Dr. Mohammad Aslam, Dept. Of physics B.Sc part-2 physics (Hons) paper-iii, lecture no-78

Topic: Fresnel's Theory of Optical Rotation

According to Fresnel's a linearly plane polarised light can be supposed to be consists of two circularly polarised vibrations rotating in opposite directions. When a plane polarised light enters a crystal of calcite (which is optically inactive substance) along optical axis, it is resolved into two circularly polarised vibration rotating in opposite direction with same angular frequency or velocity such that resultant of these two vibrations at all point of time is along the optic axis. Vibrations rotating in clockwise (in Figure 6.21 (a)), direction are represented by OR and vibration rotating in anticlockwise direction are represented by OL ·The resultant OR and OL at all point of time will be along AB. In case of Quartz (which is optically active), a linearly polarised light on entering the crystal is resolved into two circularly

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polarised vibrations rotating in opposite direction with different angular velocity or frequency. In case of left handed optically active quartz crystal, anticlockwise vibrations travel faster, while in case of right handed optically active, quartz crystal, clockwise vibrations travel faster

Consider a right handed quartz crystal in which clockwise component travels faster than Left handed component. Suppose at any instant of time, right handed component traverse angle δ greater than left handed component as shown in Figure 6.21 (b). The new position of resultant of L' and OR' will be along CD i.e., plane of vibration of light has been rotated through angle δ/2 towards right after passing through quartz crystal. The angle δ/2 depends upon thickness of crystal

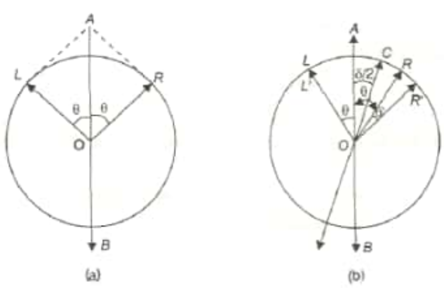

FIGURE 6.21

Mathematically,

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(a) For calcite crystal which is optically inactive: when linearly plane polarised light enters a calcite crystal it get resolved into two circularly polarised vibrations. One is moving nticlockwise with same angular frequency or velocity. As each circularly polarised vibration further consist of two rectangular components having phase differences n/2, so,

for clockwise circular vibration

x_1 =a sinθ =a sin wt

x_2 =a cos θ =a cos wt

for clockwise circular vibration

x_2 =-a sinθ =- a sin wt

y_2 =a cos θ =a cos wt

From above, the resultant displacement of vibrations along x-axis and y-axis respectively

are given as,

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$x = x_1 + x_2 = a \sin \theta - a \sin \theta = 0$

$y = y_1 + y_2 = a \cos wt + a \cos wt = 2 a \cos wt$

Hence resultant vibration has amplitude 2a and is plane y-axis i.e., along original direction AB. Hence two oppositely circularly polarised vibrations give rise to a plane polarised

vibrations.

(b) For quartz crystal which is optically active: When linearly plane polarised light enters quartz crystal (right handed), it gets resolved into circularly polarised vibrations moving in opposite direction with different angular frequency or velocity. In case of right handed crystal clockwise vibrations travel faster than anticlockwise vibrations. Let at any instant of time anticlockwise vibrations has traversed angle e and clockwise vibrations has traversed angle ($\theta + \delta$). Therefore, component of two circular vibrations at that instant of time will be,

for clockwise vibration

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$x_1 = a \sin (wt + \delta)$

$y_1 = a \cos (wt + \delta)$

for anticlockwise circular vibration

$x2 = - a \sin wt$

$y2 = a \cos wt$

From resultant displacement of vibrations along x-axis and y-axis respectively are given as,

$x = x_1 + x_2 = a \sin (wt = \delta) - a \sin wt$

$= 2a \sin \delta /2 \cos (wt + \delta/2)$

$Y = y_1 + y_2 = a \cos (et + \delta) + a \cos wt$

$= 2a \cos \delta/2 \cos (et + \delta /2)$

The resultant vibration along x-axis and y-axis are in same phase, so resultant of these vibrations is plane polarised and makes an angle of 8/2 with original direction AB. Thus, plane of vibrations get rotated through angle 8/2 towards right after passing through a right handed quartz crystal.

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