# Circular dichroism
# Non-linear optics assignment

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## I. About

Circular dichroism is a optical effect, used as an absorption spectroscopy method based on differential absorption of left circular polarised light and right circular polarised light. It was discovered by Jean-Baptiste Biot, Augustin Fresnel, and Aimé Cotton in the first half of the 19th century.

As we know, electro-magnetic radiation consists of oscillating electric field ($\vec{E}$) and magnetic field ($\vec{B}$) perpendicular to each other and to the direction of propagation. Linearly polarised light has electric field oscillating in only one plane, while in circularly polarised light, the direction of the electric field (of constant magnitude) rotates about the propagation direction. Circularly polarised light is either right-handed or left-handed, depending on whether $\vec{E}$ rotates clockwise or anticlockwise about the propagation (directed towards the observer). When circularly polarised light passes through a optically active medium, the right and the left circularly polarised light face different refractive index, hence have different speeds. This leads to differential absorption of left and right circularly polarised light.

The difference in absorbance, $\Delta A = A_L - A_R$ , is a function of wavelength. By Beer-Lambert law, $\Delta A = \Delta\epsilon Cl$, where C is the molar concentration and l is the path length. $\Delta\epsilon$ is the molar circular dichroism which is given by ($\epsilon_L - \epsilon_R$), where $\epsilon_L$ and $\epsilon_R$ are molar extinction coefficients for left and right circularly polarised light. It is an intrinsic property of the medium, which is observed in CD experiments. Also, it depends on molecular conformation hence the factors like temperature, concentration and chemical environment comes into play. So during a CD experiment these factor need to be constant. The results from the experiments are reported as molar elipticity $\theta$, given by $3298.2\Delta\epsilon$.

## II. Applications

This effect is exhibited by optically active samples, in their absorption bandwidth. This is why it has applications in the field of molecular biology. CD spectroscopy helps in determining secondary structures of proteins. The figure below shows how CD spectroscopy looks different for different secondary structures. The identification of an unknown sample is done by matching the CD spectroscopy.

Similiar to Circular Dichroism, there is another technique called optical rotatory dispersion (ORD). The difference is that, CD is measured in or near the absorption bands of the sample molecule, while ORD can be measured far from these bands. Still, the resolution of the recorded bands in CD is much higher than that of ORD. In principle, these two spectral measurements can be interconverted through an integral transform (Kramers–Kronig relation), if all the absorptions are included in the measurements.

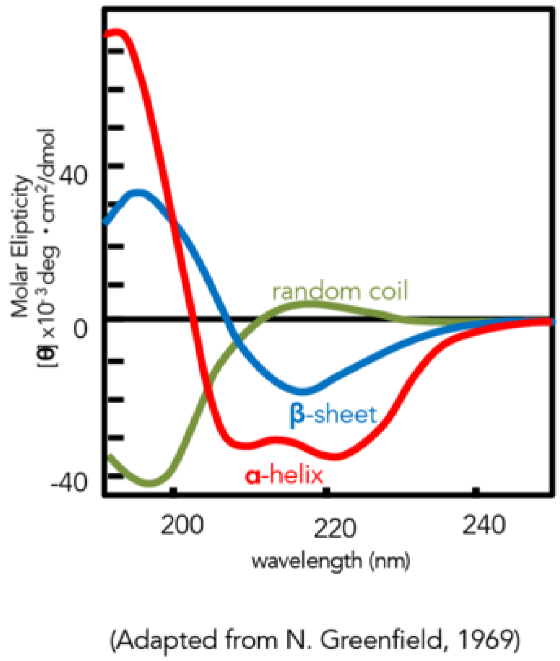


Figure 1. Molar ellipticity (as a function of wavelength) for secondary structures of proteins [1]


## References

[1] Wikipedia, “Circular dichroism,” https://en.wikipedia.org/wiki/Circular_dichroism, accessed 2021.

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