

Arago (1811) first observed it for quartz.

Demonstration

For solids:

$$\varphi = d \cdot \rho \quad (\text{Arago, Herschel, 1820})$$

d - rotary power

For quartz $d = 21.7^\circ/\text{mm}$ at $\lambda = 589 \text{ nm}$.

For solutions:

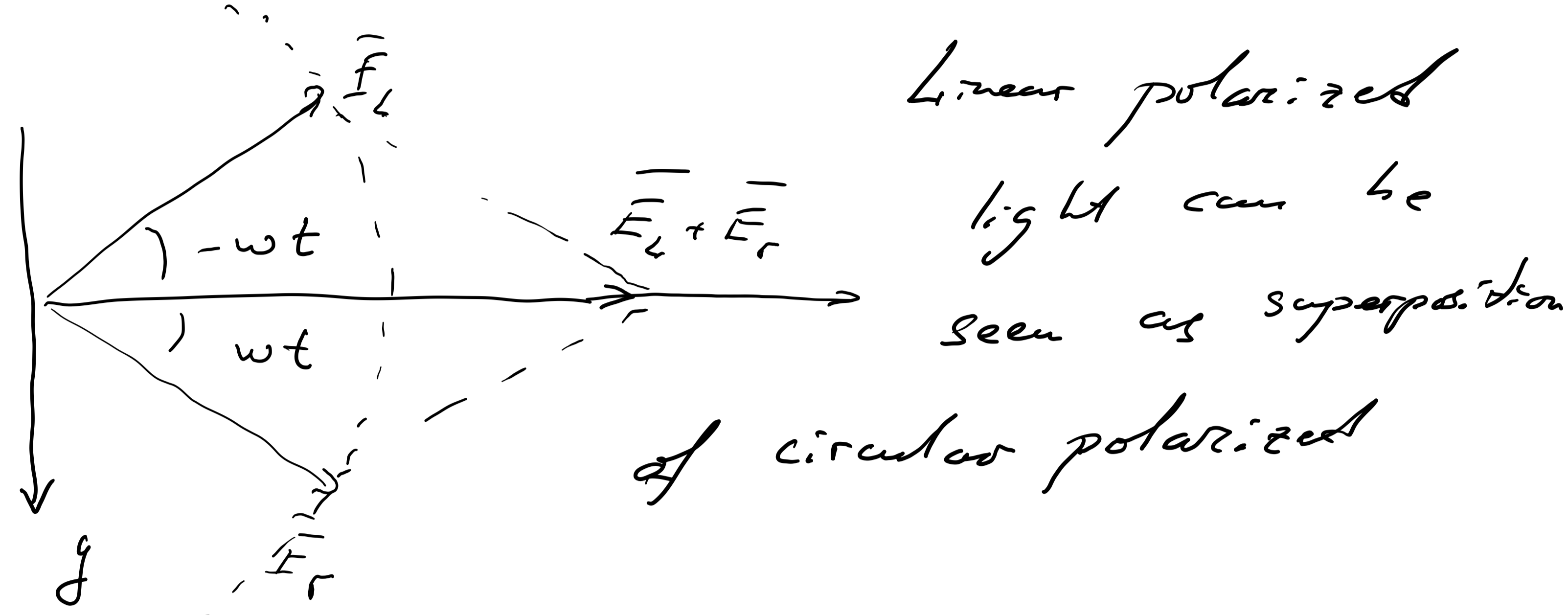
$$\varphi = [\alpha] \cdot c \cdot l \quad \text{Biot}$$

c - concentration

l - thickness

Phenomenological theory of polarization rotation by Fresnel

What was Fresnel's idea?



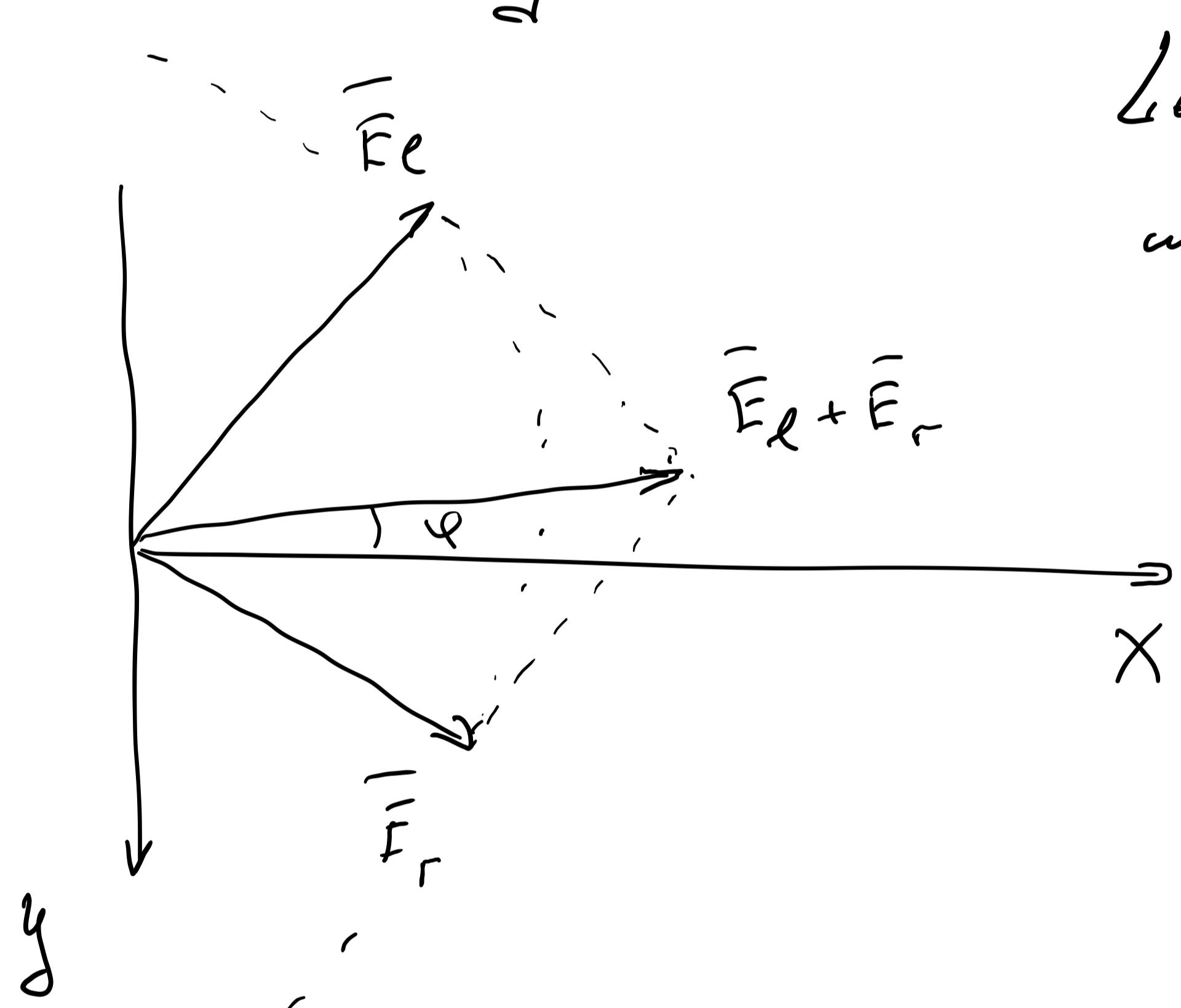
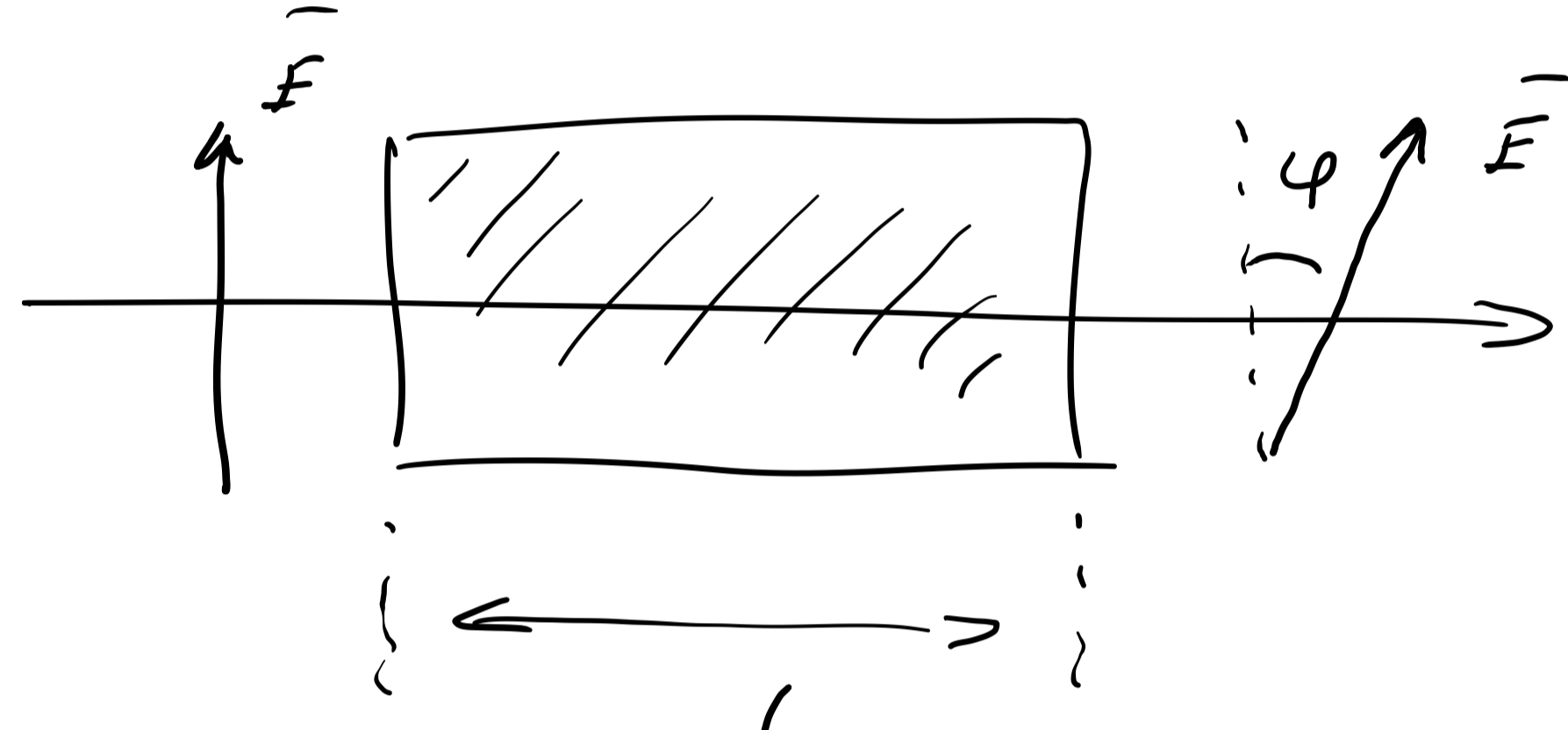
waves, but in different directions.

The point is that $n_e \neq n_r$

Let's write projections of these waves:

$$\begin{cases} E_{Lx} = E_0 \cos \omega t \\ E_{Rx} = E_0 \cos \omega t \end{cases} \quad \begin{cases} E_{Ly} = -E_0 \sin \omega t \\ E_{Ry} = E_0 \sin \omega t \end{cases}$$

How these waves will sum up if they will propagate through optically active medium of thickness d .



Left and right waves will acquire phase difference

$$\begin{cases} E_{Lx} = E_0 \cos(\omega t - k n_e d) \\ E_{Rx} = E_0 \cos(\omega t - k n_r d) \end{cases} \quad \begin{cases} E_{Ly} = -E_0 \sin(\omega t - k n_e d) \\ E_{Ry} = E_0 \sin(\omega t - k n_r d) \end{cases}$$

Let's find the angle φ :

$$\begin{aligned} \tan \varphi &= \frac{E_y}{E_x} = \frac{E_{Ly} + E_{Ry}}{E_{Lx} + E_{Rx}} = \frac{E_0 \sin(\omega t - k n_r d) - E_0 \sin(\omega t - k n_e d)}{E_0 \cos(\omega t - k n_r d) + E_0 \cos(\omega t - k n_e d)} \\ &= \frac{\sin \left[\frac{k d}{2} (n_r - n_e) \right] \cos \left[\omega t - \frac{k d}{2} (n_e + n_r) \right]}{\cos \left[\frac{k d}{2} (n_e - n_r) \right] \cos \left[\omega t - \frac{k d}{2} (n_e + n_r) \right]} \\ &= \tan \left[\frac{k d}{2} (n_e - n_r) \right] \end{aligned}$$

$$\varphi = \frac{k d}{2} (n_e - n_r) \quad \varphi = \frac{\pi d}{\lambda} (n_e - n_r)$$

It is important to note that rotation φ will depend on λ . This can be called rotational dispersion.

Demonstration

Why stripes are tilted?

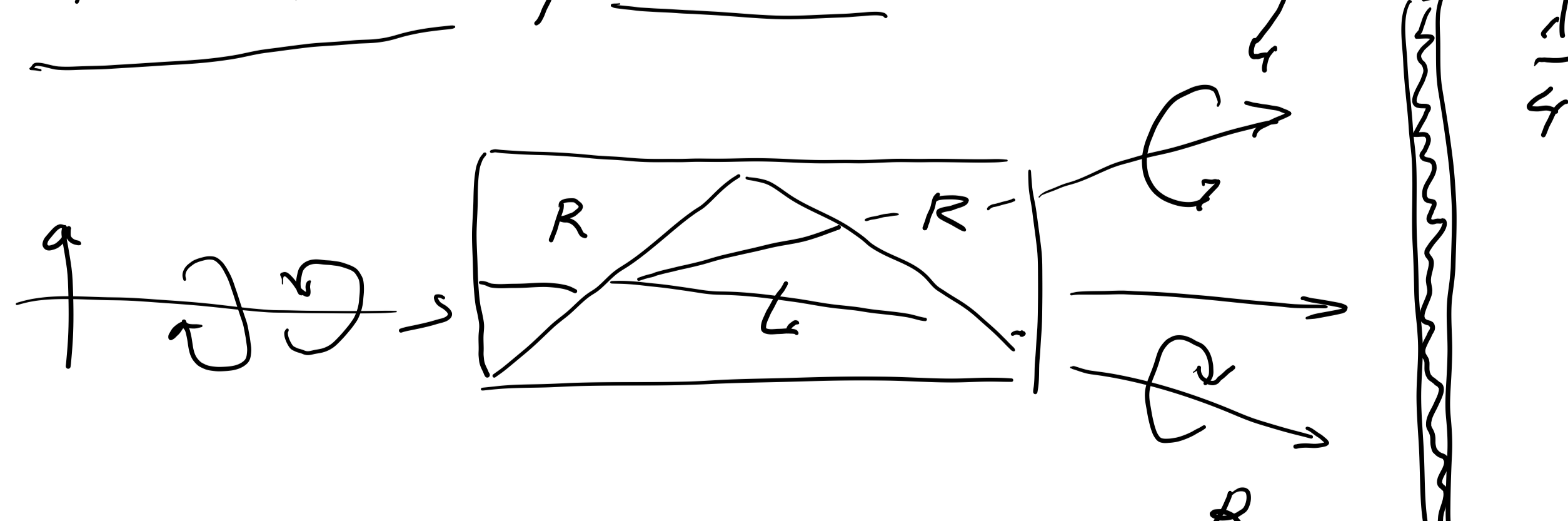
If $n_e > n_r \rightarrow$ right circular rotation
 $n_e < n_r \rightarrow$ left circular rotation

It is important to note that difference in phase velocities for left and right polarization is the result of fact that field is different in different parts of molecule.

even though $\frac{a}{\lambda} \sim 10^{-3}$

Induced dipole moment \bar{p} of molecule depend on field distribution along the whole molecule $\bar{E}(\bar{r})$.

Fresnel's experiment



Optical isomers

Spatial isomers, which molecules have mirror symmetry

Chiral molecules may also not just rotate, but absorb different polarization states. Since absorption will be directly connected to the structure, we can learn the structure of optically active media.