

# Light Modulation: Lab 6

6.2370 Modern Optics Project Laboratory

Daniel Sanango

# Overview

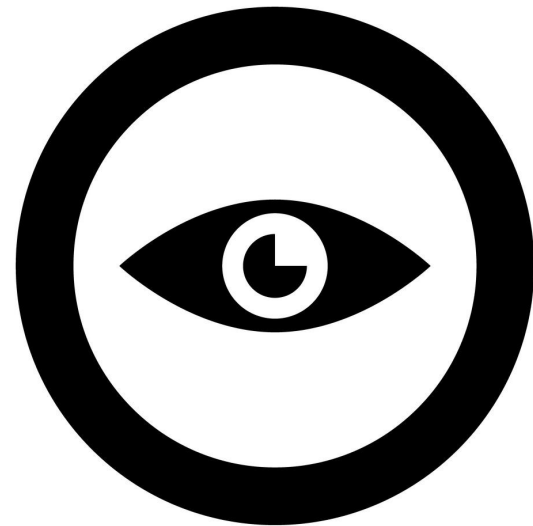
Essentials



Experiment



Observations

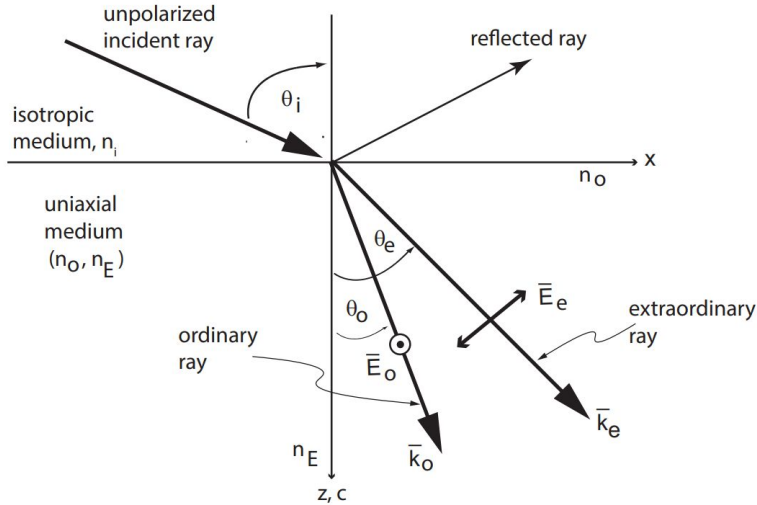




# Modulation Essentials

## 1) Extraordinary Rays

- TE vs TM
- Manipulating Index of Refraction ( $n$ )
- Adjusting voltage can adjust output



Rays in Crystal Example [6.2370 Chapter 6 Notes]

## 2) Crystal Properties

- Unique geometries  $\rightarrow$  Unique modulation effects

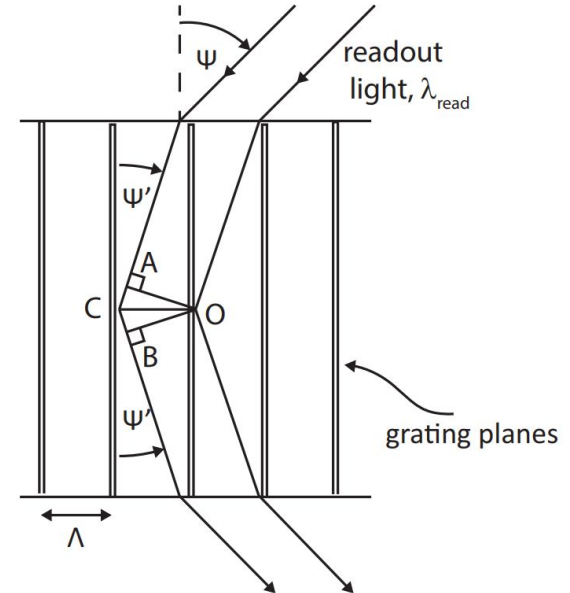
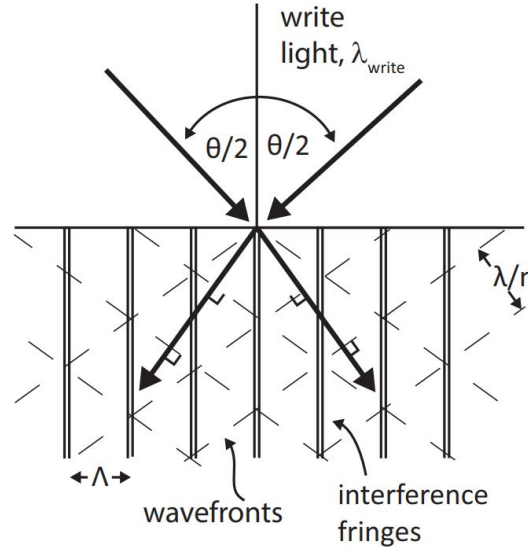


Sample Crystal (ADP) [[researchgate.net](https://www.researchgate.net) (hyperlink)]



# Holography and Bragg Condition

- 1) Writing
  - Produce Fringes
- 2) Reading
  - Particular angle (Bragg Angle)
  - Fringes from write phase allow diffraction



Write and Read Schematics [6.2370 Lecture Notes]



# Propagation Through Crystals

## Objective:

Differentiate between TE and TM light manipulation from crystal

Find c-axis

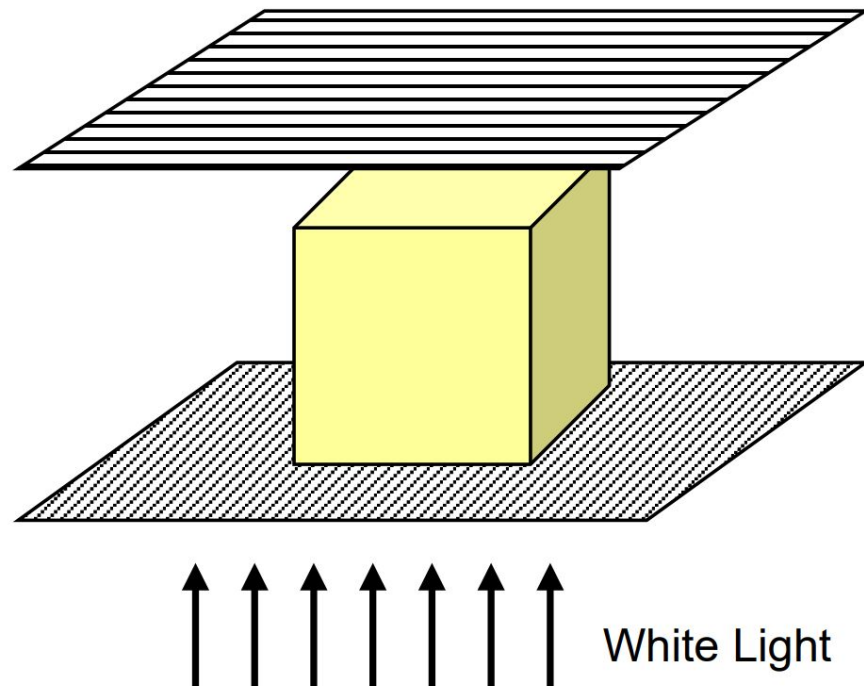
C-axis: axis where no double refraction occurs

## Approach:

Place crystal between polarizers

Rotate polarizer to observe impact on each face

Vary polarization to see light extinguishment

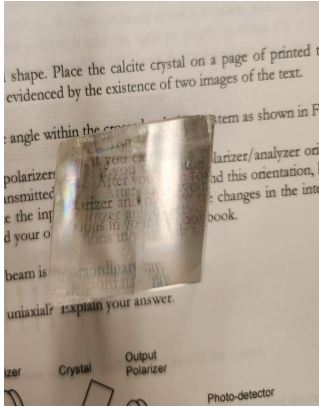


Schematic Setup [6.2370 Lab 6 Handout]

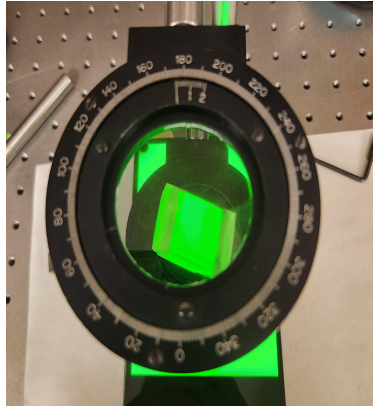


# Propagation Through Crystals

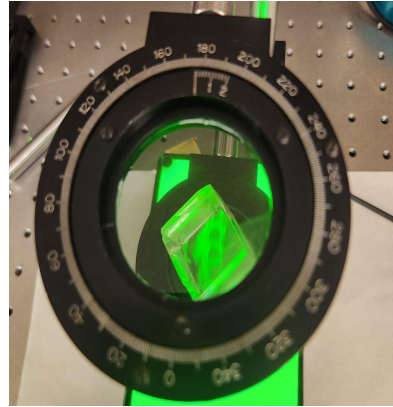
## Results and Analysis:



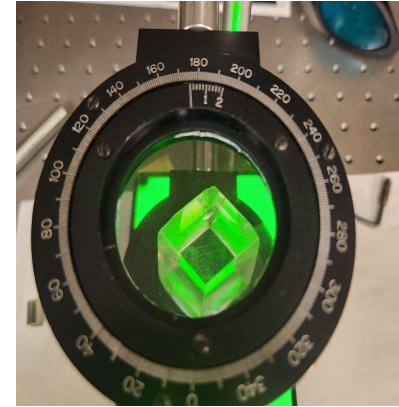
(1) Double Refraction



(2) No Extinguishment



(3) Partial Extinguishment



(4) Complete Extinguishment

- (1) Two Beam acting on text
- (2) TE and TM exist
- (3) TE or TM extinguished--some light still get through
- (4) TE and TM extinguished--c-axis discovered (most symmetry)



# Liquid Crystal Modulator

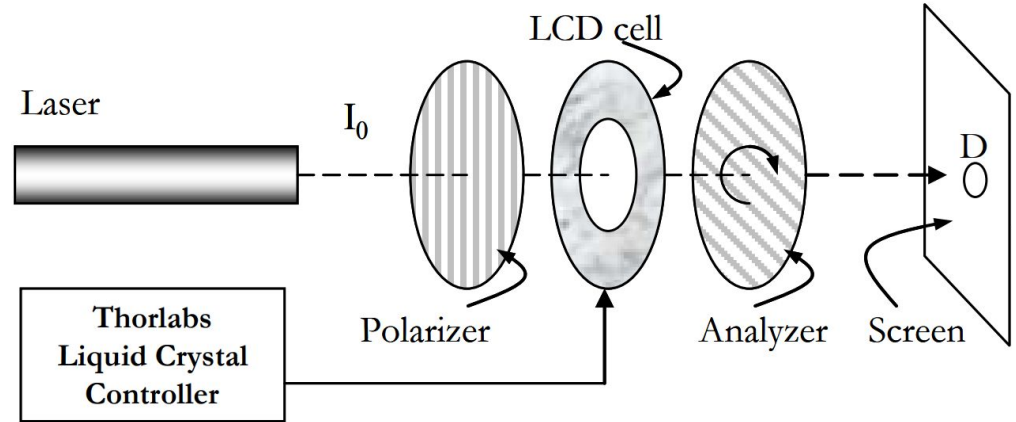
## Objective:

Manipulate LCD cell to produce a variable waveplate

## Approach:

Adjust voltage on LCD cell

LCD cell acts as a polarizer that can “rotate” by applying voltage

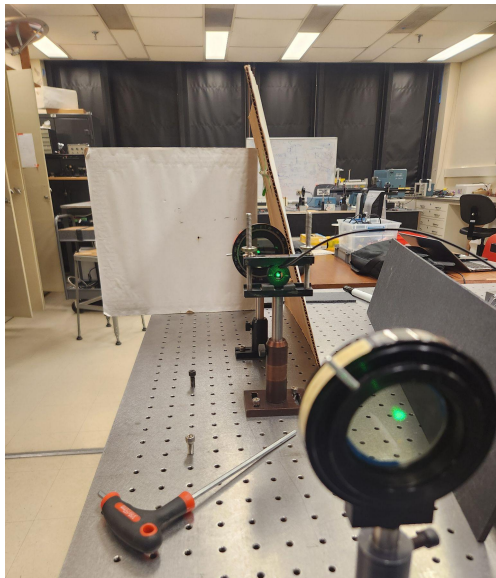


Setup Schematic [6.2370 Lab 6 Handout]

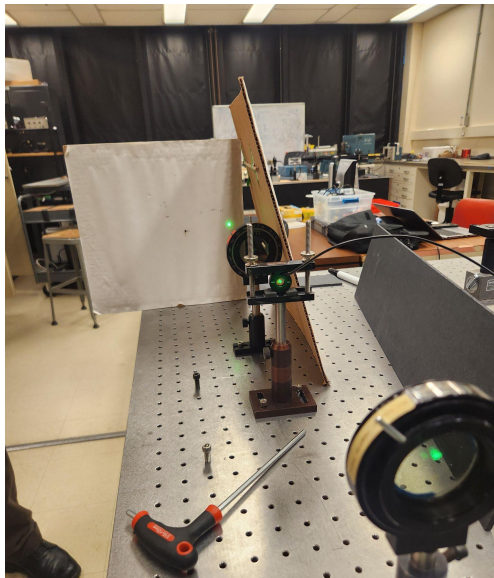


# Liquid Crystal Modulator

## Results:



3.390 Vpp



3.600 Vpp

## Analysis

3.390 Vpp: No output → Acts as a full waveplate

3.600 Vpp: Output → Acts as a half waveplate

Quarter waveplate: Active if rotating polarizer does not affect output



# Acousto-Optic Modulator

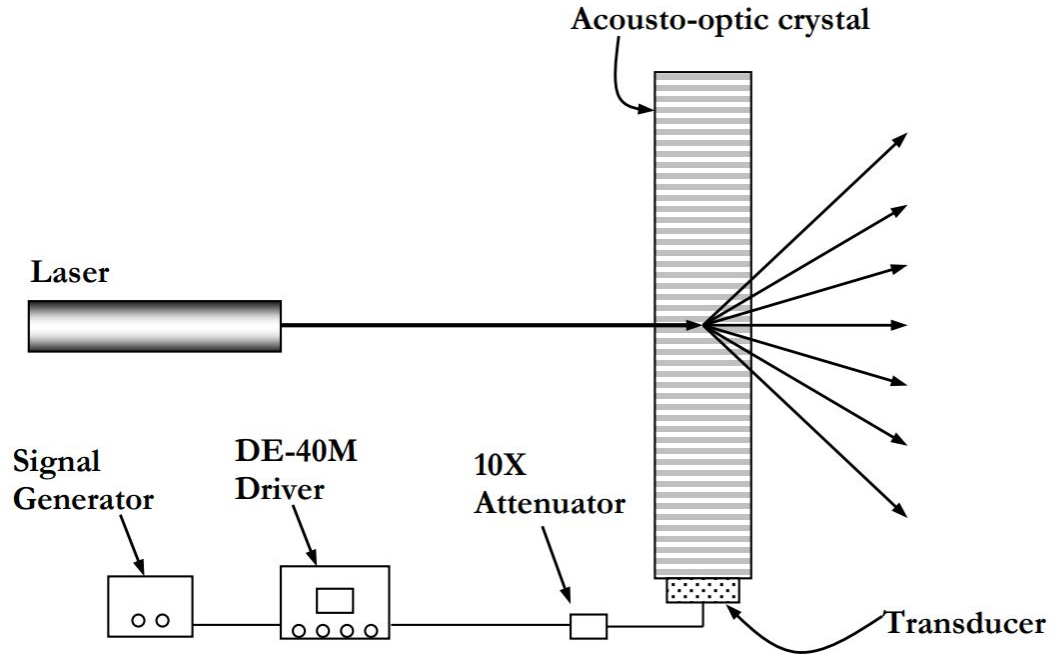
## Objective:

Observe relation between input frequency and output light

*DE-40M: variable oscillator*

## Procedure:

- 1) Attach *10X Attenuator* to Signal Generators--prevents damage to electronics
- 2) Vary input Hz
- 3) Observe output light





# Acousto-Optic Modulator

## Results and Analysis:

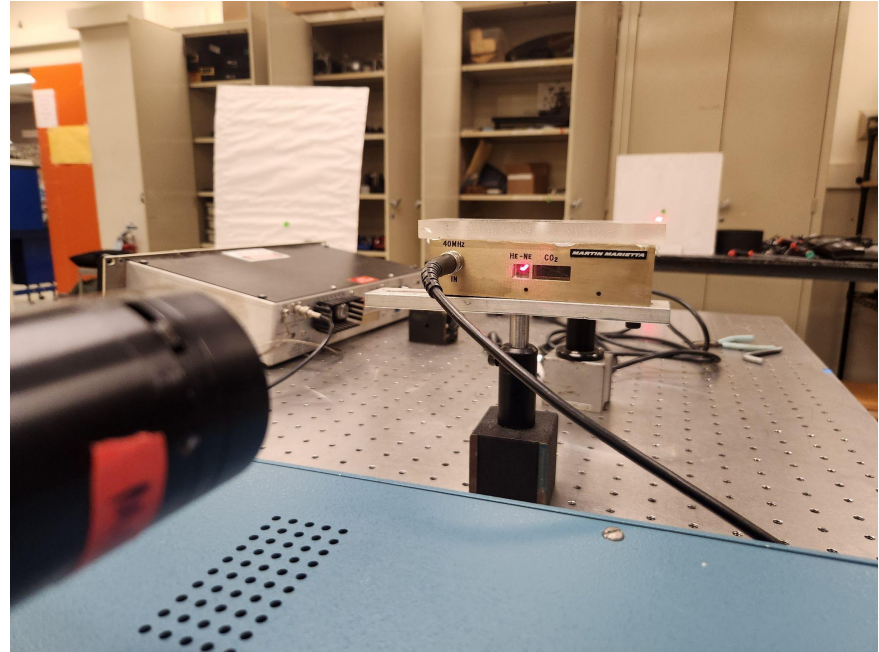
Lower frequencies  $\rightarrow$  closer beams on screen

Higher frequencies  $\rightarrow$  beams spaced out

Consistent with:  $f_g = 1/\Lambda$

Frequency increase  $\rightarrow$  Fringe spacing decrease

Less spacing  $\rightarrow$  Smaller Bragg angle



Lab Setup



# Real-Time Holography in Photorefractive Materials

## **Objective:**

Successfully perform readout of hologram

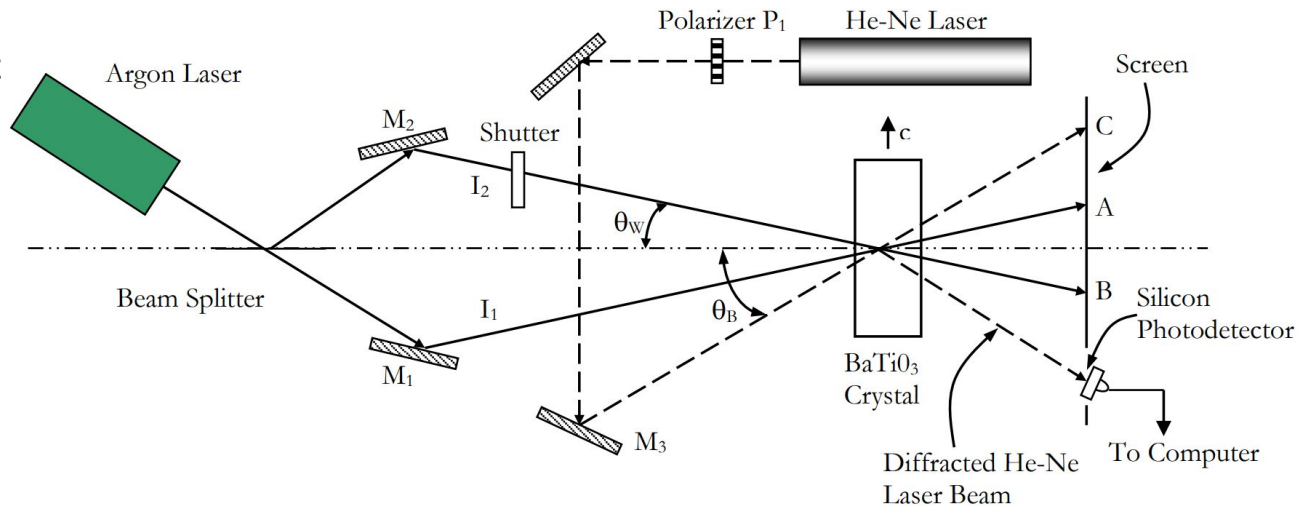
## **Procedure:**

1) “erase” hologram with *Argon Laser* and *Shutter*

2) “write” hologram with *Argon Laser*

3) “read” hologram with *He-Ne Laser*

4) Determine Bragg angle



## **Main Challenge:**

Read angle pre-determined, but hard to line up *just* right

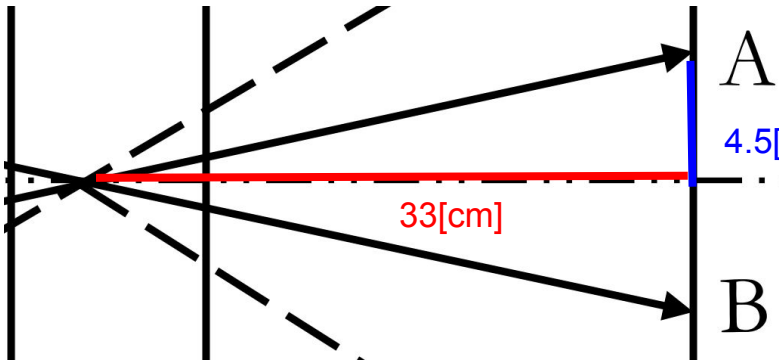
## **Safety:**

To get a visible readout, high power needed → goggles used



# Real-Time Holography in Photorefractive Materials

## Results and Analysis:



$$\therefore \theta_{write} = \arctan\left(\frac{9/2}{33}\right) = 7.7[degrees]$$

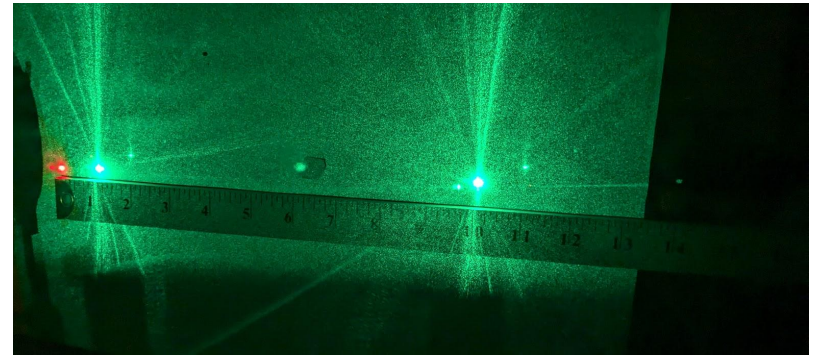
$$\sin(\theta_{read}) = \frac{\lambda_{read}}{\lambda_{write}} \sin(\theta_{write}) \text{ [6.2370 Lecture Notes]}$$

$$\lambda_{read} = 700[nm]$$

$$\lambda_{write} = 550[nm]$$

$$\theta_{write} = 7.7[degrees]$$

$$\therefore \theta_{read} = 10[degrees]$$



# Closing Thoughts

## Electro-Optics

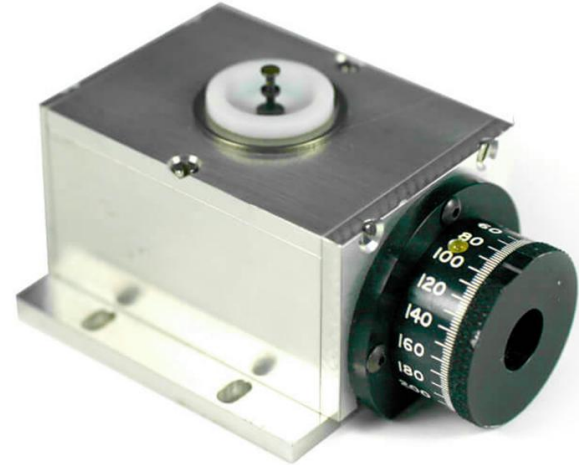
- Phase Manipulation
- Polarization Manipulation

## Acousto-Optics

- Frequency Manipulation
- Diffraction Manipulation

## Ultimately...

- Fast and effective
- High Speed Communications
- Laser Scanning and Imaging



Modern Modulator [coherent.com]