Arago (1811) first observed it for quartz.

For solids:

$\varphi = \alpha \cdot l$ (Arago, Herschel, 1820)

α – rotary power

For quartz $\alpha = 21.7\ °/mm$ at $\lambda = 589\ nm$.

For solutions:

$\varphi = [\alpha] \cdot c \cdot l$ Biot

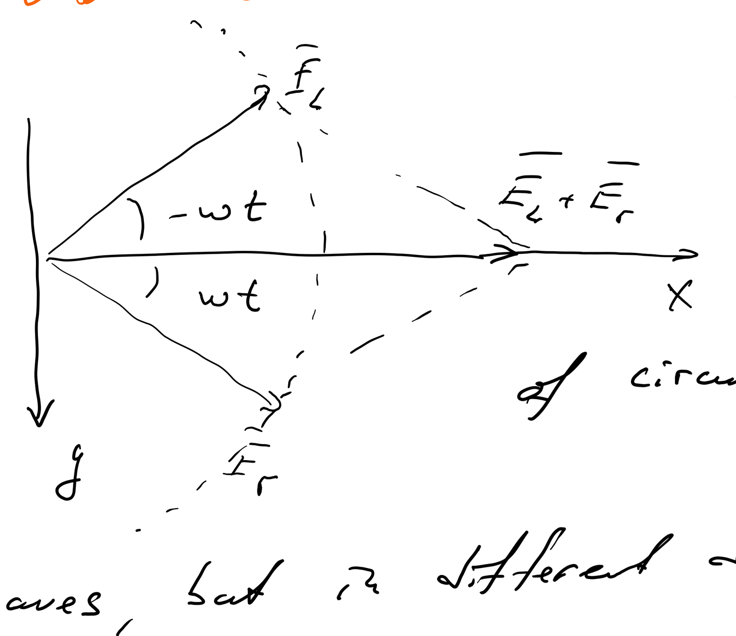
c – concentration

l – thickness

Demonstration

Phenomenological theory of polarization rotation by Fresnel

What was Fresnel's idea?



Linear polarized light can be seen as superposition of circular polarized waves, but in different directions.

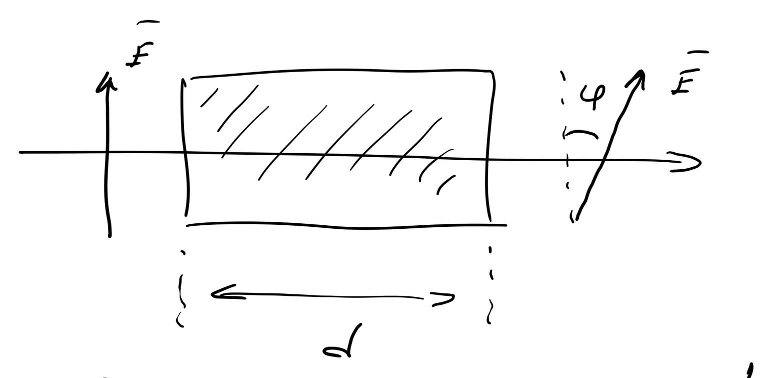
Demonstration

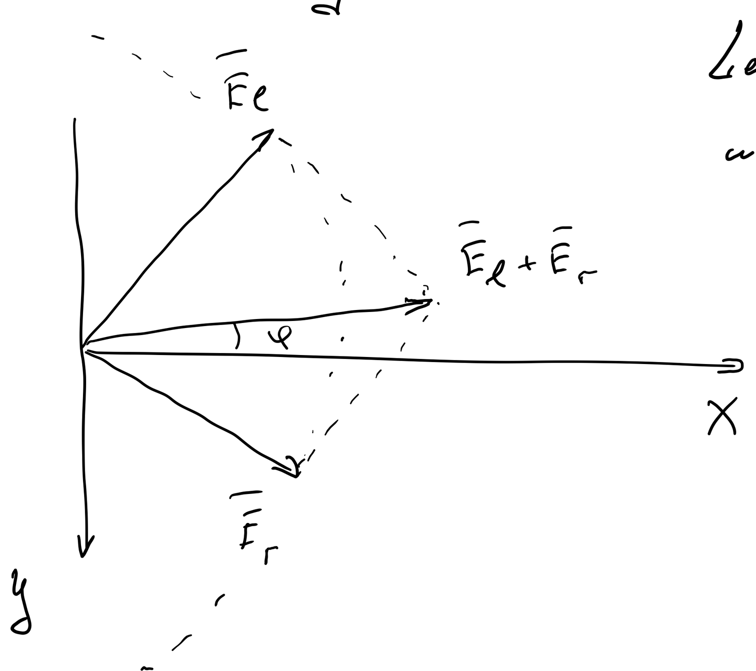
The point is that $n_l \neq n_r$

Let's write projections of this waves:

$$\begin{cases} E_{lx} = E_0 \cos\omega t \\ E_{rx} = E_0 \cos\omega t \end{cases} \qquad \begin{cases} E_{ly} = -E_0 \sin\omega t \\ E_{ry} = E_0 \sin\omega t \end{cases}$$

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





Left and right waves will acquire phase difference

$$\begin{cases} E_{lx} = E_0 \cos(\omega t - k n_l d) \\ E_{rx} = E_0 \cos(\omega t - k n_r d) \end{cases} \qquad \begin{cases} E_{ly} = -E_0 \sin(\omega t - k n_l d) \\ E_{ry} = E_0 \sin(\omega t - k n_r d) \end{cases}$$

Let's find the angle φ:

$$\operatorname{tg}\varphi = \frac{E_y}{E_x} = \frac{E_{ly} + E_{ry}}{E_{lx} + E_{rx}} = \frac{E_0 \sin(\omega t - k n_r d) - E_0 \sin(\omega t - k n_l d)}{E_0 \cos(\omega t - k n_r d) + E_0 \cos(\omega t - k n_l d)} =$$

$$= \frac{\sin\left[\frac{kd}{2}(n_r - n_l)\right]\cos\left[\omega t - \frac{kd}{2}(n_l + n_r)\right]}{\cos\left[\frac{kd}{2}(n_l - n_r)\right]\cos\left[\omega t - \frac{kd}{2}(n_l + n_r)\right]} =$$

$$= \operatorname{tg}\left[\frac{kd}{2}(n_l - n_r)\right]$$

$$\varphi = \frac{kd}{2}(n_l - n_r) \qquad \varphi = \frac{\pi d}{\lambda}(n_l - n_r)$$

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

If $n_l > n_r \rightarrow$ right circular rotation

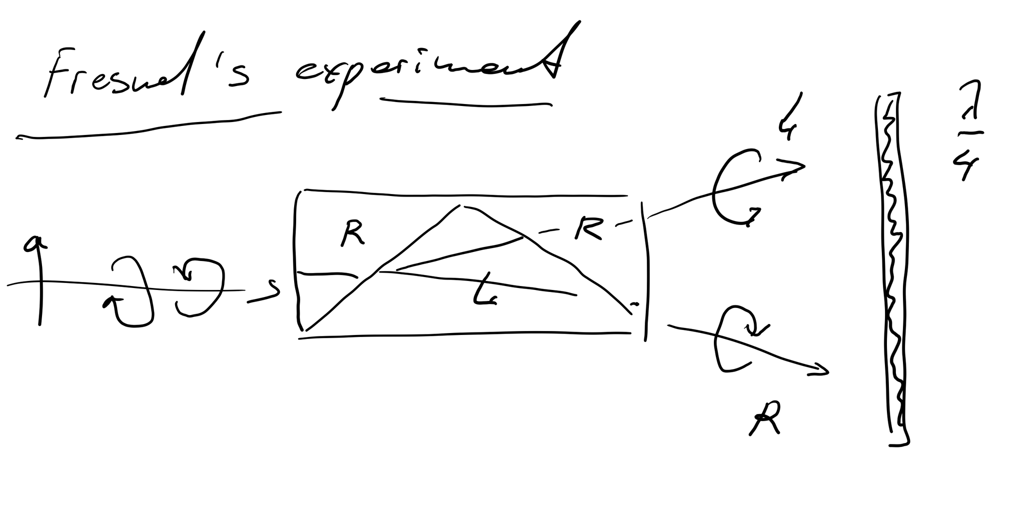
$n_l < n_r$ – left circular rotation

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

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

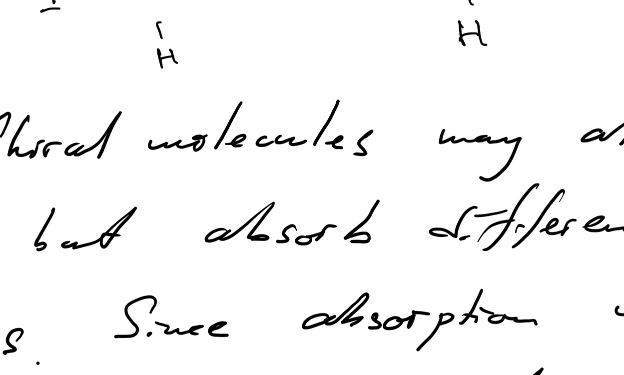
Induated dipole moment $\bar{p}$ of molecule depend on field distribution along the whole molecule $\bar{E}(\bar{r})$

Fresnel's experiment



Optical isomers

Spatial isomers, which molecules have mirror symmetry



Chiral
χειρ – hand

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.

Demonstration

1) Why there are stripes?
2) Why these stripes are colored?
3) What pattern one will observe if monochromatic light is used?
4) Why stripes move left and right if polarizer is rotated?
5) Why stripes are tilted?
6) What direction the tilt will be if not sugar, but glucose is used?