MIT World Peace University

Physics
First Year B. Tech, Trimester 3
Academic Year 2021-22

Law of Malus

Experiment No. 3

Prepared By

109054. Krishnaraj Thadesar
Division 9 Batch I3

May 6, 2022

Pledge

I solemnly affirm that I am presenting this journal based on my own experimental work. I have neither copied the observations, calculations, graphs and results from others nor given it to others for copying.

Signature of the student

Experiment 2: Diffraction Grating

1 Aim

To verify law of Malus

2 Apparatus

1. Monochromatic source of light
2. Two polarizers with angular scale from 0-360o
3. Luxmeter
4. Metallic tube for mounting polarizer and analyzer

3 Significance of the Experiment

Law of Malus, which relates the intensities transmitted by a polarizer and analyzer, is the basis of several applications such as polarizing sunglasses, visors of the automobiles, seven segment LCDs, polarimeters, optical activity, blue sky, red sunset, Faraday effect, Kerr effect, photoeleasticity etc. Law of Malus is also used in analysis of polarized light

4 Theory

An unpolarized light consists of the vibrations which are isotropically distributed in all 360° directions transverse to direction of propagation. Since vibrations exist in all the directions, their net X and Y components are equal i.e. 50%. If such light is passed through a polarizer, the components parallel to optic axis are transmitted and components perpendicular to optic axis are eliminated. Thus when the light is polarized once, its intensity decreases by 50%. Consider a system of two polarizers having an angle θ between their optic axes. Let the amplitude and intensity of the light incident on the first polarizer be E_o and I_o respectively. When the light passes through first polarizer, its amplitude and intensity reduces. Let these reduced amplitude and intensity be E_l and I_l respectively. (We have $I_1 \cong \frac{I_o}{2}$). As the angle between the optic axes of the polarizers is θ, the light polarized by the first polarizer (E_l) is incident on the second polarizer at θ itself (refer Fig 3.1). Second polarizer transmits the cosine component of E_1 as it is along its optic axis. If the E_2 and I_2 are the amplitude and intensity of the light transmitted by the second polarizer, then we have

$$E_2 = E_1 \cos\theta \Rightarrow I_2 = I_1 \cos^2\theta$$

Eqn (3.1) signifies that I_2 is the function of θ and I_1 is the maximum value of I_2. Thus, by choosing appropriate notations,

$$I_\theta = I_m cos^2\theta$$

Eqn (3.1) and (3.2) represent law of Malus. The law states that the intensity transmitted by a pair of polarizers is a cosine square function of the angle between their optic axes.

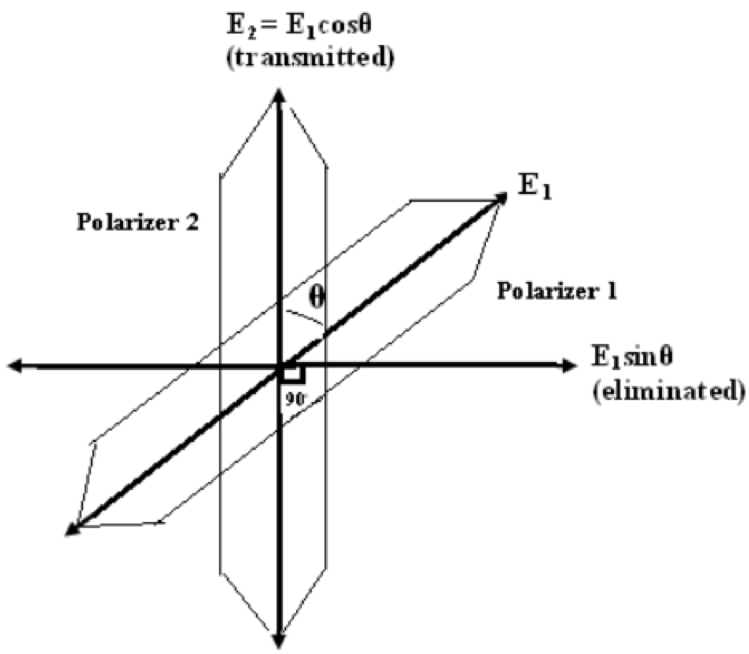


Figure 3.1: Law of Malus (Schematic)

5 Procedure

1. Remove slit as well as lens of a collimator (of the spectrometer) and mount polarizers at both the ends.
2. The polarizer towards the light source is called polarizer and that towards the observer is called analyzer.
3. Level the collimator tube using spirit level.
4. Perform the experiment in dark room so that no other light except that from sodium will enter the detector (Luxmeter)

5. Make the luxmeter ON and set it at appropriate range (0-200 Lux)

6. Rotate the analyzer through 360° while looking through it. The intensity will maximize three times at θ equal to $0°, 180°$ and $360°$, while intensity will be extinguished at θ equal to 90° and 270°.

7. Adjust the analyzer so that it transmits maximum intensity. This corresponds to $\theta = 0°$ condition. Confirm this position by using a Luxmeter. Hold the sensor of the Luxmeter on the analyzer and move the analyzer slightly back and forth and detect the exact maximum intensity position. Note the corresponding angular position of the analyzer. Let this be θ'. As this is maximum intensity condition, it corresponds to $\theta = 0°$. θ' is the angular position of the analyzer and θ is the angle between the optic axes of polarizer and analyzer. θ 'and θ need not be same. Also record the maximum intensity shown by the luxmater. This is I_m 30

8. Now rotate the analyzer by 30° each time and record both θ'' and θ. Also record the corresponding intensities using the Luxmeter. These intensities are denoted by I_θ Continue the observations till θ reaches 360°. Record all your readings in the observation table 3.1.

9. Calculate $\frac{I_\theta}{I_m}$ and $\cos^2\theta$ for each θ

10. Plot the graph of $\frac{I_\theta}{I_m}\text{Vs}\theta$ for all 13 values of θ. It will show cosine square nature.

11. Also plot the graph of $\frac{I_\theta}{I_m}\text{Vs}\cos^2\theta$ only for first four values. It will be a straight line

12. Both these graphs signify law of Malus

6 Observations

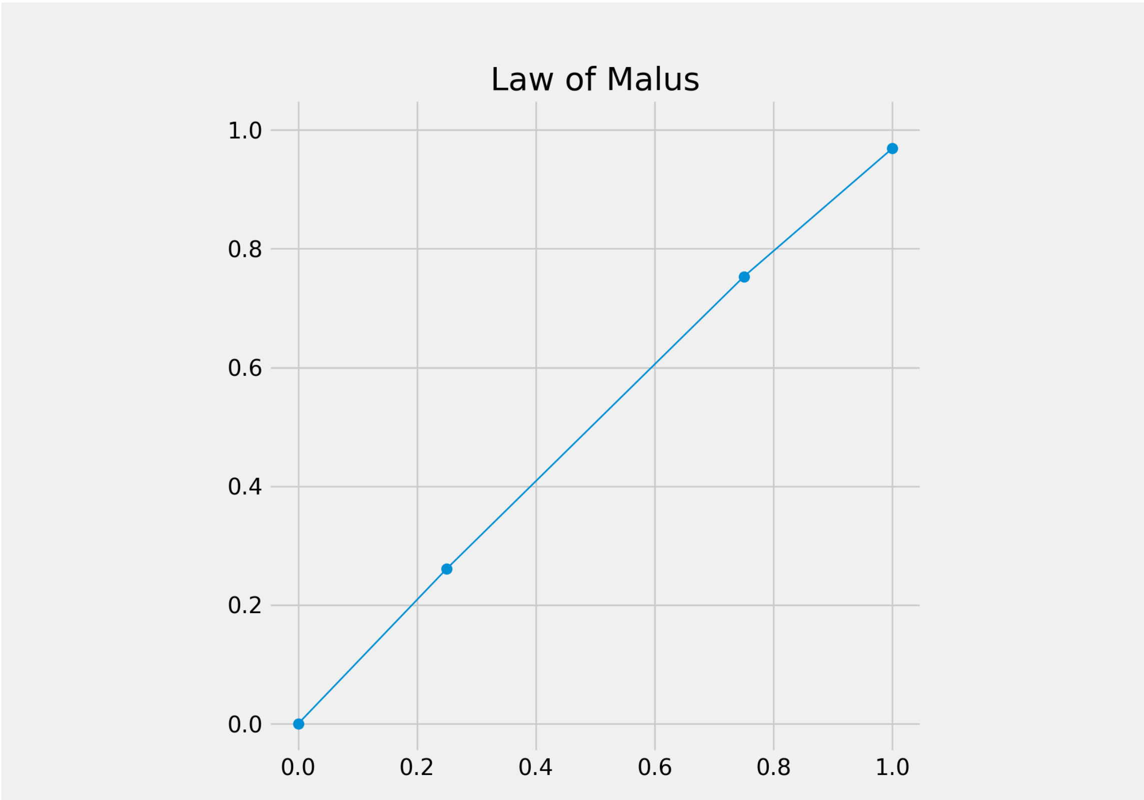
Table (3.1): Observations, Calculations and Results.

1. The least count of the angular scale on the analyzer = 1deg
2. The maximum intensity (at $\theta = 0^0$), $I_m = \ldots\ldots$ lux

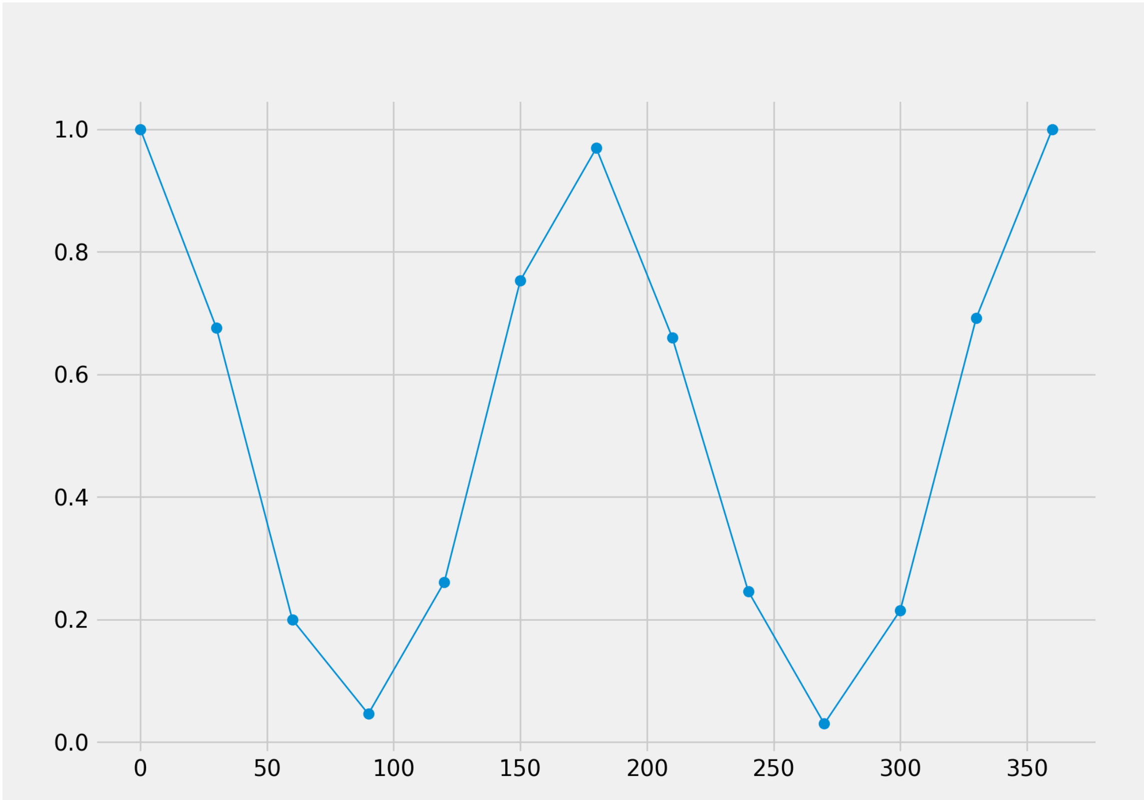
Sr. No.	**The reading on the angular scale on the analyzer $\theta' deg$**	**The angle between polarizer & analyzer θdeg**	**Intensity through the analyzer (I_θ), lux**	**Relative intensity $\frac{I_\theta}{I_m}$**	$cos^2\theta$
1		0	$I_\theta = I_m = \ldots$	1	1
2		30			
3		60			
4		90			
5		120			
6		150			
7		180			
8		210			
9		240			
10		270			
11		300			
12		330			
13		360			

7 Graphs

7.1 Plot between I_θ/I_m vs $\cos^2\theta$



7.2 Plot between I_θ/I_m vs θ



8 My Understanding of the Experiment

Law of Malus relates the intensity of light emitted from the analyzer to the polariser. This is important because it gives practical value to the role of the analyzer. By finding out the intensity of light obtained by the analyzer, one can conclude whether or not the light is polarized, partially polarised, or unpolarised. *Therefore, that would be one of the main applications of this experiment.*

If the light rays were polarized, then they would travel in the direction parallel to the optic axis of the polariser, and if the analyzer were kept on the same optic axis, or 180 deg to it, then the parallel components of light would pass through with the same intensity, and if not then it it would reduce by some factor, which is a function of the angle θ between the analyzer and the polarizer.