PhysicsTutor

Polarizer

Problem:

- A linearly polarized light source of unknown polarization direction illuminates a vertical LP, followed by another LP whose axis is rotated by 60 degrees with respect to the first.
- The observed intensity equals 0.15 I_0, where I_0 is the intensity of the light source.
- By which angle φ is the source polarization direction rotated from the vertical LP axis?

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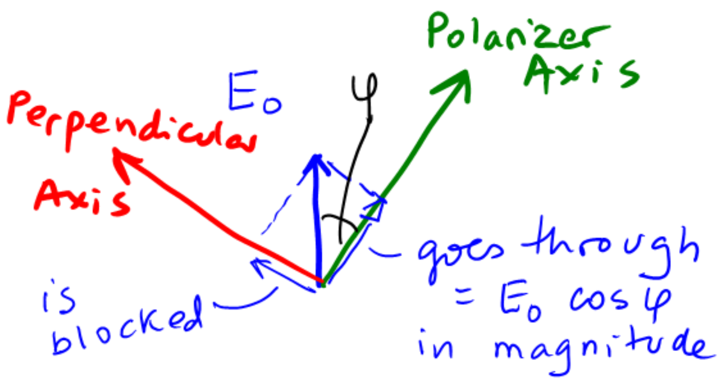
- After the vertical LP we get $I_0 \cos^2(\varphi)$.
- The second polarizer reduces the intensity by $\cos^2(\theta)$.

Equations associated with ideas:



$$I_0 \cos^2\varphi = E_0^2 \cos^2\varphi$$

= transmitted intensity of an ideal polarizer

(@ $\varphi = 0$ perfect transmission)

In this problem: 1st Polarizer axis is vertical, light source is linearly polarized with unknown orientation φ

$$I_0^{observed} = 0.15\, I_0 = I_0 \cos^2\varphi \cos^2\vartheta$$

where $\vartheta = 60° = \pi/3$

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- The known factor is: $\cos^2(\pi/3)$; the unknown: $\cos^2(\varphi)$
- Isolate φ in $\cos^2(\varphi)\cos^2(\pi/3) = 0.15$.
- Note that $\cos^2(\pi/3) = ¼$, and, thus, $\cos^2(\varphi)=0.6$.

Solution

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- $\cancel{I_0} \cos^2\varphi \underbrace{\cos^2\left(\frac{\pi}{3}\right)}_{1/4} = 0.15 \cancel{I_0}$ ____

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- $\cos^2\varphi = 4 \cdot 0.15 = 0.60$

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- $\cos^2\varphi = 4 \cdot 0.15 = 0.60$
- $\cos\varphi = \sqrt{0.60} = 0.775$

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- $\cos\varphi = \sqrt{0.60} = 0.775$
- $\varphi = 0.685 \text{ rad} = 39°$

Note: due to the $\cos^2\varphi$ behaviour we can't distinguish which way $(\pm\varphi)$ the orientation is with respect to the vertical (1st polarizer alignment).