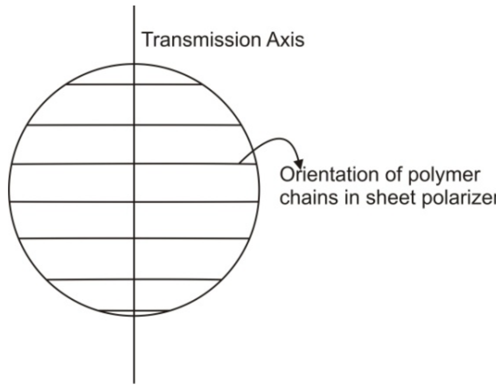
Physics 4062/5062 –Tutorial 2 – Polarization

Linearly Polarized

- E field measured in plane perpendicular to direction of propagation
- **E** orientation constant
- |**E**| and sign vary with time
- Eg: Laser Output
- Consider polarizer oriented at angle θ to vertical

  $\mathbf{E}_y = E_o\cos\theta$ is transmitted

  $I_T \;\alpha\; E_o^2\cos^2\theta = I_o\cos^2\theta$ → transmission function

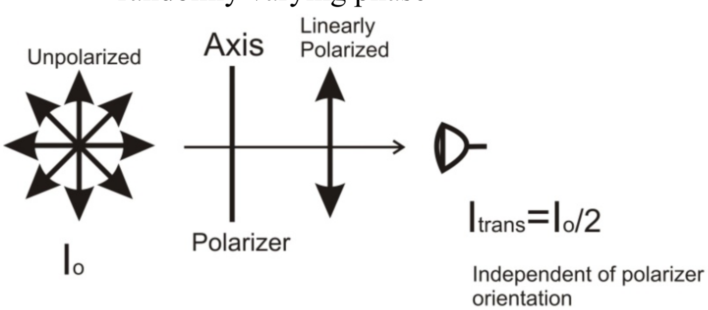


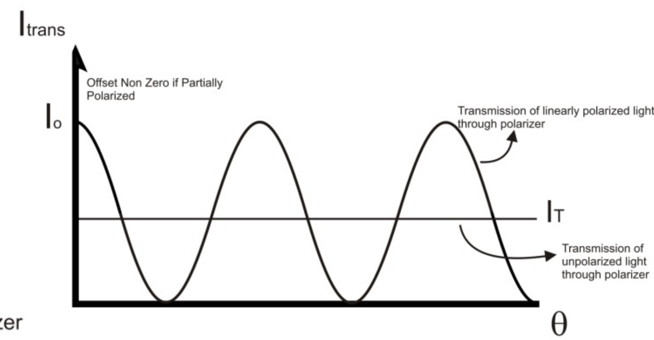
- Note that the plane polarized or linearly polarized light can be represented as the sum of two orthogonally polarized components that have the same phase

$$E = (\hat{x}E_{ox} - \hat{y}E_{oy})\cos(kz - wt)$$

Unpolarized Light

- Eg: Light Bulb
- superposition of linear polarizations with randomly varying phase

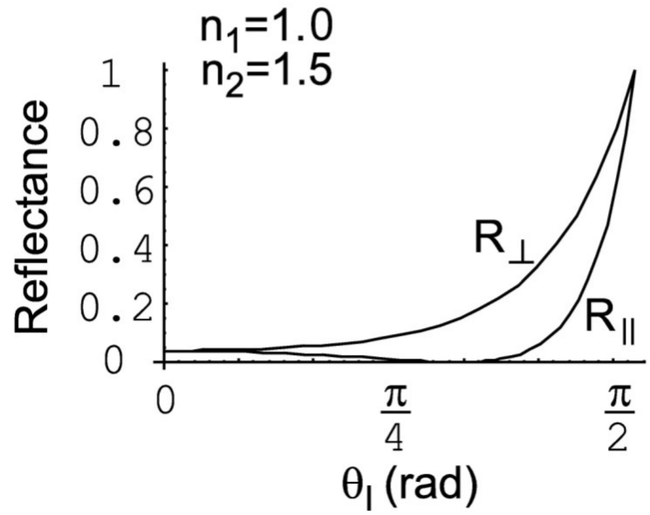




- On Average, equal amounts of linearly polarized light transmitted at all polarizer orientations θ, so that $I_T = I_o/2$

Polarization by Reflection

- Light reflected differently depending on polarization



Circular Polarization

$$E_{oy} = E_{ox}$$

- Circular polarization can be represented as the superposition of two phase shifted linearly polarized components
- Combination of two perpendicular E fields with 90 degree phase shift
- Likewise, linear polarization can be expressed as the sum of two opposite circular polarizations

Wave plates

$\lambda/4$	$\delta = 90^o$	$d\|n_\perp - n_\parallel\| = \lambda/4$
$\lambda/2$	$\delta = 180^o$	$d\|n_\perp - n_\parallel\| = \lambda/2$
Λ	$\delta = 360^o$	$d\|n_\perp - n_\parallel\| = \lambda$

- $n_\perp$ and $n_\parallel$ are indices of refraction perpendicular and parallel to the optic axis of the wave plate
- Difference in phase velocities along these directions produces a phase shift

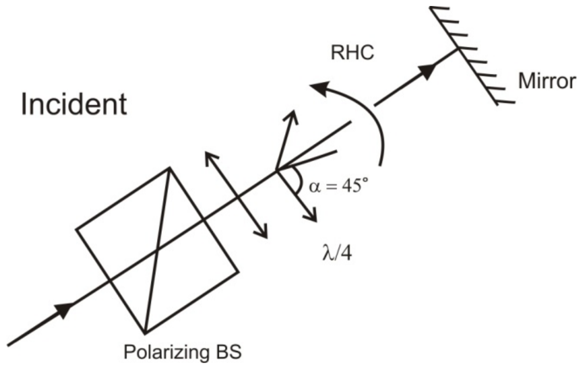
Effect of Quarter Wave Plate on Linearly Polarized Light

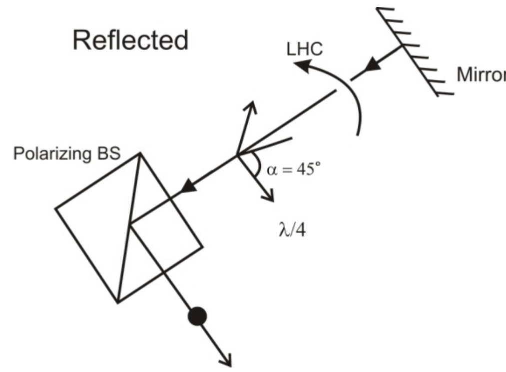
1. $\alpha = \pm 45°$ (RHC and LHC), where α is angle of optic axis of wave plate with plane of polarization
    - Represent incident light as sum of two orthogonal linearly polarized components
    - E field components parallel and perpendicular to optic axis are phase shifted by $\delta = \pi/2$
    - after $\lambda/4$ = > result is circularly polarized light
2. $\alpha = 0°$ or $90°$
    - No effect
    - Linearly polarized output
3. $\alpha \neq 45°$, $0°$ or $90°$
    - Elliptically polarized output

Half Wave plate

- two quarter wave plates with $\alpha_1 = \alpha_2 = 45°$
- $\delta = \delta_1 + \delta_2 = \pi$, which corresponds to a path difference of $\lambda/2$

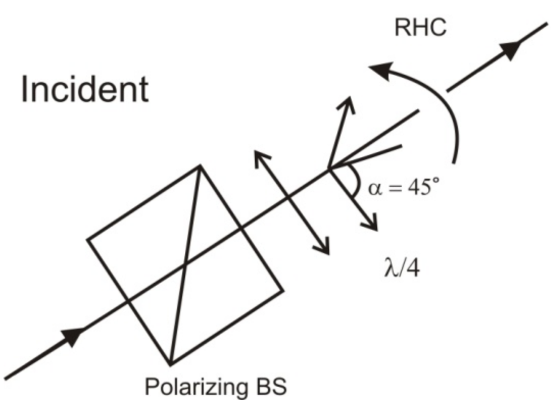
Mirror Reversal

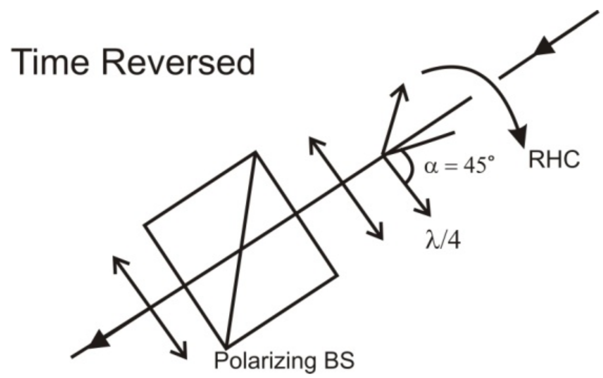




- No change in angular momentum of light **L**
- No transfer of angular momentum to mirror
- Change in polarization - RHC changes to LHC

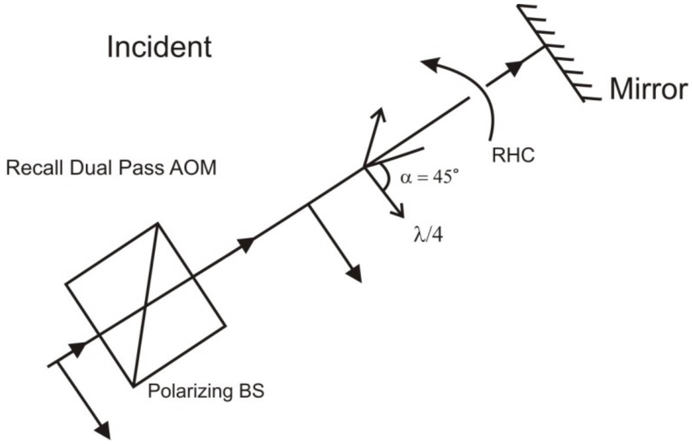
Time Reversal (different from mirror reversal)

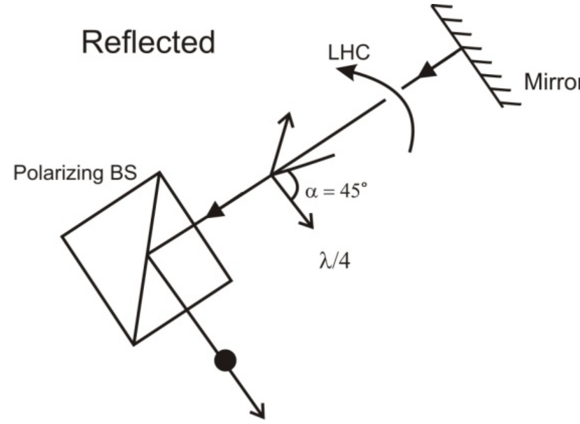




- Change in angular momentum
- No change in outgoing polarization
- Angular momentum unchanged

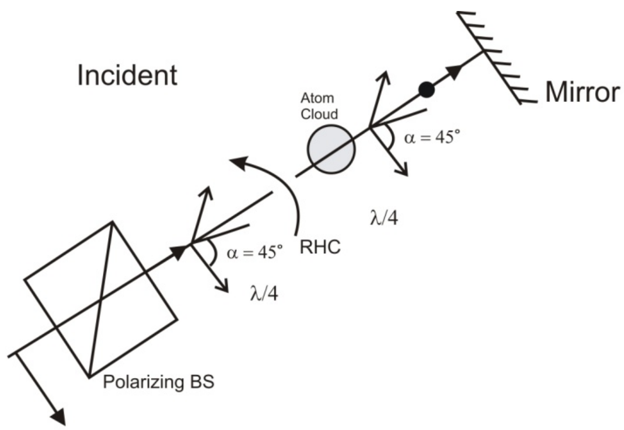
Standing Wave Case

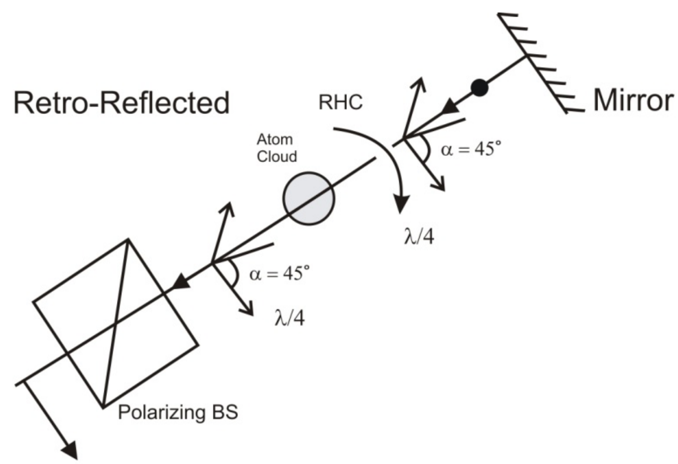




Retro-Reflected Beams for Atom Trap

- opposite angular momentum
- Need σ^+ and σ^-





The second QWP is shown identical to the first QWP.

However, σ+(incident) and σ-(retro) beams will be produced for any orientation of the second QWP.

Assume that incident is σ^+
and Reflected light is σ^-