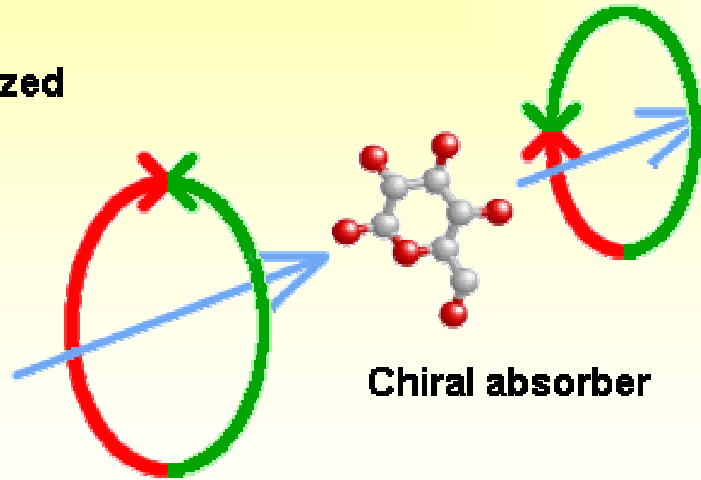


Biological Sensing via THz Circular Dichroism

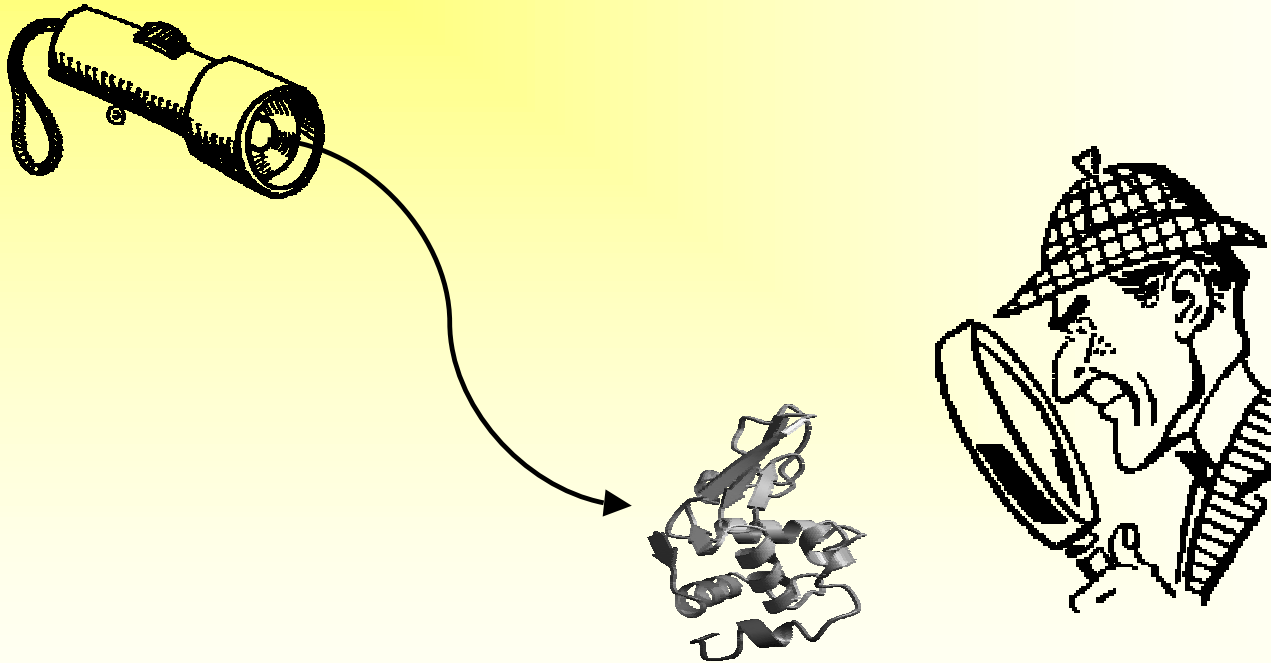
Right and left
circularly polarized
light



Differential
absorbtion
circular
polarization

WHAT???

- We shine light through stuff...



<http://school.discovery.com/clipart/clip/flashlts.html>

<http://www.astbury.leeds.ac.uk/gallery/tly.gif>

Still to Come

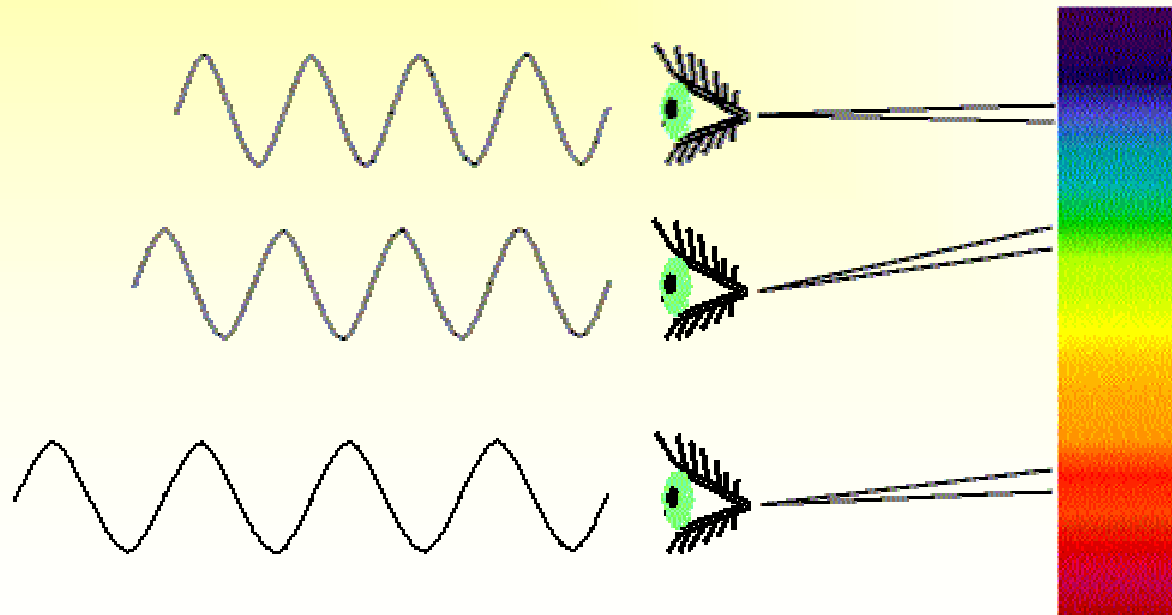
- Background
 - Light as an Electric Field
 - Polarized Light
 - Chirality
 - Circular Dichroism
- The Experiment
 - Biological Sensing
 - Why Circular Dichroism?
 - Why Terahertz?
 - Research Approach
 - Developing the Spectrometer
 - Conclusion
- Acknowledgements

Background



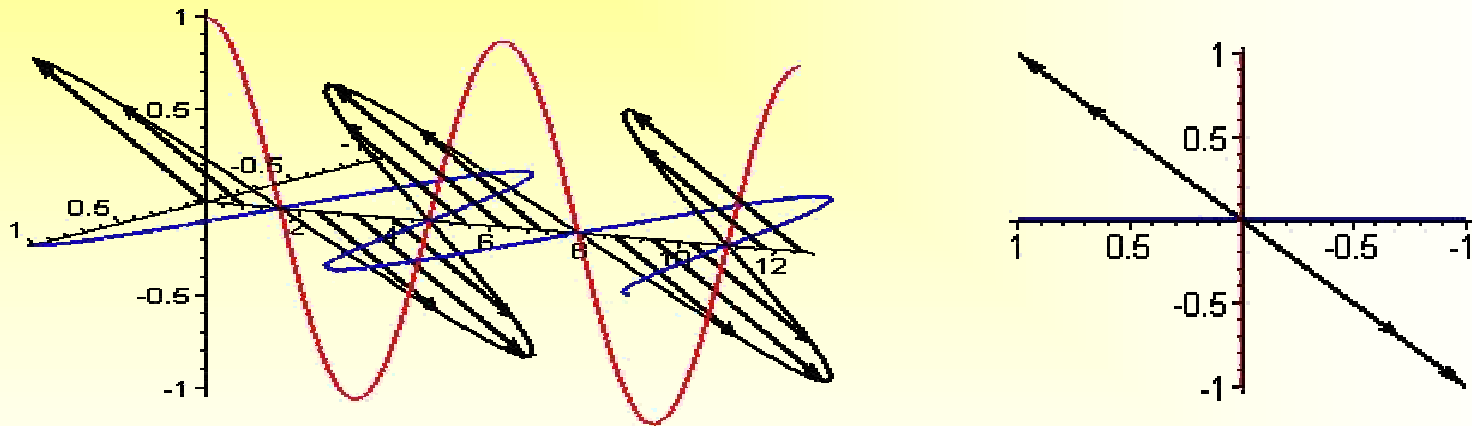
Light as an Electric Field

- The human eye detects electromagnetic waves (a moving electric field) and interprets wave frequency and amplitude as color and intensity.



Polarized Light

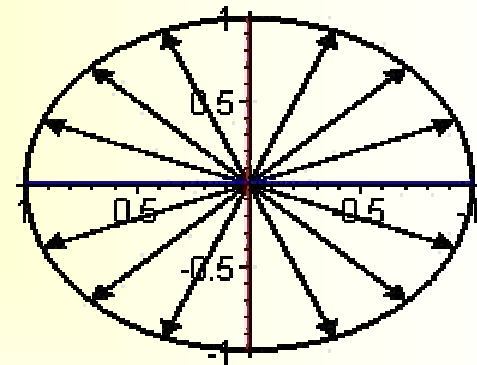
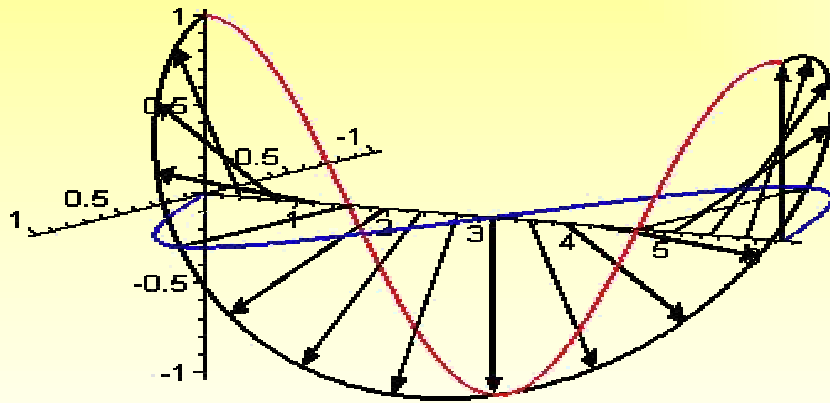
- Linearly Polarized Light



The electric field exists in a *constant plane*, while *changing magnitude* periodically.

Polarized Light

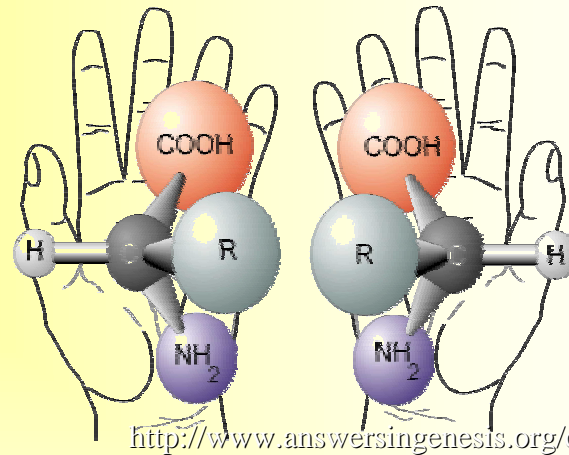
- Circularly Polarized Light



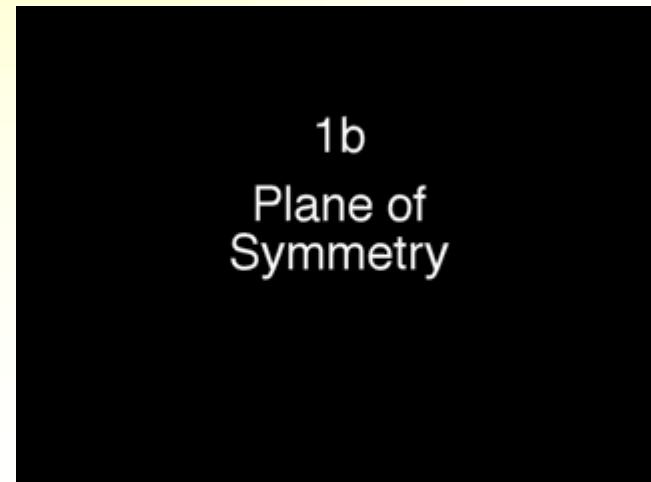
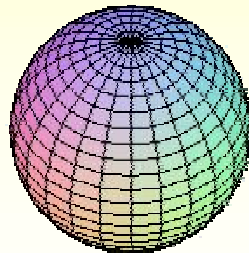
The electric field remains *constant in magnitude*, while *changing direction* periodically.

Chirality

- A chiral object has no plane of symmetry.

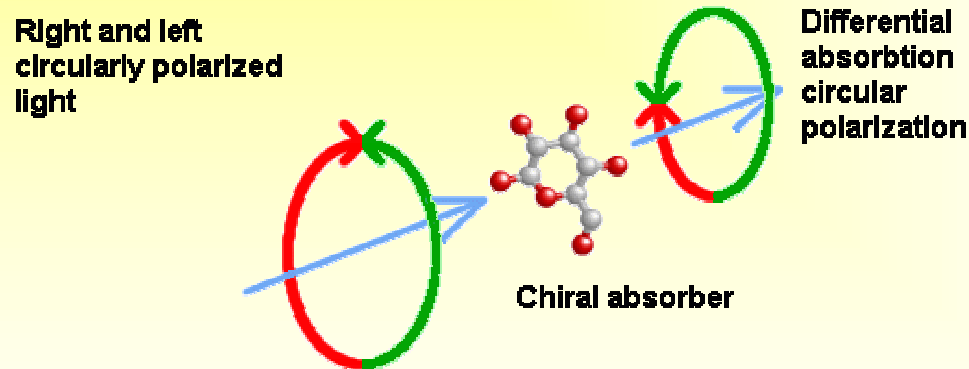


- An achiral object has a plane of symmetry.



Circular Dichroism

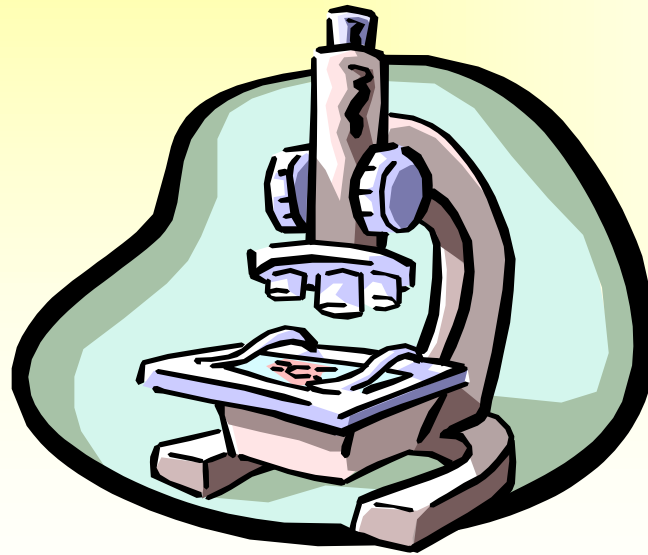
- Chiral (asymmetric) objects are unequally sensitive to left and right circularly polarized light.
- Circular dichroism is a term that describes this sensitivity.



<http://www.isa.au.dk/SR/UV1/cd-spectroscopy.html>

- An object that absorbs the two circular polarizations *differently* will give a CD signal.

The Experiment



Biological Sensing

- Must distinguish between biological and abiological materials
 - Biological materials exist in enantiomeric excess (a single handedness is dominant).
 - Abiological materials exist in enantiomeric equality.
- Species specific characterization
 - Each biological material exhibits unique spectral features.
 - These spectral features provide a potential “fingerprint” for biopolymers.

Why Circular Dichroism?

- Sensitive to net left versus right sample chirality
 - CD could provide life detection!

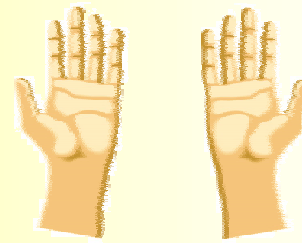
Biological systems



100%

0%

Non-Biological systems



50%

50%

<http://cwx.prenhall.com/bookbind/pubbooks/bruice2/chapter4/deluxe.html>

- Eliminates artifacts and background absorbances of non-biological materials.
 - Allows for potential species specific spectral analysis in the presence of non-biological absorbers.

Why Terahertz?

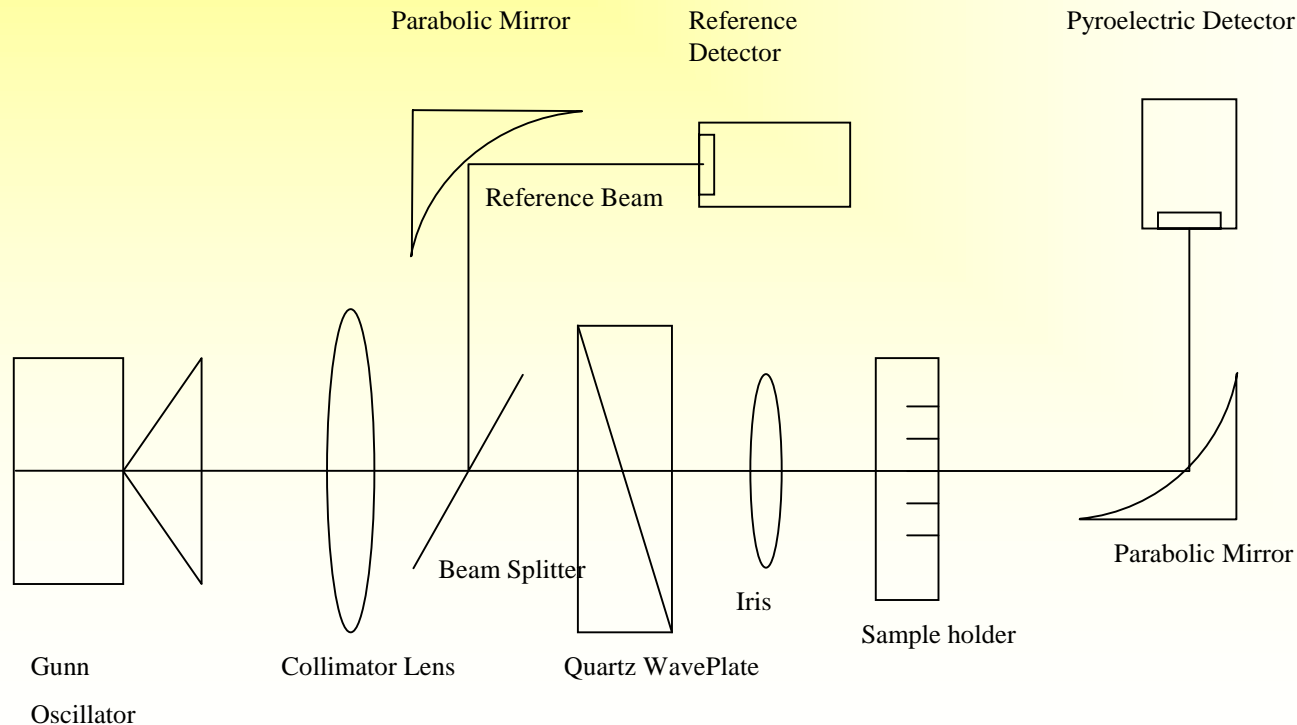
- Visible light stimulates electronic transitions that are symmetric (yield no net CD signal).
 - These transitions respond equally to left and right circular polarizations.
- THz radiation tends to excite overall vibrational modes.
 - Dynamic modes of oscillation respond differently to left versus right circular polarizations.

Visible light shakes *bonds*, THz shakes the entire *molecule*.

Research Approach

- Before we can investigate the THz spectral features of biological specimen using CD we must first develop the spectrometer.

First unsuccessful optical setup.

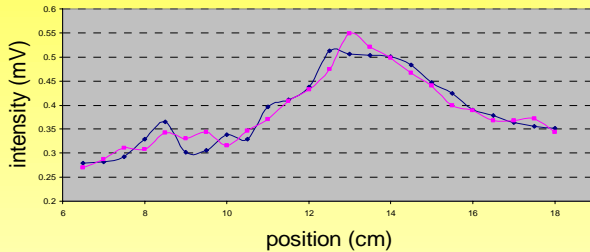


Developing the Spectrometer

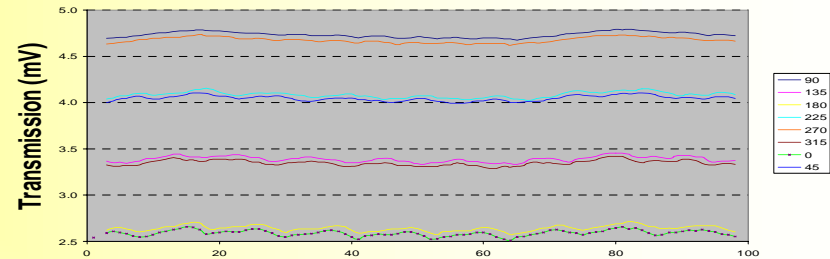
- First unsuccessful optical setup.

- Focusing lens too thick.
- Undesirable waveplate behavior.

Intensity vs. Position (along beam axis $y=k$) with Collimator

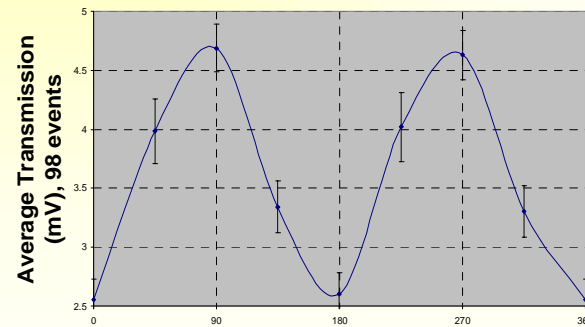


Source Horn close to Wave Plate



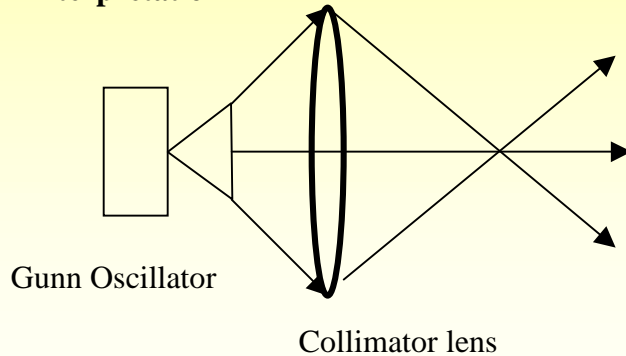
98 Independent Measurements

Source Horn close to Wave Plate



Wave Plate Orientation (deg)

Interpretation

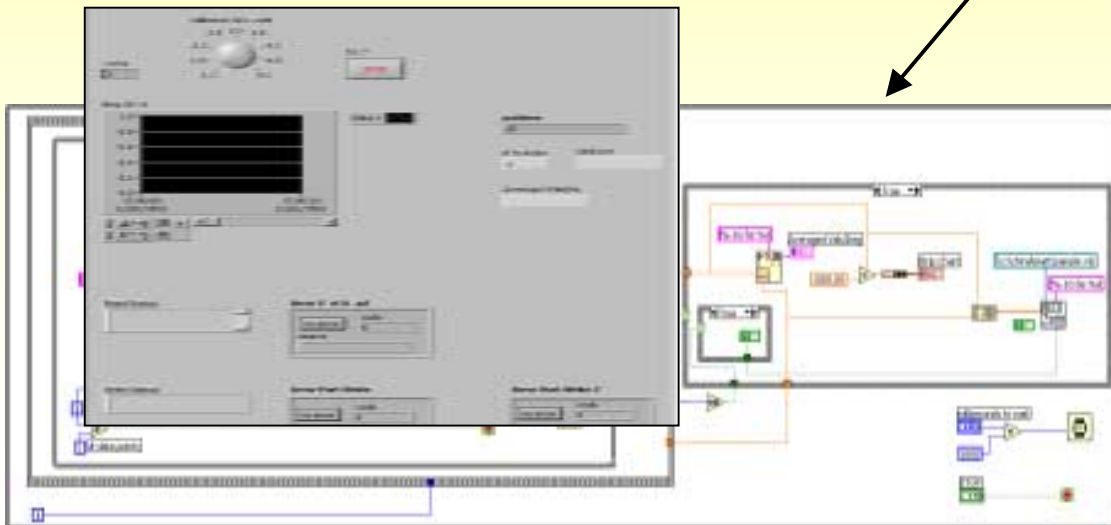
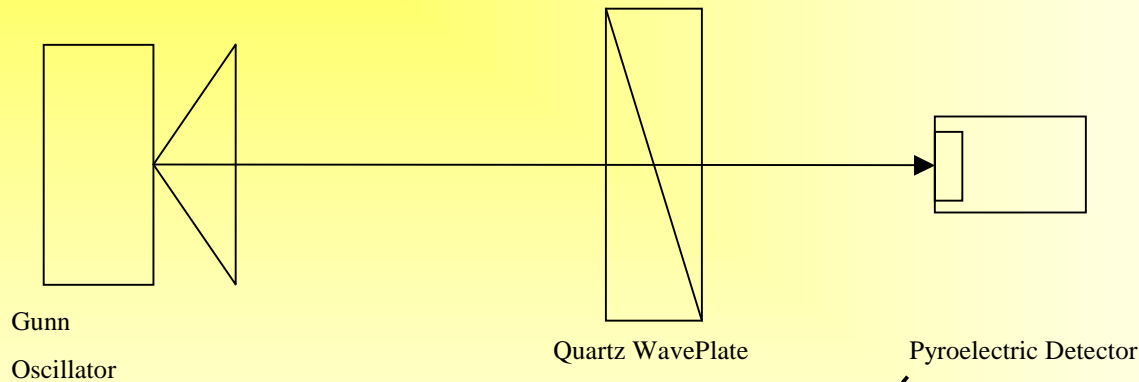


- Close to the lens the beam converges accounting for the increasing intensity.
- Farther away from the lens the beam diverges accounting for decreasing intensity.

- $n \cdot 90$ degrees, for $n = 0, 1, 2, \dots$ represent the optical axes of the waveplate.
- Minimizing the difference in transmission between the axes of the quartz is crucial to the quality of circular polarization produced.

Developing the Spectrometer

- We are currently using this experimental setup to examine the relationship between source, waveplate, and detector.



- The LabVIEW programming environment is used to collect and process data.

Conclusion

- We will next explore several methods to improve waveplate performance, such as:
 - Introducing a small tilt in the plates orientation.
 - This will alter the path length of the beam, potentially reducing the deconstructive interference due to internal reflections.
 - Evaporate specialized thin films to the plates surface.
 - These films are designed to reduce reflections.
- Alternative methods to generate circular polarization may need to be employed if we are unable to sufficiently minimize the difference in transmission between the waveplate axes.
- More experiments are needed to discover the optimal experimental setup.

Acknowledgements

Primary Investigators

- Kevin Plaxco

- University of California at Santa Barbara Department of Chemistry and Biochemistry

- Gerald Ramian

- University of California at Santa Barbara Institute for Quantum Engineering, Science and Technology

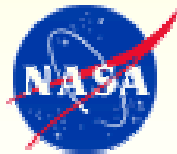
- S. James Allen

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THANK YOU

THE END

