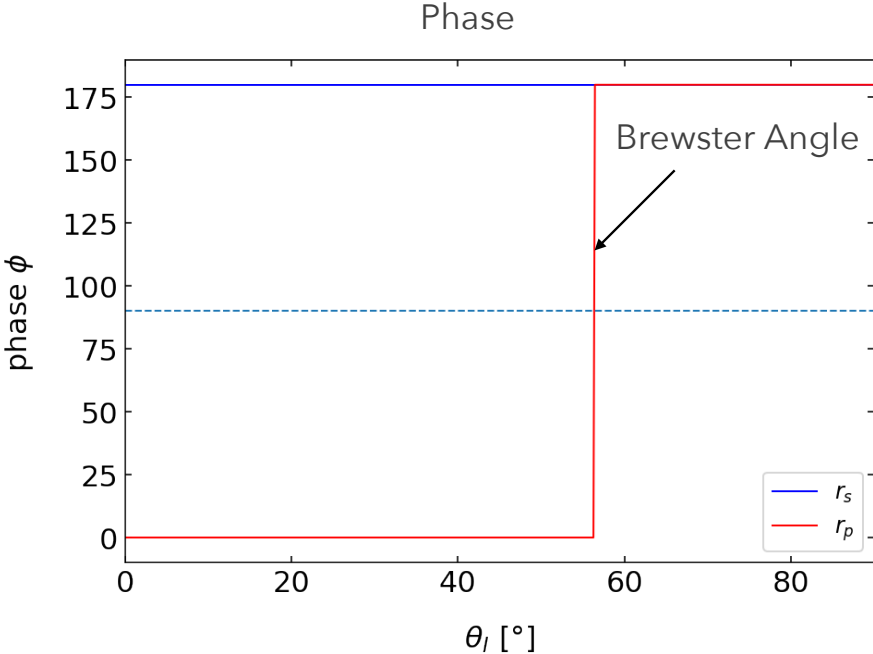
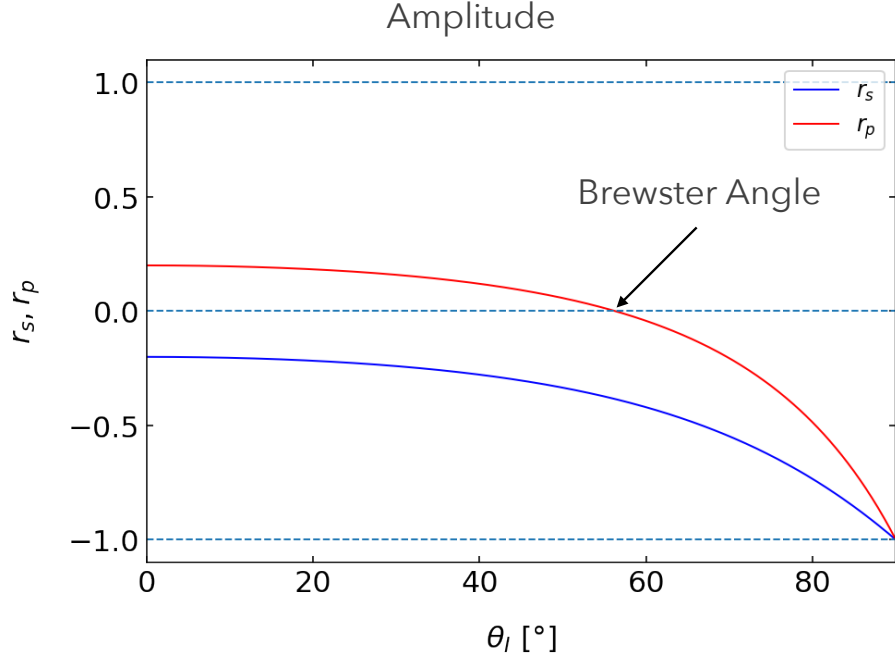


Experiment Fresnel Equations



Fresnel Equations - Reflection

Air to Glass



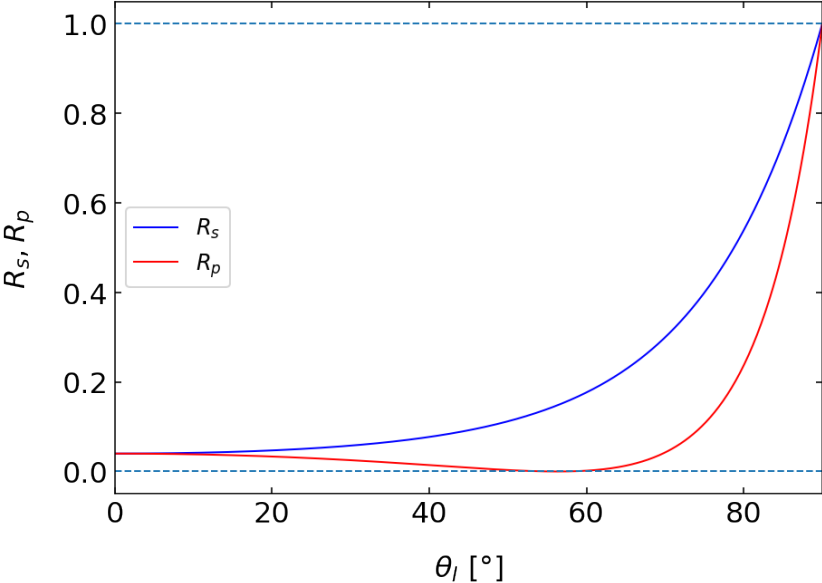
Brewster Angle



Fresnel Equations - Reflection

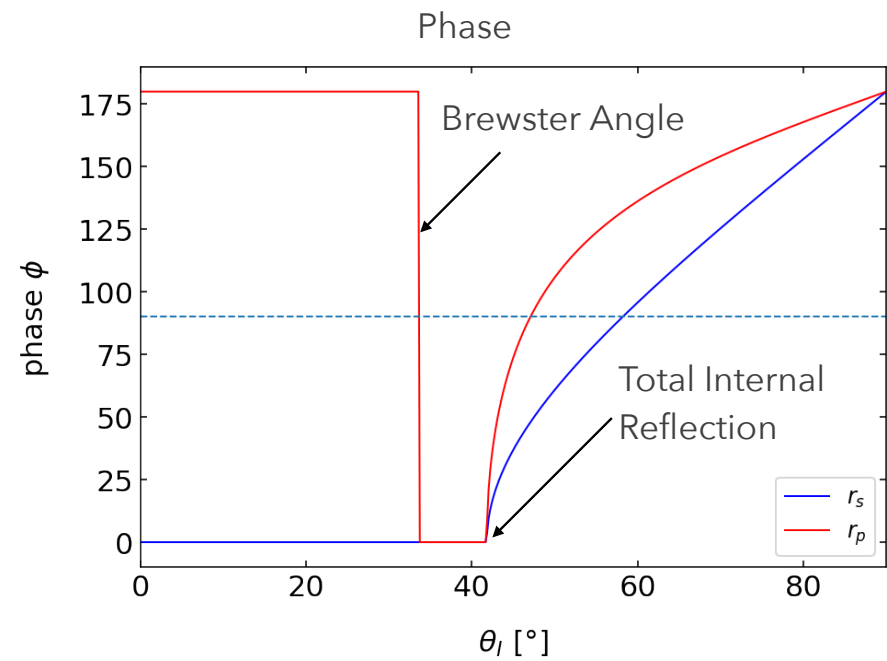
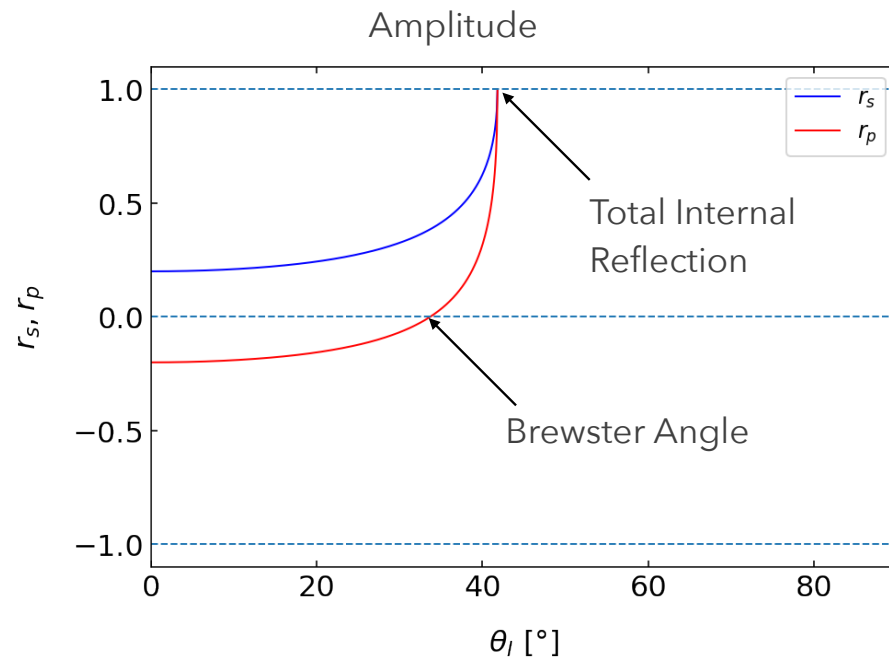
Air to Glass

$$R_i = |r_i|^2$$



Fresnel Equations - Reflection

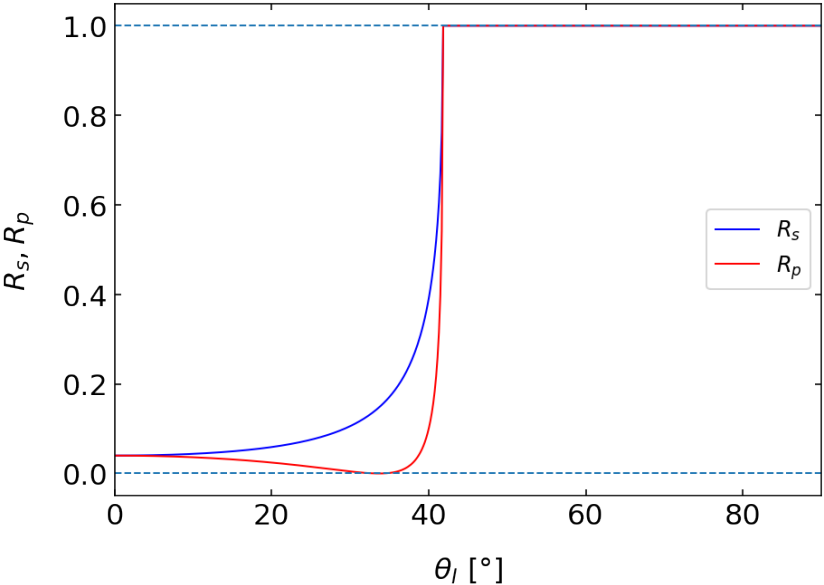
Glass to Air



Fresnel Equations - Reflection

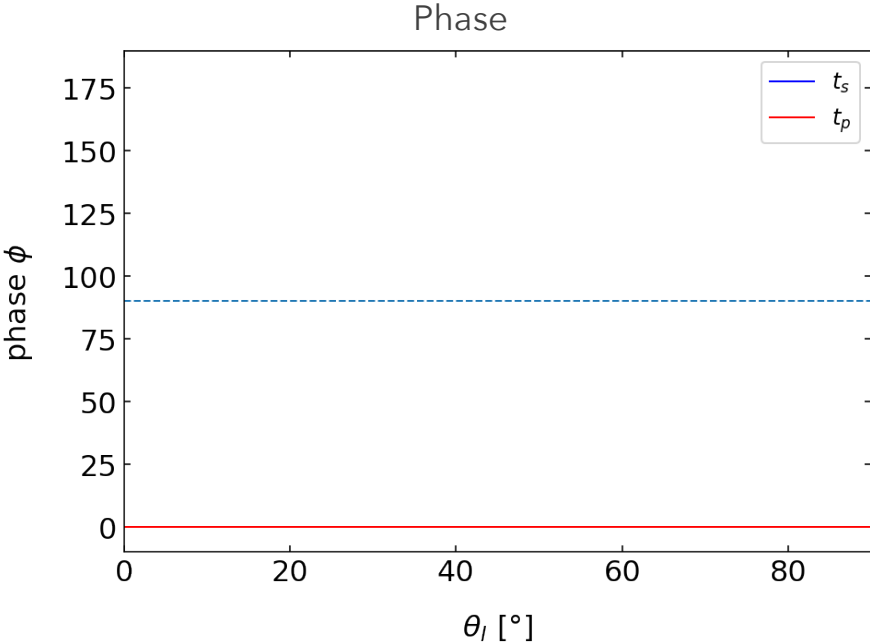
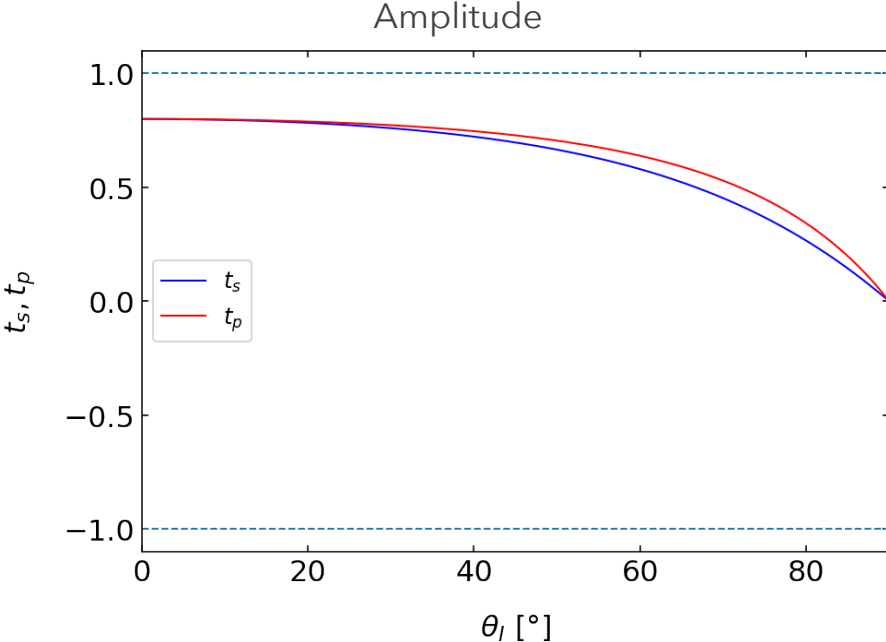
$$R_i = |r_i|^2$$

Glass to Air



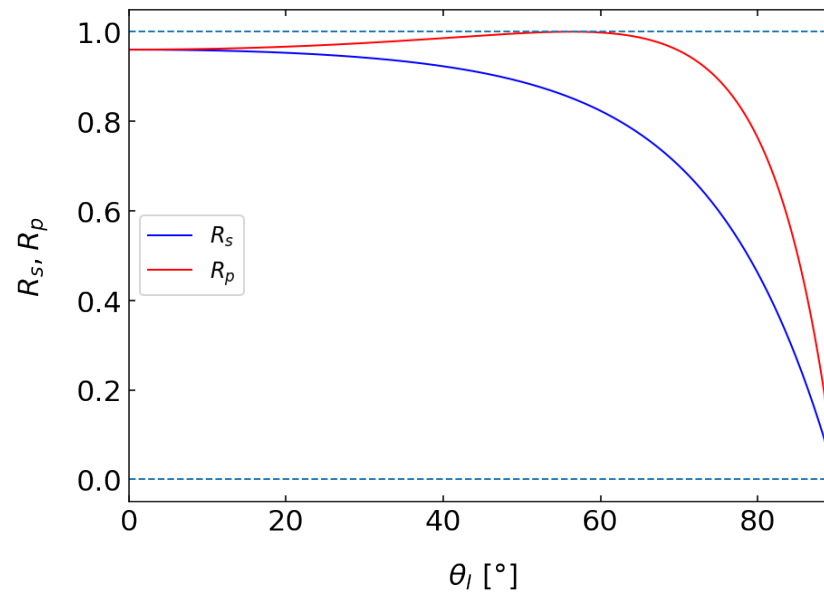
Fresnel Equations - Transmission

Air to Glass



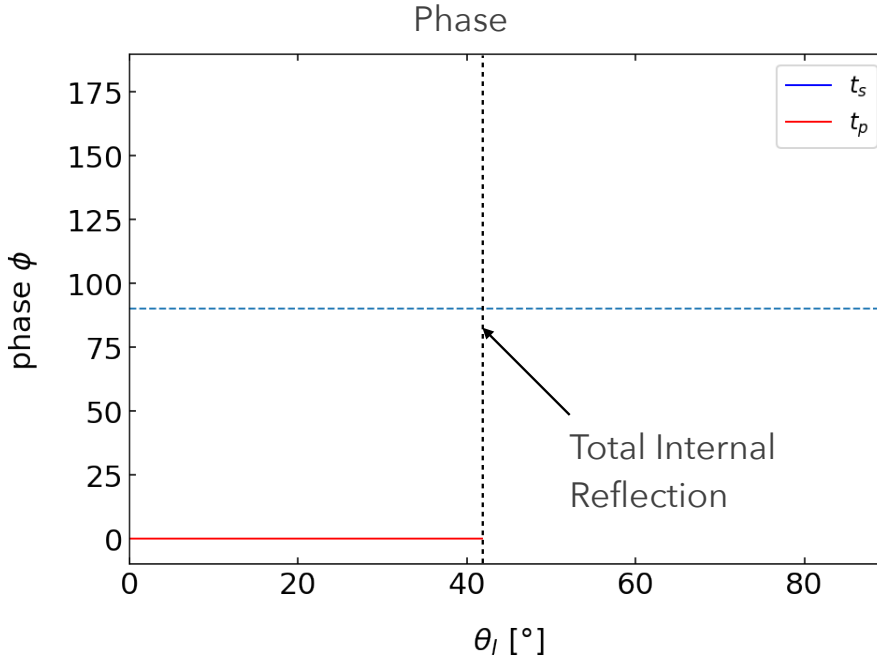
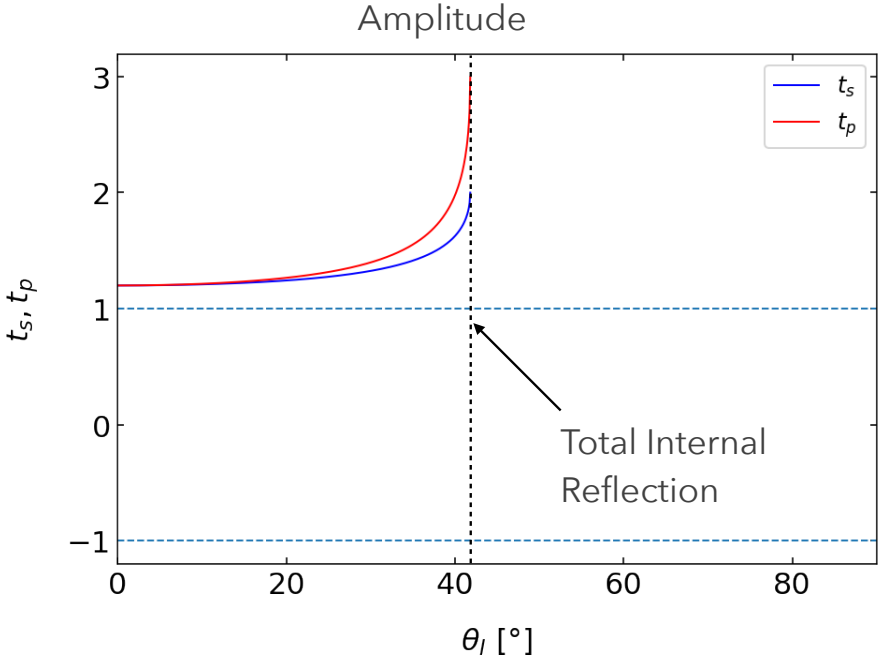
$$T_i = \frac{n_2 \cos(\theta_T)}{n_1 \cos(\theta_I)} |t_i|^2$$

Air to Glass



Fresnel Equation - Transmission

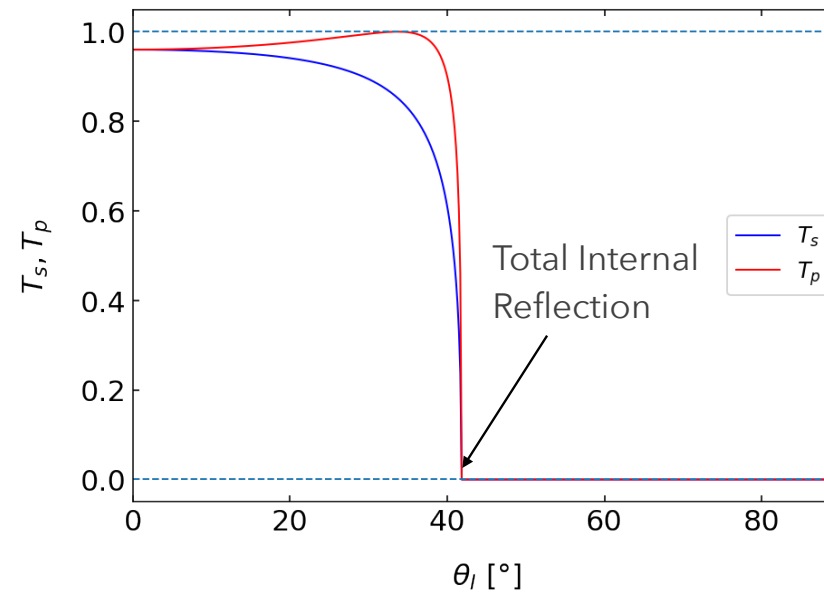
Glass to Air

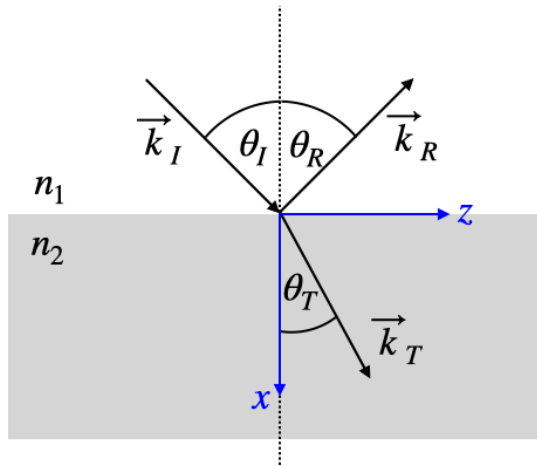


Fresnel Equation - Transmission

$$T_i = \frac{n_2 \cos(\theta_T)}{n_1 \cos(\theta_I)} |t_i|^2$$

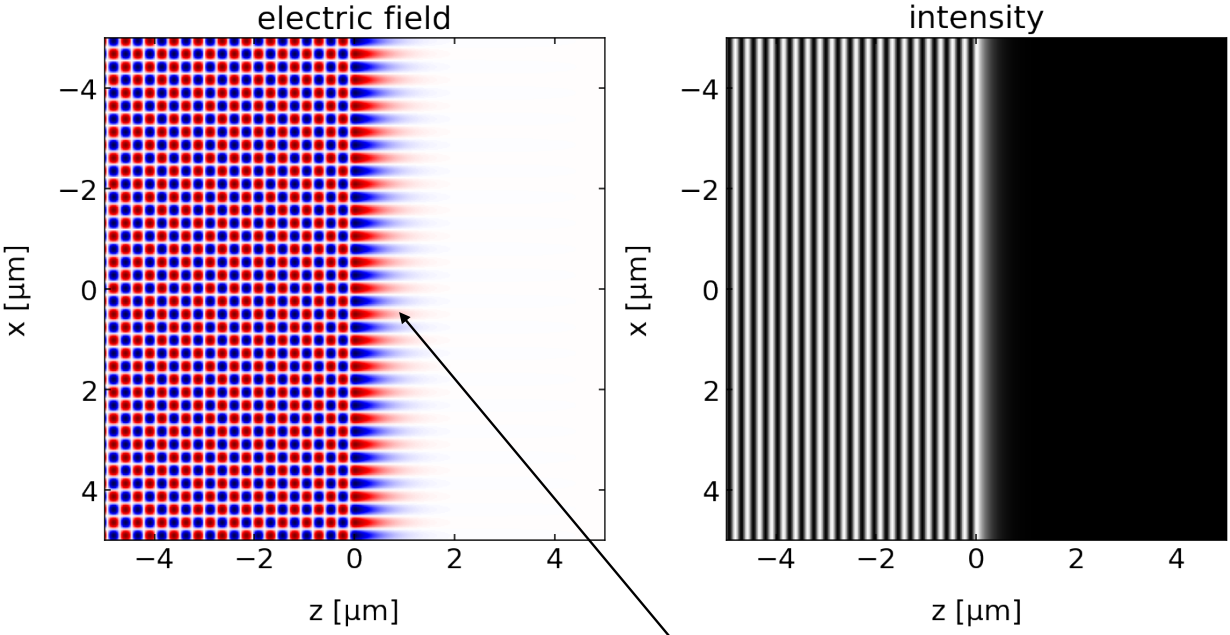
Glass to Air



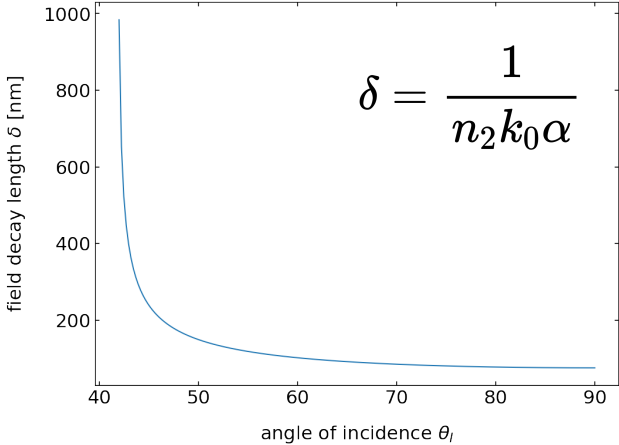


$$\vec{E}_{\text{trans}} = \vec{E}_T e^{i(\omega t - n_1 k_0 \sin(\theta_I) z)} e^{-n_2 k_0 \alpha x}$$

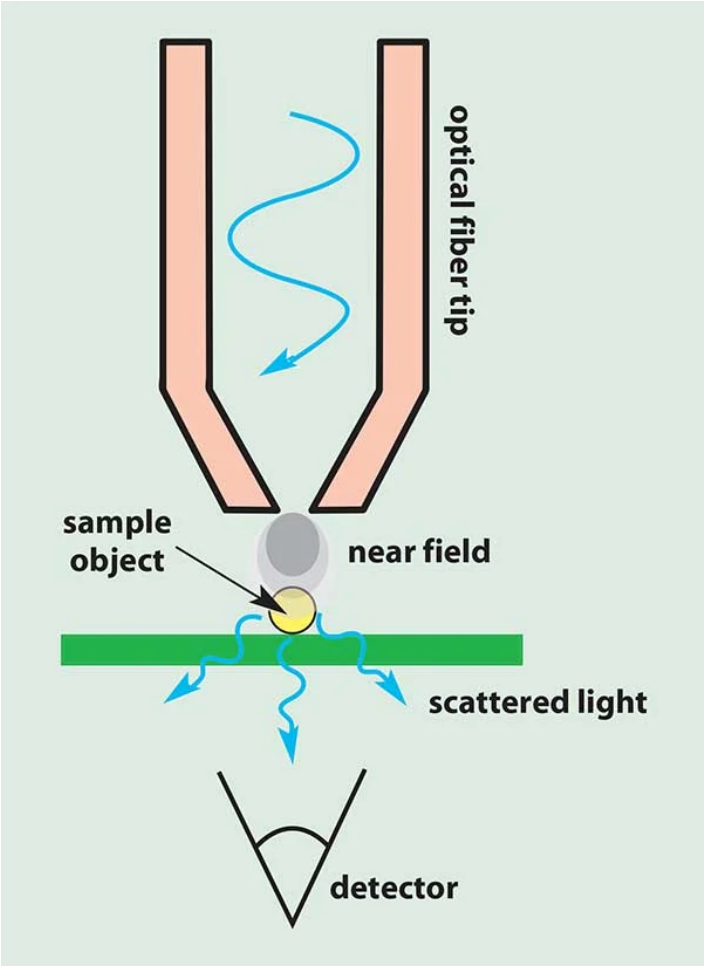
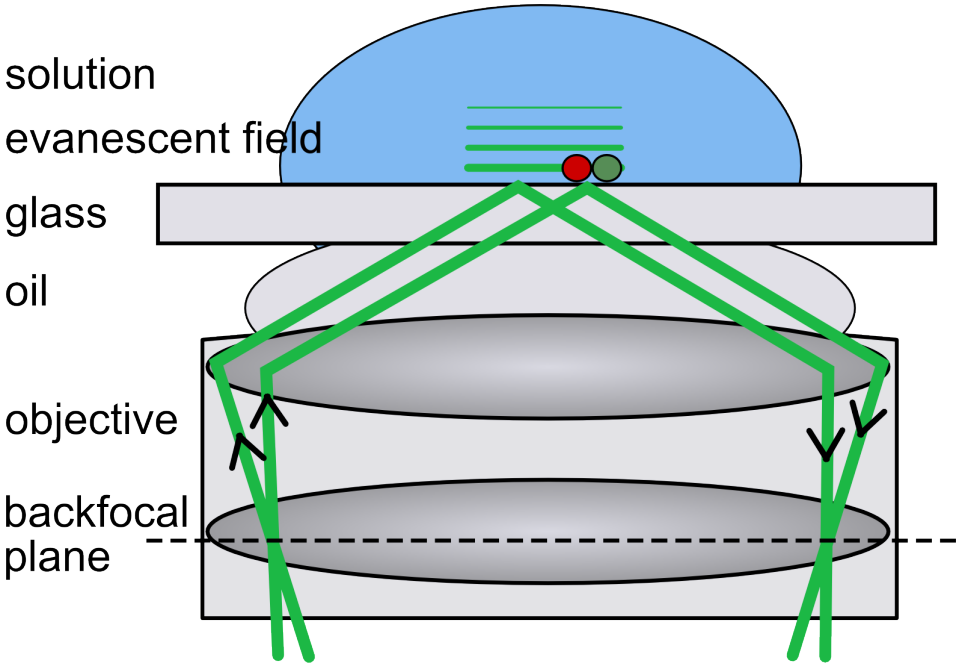
Total Internal Reflection



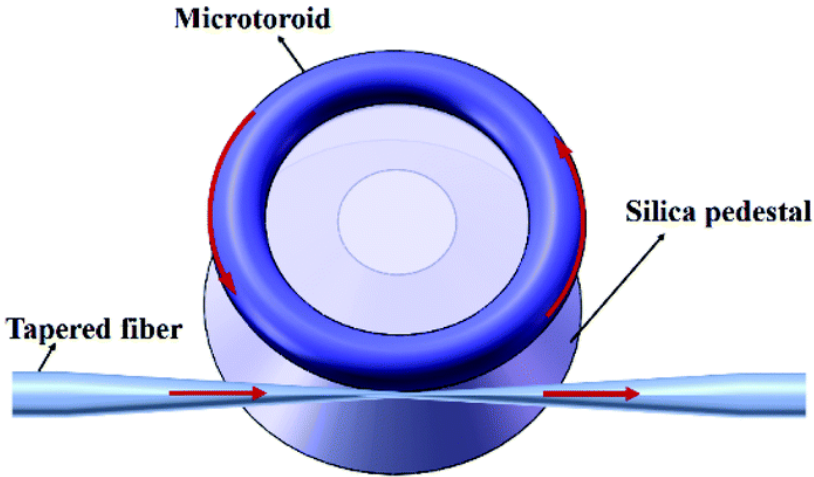
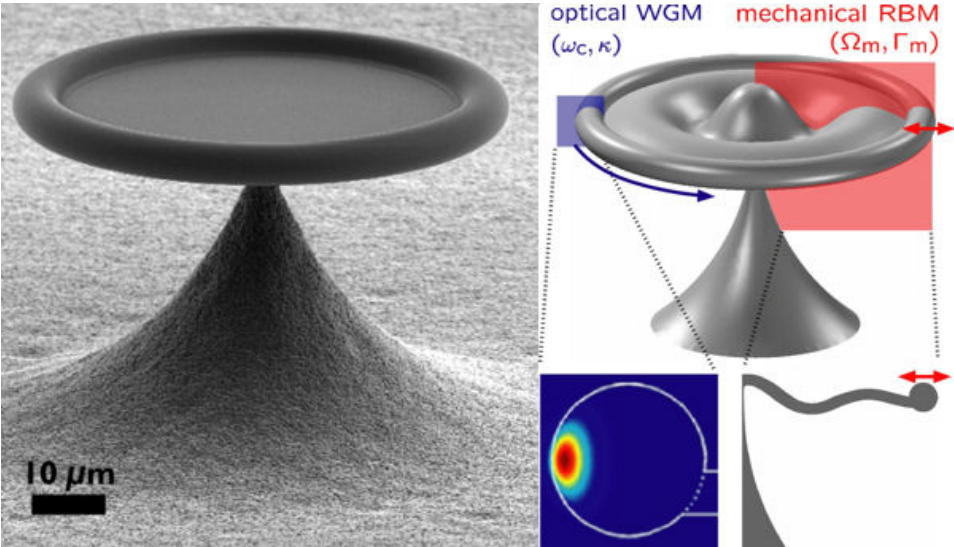
Evanescent wave



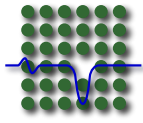
TIRF/NSOM Microscopy



Optomechanical Cooling and Sensing



Anisotropic Materials



optical anisotropy

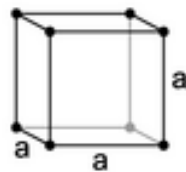
optical anisotropy is related to crystal structure

Symmetry	Lattice	$\overline{\chi}$	Indices of Refraction
Isotropic	Cubic	$\begin{pmatrix} a & 0 & 0 \\ 0 & a & 0 \\ 0 & 0 & a \end{pmatrix}$	$n = \sqrt{1+a}$
Uniaxial	Triagonal Tetragonal Hexagonal	$\begin{pmatrix} a & 0 & 0 \\ 0 & a & 0 \\ 0 & 0 & b \end{pmatrix}$	$n_O = \sqrt{1+a}$ $n_E = \sqrt{1+b}$
Biaxial	Triclinic Monoclinic Orthorhombic	$\begin{pmatrix} a & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & c \end{pmatrix}$	$n_1 = \sqrt{1+a}$ $n_2 = \sqrt{1+b}$ $n_3 = \sqrt{1+c}$

diamond

Calcit

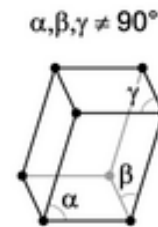
MICA



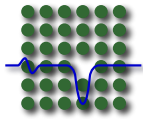
cubic



hexagonal



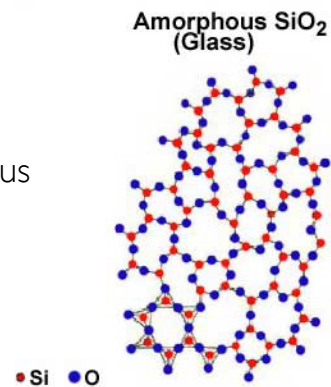
triclinic



Material structure - optical properties

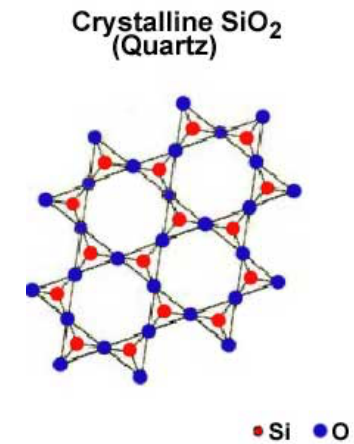
random positions and random orientations

- amorphous
- liquid

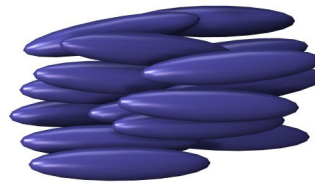
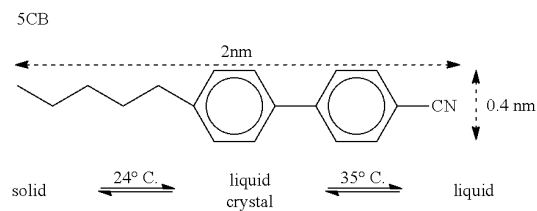


periodic lattice of atoms or molecules

- crystal

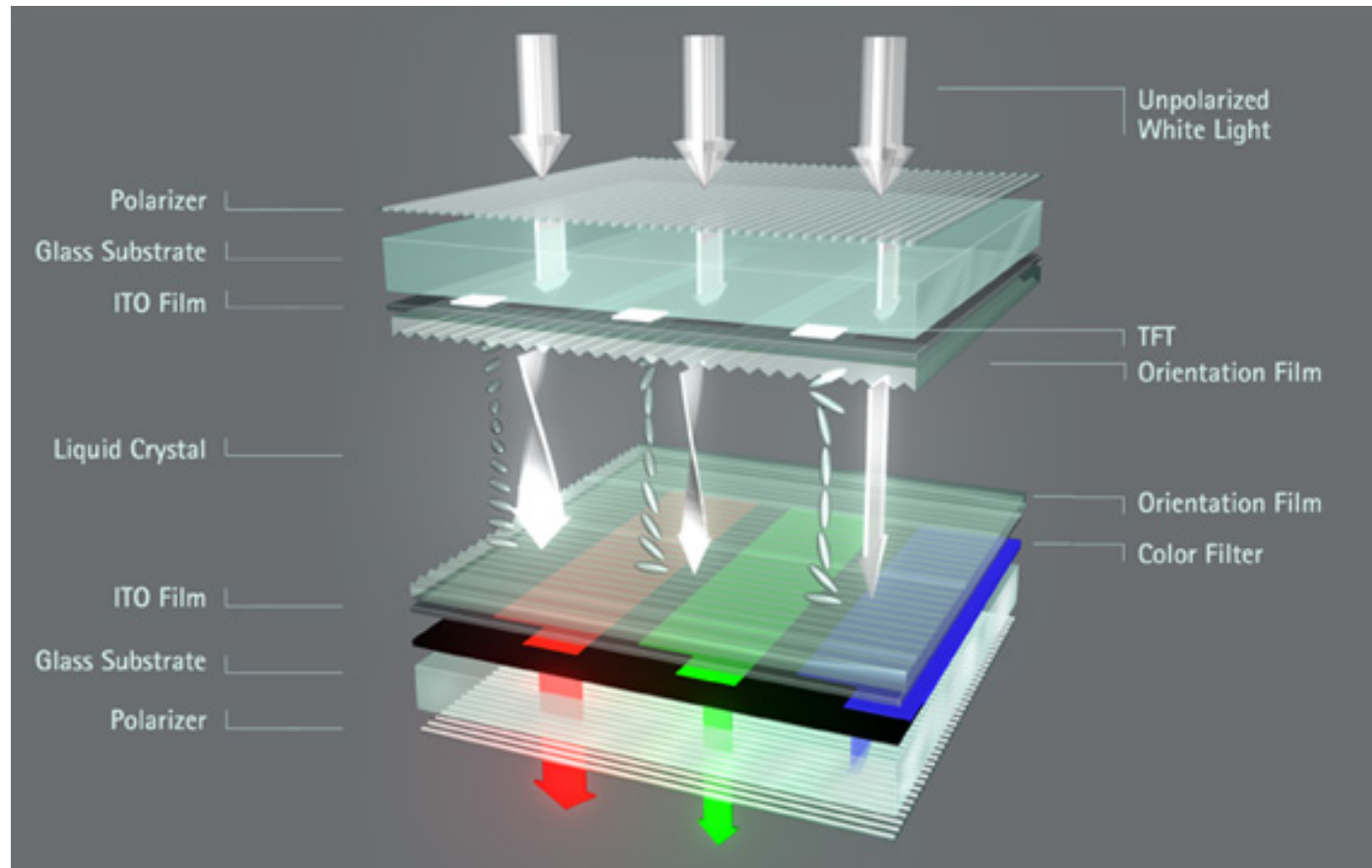


random positions and aligned orientations

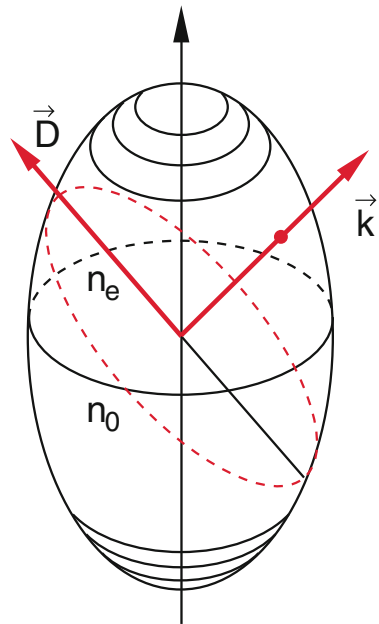


- liquid crystal

Liquid Crystal Display

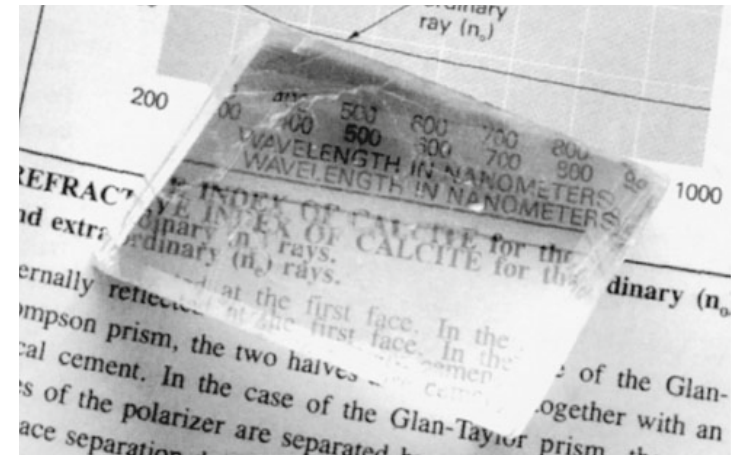
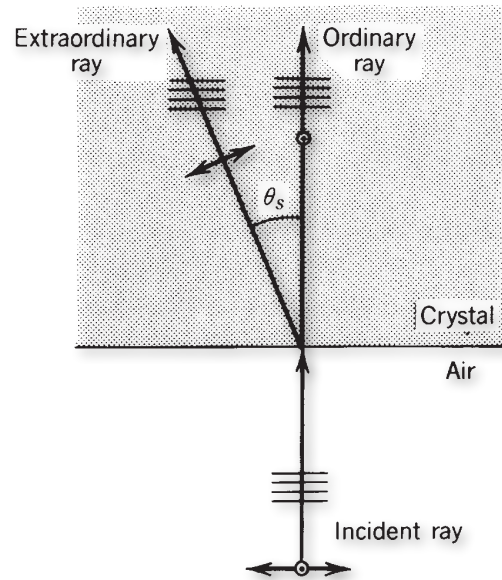
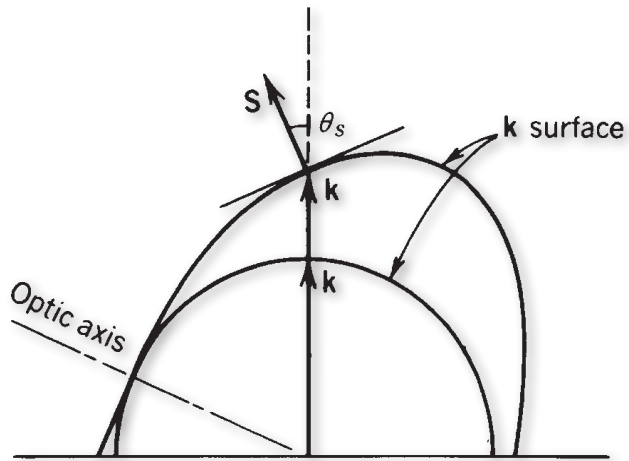


Anisotropic Materials - Index Ellipsoid

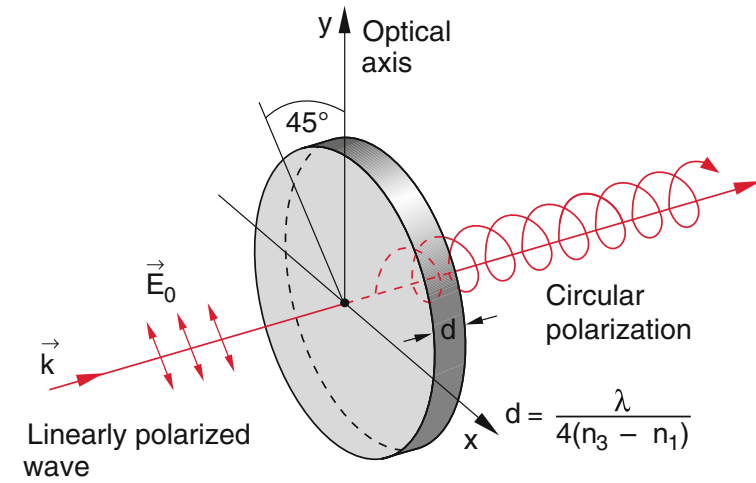
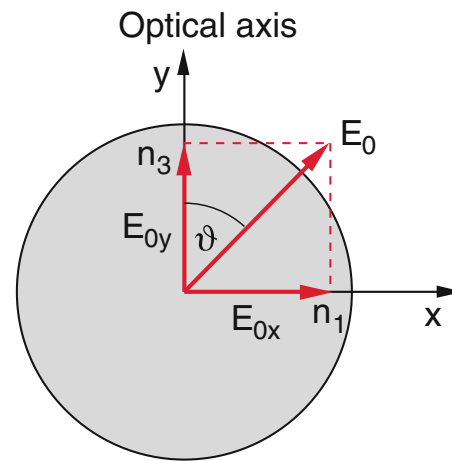
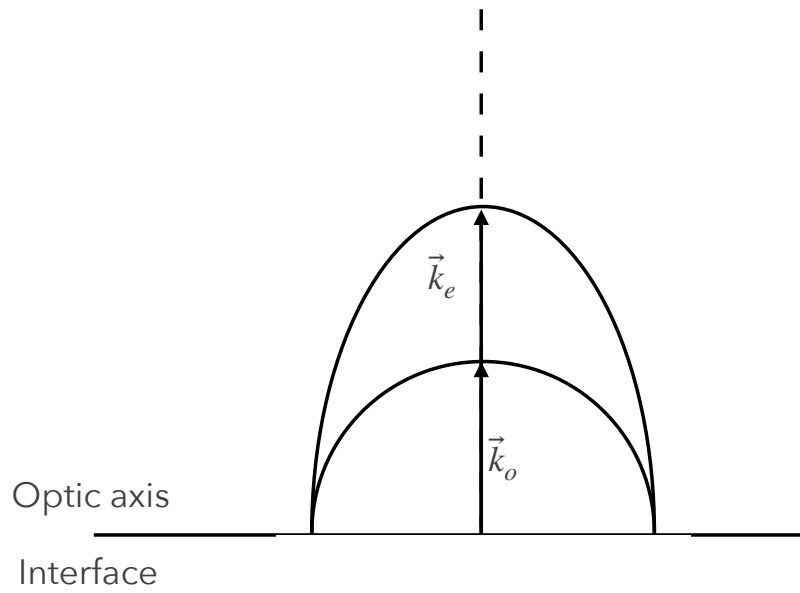


$$\mathbf{D} = \begin{bmatrix} \epsilon_{11} & 0 & 0 \\ 0 & \epsilon_{22} & 0 \\ 0 & 0 & \epsilon_{33} \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix}$$

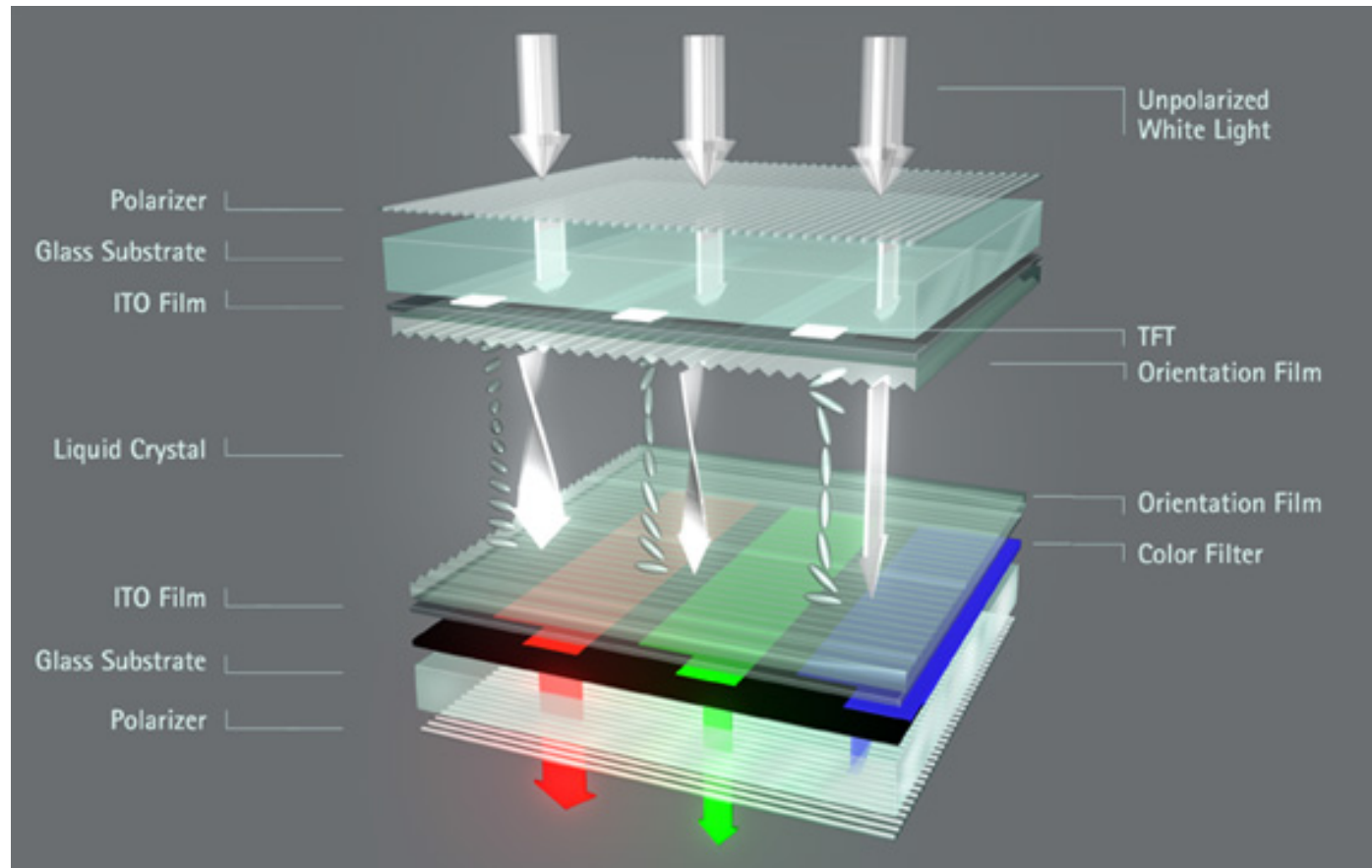
Birefringence



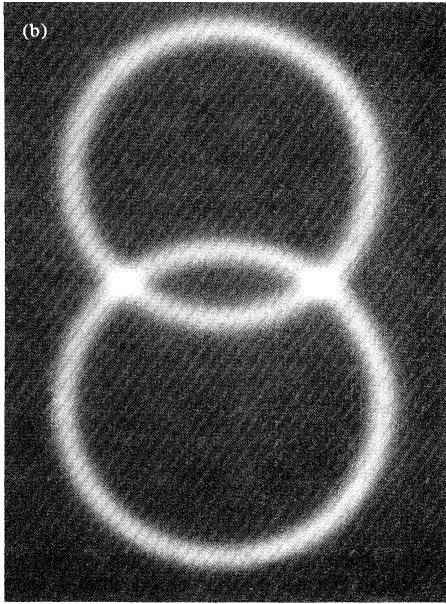
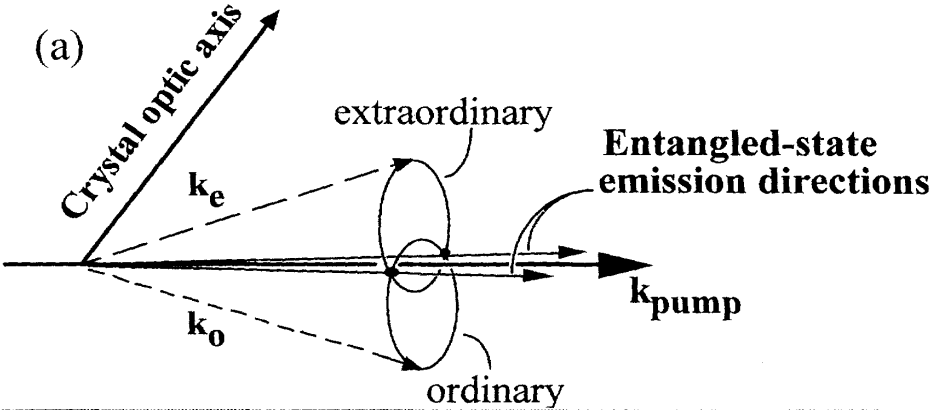
Birefringence - Wave Retarder



Liquid Crystal Display



Phase Matching in Non-linear Optics



Polarization Optics

