Elliptical and circular polarisation

$$E_x = E_\pi \sin(\omega t)$$

$$E_y = E_\sigma \sin(\omega t + \phi)$$

Plane polarised $\phi = 0, \pi, 2\pi$ Etc.

$\phi = \pi/2, 3\pi/2..,$ $E_\sigma = E_\pi$

Circularly polarised

Superposition of two SHM in perpendicular directions:

$$\begin{aligned} x(t) &= a\cos(\omega_1 t + \phi_1) \\ y(t) &= b\cos(\omega_2 t + \phi_2) \end{aligned}$$

Case I: $\omega_{\mathbf{1}} = \omega_{\mathbf{2}} = \omega$

$$\begin{aligned} \left(\frac{x}{a}\cos\phi_2 - \frac{y}{b}\cos\phi_1\right) &= \sin(\omega t)\sin(\phi_2-\phi_1) \\ \left(\frac{x}{a}\sin\phi_2 - \frac{y}{b}\sin\phi_1\right) &= \cos(\omega t)\sin(\phi_2-\phi_1). \end{aligned}$$

$$\boxed{\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab}\cos(\phi_2-\phi_1) = \sin^2(\phi_2-\phi_1)}$$

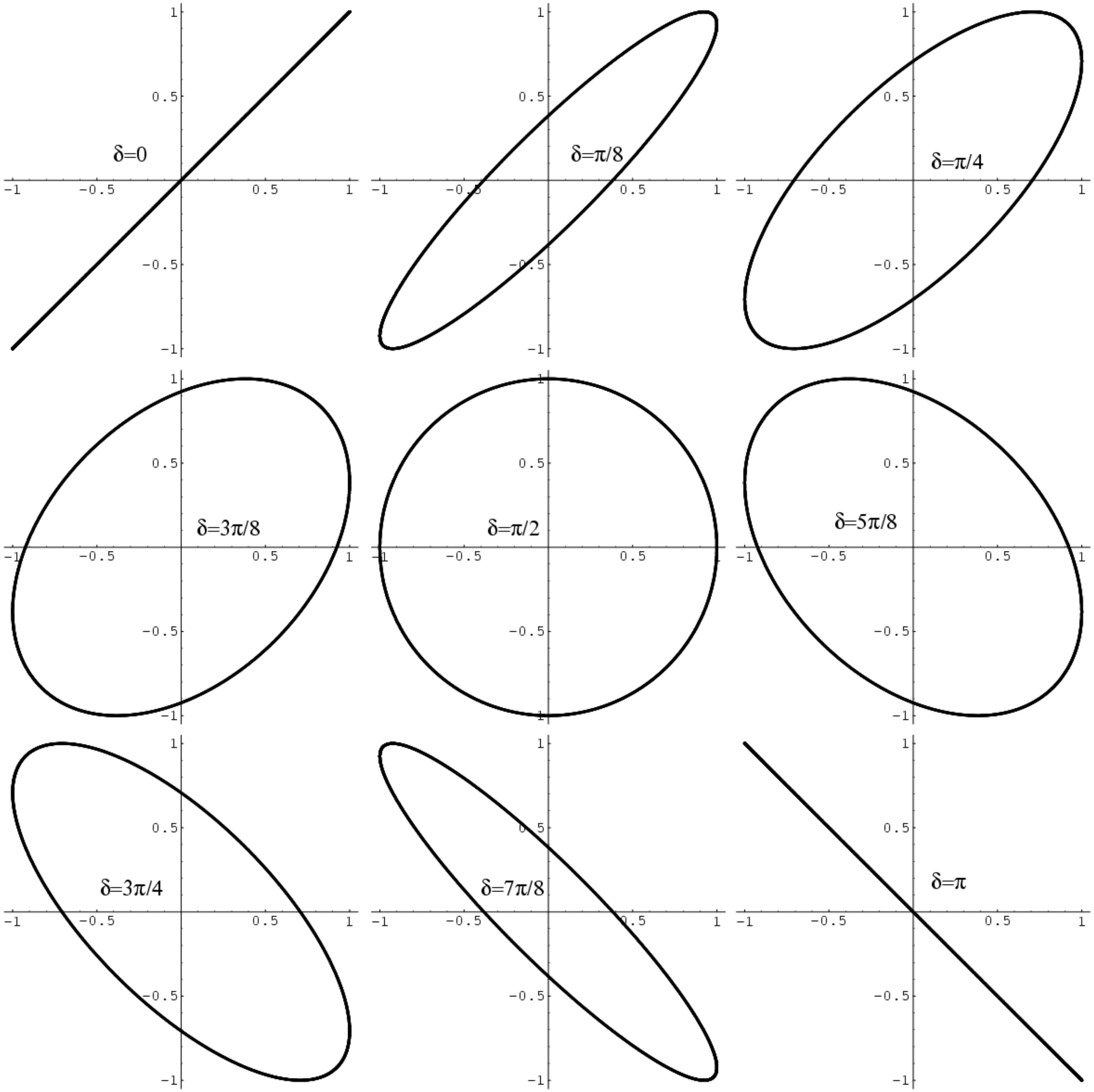
$$\delta = \phi_2 - \phi_1 = \pm n\pi$$

Straight line

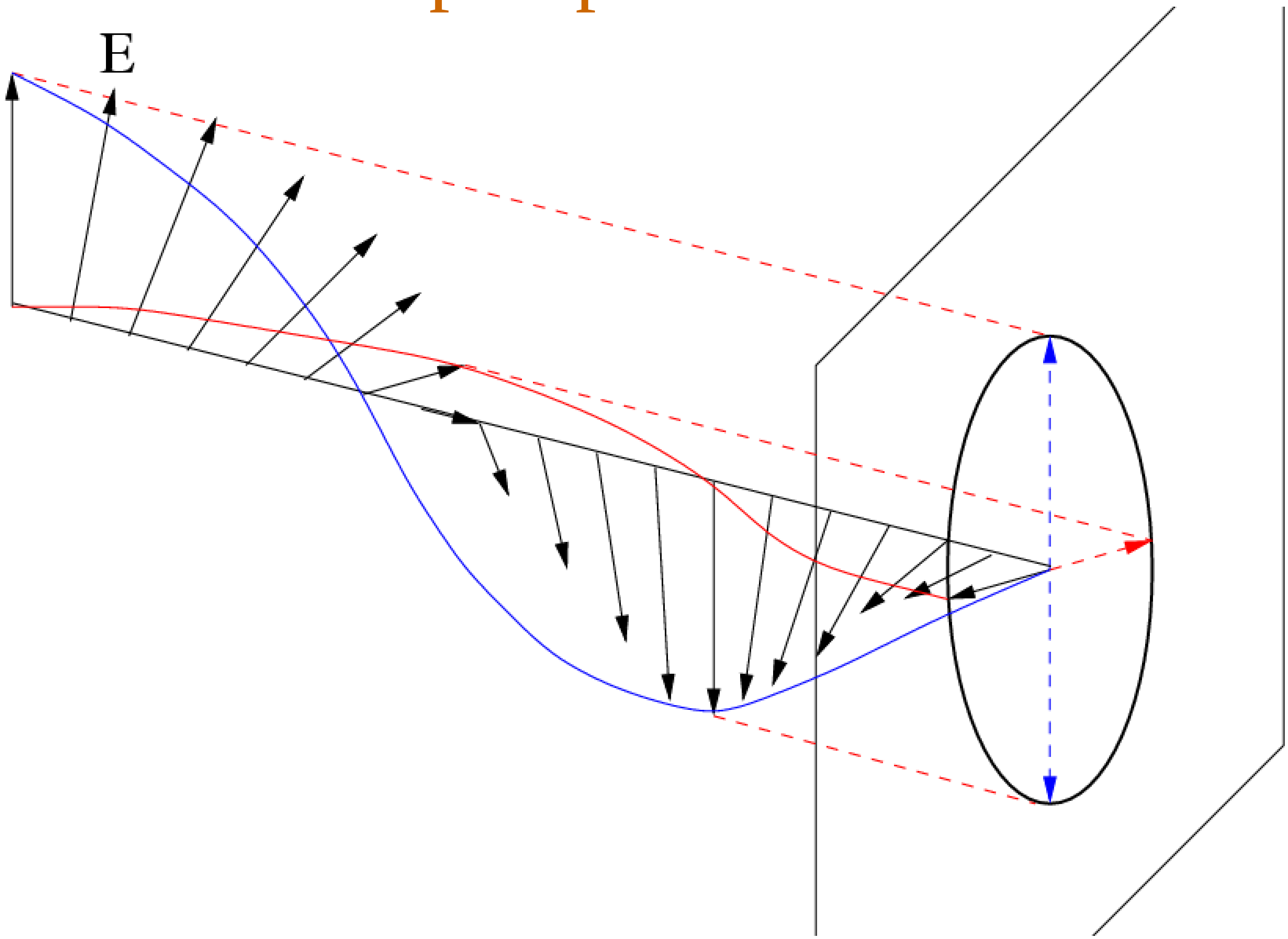
$$\delta = \pi/2 \text{ and } a = b$$

Circle

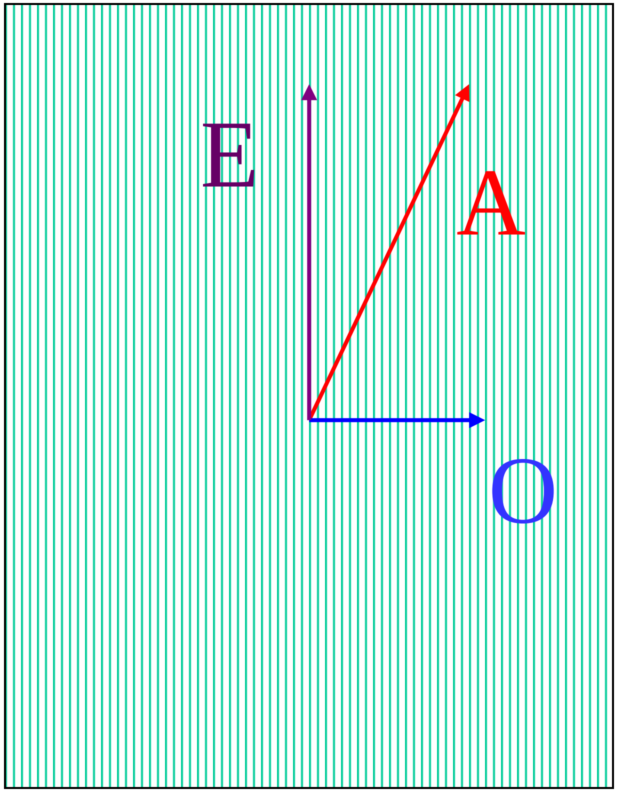
Ellipse otherwise


δ=0
δ=π/8
δ=π/4
δ=3π/8
δ=π/2
δ=5π/8
δ=3π/4
δ=7π/8
δ=π
-1
-0.5
0.5
1

Elliptic polarisation



Production of elliptically polarised light



$$\mathrm{O} = A\cos\theta$$

$$\mathrm{E} = A\sin\theta$$

Birefringent crystal

Green lines show the direction of the optic axis

Retarders

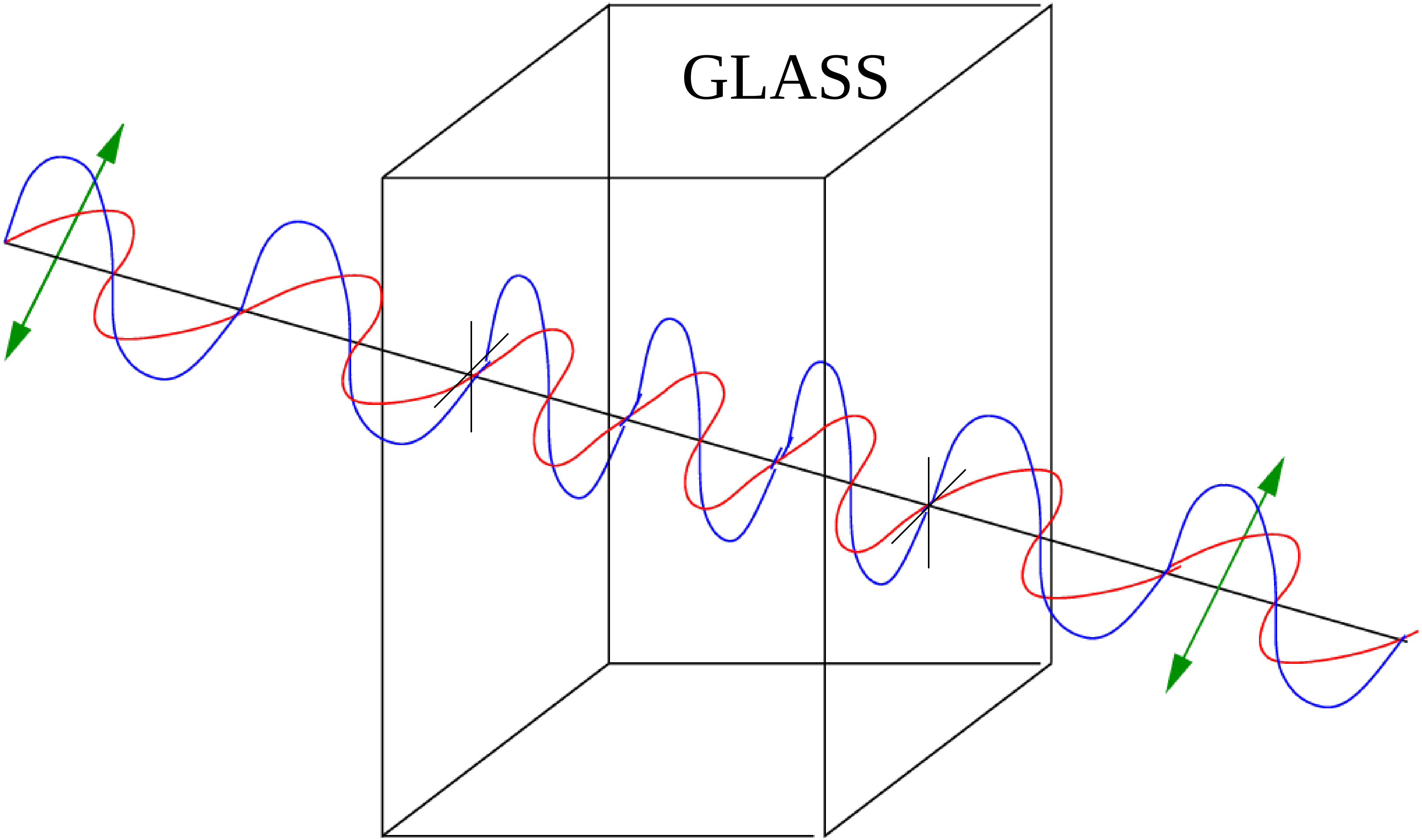
Optical path difference created between the O-ray and the E-ray when the light travelled *d* distance in a birefringent medium.

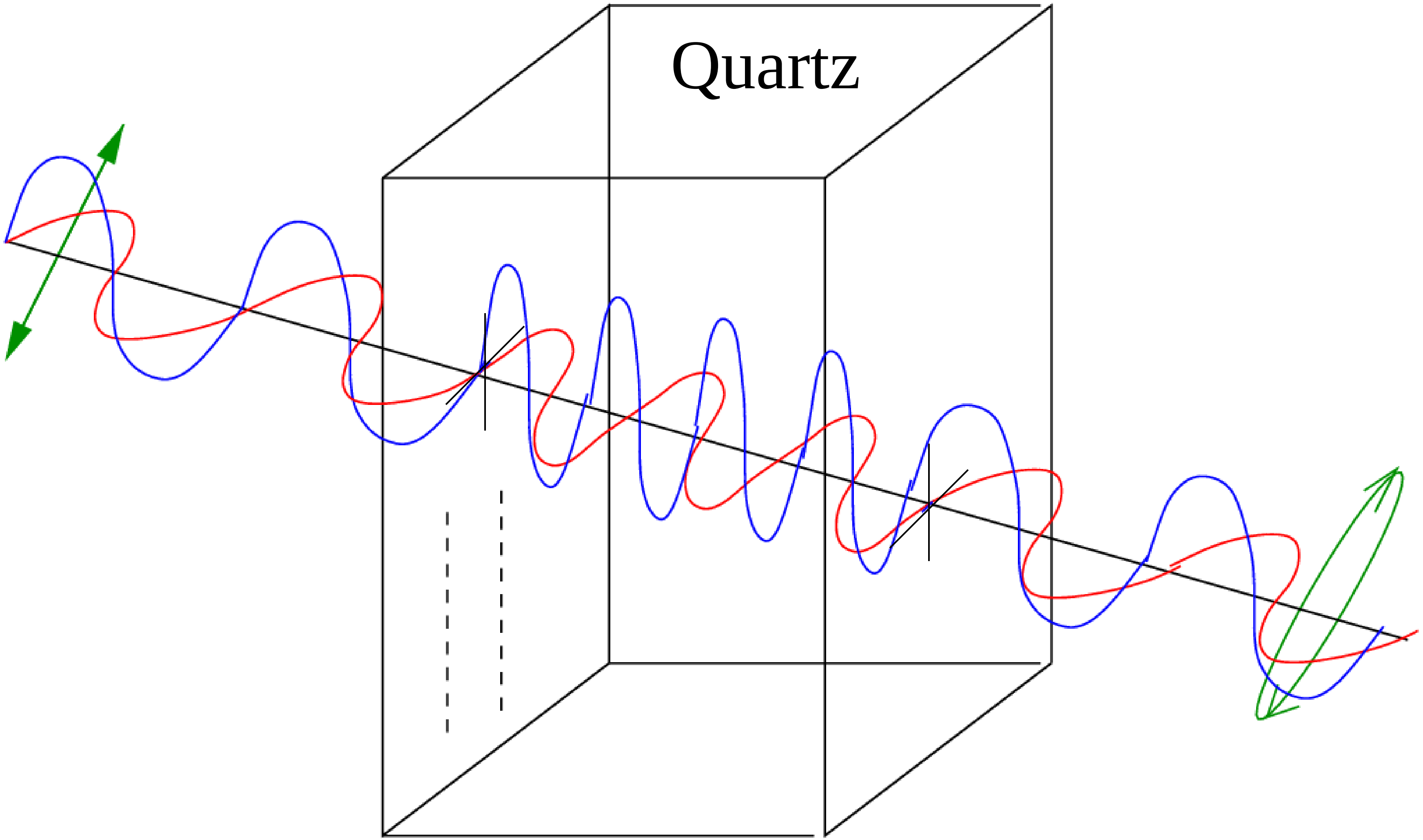
$$\Delta = d|n_0 - n_e|$$

$$\phi = \frac{2\pi}{\lambda} d|n_0 - n_e|$$

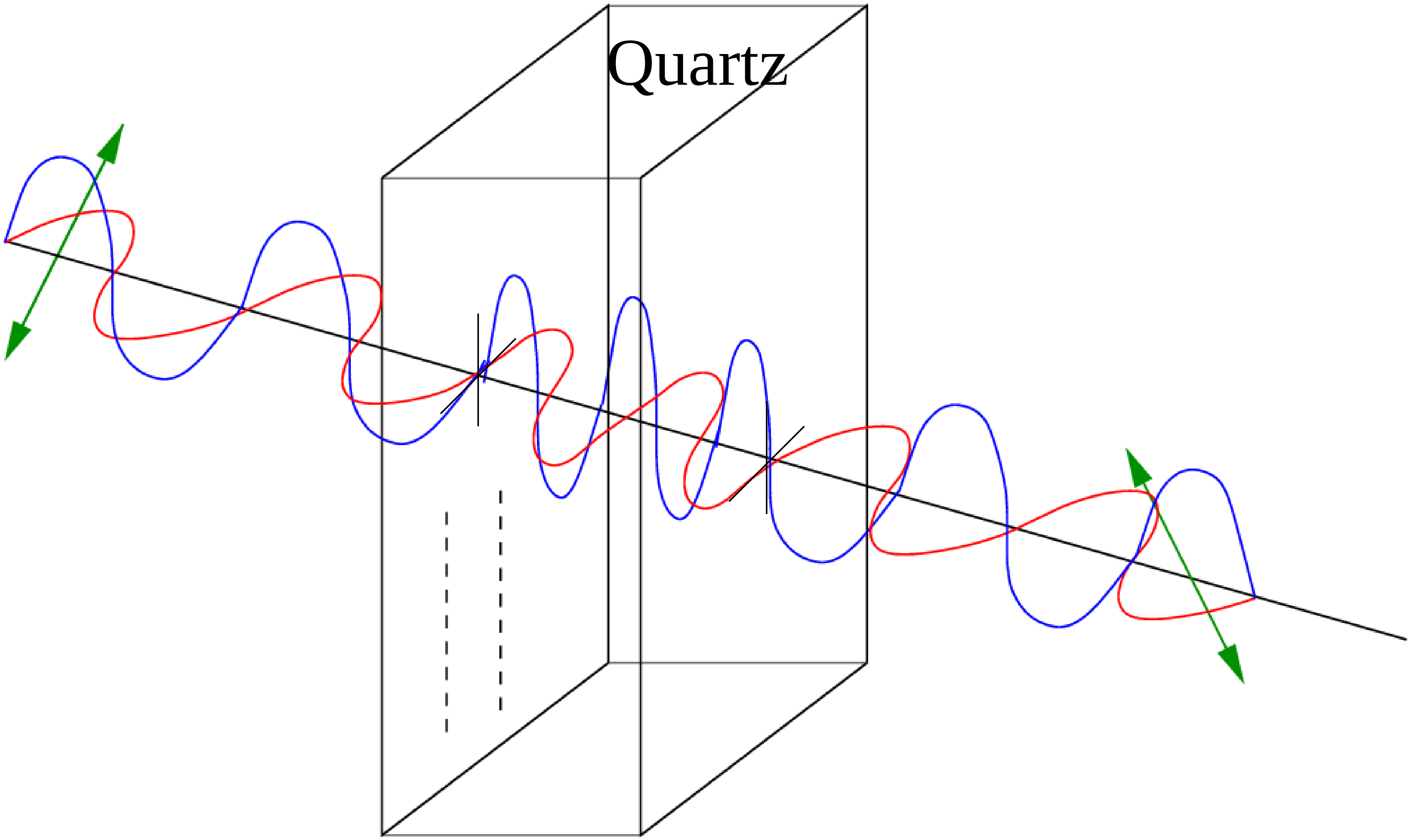
Quarter wave, Half wave and Full wave

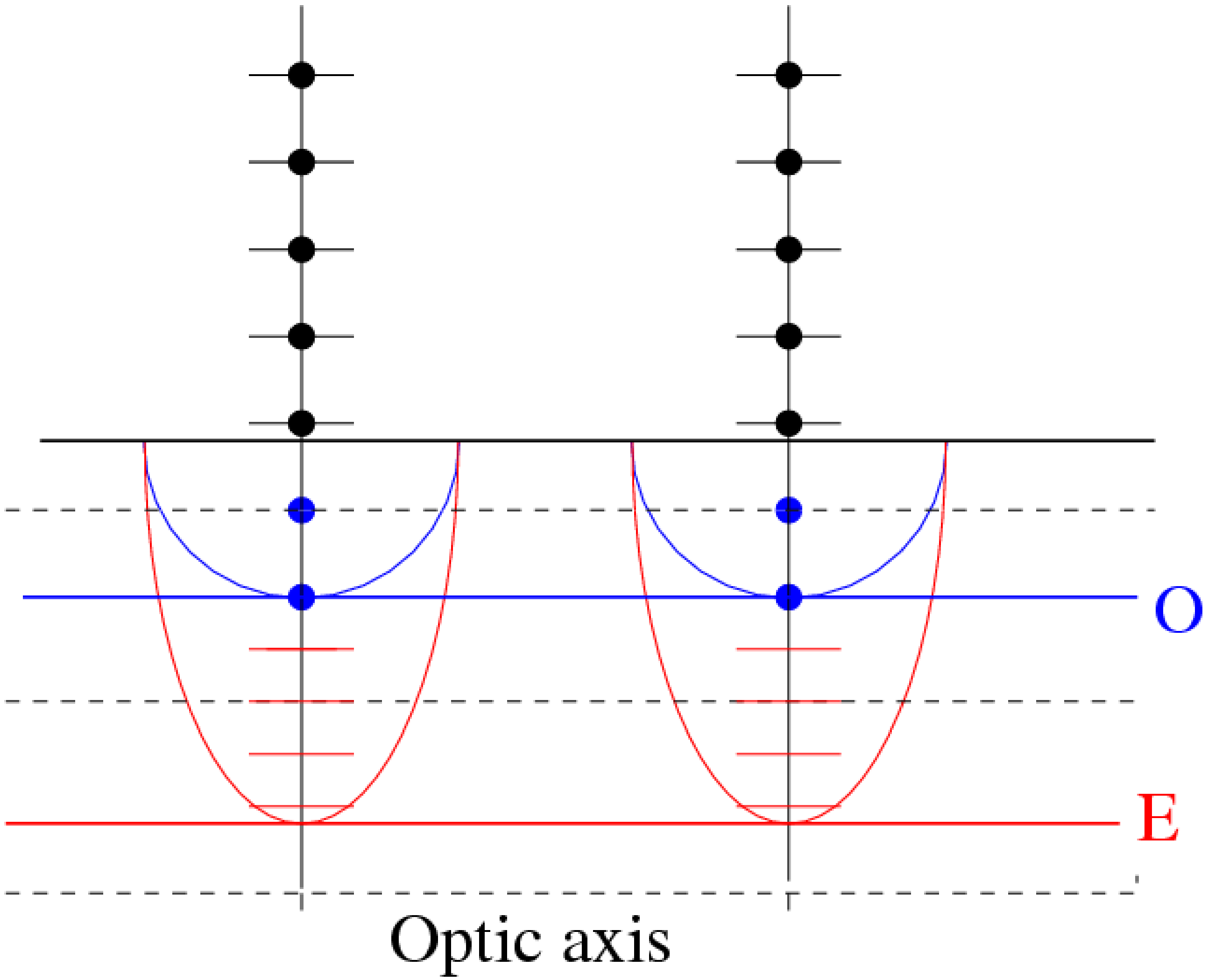
$$\Delta = \lambda/4, \qquad \lambda/2, \qquad \lambda$$


GLASS


Quartz

Half wave plate




O
E
Optic axis

Interference of polarised light

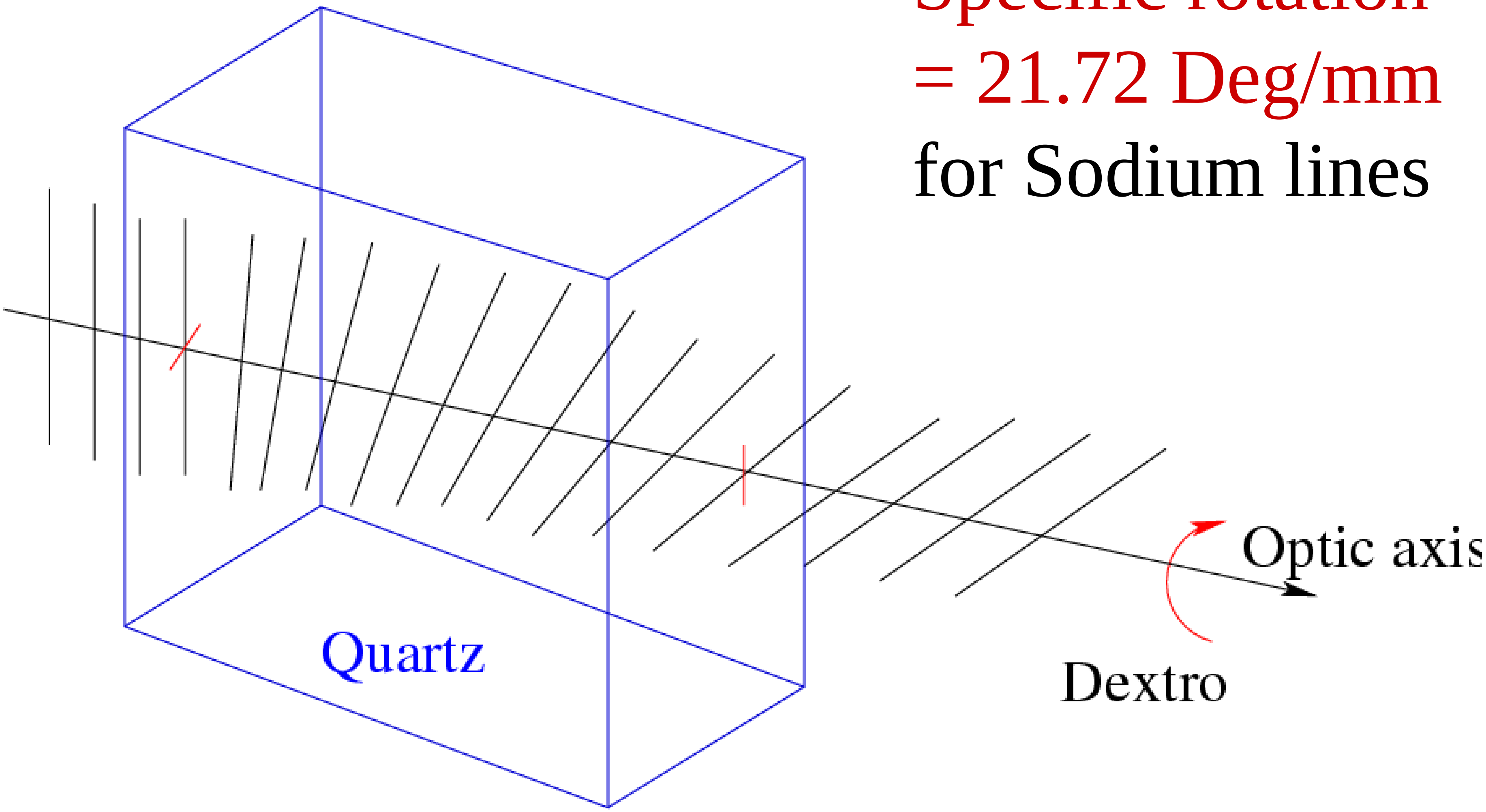
Fresnel-Arago laws

1. Two coherent rays polarised at right angles do not interfere

2. Two parallel coherent polarised rays will interfere in the same way as will ordinary light

Optically active medium

Specific rotation
= 21.72 Deg/mm
for Sodium lines

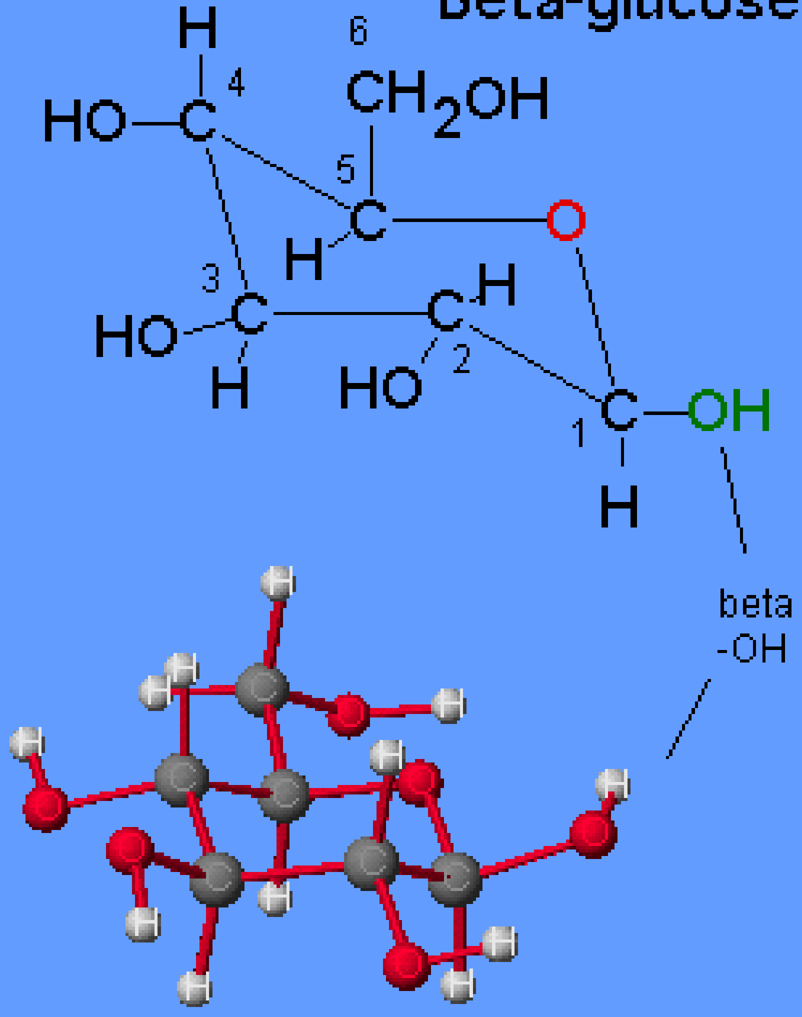


Sugar, Glucose and Fructose

		Specific rotation
Sugar (Sucrose or Cane sugar)	$C_{12}H_{22}O_{11}$	66.47^{o}
Glucose-D (Dextrose or Grape sugar)	$C_6H_{12}O_6$	52.7^{o}
Fructose (Levulose or Fruit sugar)	$C_6H_{12}O_6$	-92^{o}

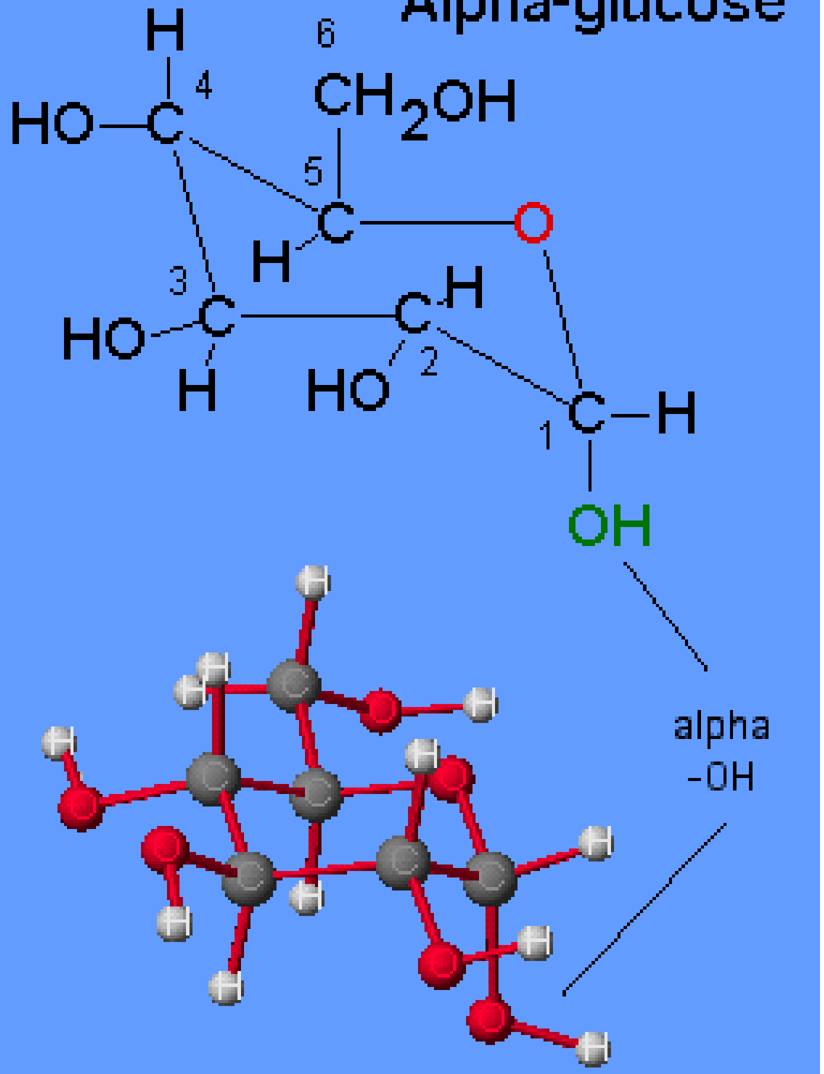
Mutarotation. The specific rotations of the α and β anomers of d-glucose are +112 degrees and +18.7 degrees, respectively. Specific rotation, $[\alpha]_d$, is defined as the observed rotation of light of wavelength 589 nm (the d line of a sodium lamp) passing through 10 cm of a 1 g ml^{-1} solution of a sample. When a crystalline sample of α-d-glucopyranose is dissolved in water, the specific rotation decreases from 112 degrees to an equilibrium value of 52.7 degrees. On the basis of this result, what are the proportions of the α and β anomers at equilibrium? Assume that the concentration of the open-chain form is negligible.

Beta-glucose



beta
-OH

Alpha-glucose

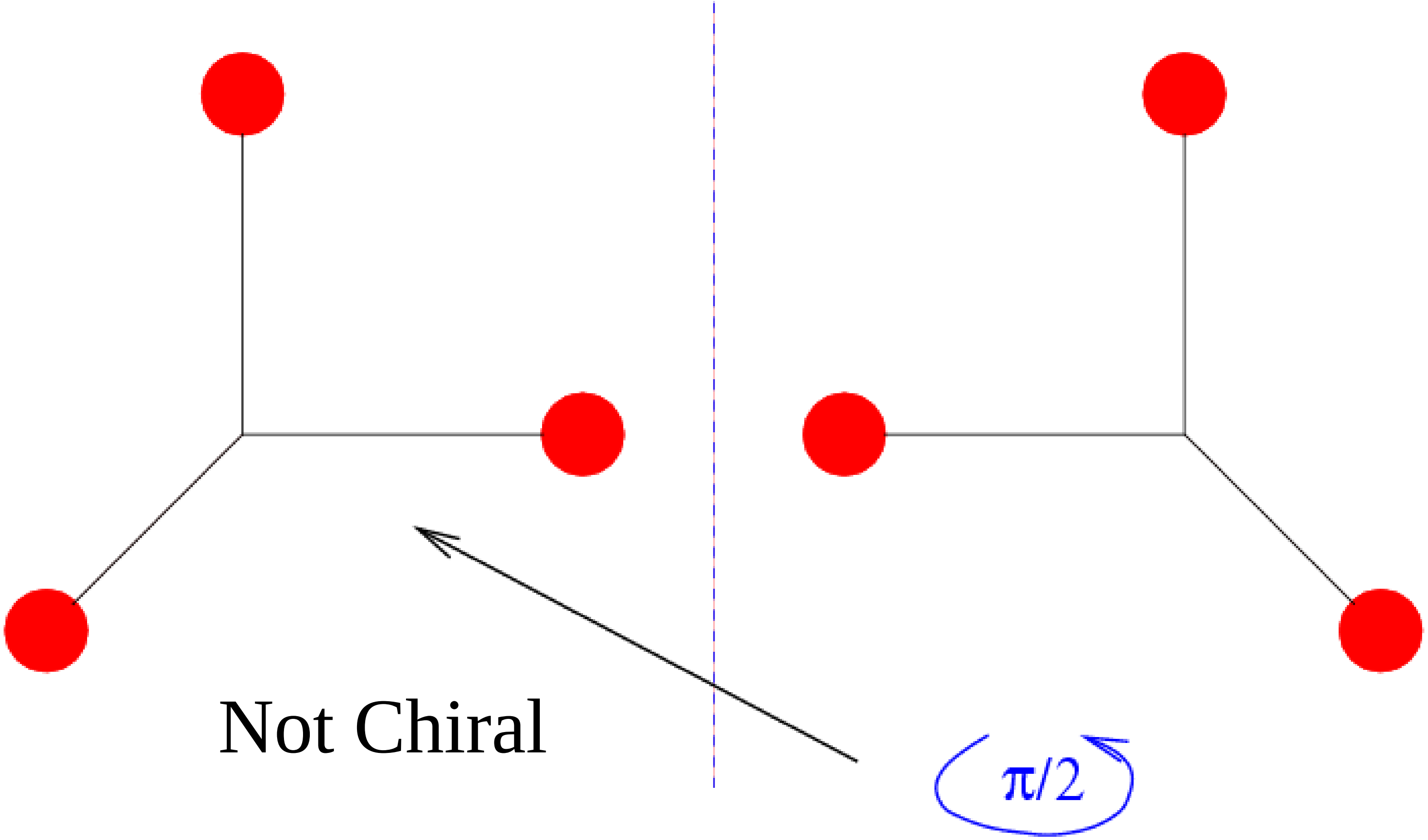


alpha
-OH

C. Ophardt, c. 2003

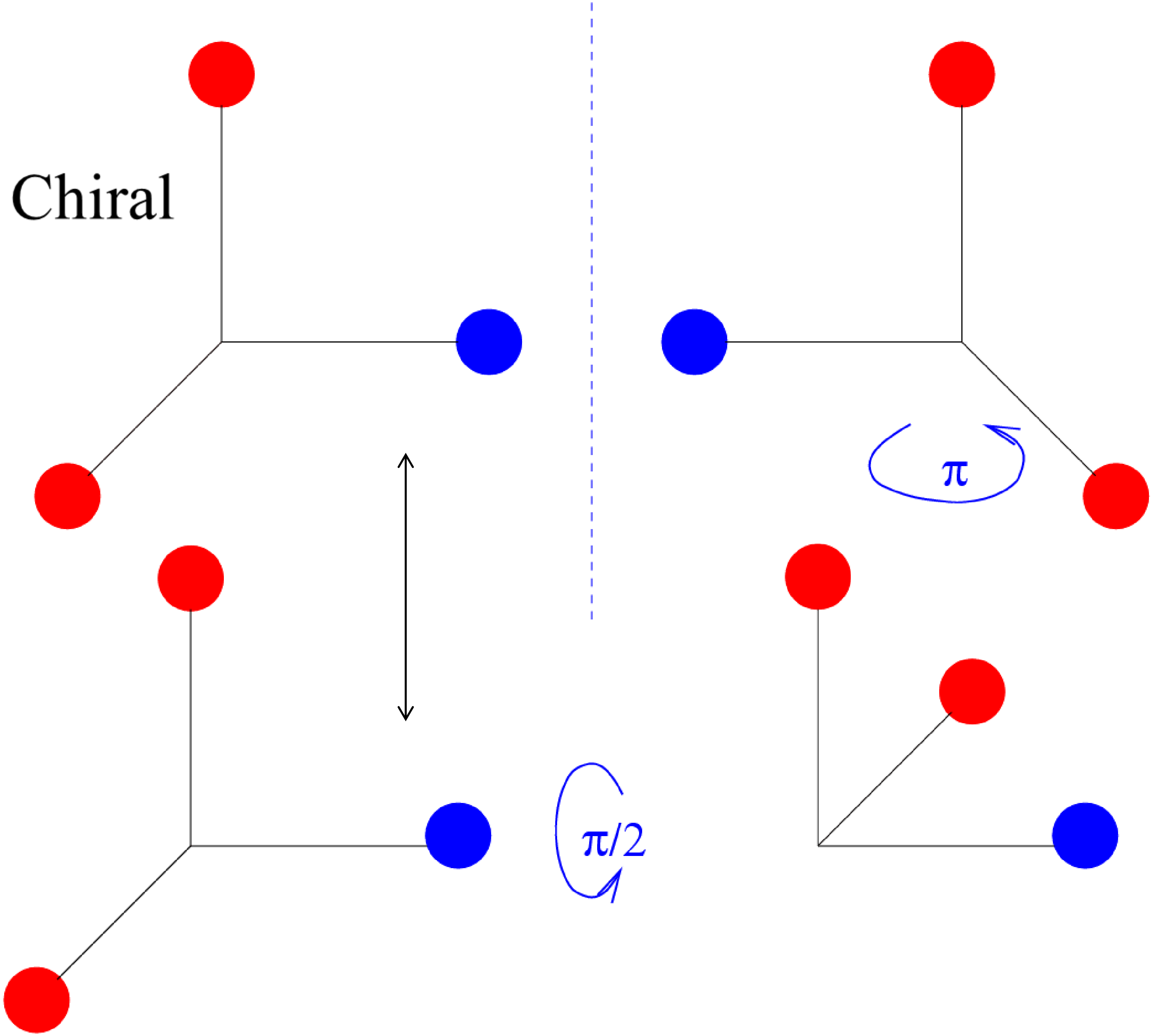
Chirality (handedness)

Chiral object: When the mirror image of the object cannot be superimposed exactly with the object with rotation in three dimensions.

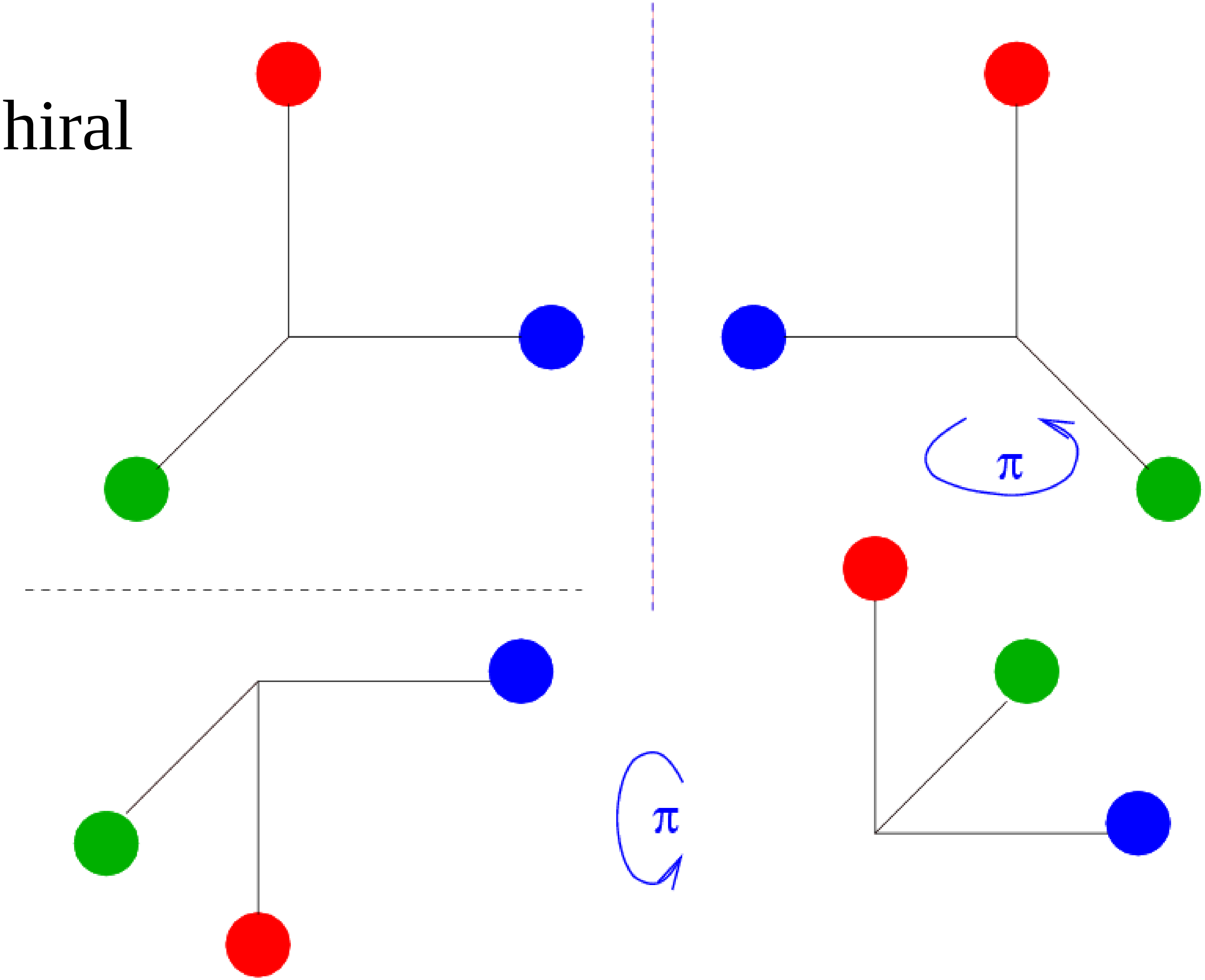


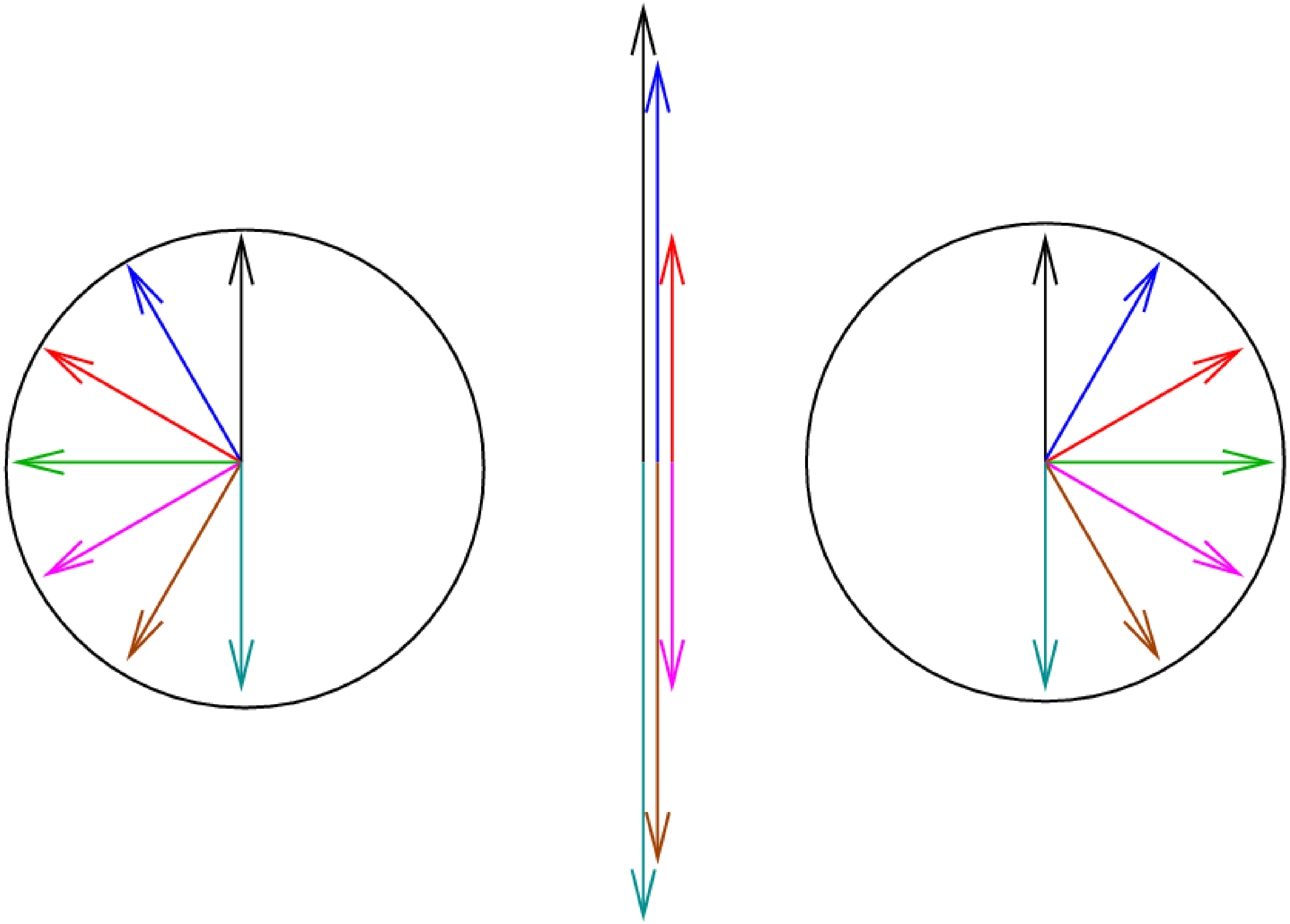
Not Chiral

Not Chiral

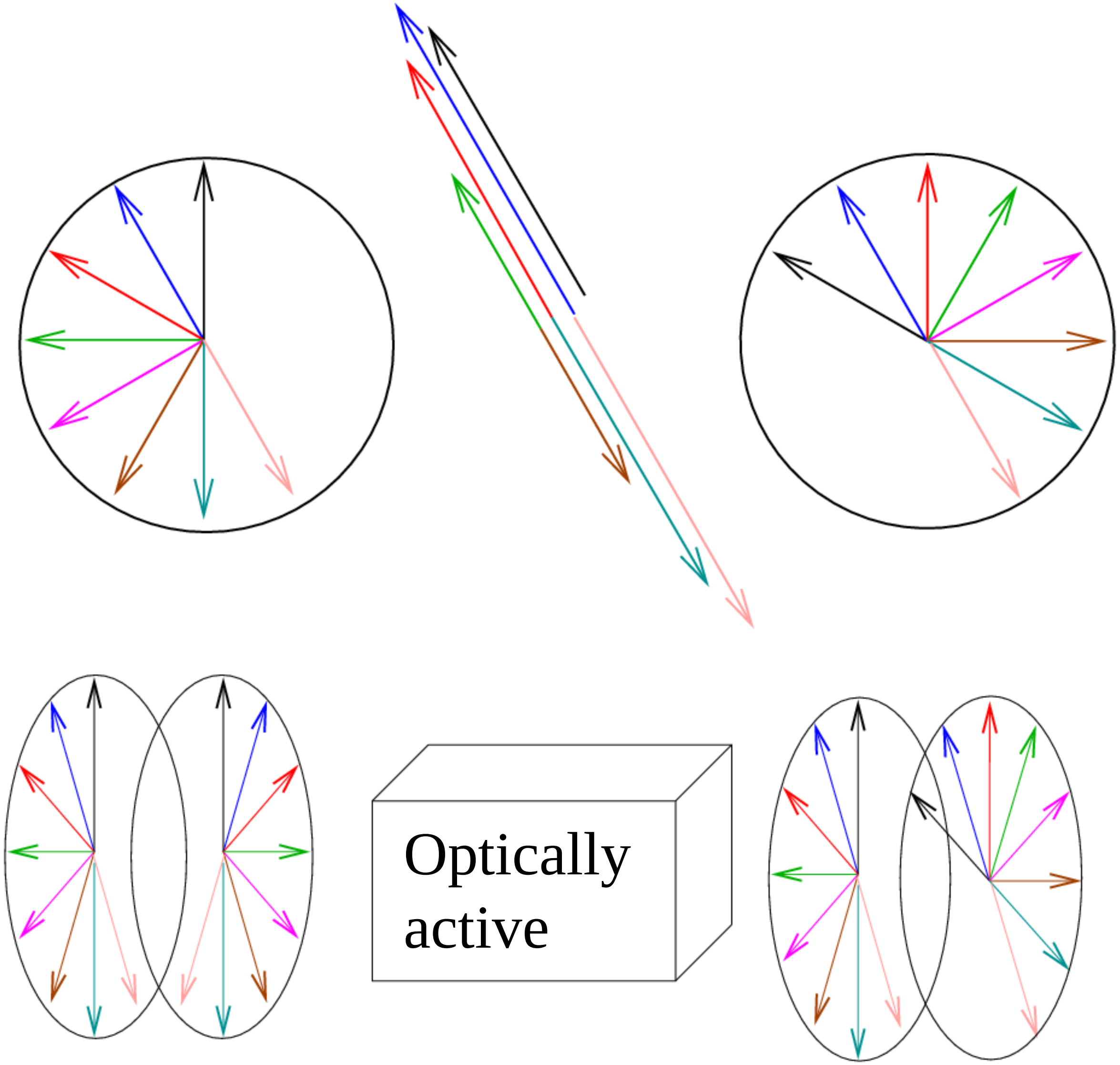


Chiral





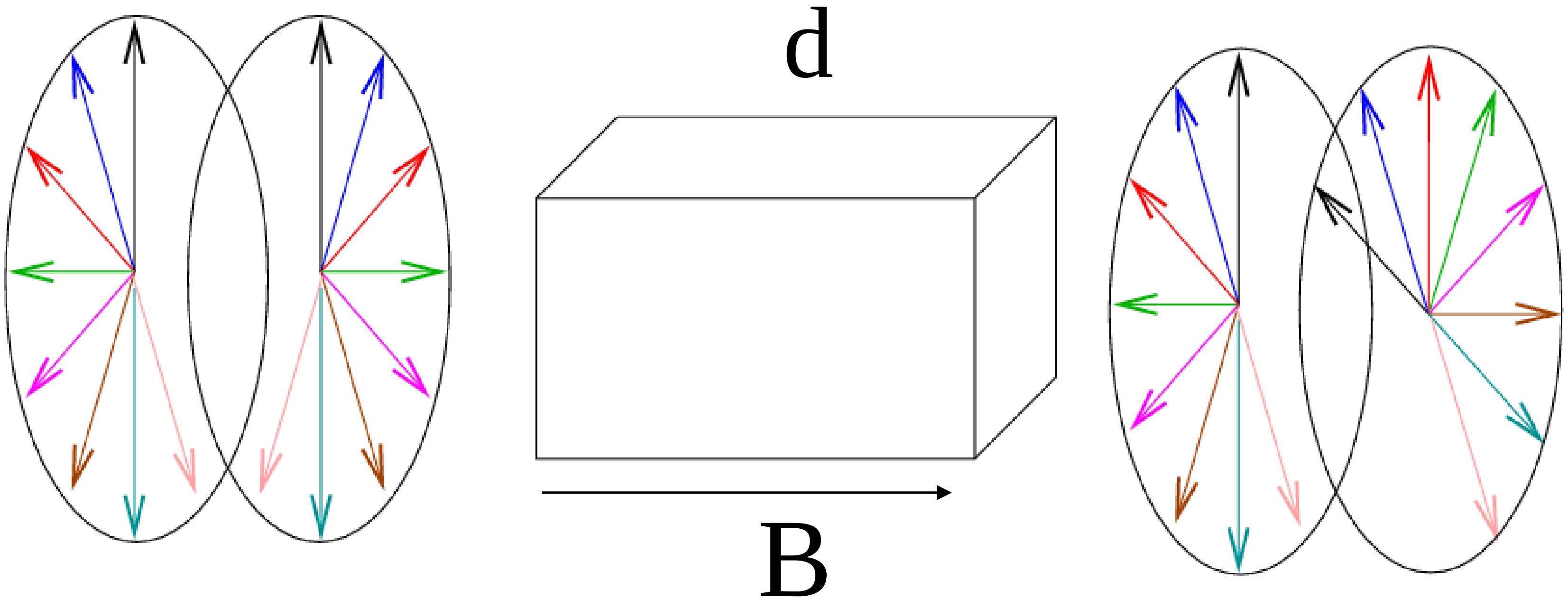
Linearly polarised light as equal mixture of left and right circularly polarised light.



Optically active

Due to the chirality of the molecules in an optically active medium one of the circular polarisations moves with greater speed and the emerging light has its plane of the linear polarisation rotated.

Faraday effect: The action of magnetic field makes some media optically active.



$$\beta = \mathcal{V} B d$$

$\mathcal{V}$ =Verdet cosntant

0.00001-0.01 min /Gauss-cm

Kerr effect/Pockels effct

An isotropic medium becomes birefringent by an application of *electric* field.

It behaves like a uniaxial crystal with optic axis in the direction of the applied field.

The electric field breaks the symmetry and the medium is polasrised and non-isotropic.

$$\Delta n = n_e - n_o = \lambda K E^2$$