Design and Prototyping of Optical Systems for Engineering Applications
Experiment 4

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Agenda

- Experiment 3 Results
  - Filter transmission and reflection
  - Diffuse reflection
  - Light sources
  - Cleaning optics
  - Laser Safety (slides 12315)
  - Fluorescence Observations
- Experiment 6 Plans
- Experiment 4 — Polarization

Lab 6

- Your experiment
- Ideally Related to research in your team
- Use mostly available equipment
- You determine the questions

Lab 4 Learning Objectives

- Laser Polarization
- Linear Polarization, Circular Polarization
- Polarizers:
  - Rotational Mounts: Alignment
  - Insertion Loss, Extinction
- Waveplates: Changing the Polarization
- Power Meter: Calibration and Measurement

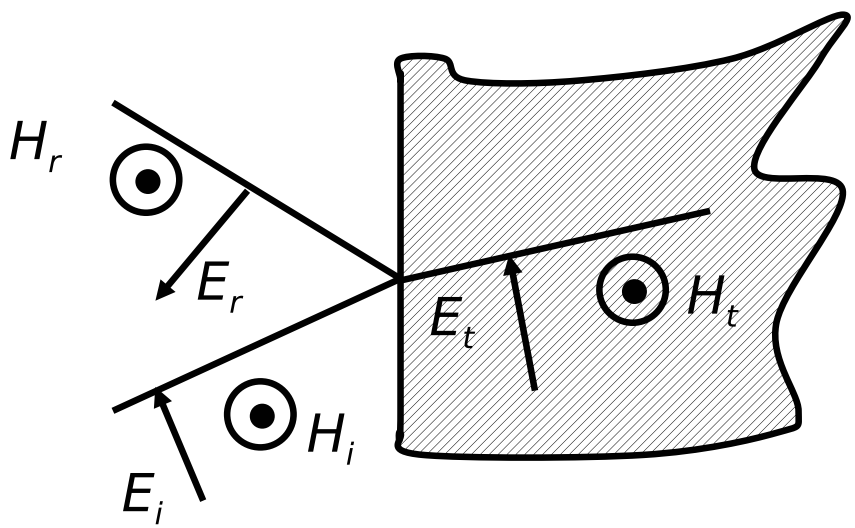
Polarization Comments

- Polarizer Blocks One Polarization
- Half–Wave Plate Retards Phase by 1/2 Wave
  - Reflects Polarization Vector
  - Often Used for 90 Degree Flip
- Quarter–Wave Plate Retards Phase by 1/4 Wave
  - Converts Linear to Elliptical
  - Often Used to Convert to Circular

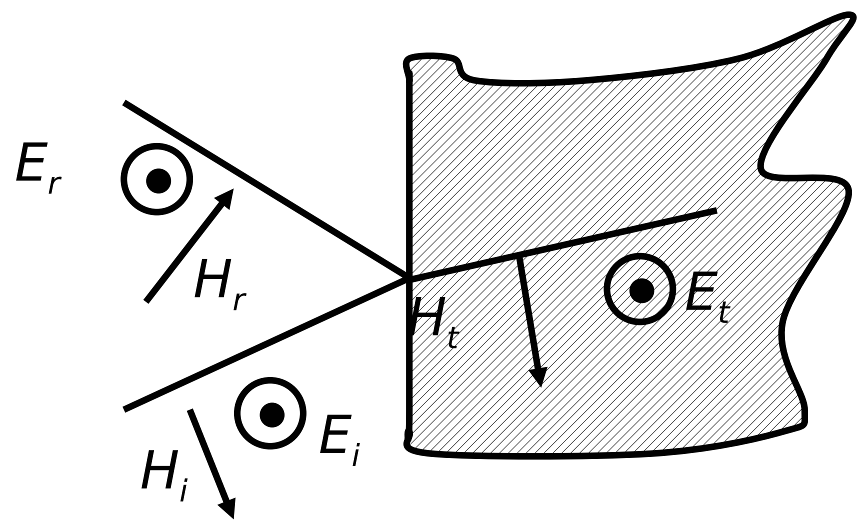
S,P Basis at an Interface

- P Means $\vec{E}$ Parallel to Plane of Incidence (More Later)
- S Means $\vec{E}$ Perpendicular (Senkrecht) to Plane of Incidence

$$\vec{E} = [E_s\hat{s} + E_p\hat{p}]\, e^{j(\omega t - kz)} \tag{1}$$

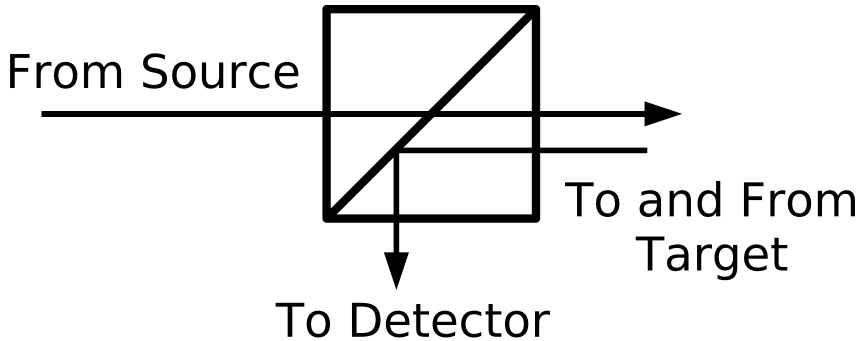


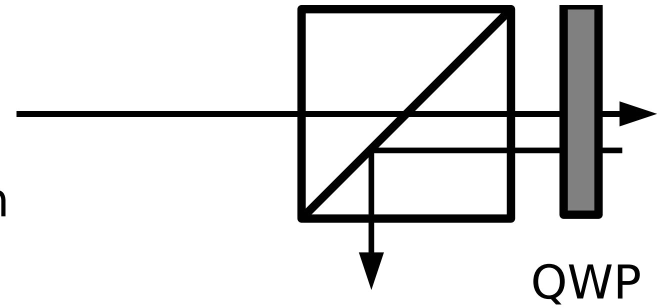
P Polarization (TM)



S Polarization (TE)

Transmit–Receive Switch





- Constraint

$$T = 1 - R$$

- Signal F for Target

$$P_{in}TFR$$

- Optimization

$$R = \frac{1}{2} \qquad TR = \frac{1}{4}$$

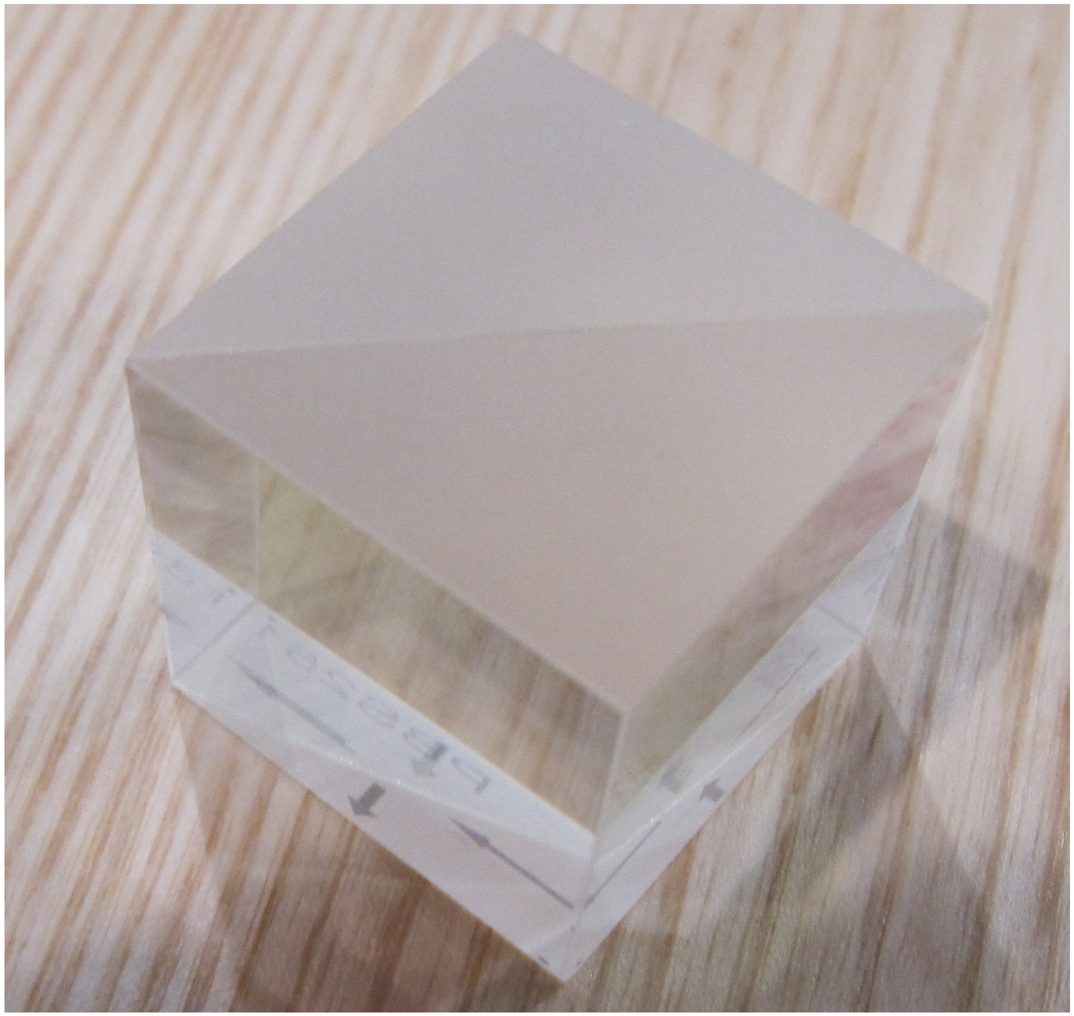
- No Constraint

$$T_P \approx 1 \qquad R_S \approx 1$$

- Polarizing Beamsplitter
- P–Polarization In
- QWP Twice is HWP
- Return is S–Polarized
- Assumes Target Retains Polarization

Precision Rotation Mount

Polarizing Beamsplitter



Prelab 4

Watch this about aligning a laser to the table
https:////www.youtube.com/watch?v=qzxILY6nOmA

Watch to about aligning a polarizer to the table
https://www.youtube.com/watch?v=W9pALZ5Z8ms

Look at the graphs for the PBS253 polarizing beamsplitter cube. Calculate the product TR at the laser wavelength.

What fraction of the laser light will be transmitted if the laser's polarization angle is θ with respect to the axis of a polarizer?

Design your experiment to have the HeNe laser as a source, a polarizer oriented to pass horizontally–polarized light, followed by the polarizing beamsplitter and quarter waveplate. Use a mirror as the target. Leave room to insert the power meter between every pair of optical elements. Look at the mechanical components available and think about how to mount the beamsplitter cube and how to align the quarter–wave plate.

Experiment 4

Assemble your system. Align the polarizer to transmit horizontally–polarized light. Then rotate the laser (or add a half–wave plate between the laser and polarizer) to convert the laser's polarization to horizontal.

Measure the power at each location and determine the "insertion loss" of each component.

The quarter–wave plate should produce circular polarization. Rotate a polarizer after it and see how well it performs.

Compute the product TR from your experiment.

Reflection 4

How well does your experiment compare to your prediction?

What are the other losses in your experiment?

What fraction of the laser light reaches the output? What would this fraction have been with an optimized non–polarizing beamsplitter? To answer this, think about what components you would not have needed in that case.

How would this experiment be different if the target were a scattering surface instead of a mirror?