PHYS134
Homework/Project 6
2021-03-29

Steck 8.2 (5 pts)

(a) Consider a linear polarizer and a wave linearly polarized at an angle θ with respect to the polarizer's transmission axis. Show that the intensity of the wave is reduced by $\cos^2\theta$ after passing through the polarizer (this is called the **Law of Malus**). [Hint: Use the rotation matrix and its inverse.]

(b) Consider a system of N cascaded polarizers. The polarizers have their transmission axes at angles $\pi/2N, 2\pi/2N, 3\pi/2N, \cdots \pi/2$ from the x-axis, in the order that an input wave sees them. That is, the last polarizer is oriented along the y-direction. Suppose that an input wave is polarized in the x-direction. Compute the intensity transmission coefficient for the system. Show that the transmission coefficient approaches unity as $N \to \infty$. This is a simple realization of the **quantum Zeno effect**, where each polarizer acts as a "measurement" of the polarization state—the polarization is "dragged" by the measurements as long as they are sufficiently frequent.

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Arbitrary Waveplate Jones Matrices (10 pts)

(a) Write the Jones Matrix for an arbitrary wave plate, which adds a phase η in the y-direction relative to the x-direction.

(b) Find the Jones Matrix for such a waveplate when it's oriented at some angle θ. [For this and what follows, something like Mathematica is helpful. And don't worry about the sign of θ that I worried about in my lecture—everything here is even in θ.]

(c) If horizontally-polarized light passes through this waveplate and then thorugh a horizontal polarizer, what fraction of intensity makes it through as a function of θ and η?

(d) Simplify this fraction as a function of θ for a half-waveplate and a quarter-waveplate.

(e) Plot this fraction as a function of θ for three different cases on the same plot (with a legend): half-waveplate, quarter-waveplate, and eighth-waveplate.

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Fitting Waveplate Data (10 pts) Watch the video `Lab5Polarization.mp4`. I wasn't careful enough with the polarizer and HWP data, and the motorized data at the end had some strange features, so I'll only ask you to analyze the quarter-waveplate data. The others would have been boringly similar.

Download `QWP.csv`. Briefly look at the file in a text editor or spreadsheet program. Fit the data to the function you found in the previous problem for the arbitrary waveplate. You'll need 3 parameters:

- the overall amplitude (the meter reads in mW, not fraction transmitted),
- the angular offset of the waveplate in the mount (a few degrees plus or minus—by convention, this parameter is meant to be the reading on the dial that sets the actual wave-plate to true zero degrees), and
- the fractional retardance (should be close to 0.25 because it would be a quarter waveplate if the wavelength of the laser diode exactly matched the wavelength that the waveplate was designed for, which is almost never perfectly the case).

Be sure to supply reasonable, non-zero initial guesses for these parameters because this is a non-linear fit.

Be sure to calculate the reduced χ^2 and PTE.

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