Experiment 9
Brewster's Angle

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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 oon 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 reflectied 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 **ENTER A REFRNCE 4 HERE**
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 ∂_B.
8. Using Equation-1, calculate the reflective index n.

1. Precautions

- Make sure the laser output is larger than the photo detector's input area.

II. OBSERVATIONS

	T_i (°C)	Length (cm)	ΔL (10^{-5} m)
Copper	24.0	59.8	75
Copper	25.5-24.5-25.5	59.7	74
Aluminium	24.0-23.0-24.7	59.9	105
Brass	24.1-23.2-24.3	59.7	85
Steel	22.1-24.8-20.5	-	74
Aluminium	24.3-23.7-24.3	59.8	104
Brass	23.7-22.4-24.3	60.0	85
Steel	24.6-25.3	59.9	76
Brass	24.8-25.3	60.1	86
Steel	23.3-23.5	59.7	76

TABLE I. Data taken on 11 Mar 2025, the variables represents the property as described in the theory. The '-' value is assumed to be 60.0 cm.

Least count of scale: 0.1 cm
Least count of thermometer: 0.1 °C
Least count of spherometer: 10^{-5} m

III. UNCERTAINTIES AND ERROR SOURCES

A. Measurement Uncertainties

- **Length Measurements:** Estimated uncertainty of ±0.1 cm due to not proper method of viewing, expansion uncertainty of $\pm 5 \times 10^{-6}$ m.
- **Temperature Measurements:** Uncertainty of ±0.05 K due to instrument resolution.

IV. CALCULATION AND ERROR ANALYSIS

A. Error Propagation

From the length and temperature uncertainty, and using Equation-1 uncertainty in α, by the basic formula for error

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propagation[1] will propogate as .:

$$\sigma_\alpha = \alpha\sqrt{\left(\frac{\sigma_{\Delta L}}{\Delta L}\right)^2 + \left(\frac{\sigma_L}{L}\right)^2 + \left(\frac{\sigma_{\Delta T}}{\Delta T}\right)^2}$$

where $\sigma_{\Delta L}, \sigma_L, \sigma_{\Delta T}$ are the uncertainties in expansion length, initial length, and temperature difference, respectively.

B. Calculation

We calculate the value of α of all data points and their uncertainity from hte above formul, we get (Refer to [3] for calculations):

Material	α (1/°C)
Aluminium	$(2.33 \pm 0.02) \times 10^{-5}$
Aluminium	$(2.32 \pm 0.02) \times 10^{-5}$

TABLE II. Calculated expansion coefficients

V. RESULT

The final expansion values by weighted average[1] are:

Material	α **(1/°C)**	**Uncertainty (1/°C)**	χ^2_ν
Aluminium	2.328×10^{-5}	6.1×10^{-8}	0.15
Brass	1.90×10^{-5}	1.73×10^{-7}	2.70
Copper	1.674×10^{-5}	3.60×10^{-8}	0.10
Steel	1.67×10^{-5}	3.07×10^{-7}	11.14

Appendix A: Temperature of rod

The temperature of rod measured with the application of thermal paste is found to be ranging between 98 °C − 99 °C (measured on 19 Mar 2025)

[1] Preston, Daryl W. and Dietz, Eric R., The Art of Experimental Physics. Available at: http://ilide.info-daryl-w-preston-eric-r-dietz-the-art-of-experimental-physics-wiley

[2] Wikipedia, Brewster's Angle, 2025. Available at: https://en.wikipedia.org/wiki/Brewster%27s_angle

[3] LAUGHINGCATMEME, PH2233 - Code Repository, 2025. Available at: github.com/LAUGHINGCATMEME/PH2233