Experiment 9
Brewster's Angle

Aumshree P. Shah
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Synopsis

In this experiment reflective index of a transparent material is measured using Brewster's angle.

I. THEORY AND PROCEDURE

A. Apparatus

- Breadboard
- Laser diode
- Polariser rotator
- Glass slide
- Rotation stage
- Photodetector
- Detector output unit

B. Theory

A beam of light incident on a dielectric transparent material can be resolved into parallel(P) and orthogonal(S) components. These components have different reflection coefficients and Brewster discovered that at a particular angle of incidence ∂_B (called Brewster's angle), the reflection coefficient of P-component goes to zero. At this angle direction of reflected and transmitted beam are orthogonal to each other.

By Snell's law,

$$\tan \partial_B = n \tag{1}$$

where n is the refractive index of the material

C. Procedure

1. Read the user manual [4].
2. Mount diode laser to the laser mount.
3. Switch on the laser and place the polariser rotator & analyser in front of it so as to make the E field parallel to breadboard.
4. Mount the glass slide on the rotation stage.
5. Orient the microscope slide to reflect the laser beam back into the laser output aperture.
6. Rotate the glass slide slowly and note the corresponding degree with intensity of the reflected beam from the glass slide.
7. The intensity has a minimum (almost zero) at Brewster's angle $\partial_B = \theta_i - \theta_f$.
8. Using Equation-1, calculate the reflective index n.

[a] aumshree.pinkalbenshah@students.iiserpune.ac.in

II. OBSERVATIONS

$\theta_i = 218^\circ$
Least Count $= 1^\circ$

$\theta_f (^\circ)$	Detector Current (mA)
228	6.6
238	5.9
248	2.5
258	1.7
268	0.3
273	0.0
278	0.2
280	0.6
288	6.2
260	1.2
262	0.8
264	0.7
266	0.6
268	0.4
269	0.3
270	0.2
271	0.1
272	0.1
273	0.0
274	0.0
275	0.1
276	0.1
277	0.2
278	0.3
280	0.5
283	1.6

TABLE I. Data taken on 26 Mar 2025 of change in angle vs intensity.

III. UNCERTAINTIES AND ERROR SOURCES

A. Measurement Uncertainties

- **Angle Measurements:** Angle measurements have uncertainty given by: $\delta\theta = \text{least count}/2 = 0.5^\circ$

IV. CALCULATION AND ERROR ANALYSIS

A. Error Propagation

From Equation-1, the error in η will travel according to the equation [1]:

$$\delta\eta = \sqrt{2}\delta\theta \sec^2 \partial_B \tag{2}$$

We also calculate η by using the best ODR fit from the data points, whose equation is given by [2]:

$$I \propto \frac{\eta_1 \sqrt{1 - \frac{\eta_1}{\eta_2}\sin(\theta)} - \eta_2 \cos(\theta)}{\eta_1 \sqrt{1 - \frac{\eta_1}{\eta_2}\sin(\theta)} + \eta_2 \cos(\theta)} \tag{3}$$

B. Calculation

1. From the angles giving 0 values

We get minimum current at two angles; 58° and 59°. Using standard formula for error propogation from equation-2 and weighted average of these two values [1], we get the value of reflective index of glass as:

$$\eta_2/\eta_1 = \tan(58.5^\circ) \pm \sqrt{3}\delta\theta \sec^2(58.5^\circ)$$
$$\eta_2/\eta_1 = 1.45 \pm 0.05$$

2. From best ODR fit

Using equation-3, we find the best fit for our data [3] and get:

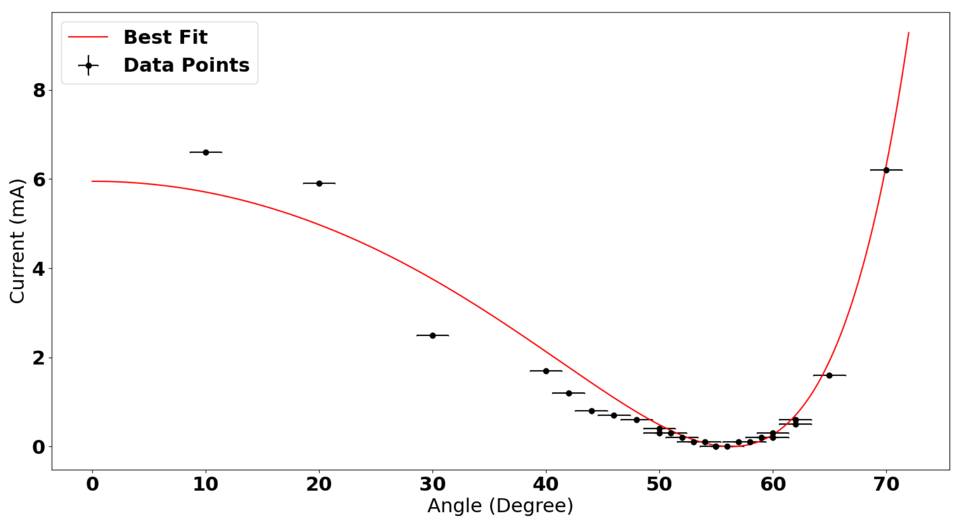

FIG. 1. Intensity Current vs Angle plot

From this we get the value of η_1 and η_2 to be:

$$\eta_1 = 1.00034 \pm 0.00003$$
$$\eta_2 = 1.50174 \pm 0.00004$$

3. Precautions

- Make sure the laser output is larger than the photo detector's input area.
- All should lie in the same plane.
- All screws should be tight enough so that the laser beam always stays in the plane.

V. RESULT

Using weighted mean we get the value of the reflective index as [1][3]:

$$\boxed{\eta_2 = 1.45 \pm 0.05\eta_1}$$

And using Best ODR Fit, we get the value of the reflective index as [1][3]:

$$\boxed{\eta_1 = 1.00034 \pm 0.00003 \quad \eta_2 = 1.50174 \pm 0.00004}$$

REFERENCES

[1] Brewester's angle manual. `cdn.pasco.com/product_document/Brewsters-Angle-Accessory-Manual-OS-8170A.pdf`, 2025. Experiment Manual.

[2] LAUGHINGCATMEME. Ph2233 - code repository. `https://github.com/LAUGHINGCATMEME/PH2233`, 2025. GitHub repository.

[3] Daryl W. Preston and Eric R. Dietz. The Art of Experimental Physics. 2025. Available online.

[4] Wikipedia contributors. Brewster's angle. `https://wikipedia.org/wiki/Brewster%27s_angle`, 2025. Accessed 2025.