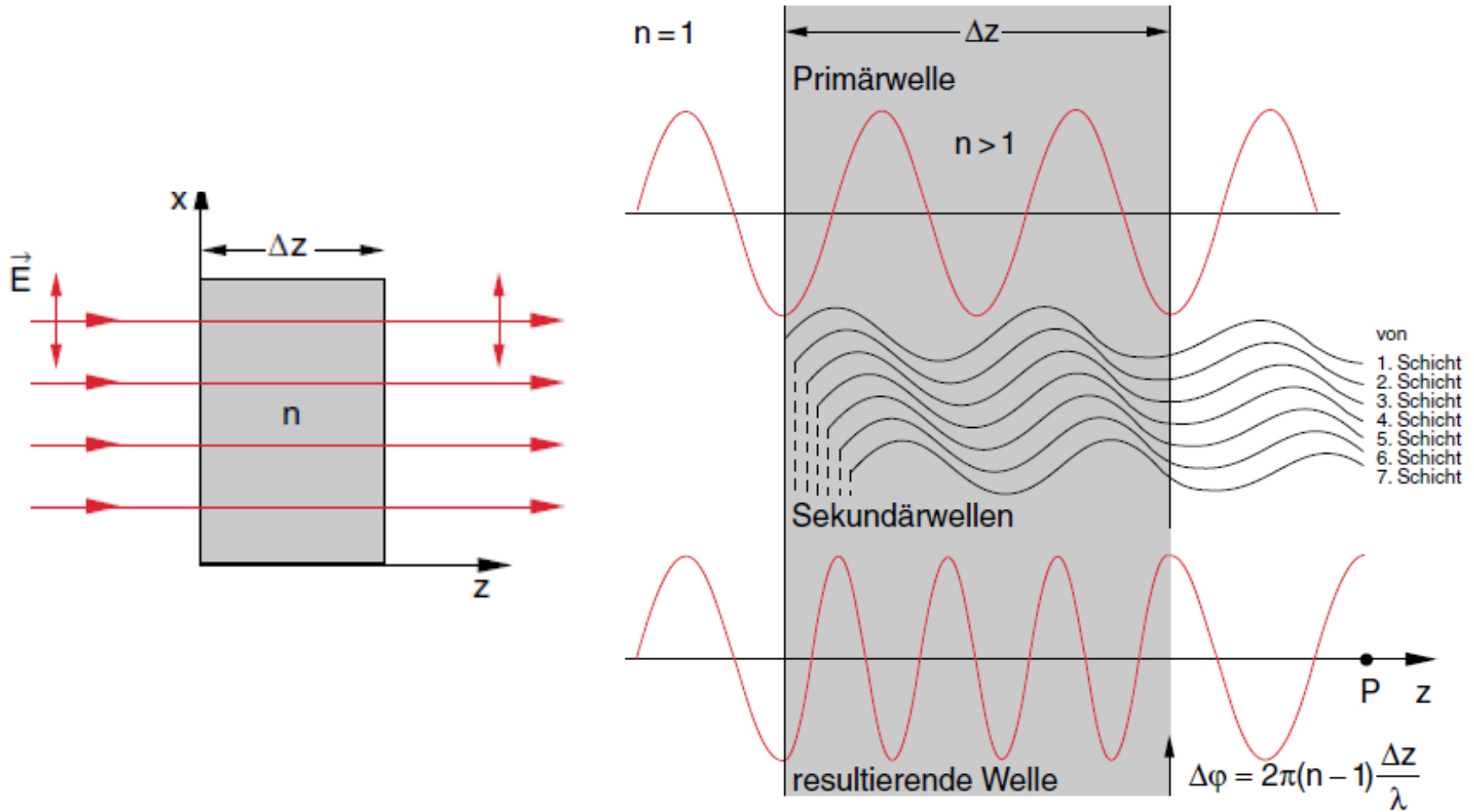


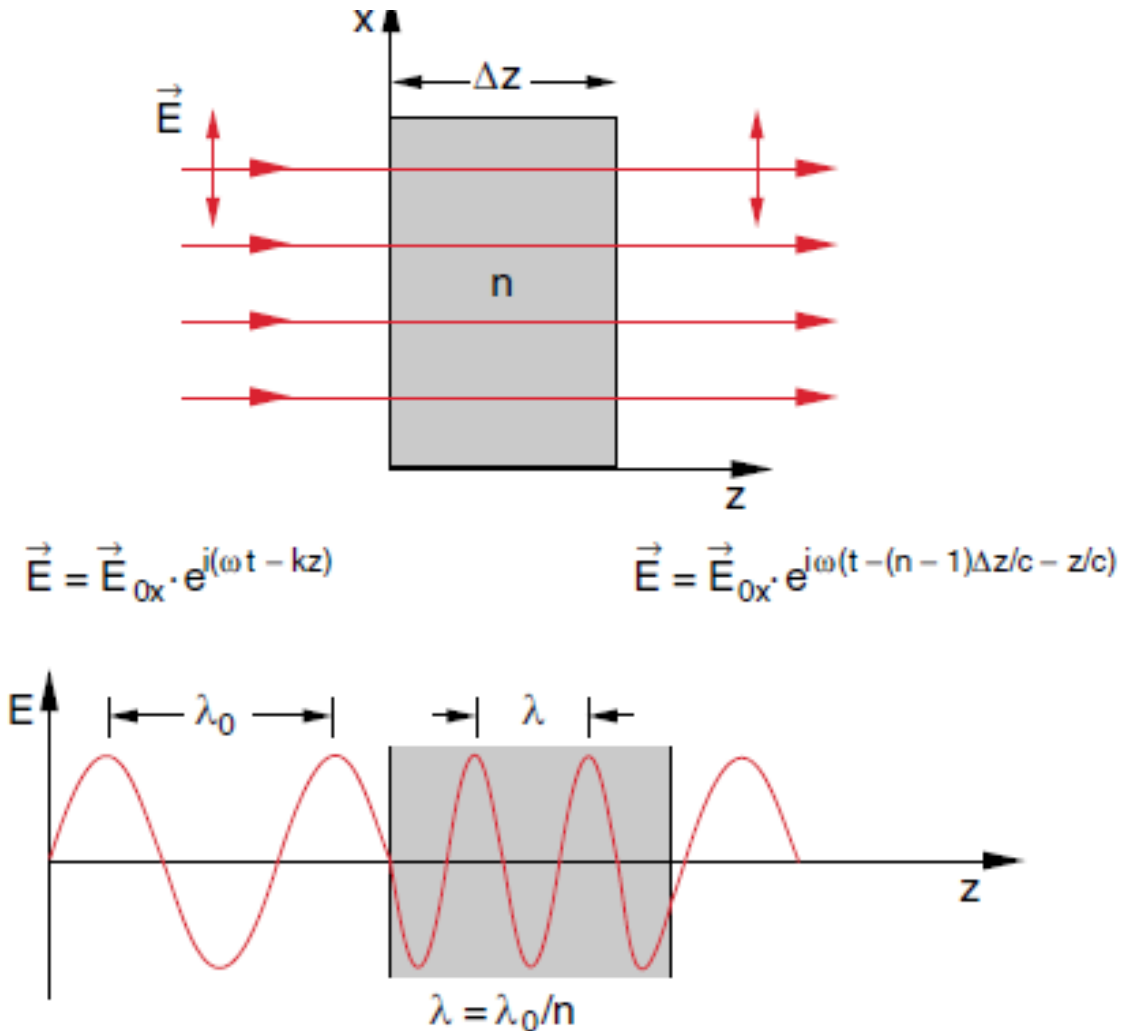
# Ch. 8 EM Wellen in Materie

- Wellengleichung in Materie
- Grenzflächen zwischen Medien
- Reflexion, total Reflexion
- Brechung, Doppelbrechung
- Brewster Winkel

# Ebene Welle durch Medium



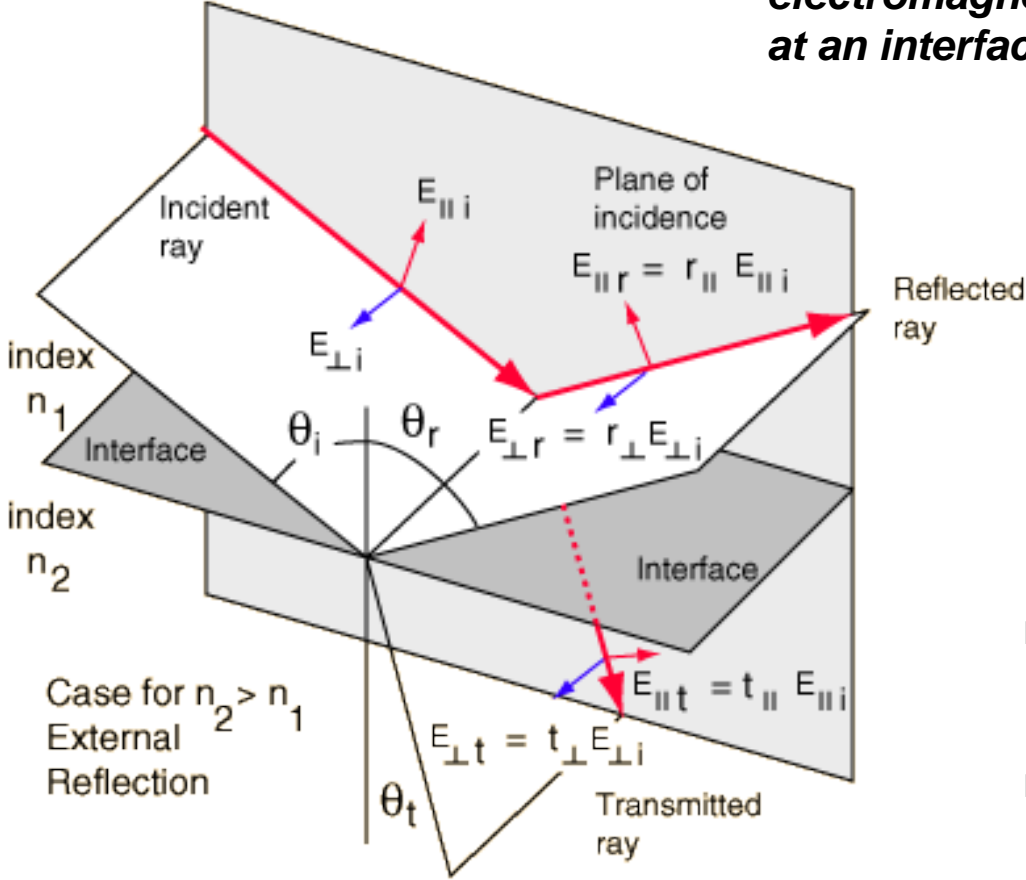
# Ebene Welle durch Medium



**Abb. 8.1.** Durchgang einer ebenen Welle durch ein Medium mit Brechungsindex  $n$ . Die Reflexion an den Grenzflächen ist hier nicht berücksichtigt

# propagation of light: em picture

## *electromagnetic (em) wave at an interface*



**reflection**      $\theta_r = \theta_i$

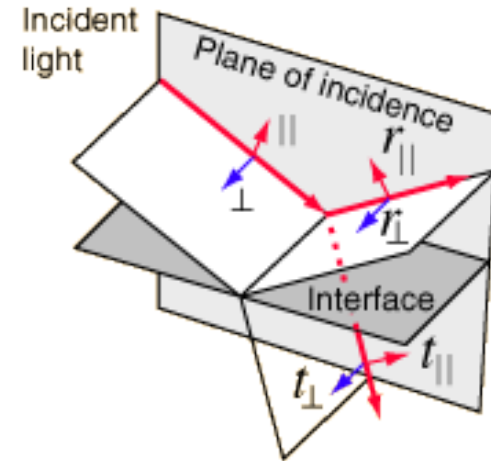
**refraction**      $n_t \cdot \sin(\theta_t) = n_i \cdot \sin(\theta_i)$   
*(Snell's law)*

# propagation of light: em picture

## Fresnel equations

reflection and transmission coefficients **r** and **t**  
 (**amplitude** coefficients;  $\text{intensity} \propto \text{amplitude}^2$ )

NB: signs refer to the specific fields directions chosen here



$$r_{\parallel} = \frac{\tan(\theta_i - \theta_t)}{\tan(\theta_i + \theta_t)}$$

$$t_{\parallel} = \frac{2 \sin \theta_t \cos \theta_i}{\sin(\theta_i + \theta_t) \cos(\theta_i - \theta_t)}$$

$$r_{\perp} = -\frac{\sin(\theta_i - \theta_t)}{\sin(\theta_i + \theta_t)}$$

$$t_{\perp} = \frac{2 \sin \theta_t \cos \theta_i}{\sin(\theta_i + \theta_t)}$$

energy conservation:

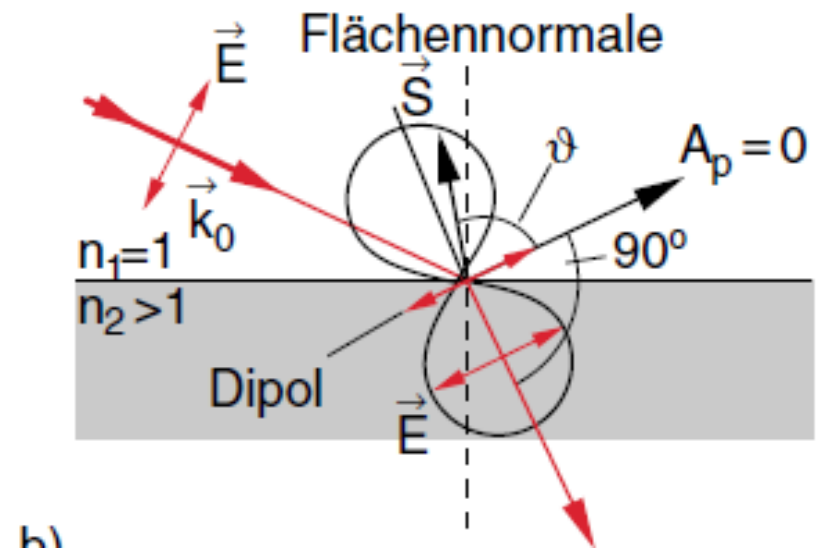
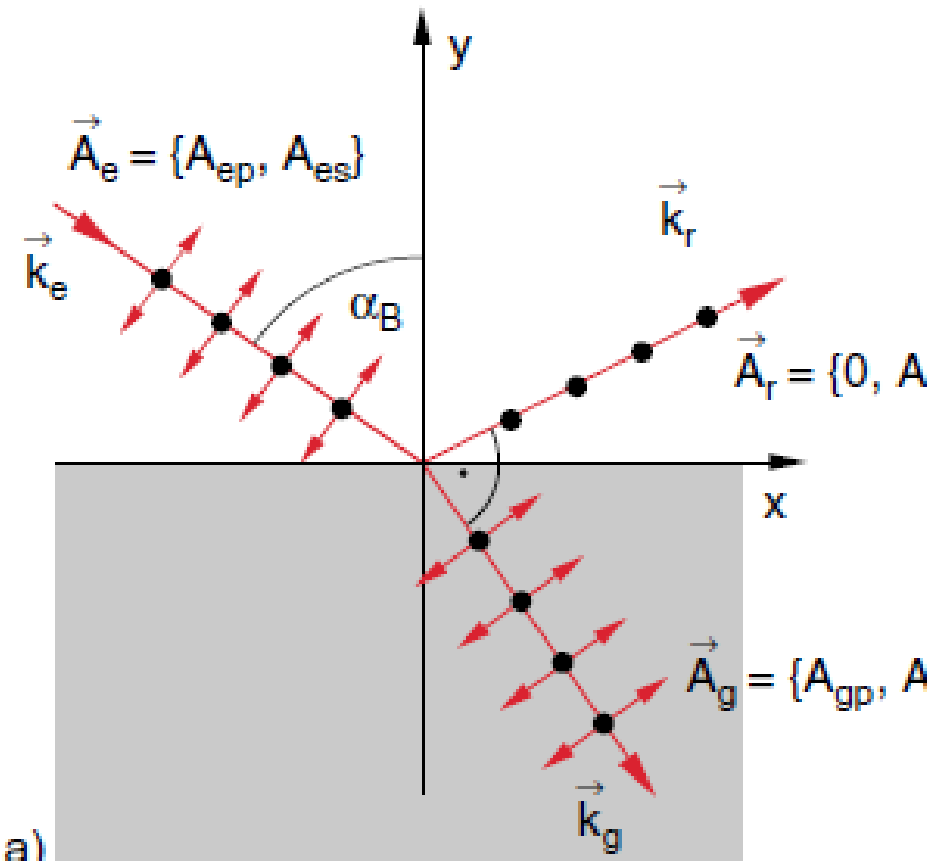
$$r^2 + t^2 \frac{n_2 \cos \theta_t}{n_1 \cos \theta_i} = 1$$

for  $\perp$  and  $\parallel$  cases

reflectance

transmittance

# Brewster Winkel





# Earthshine



# Biosignatures as revealed by spectropolarimetry of Earthshine

Michael F. Sterzik<sup>1</sup>, Stefano Bagnulo<sup>2</sup> & Enric Pallé<sup>3</sup>

**Table 1 | Earth observations**

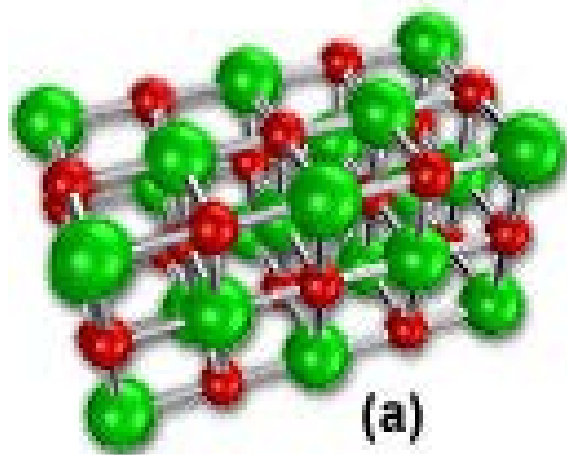
Observations	Observing date	
	25 April 2011, 09:00 UT	10 June 2011, 01:00 UT
View of Earth as seen from the Moon		
Sun–Earth–Moon phase (degrees)	87	102
Ocean fraction in Earthshine (%)	18	46
Vegetation fraction in Earthshine (%)	7	3



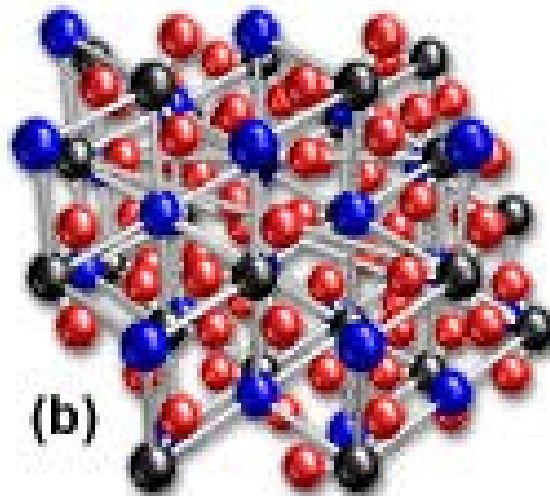
# Doppelbrechung

*birefringence*  
(double refraction)

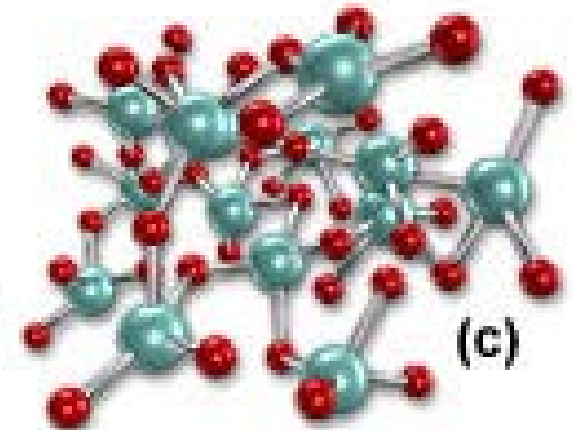
## Crystalline Structure of Isotropic and **Anisotropic** Materials



Sodium Chloride



Calcite



Amorphous Polymer

Figure 1

# Doppelbrechung

**birefringence**  
(double refraction)

Crystalline Structure of Isotropic and **Anisotropic** Materials

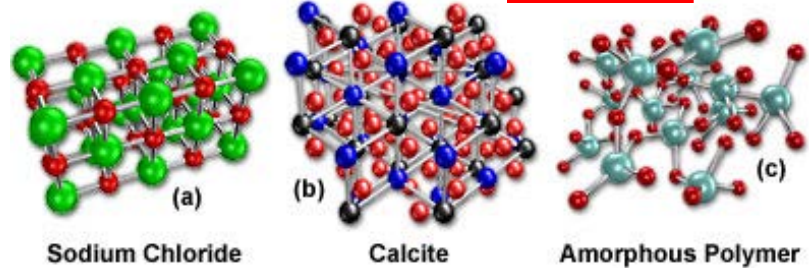


Figure 1

Light Path Through A Calcite Crystal

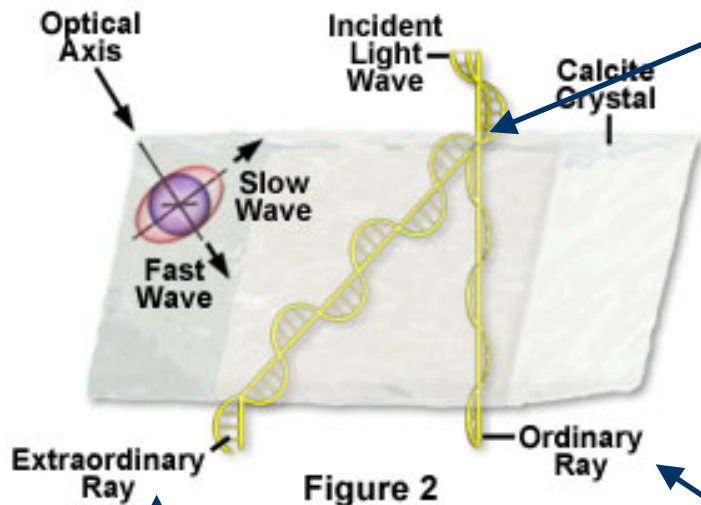


Figure 2

**⊥ polarisation**

slow refracted ray  
(dep. on crystalline direction)

splitting of incident beam in 2 rays

normally refracted ray

Birefringent Calcite Crystal Electric Vector Orientations

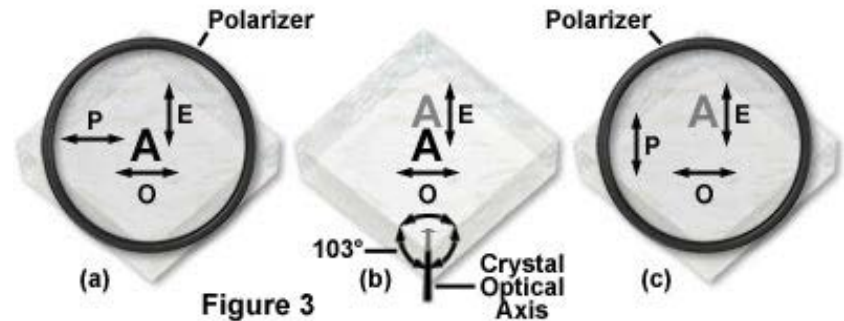
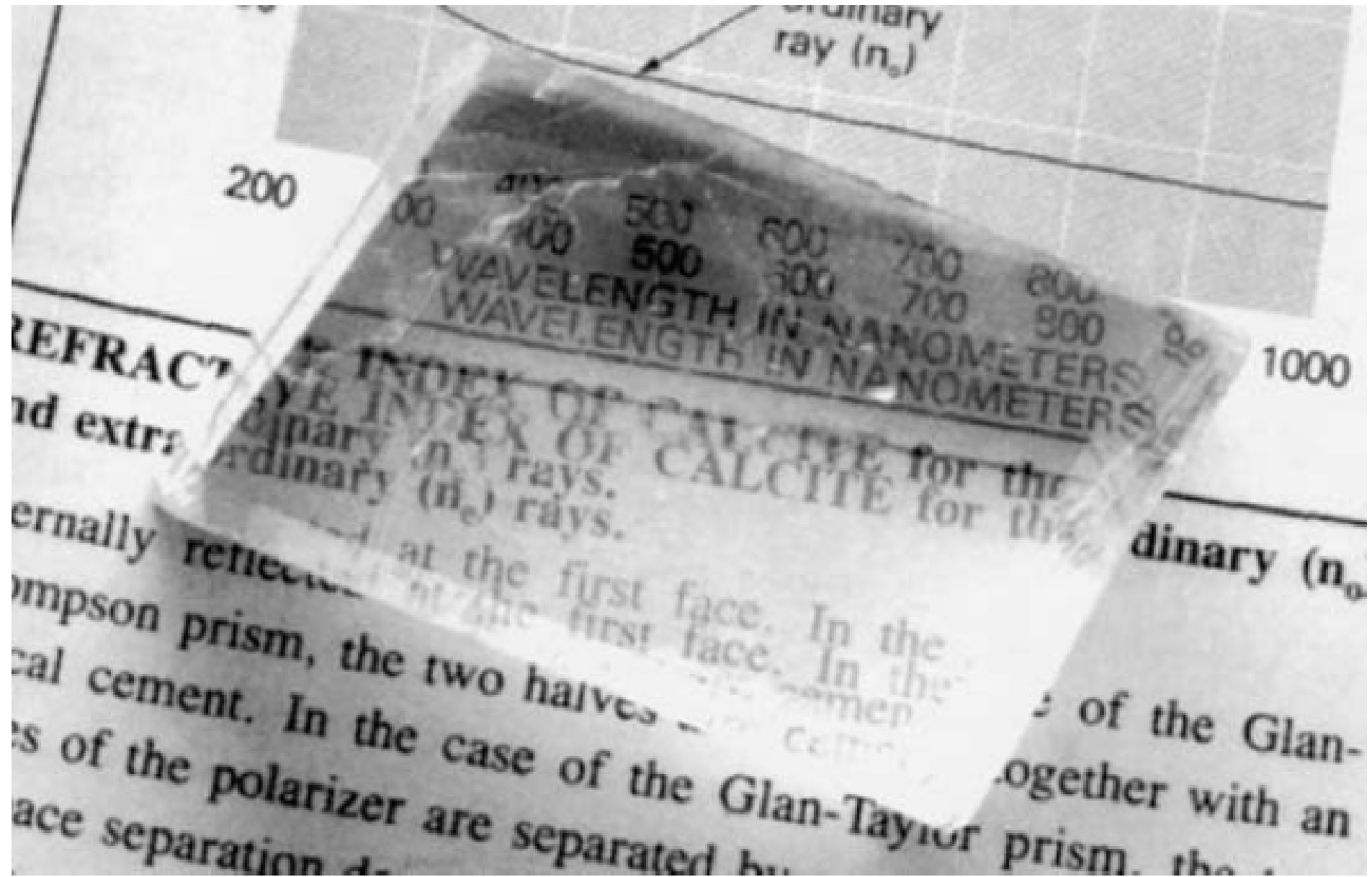


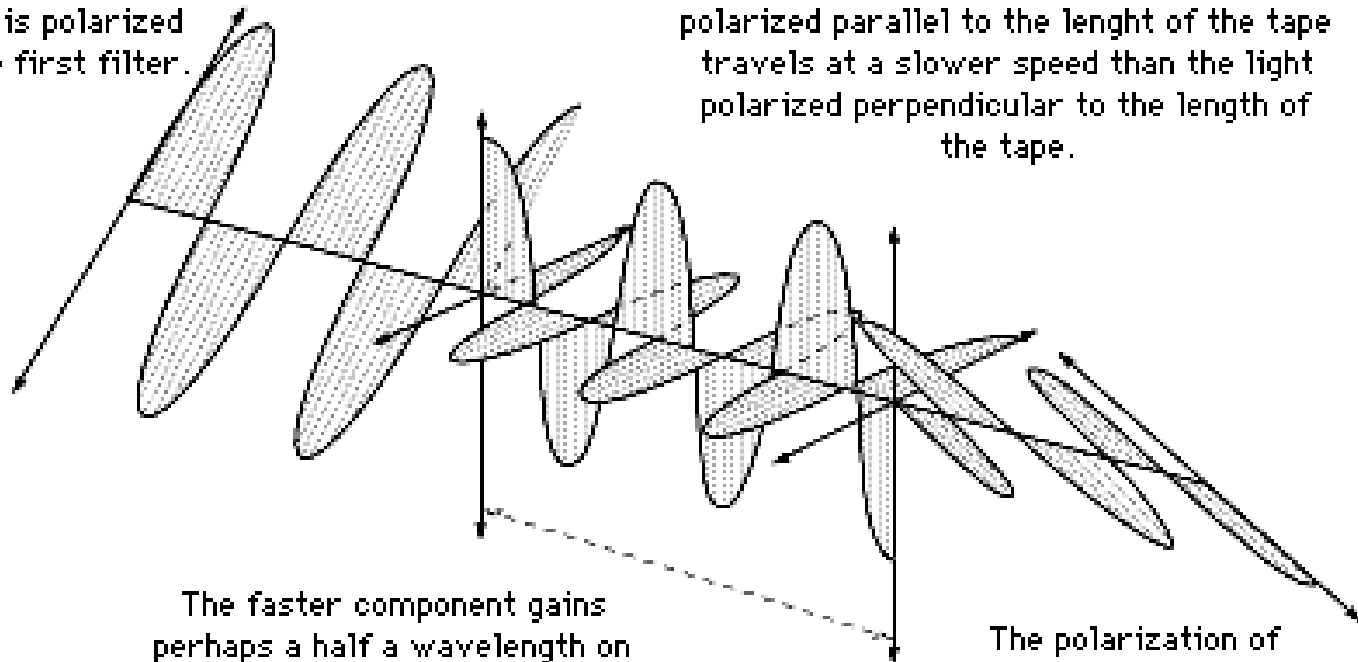
Figure 3

# Doppelbrechung



# Polarized light mosaic: scotch tape sandwich

Light is polarized by the first filter.



The light hits the tape. The part of the light polarized parallel to the length of the tape travels at a slower speed than the light polarized perpendicular to the length of the tape.

The faster component gains perhaps a half a wavelength on the slower component.

The polarization of the light as it exits the tape is then rotated, on this case by  $90^\circ$ .

**A wave diagram of polarized light passing through a birefringent tape.**

Polarisation Rotationswinkel

$$\alpha = \alpha(\lambda, d)$$

$\lambda$ : Wellenlänge

d: Scotch tape Dicke