Notes for

B. Sc Part II

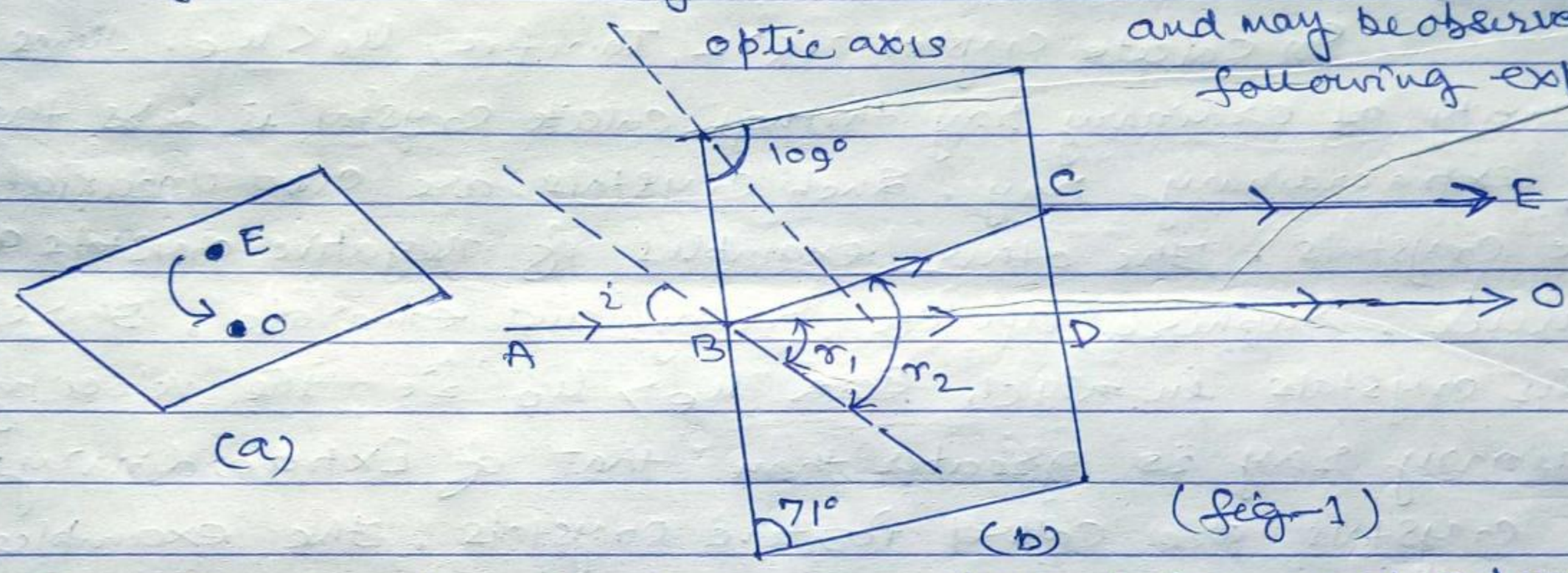
Paper — IIIrd

Dr. Bharat Singh (Pag-1)
Sher Shah College.

Double refraction in Crystals.

when a ray of ordinary unpolarised light is passed through a uniaxial crystal ie calcite, it is ~~refracted~~ split up into two refracted rays. One of the refracted rays follows the ordinary laws of refraction and hence is called the ordinary ray-O ray whereas the other refracted ray does not follow the ordinary laws of refraction is called the extraordinary rays - E ray.

Therefore if an object is viewed through such a crystal, two images of the object are observed. One image corresponds to O-ray and other E-ray. This Phenomena is called double refraction and may be observed by the following experiment.



(fig-1)

An ink dot is marked on white paper and calcite crystal crystal is placed over it. Two images of ink dot O and E are observed in fig-(1). Now if the crystal is rotated slowly about a vertical axis and the eye is placed vertically above the crystal. It is observed that one image remains fixed and the other image rotates with the rotation of the crystal. The fixed image is normal and is called ordinary image while other image is abnormal and is called extraordinary image.

Let a ray AB be incident on a calcite crystal at an angle of incidence i. The ray AB is split up →

(P.T.O)

→ inside the crystal in two refracted rays along BC and BD such that angle of refraction are r_2 and r_1 respectively. The rays emerge from the crystal along CE and DO which are parallel.

The refractive index of ordinary ray, $\mu_o = \frac{\sin i}{\sin r}$ and that of extraordinary ray, $\mu_e = \frac{\sin i}{\sin r_2}$. It is observed that refractive index of ordinary ray is constant (since it obeys ordinary laws of refraction), while refractive index of extraordinary ray varies with the angle of incidence i.

In calcite crystal $r_1 < r_2$, Therefore, $\mu_o < \mu_e$. Hence the velocity of ordinary ray through calcite crystal is less than that of extraordinary ray. Such crystals are called uniaxial negative crystals. The other examples of negative crystals are tourmaline, Saphire, apetite, ruby and emerald. There are other crystals in which $\mu_e > \mu_o$ i.e the velocity of ordinary ray is greater than that of Extraordinary ray. Such crystals are called Positive crystals. The examples of these crystals are quartz and iron oxide.

Special cases :-

(i) When a ray of light is incident along the optic axis or in a direction parallel to the optic axis, the ray is not split up in to ordinary and Extraordinary components. In this case both the rays travel along the same direction with the same velocity.

(ii) When a ray of light is incident perpendicular to the optic axis, the ray of light is not split up in to ordinary and extraordinary rays. In this case both the rays travel, along the same direction but with different velocities.

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