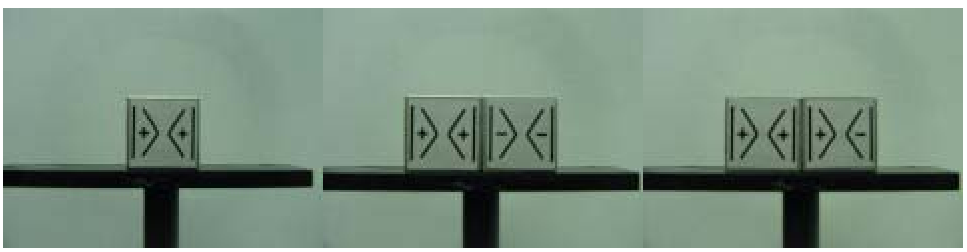
Answer #291

Part 1: The answer is (d): a combination of the above. In particular, each of the "++" and "--" cubes contains three components, such that when unpolarized light enters either side circularly polarized light will emerge. In particular, each cube contains a polaroid sheet sandwiched between two quarter-wave plates. The two quarter-wave plates are aligned at 0^o and 90^o; for the "++" cube the polaroid is aligned at -45^o and for the "--" cube the polaroid is aligned at $+45^o$. This ensures that only right-handed polarized light can enter and exit the "++" cube, while only left-handed polarized light can enter and exit the "--" cube. Click on the photograph at the left below to see what happens when a polaroid sheet is rotated in front and behind the "++" cube. Click on the photograph at the center below to see what happens when the "--" cube is rotated about the optic axis of the "++" cube. Click on the photograph at the right below to see the "++" cube rotated, both in front and behind, about the axis of the "+-" cube.



Part 2: the answer is (d): a combination including a polaroid sheet at $+45^o$ with two quarter-wave plates aligned with their extraordinary axes vertical. This arrangement inverts the phase of one of the two components of the circularly polarized light, reversing its chirality, so it changes right-handed circularly polarized light entering the "+" end into left-handed circularly polarized light leaving the "-" end, and vice versa. No significant change is seen in the light when a polaroid is positioned adjacent to either of the cubes and rotated.

These blocks can therefore represent two quantum mechanical "admixture states" for the electron, where the "+-" or "-+" block would represent the quantum mechanical operator that changes the electron from one of these states to the other. Written in matrix form:

QUANTUM STATES:

$|+\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}1\\ i\end{pmatrix}$ (RH CIRCULAR POLARIZATION)

$|-\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix}1\\ -i\end{pmatrix}$ (LH CIRCULAR POLARIZATION)

OPERATORS:

$|+\rangle\langle+| = \frac{1}{2}\begin{pmatrix}1 & -i\\ i & 1\end{pmatrix}$ (RH)

$|-\rangle\langle-| = \frac{1}{2}\begin{pmatrix}1 & i\\ -i & 1\end{pmatrix}$ (LH)

$|+\rangle\langle-| = \frac{1}{2}\begin{pmatrix}1 & i\\ i & -1\end{pmatrix}$ (LH $\rightarrow$ RH)

$|-\rangle\langle+| = \frac{1}{2}\begin{pmatrix}1 & -i\\ -i & -1\end{pmatrix}$ (RH $\rightarrow$ LH)

For example, applying the "-+" operator to the "+" state will reverse the chirality of the circularly polarized light, resulting in a "-" state of circularlar polarization, from right-handed to left-handed.

The final state is one with left-handed circularly polarized light, and light is therefore seen when you look through that sequence of two cubes.

Question #292 is a follow-up to this question.

Archive 15

Question of the Week

Outreach Index Page

Lecture-Demonstration Home Page

For questions and comments regarding the *Question of the Week* contact
Dr. Richard E. Berg by e-mail or using phone number or regular mail address
given on the Lecture-Demonstration Home Page.