CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

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Project Number

J1805

Project Title

Probing Photons with Polarizers, Counting Them with Cosines

Abstract

Objectives/Goals

The objective of this project studies the effects of introducing photons into polarization sets. Specifically, this project applies and extends Malus' Law, which states that when polarized light traverses a polarizer, the intensity of the departing light will equate to the intensity of the incoming light multiplied by the cosine squared of the angle between the transmission axis of the polarizer and the initial plane of polarization. Further, it derives new mathematical equations based on extending Malus' Law.

Methods/Materials

The intensity proportions of the Equiangular Polarizer Configuration and the Two Polarizer Configuration were calculated using a flashlight, green laser, and LUX meter with varying numbers of polarizers. In total, 152 trials were conducted. F-tests and t-tests, were conducted to test the statistical significance of certain treatments of data. Also, six Java classes were coded to simulate each polarizer configuration. Equations were derived to calculate the intensity proportion of each of these sets using calculus.

Results

It was found that the measured data from the Two Polarizer Configuration supported Malus' Law when the reflections caused by imperfect polarizers were taken into account. Further, a statistical t-test was used to compare the experimental and theoretical results, which resulted in the acceptance of the null hypothesis, confirming Malus' Law.

Additionally, the intensity proportion of the Equiangular Polarizer Configuration was compared to the computer simulation output, and there appeared to be a pattern that described the propagation of error as the number of polarizers increased. Because imperfect polarizers reflect a constant percentage of light, the theoretical intensity proportion must be multiplied by the light reduction proportion for every polarizer to align with the experimental results. After researching the literature, the proportion turned out to be related to the HN value. Since the light reduction proportion was calculated to be 0.8, the polarizers were therefore equivalent to HN-40 quality.

Conclusions/Discussion

Overall, the results supported Malus' Law while new mathematics was derived extending it. The Java programs successfully simulated novel polarizer configurations, which may have applications in the construction of adjustable brightness in windows. In conclusion, this project confirmed Malus' Law and revealed some previously unknown concepts.

Summary Statement

This project confirms and expands upon Malus' Law by measuring the intensity of light traversing various polarizer configurations.

Help Received

I collected the experimental data, coded all six (6) Java programs, and conducted the t-test and F-test. My Java mentor taught me Java since I was 10, while my mother taught me how to perform the t and F tests.