

Light Modulation: Lab 6

6.2370 Modern Optics Project Laboratory
Daniel Sanango

Overview

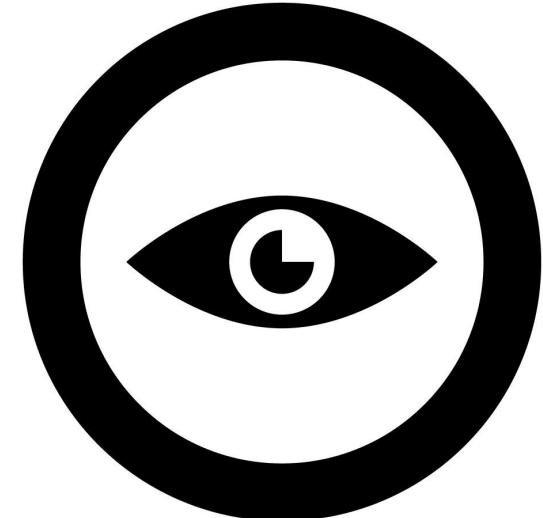
Essentials



Experiment



Observations

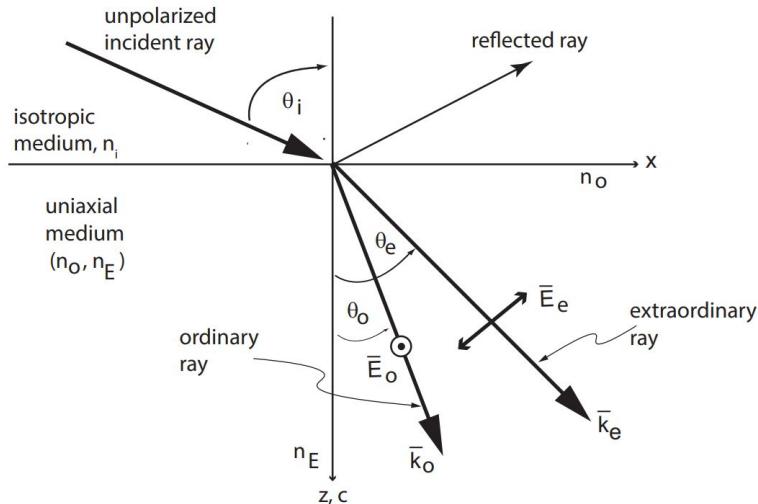




Modulation Essentials

1) Extraordinary Rays

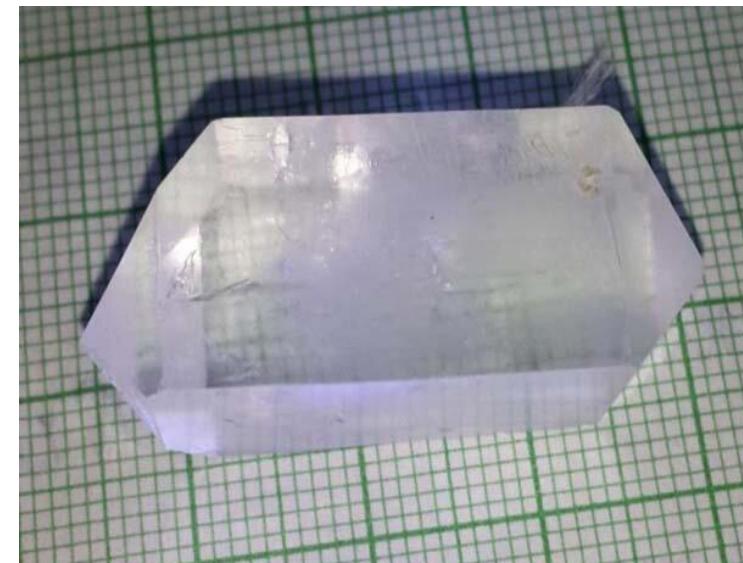
- TE vs TM
- Manipulating Index of Refraction (n)
- Adjusting voltage can adjust output



Rays in Crystal Example [6.2370 Chapter 6 Notes]

2) Crystal Properties

- Unique geometries → Unique modulation effects



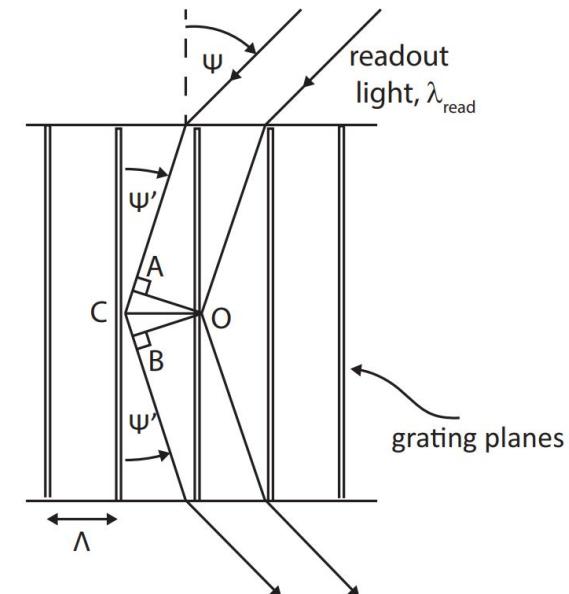
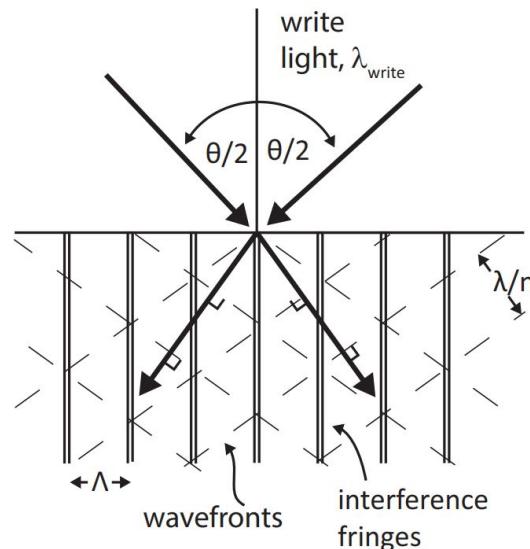
Sample Crystal (ADP) [[researchgate.net \(hyperlink\)](#)]



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

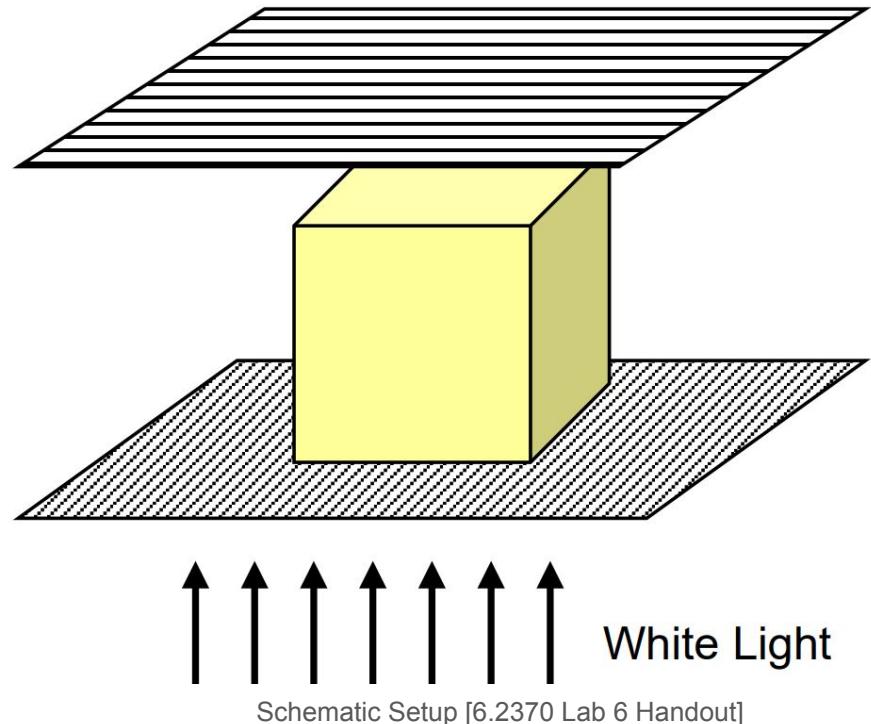
C-axis: axis where no double refraction occurs

Approach:

Place crystal between polarizers

Rotate polarizer to observe impact on each face

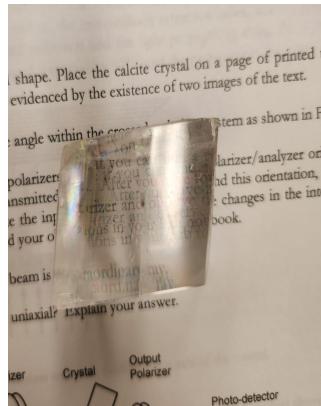
Vary polarization to see light extinguishment



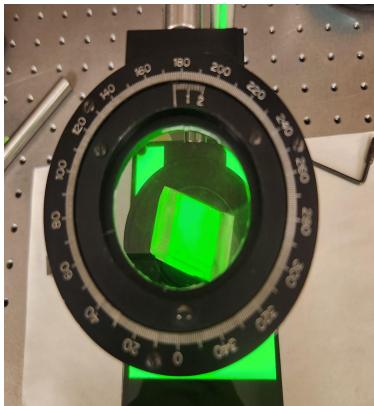


Propagation Through Crystals

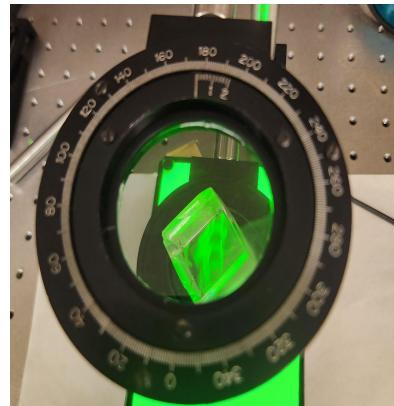
Results and Analysis:



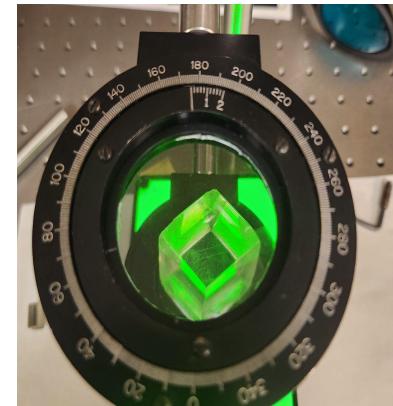
(1) Double Refraction



(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 gets through
- (4) TE and TM extinguished--c-axis discovered (most symmetry)



Liquid Crystal Modulator

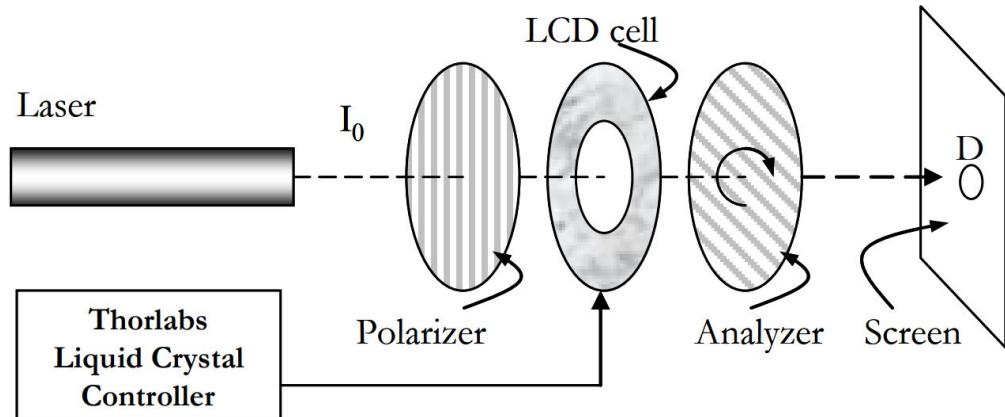
Objective:

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

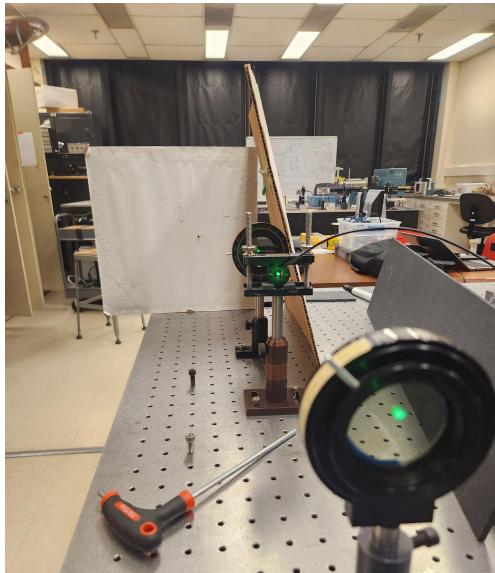


Setup Schematic [6.2370 Lab 6 Handout]

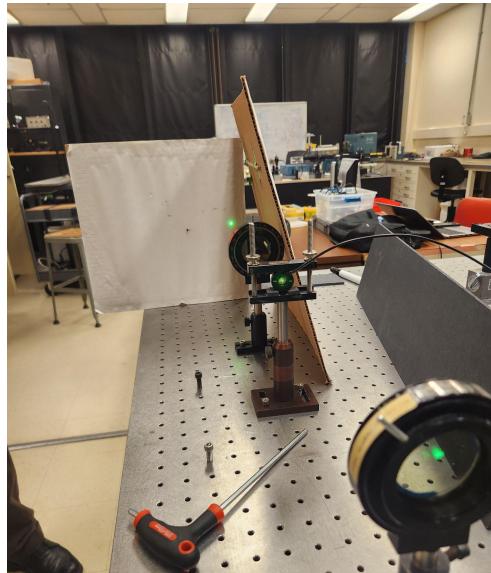


Liquid Crystal Modulator

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

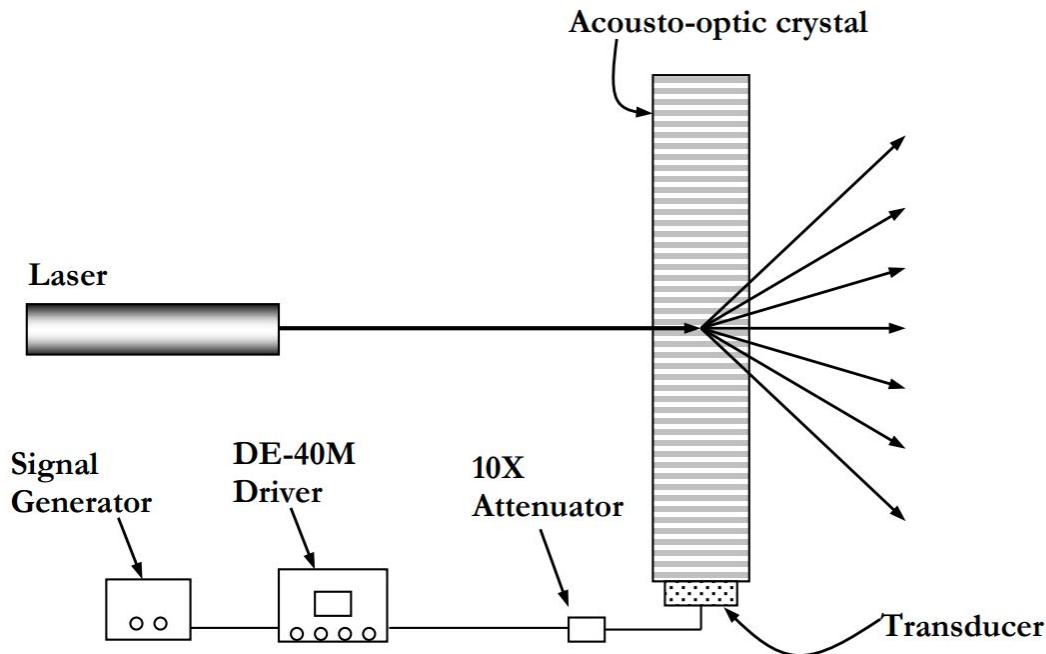
Objective:

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



Setup Schematic [6.2370 Lecture Notes]



Acousto-Optic Modulator

Results and Analysis:

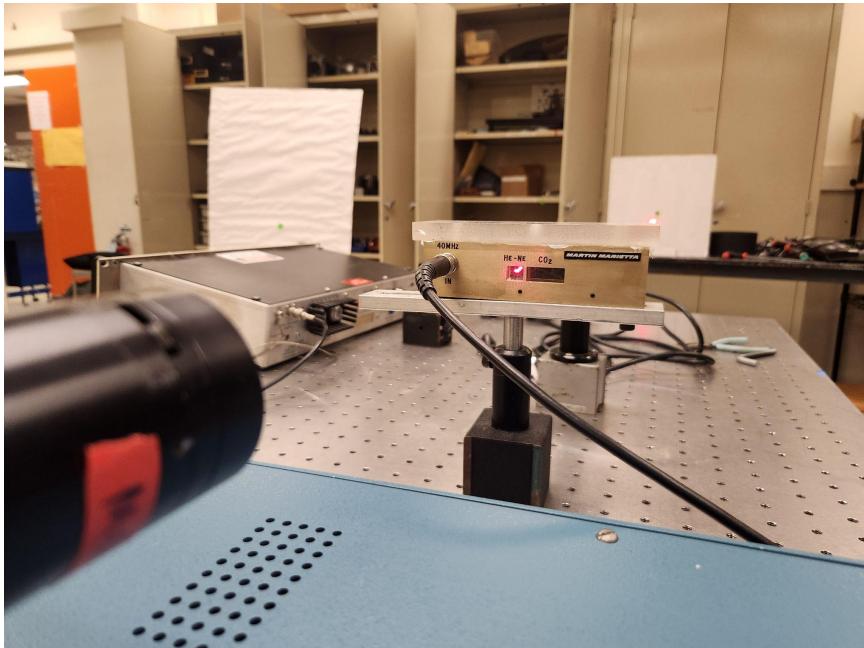
Lower frequencies → closer beams on screen

Higher frequencies → beams spaced out

Consistent with: $f_g = 1/\Lambda$

Frequency increase → Fringe spacing decrease

Less spacing → Smaller Bragg angle



Lab Setup



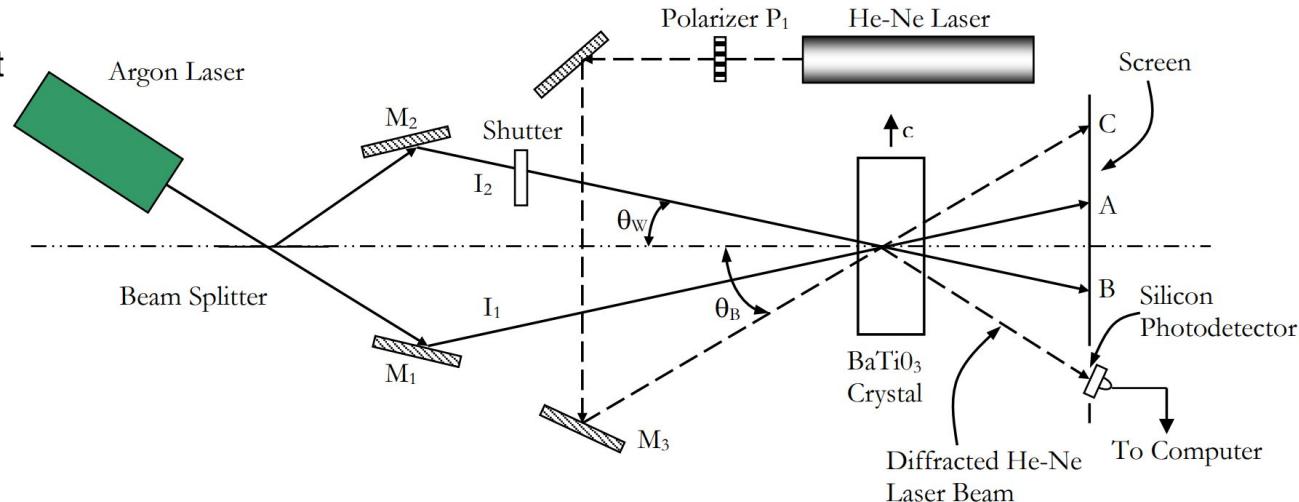
Real-Time Holography in Photorefractive Materials

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*

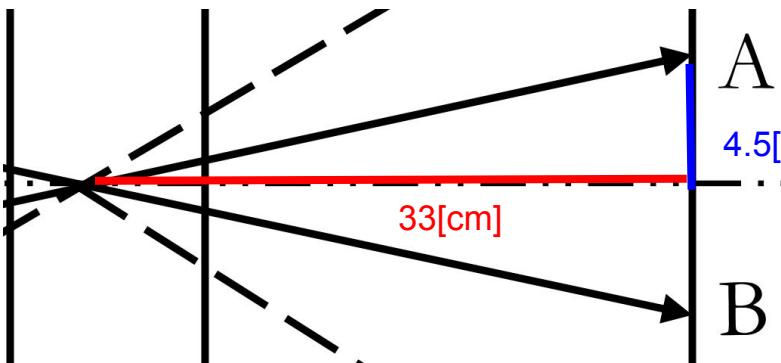
Safety:

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



Real-Time Holography in Photorefractive Materials

Results and Analysis:



4.5[cm]

33[cm]

B

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

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

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

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

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

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



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]