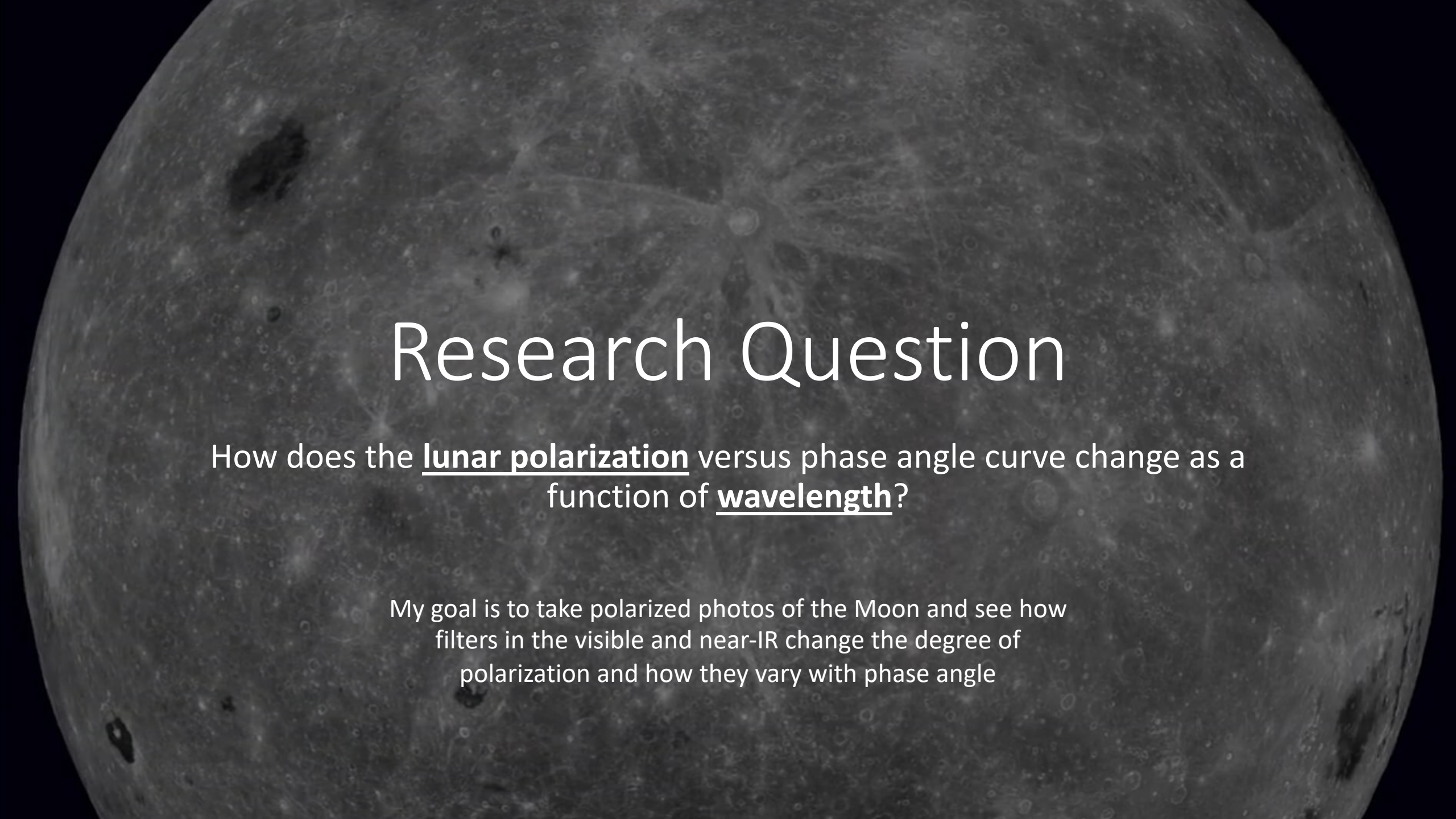


Moon Polarization in Narrow Spectral Bands



Elyse Duley with Erica Venkatesulu and Dr. Joe Shaw
Optical Remote Sensor Lab (ORSL)



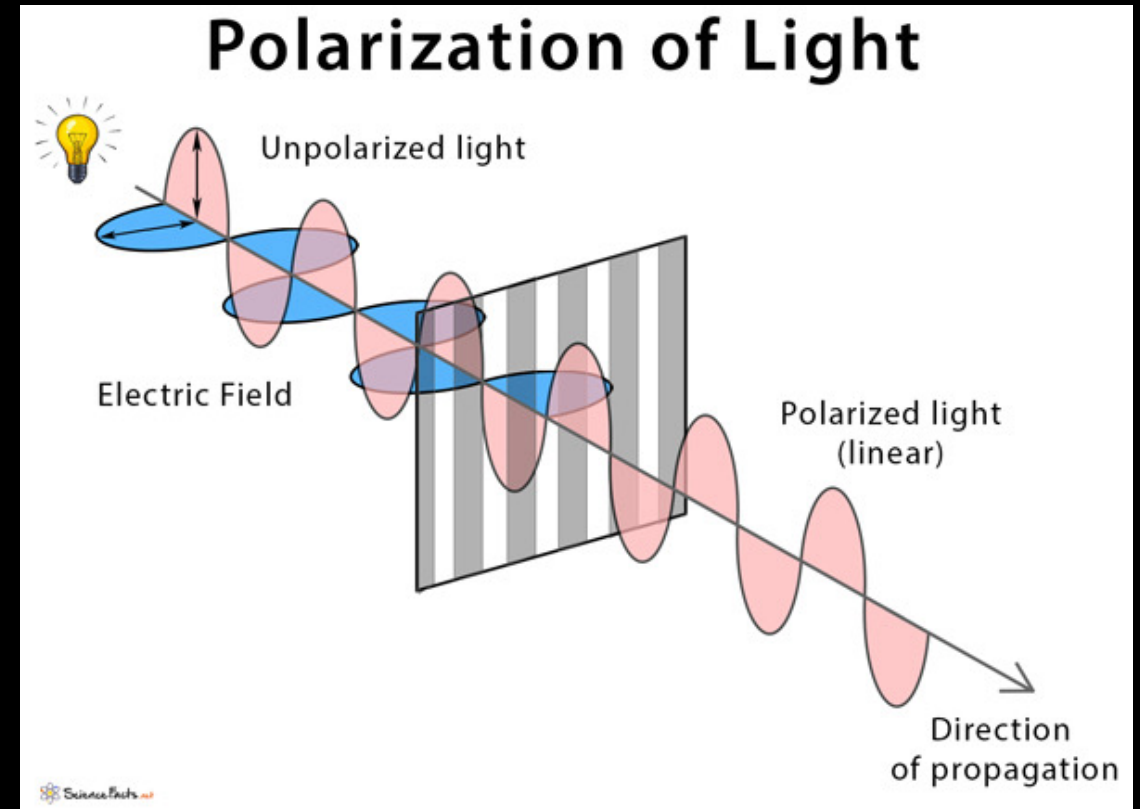
Research Question

How does the lunar polarization versus phase angle curve change as a function of wavelength?

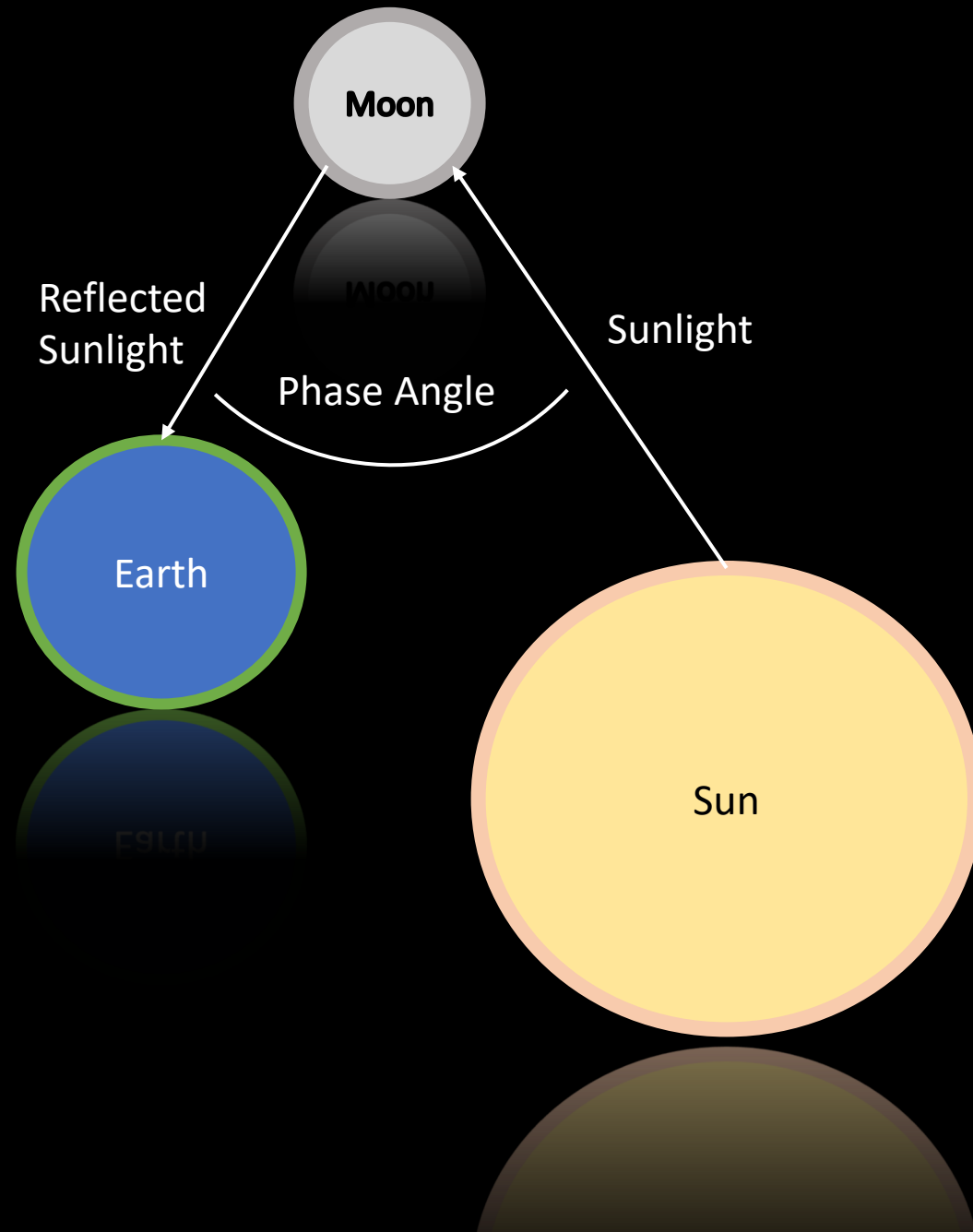
My goal is to take polarized photos of the Moon and see how filters in the visible and near-IR change the degree of polarization and how they vary with phase angle

Quick Polarization Recap

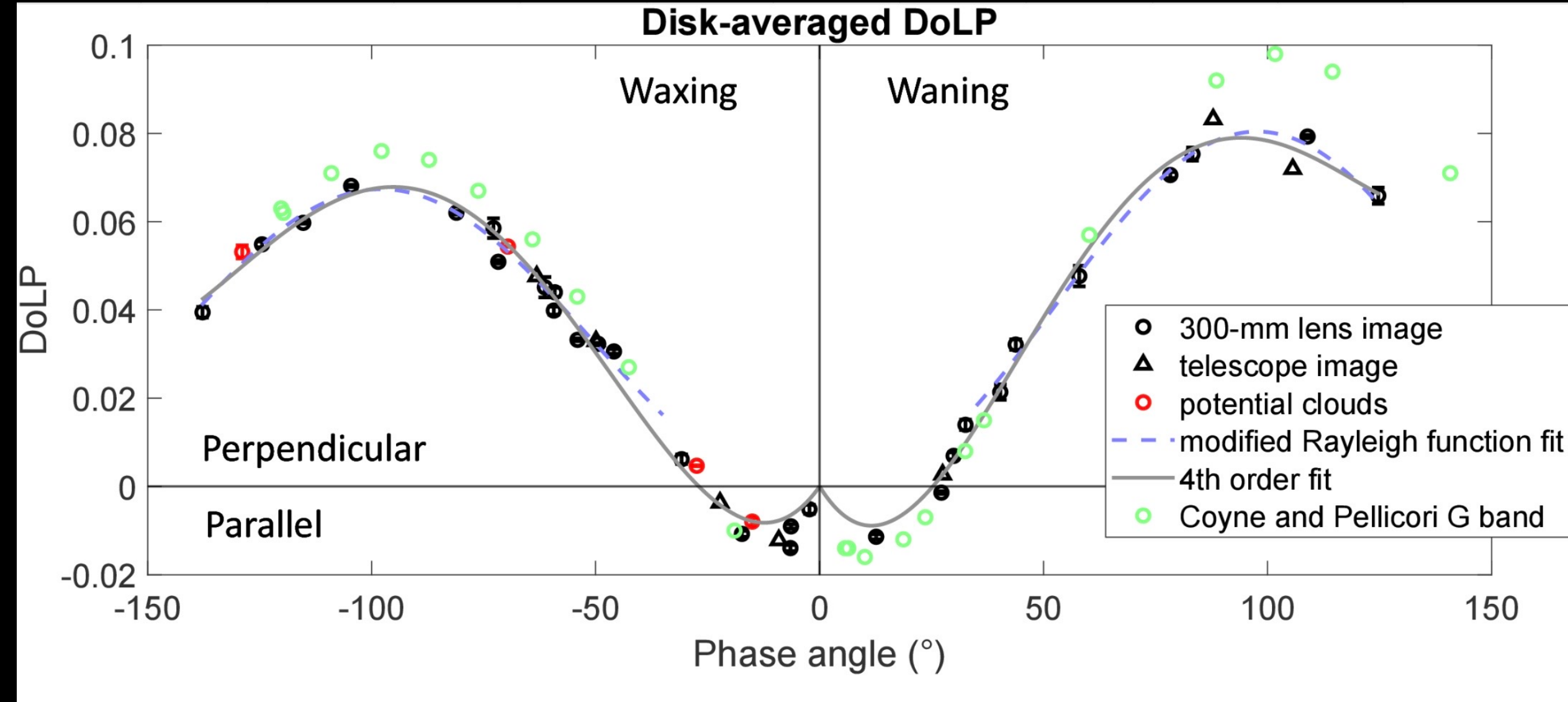
- Polarization is the tendency of electric field lines to oscillate
 - scattering and reflection
 - Polarizing materials
- Direction of propagation is along the positive z-direction
- DoLP is the degree of linear polarization



Moon Diagram

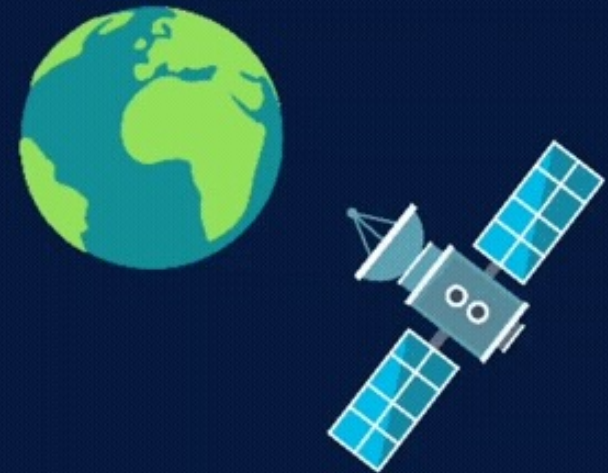


Previous ORSL Work in Broadband



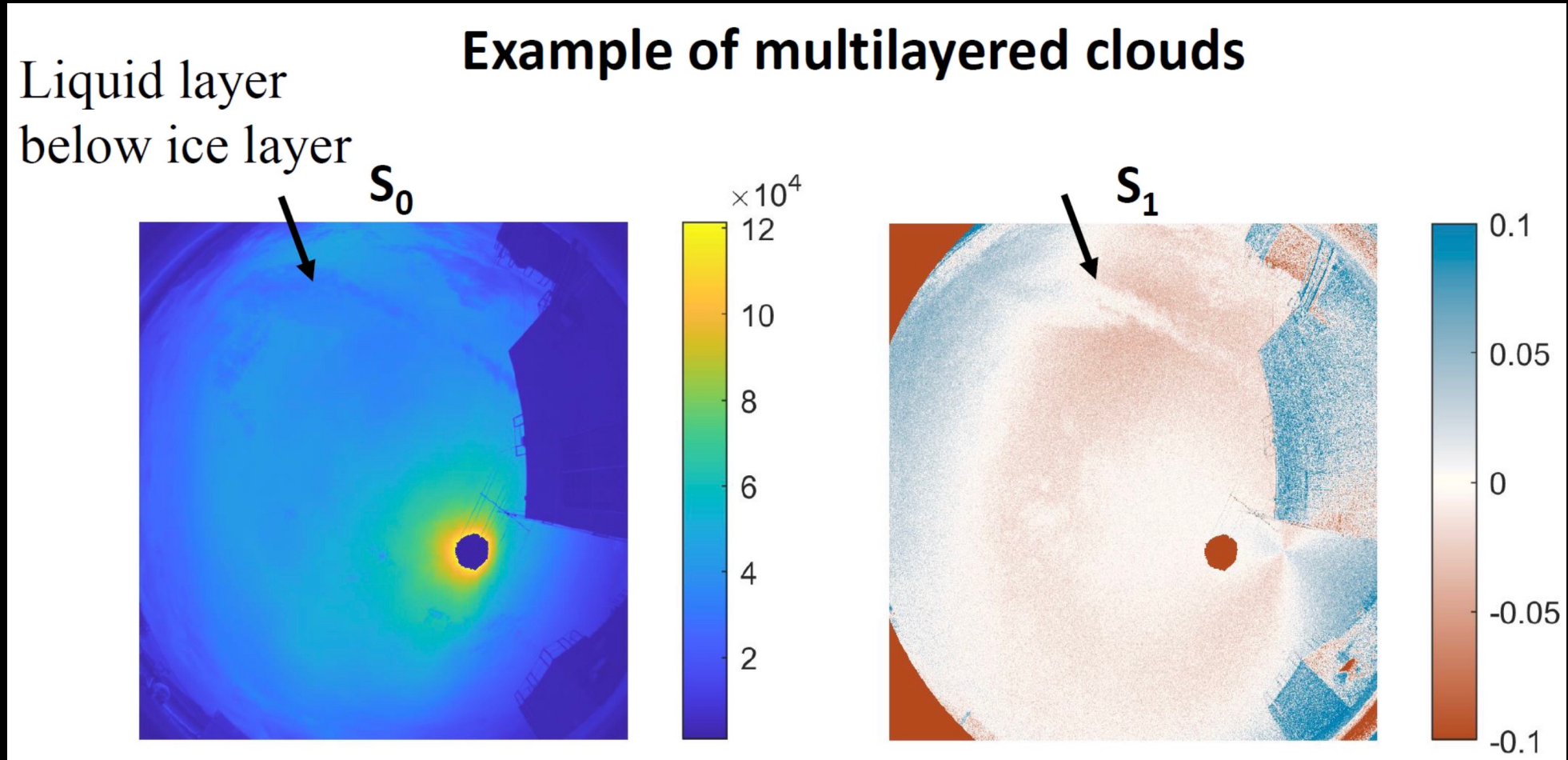
What Does This Research Lead To?

- Lunar Calibrations
 - Satellites using the Moon as a calibration source because it is stable
 - Currently have detailed radiometric Moon models but not polarization models



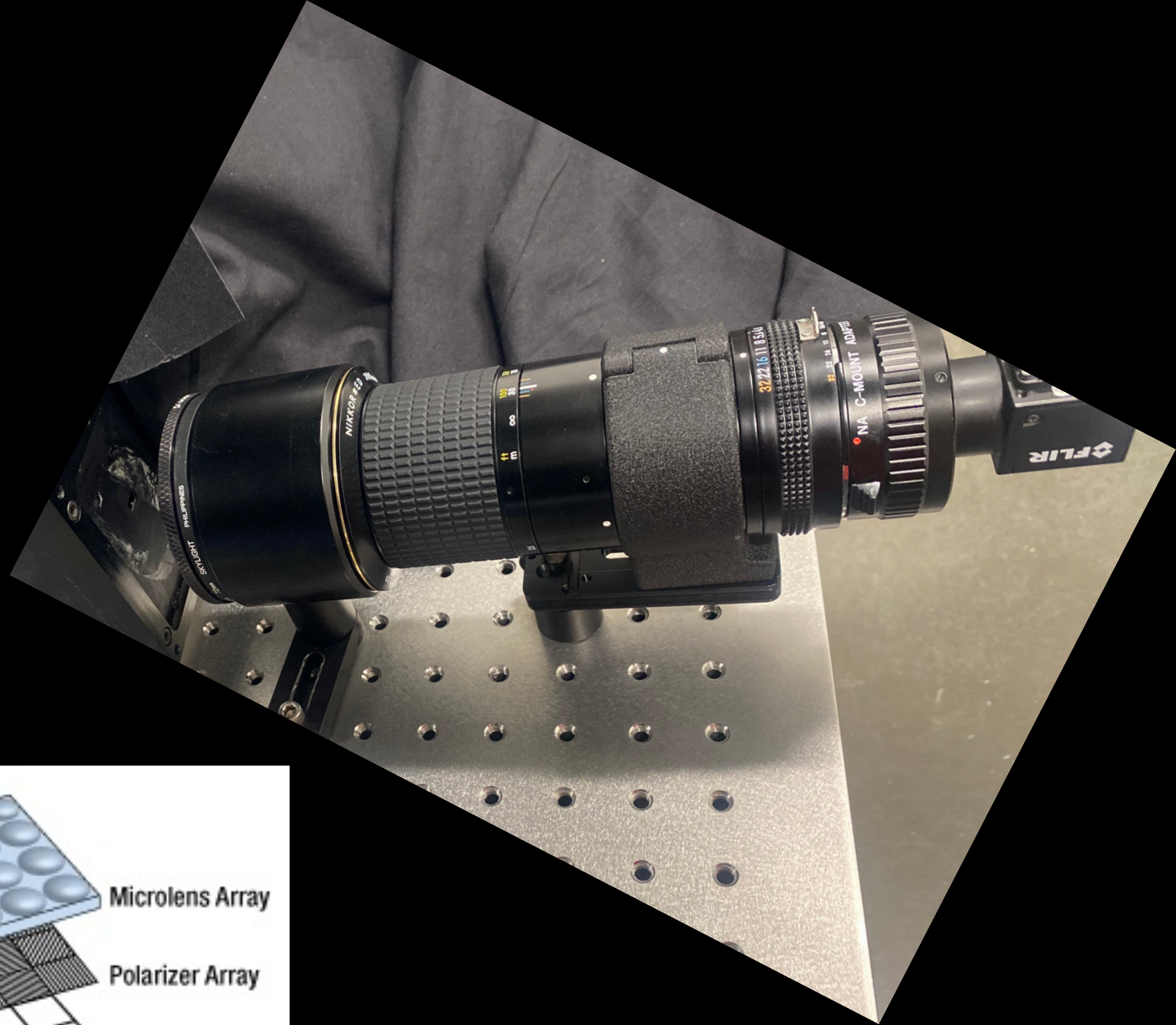
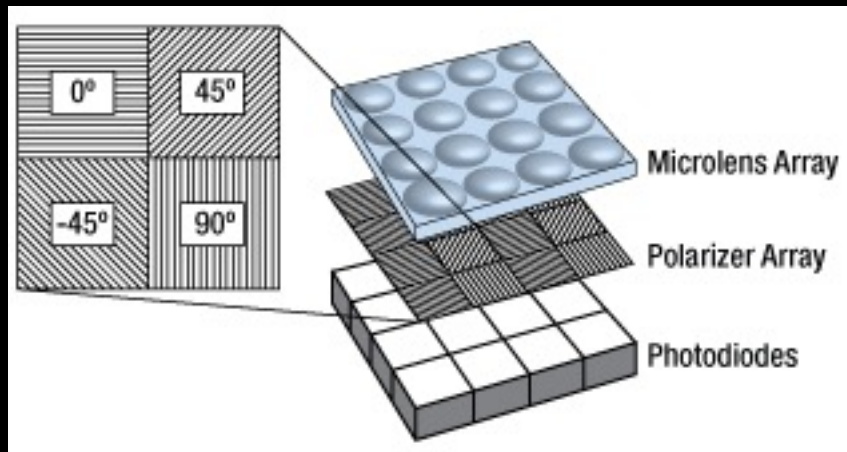
What Does This Research Lead To?

- Nighttime Polarization Remote Sensing
 - Polarized Cloud Data affected by polarization state of the moon at different phase angles



Set-Up

- Camera with Polarizer-> Lens
-> Filter
- Polarized Camera
- 300 mm Lens
- 5 Filters (nm)
 - 450
 - G (~520)
 - 650
 - 800
 - 900



Observing Process



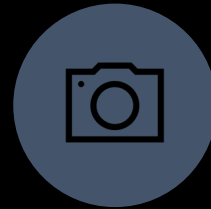
FIVE FILTERS



TAKE THREE
IMAGES



PUT THE CAP
ON



TAKE A DARK

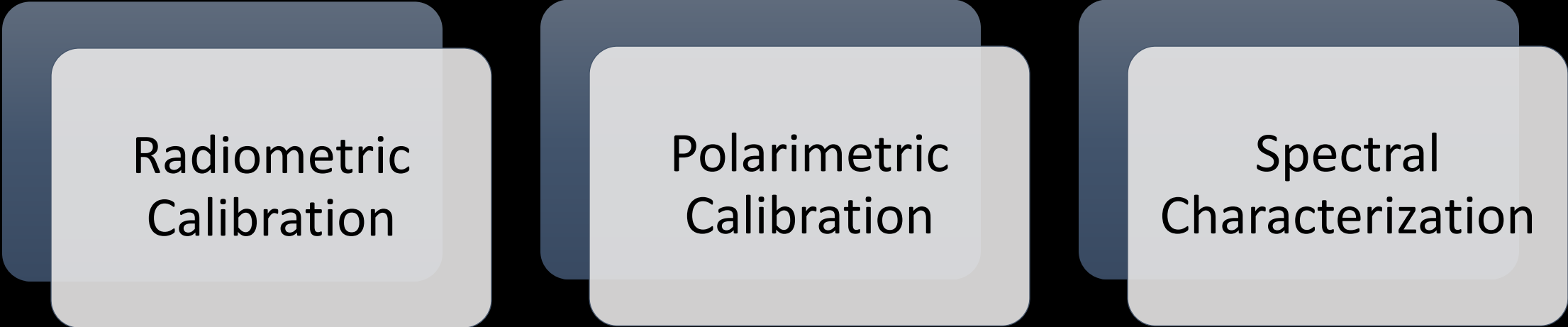


SWITCH THE
FILTER



REPEAT

Calibration List



Radiometric
Calibration

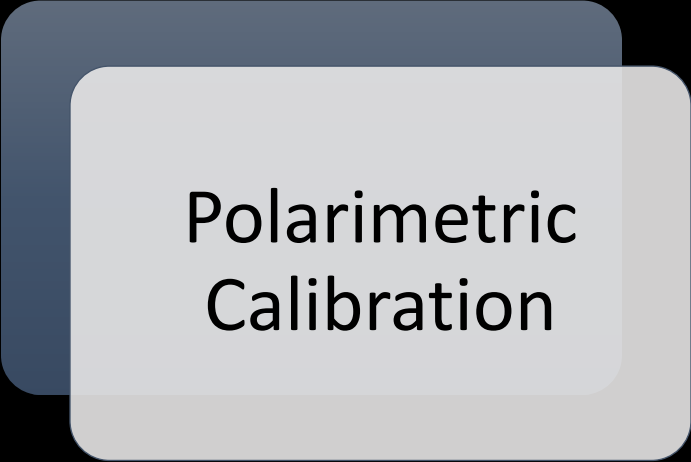
Polarimetric
Calibration

Spectral
Characterization

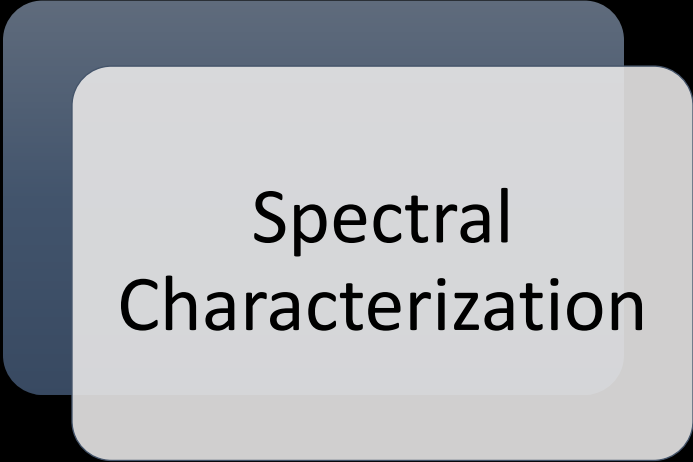
Calibration List



Radiometric
Calibration



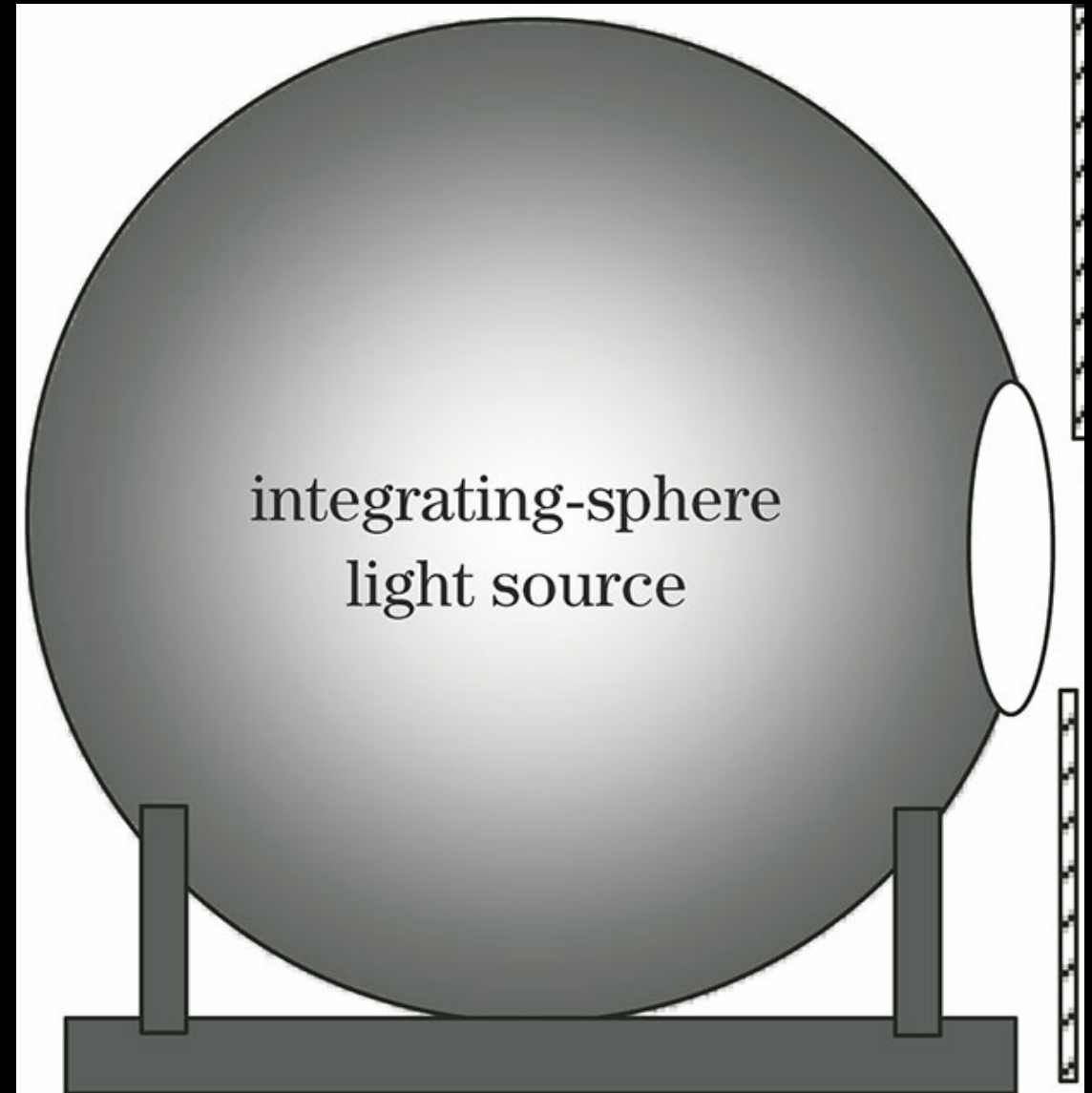
Polarimetric
Calibration



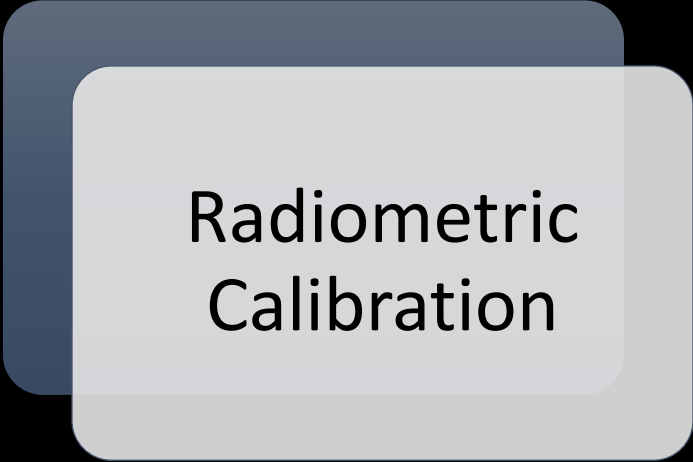
Spectral
Characterization

Radiometric

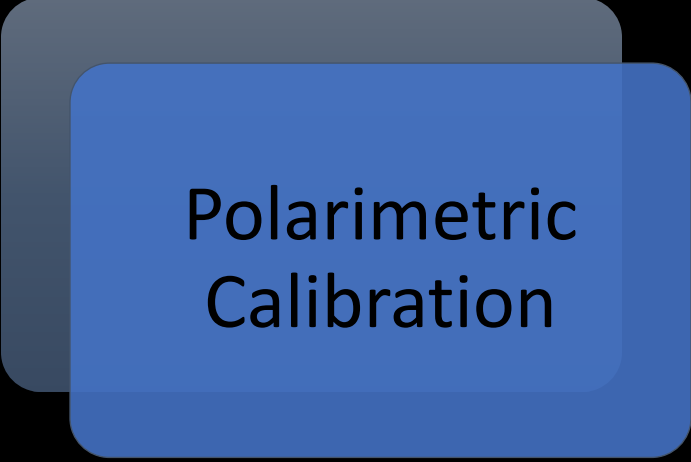
- $DN \rightarrow \frac{W}{m^2 Sr}$
- Flat Fielding Effect
- Uses Integrating Sphere



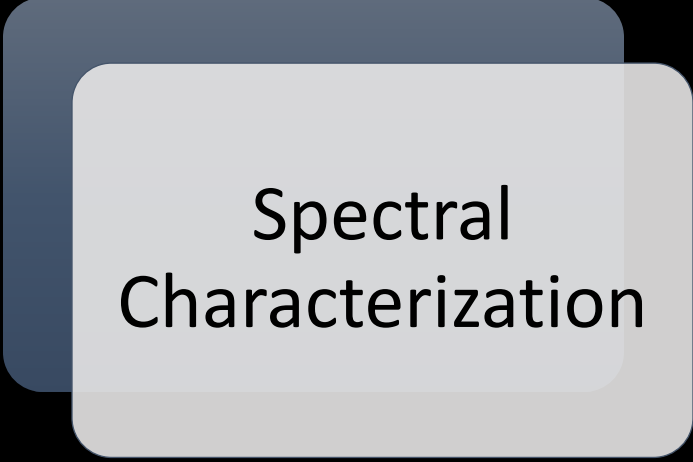
Calibration Flow List



Radiometric
Calibration



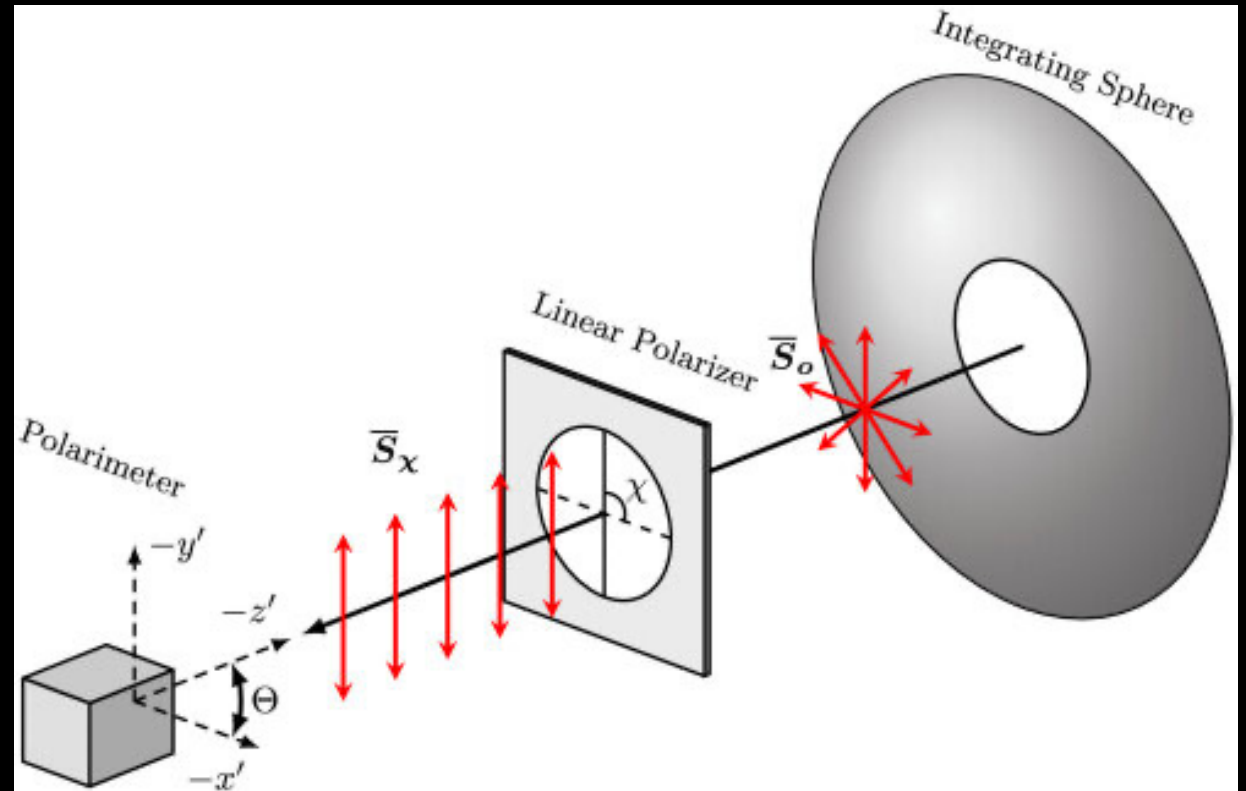
Polarimetric
Calibration



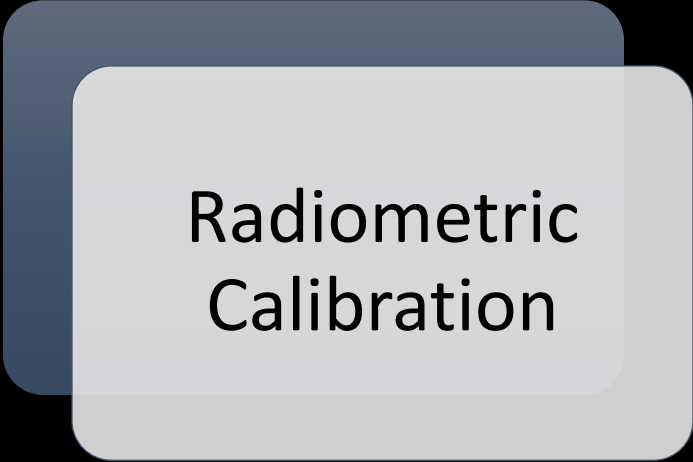
Spectral
Characterization

Polarimetric Calibration

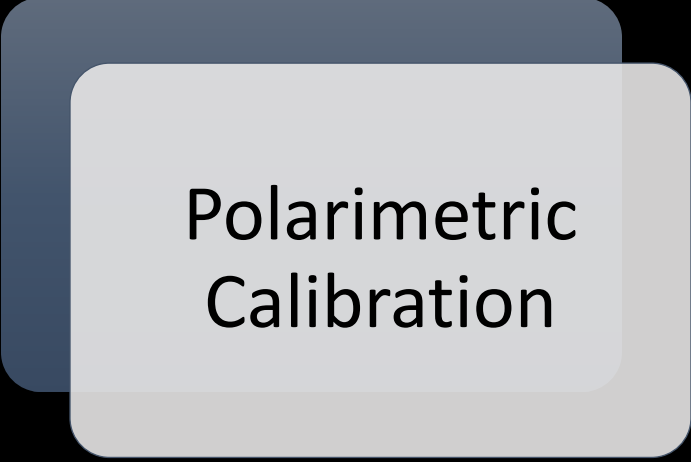
- 3x3 matrix
- Corrects Stokes Vector
- Integrating Sphere+Polarizer



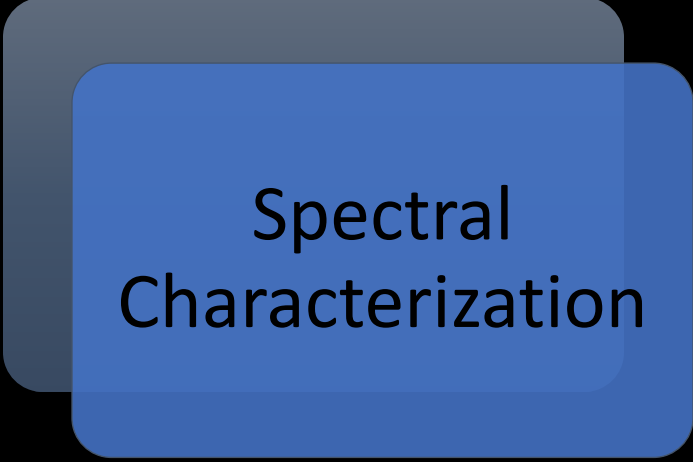
Calibration List



Radiometric
Calibration



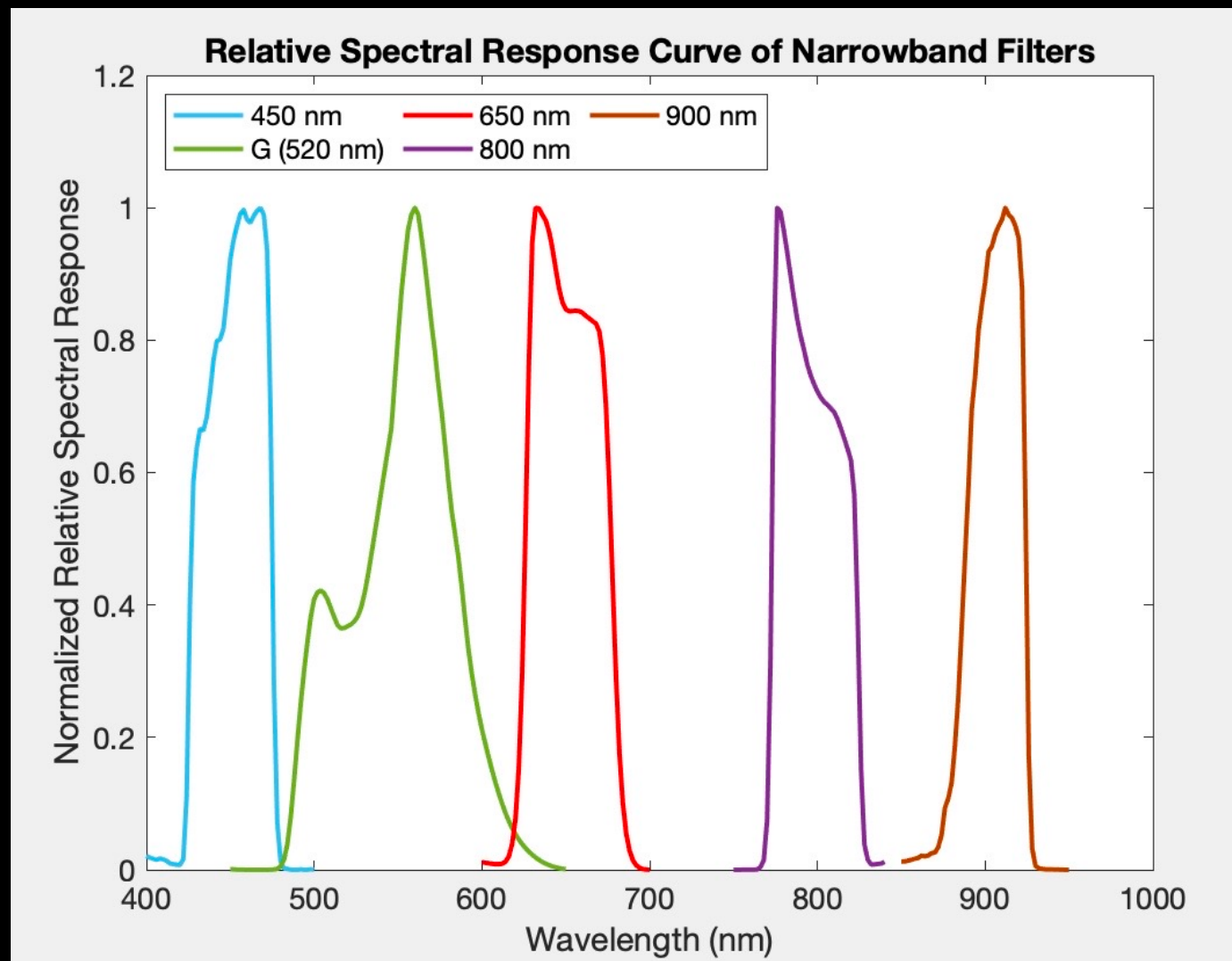
Polarimetric
Calibration



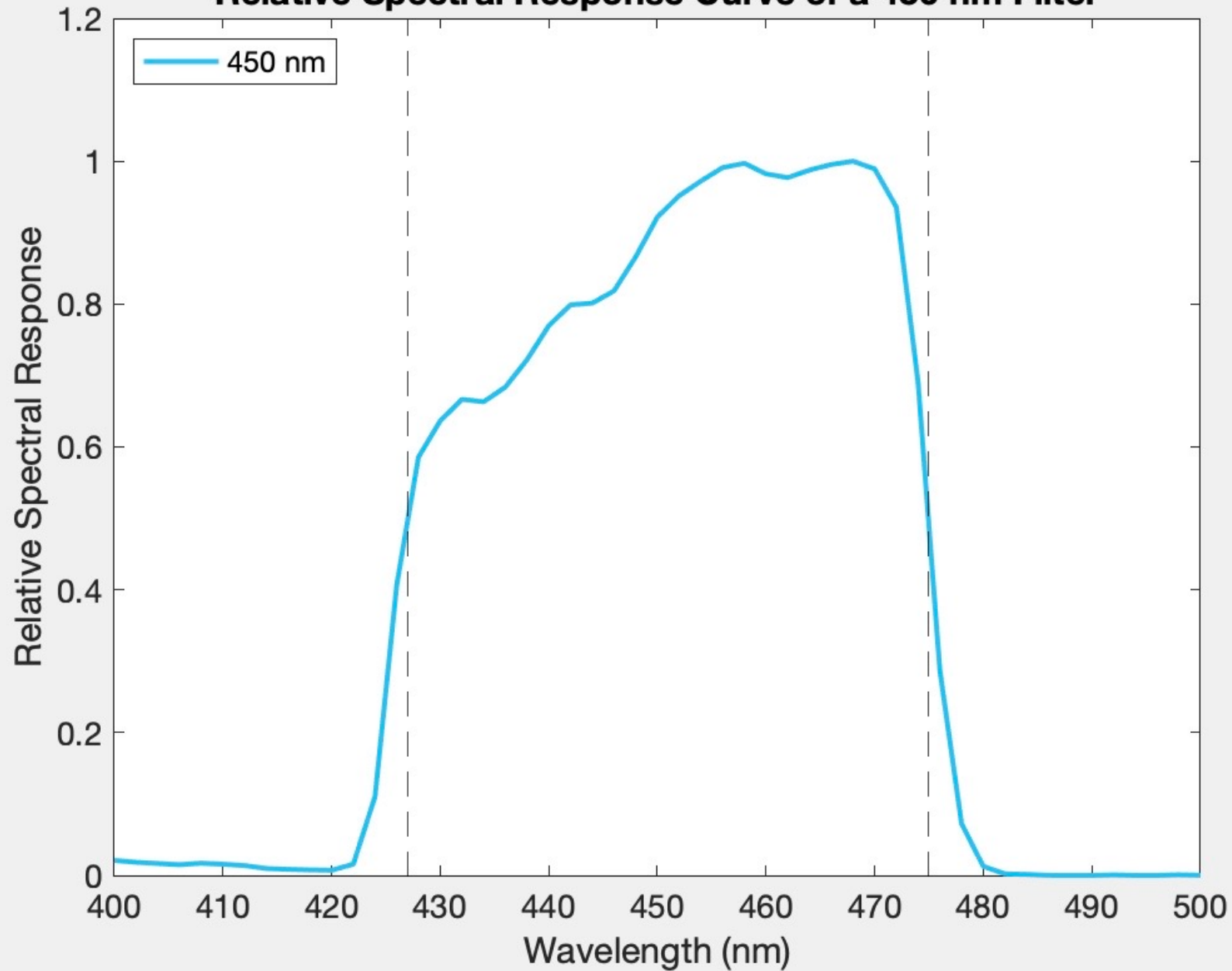
Spectral
Characterization

Spectral Characterization

- RSR = Unitless
- Calculate Radiometric Calibration
- Monochromator

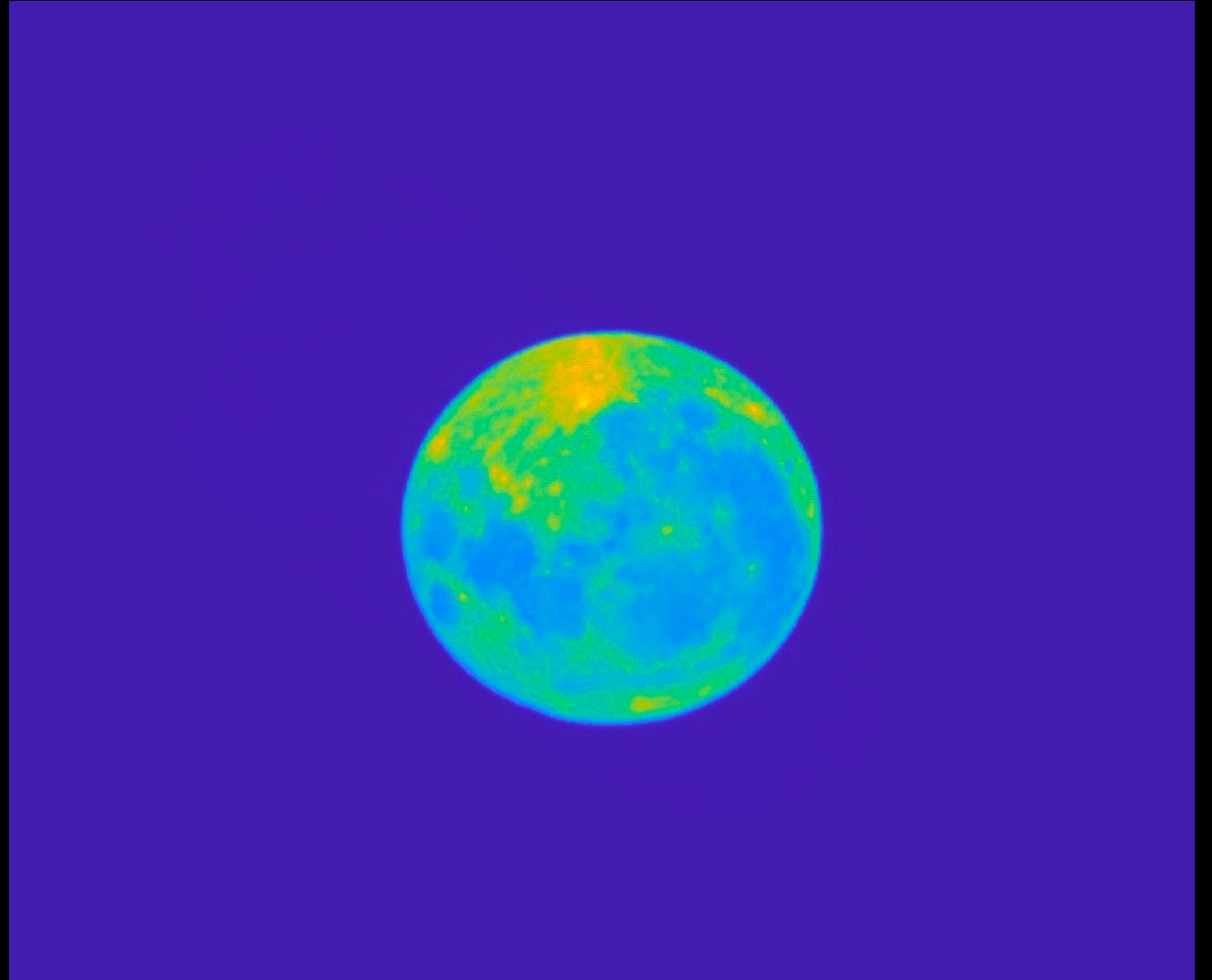


Relative Spectral Response Curve of a 450 nm Filter



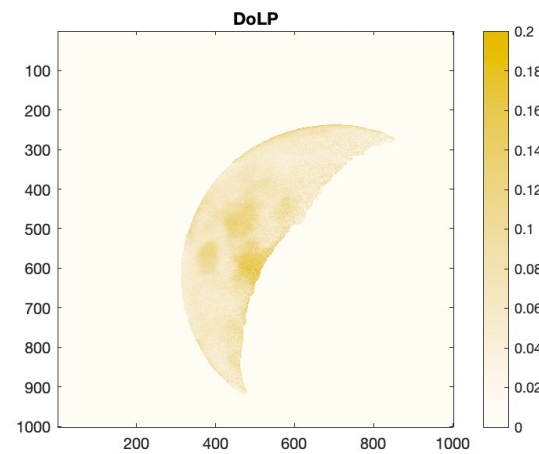
Preliminary Results

- Raw Images for 7 Different Days
- Processed Images
- DoLP Curve

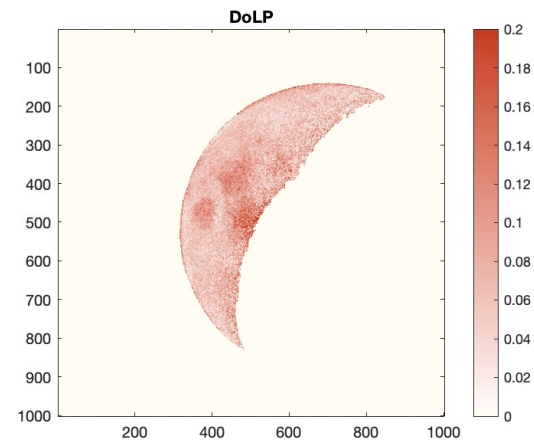


Raw Moon Image in the G Filter on June 22, 2024

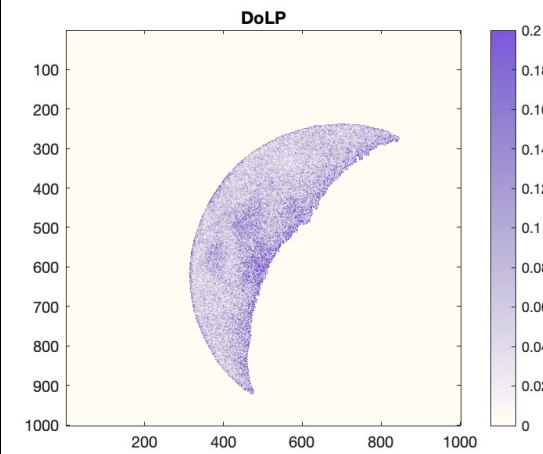
no filter



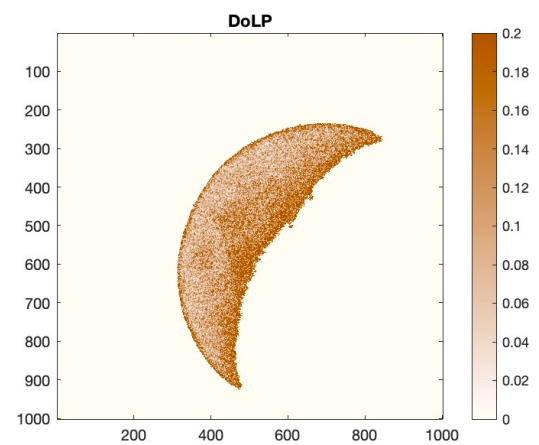
650 nm filter



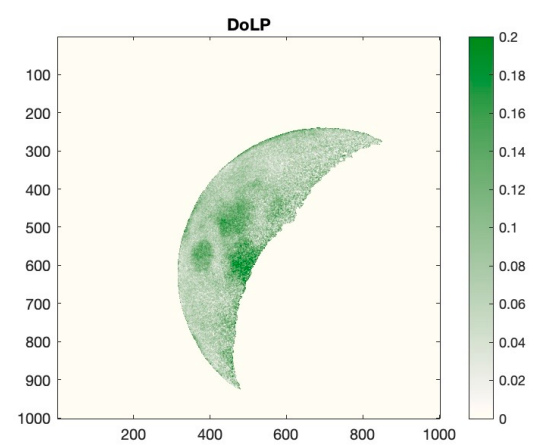
800 nm filter



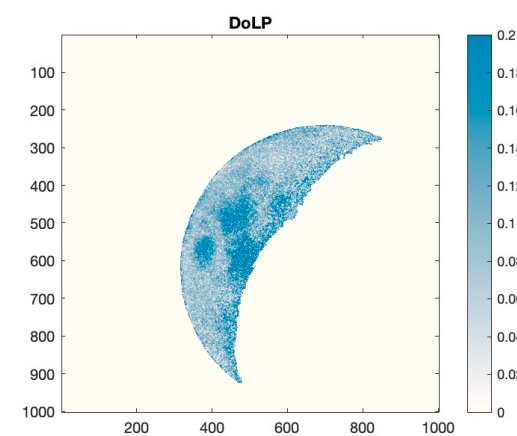
900 nm filter



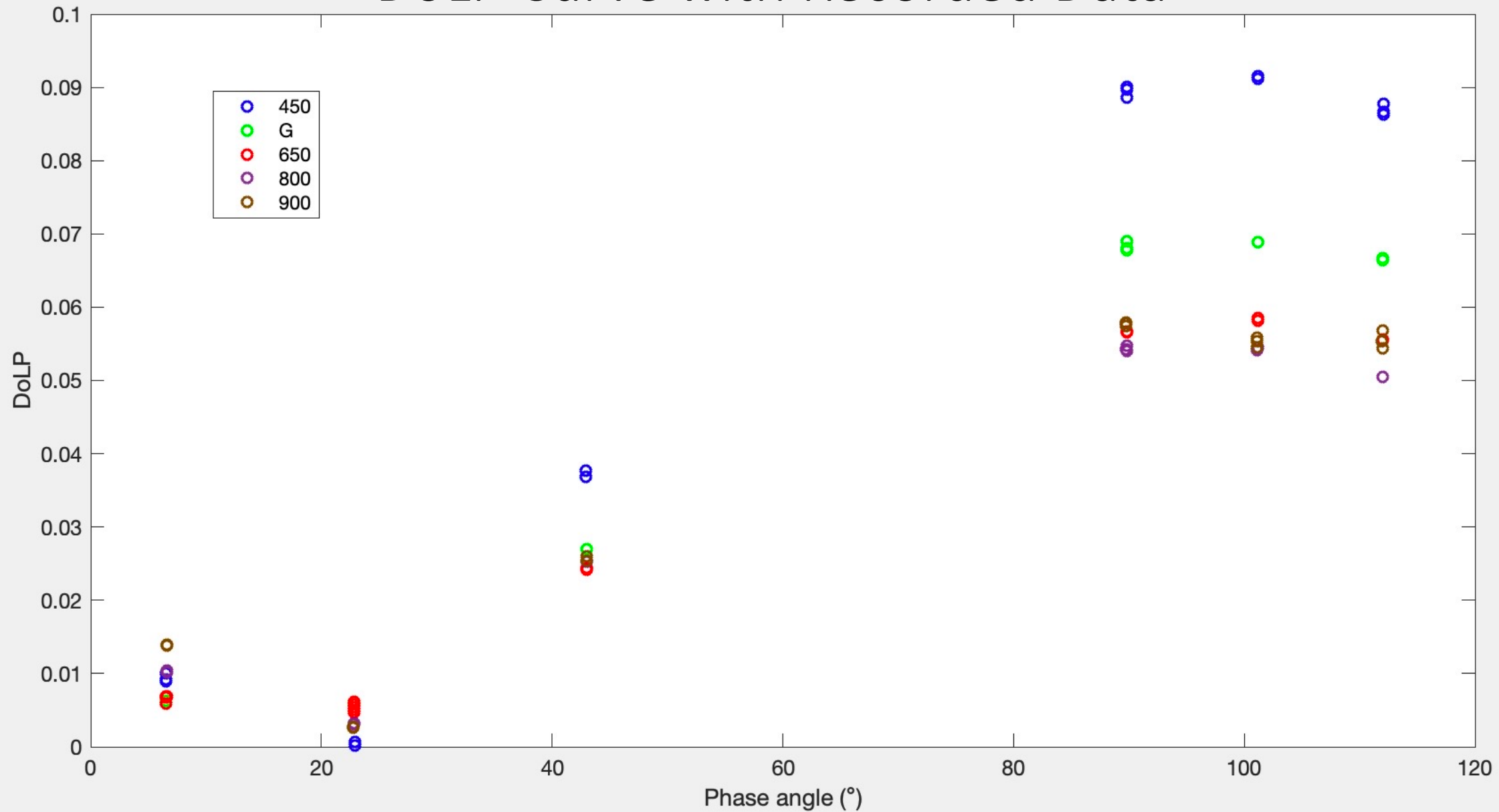
G filter



450 nm filter



DoLP Curve with Recorded Data



What is Next? Challenges?

- Weather has been a challenge...
clouds and nighttime rain
- Continuing to record and
process data
- Add to the DoLP curve



Acknowledgements

- Erica
- Dr. Joe Shaw
- ORSL and REU group



References

- Erica Venkatesulu and Joseph A. Shaw, "Polarization images of the Moon as a function of the lunar phase," Opt. Express 32, 24275-24292 (2024)
- <https://www.sciencefacts.net/polarization-of-light.html>
- Musaddeque A. Syed, Erica Venkatesulu, Joseph A. Shaw, "Cloud thermodynamic phase measured with a low-cost, ground-based, all-sky imaging polarimeter," Proc. SPIE 11833, Polarization Science and Remote Sensing X, 1183303 (1 August 2021);<https://doi.org/10.1117/12.2594204>
- <https://spaceplace.nasa.gov/all-about-the-moon/en/>
- <https://www.istockphoto.com/vector/happy-smiling-moon-gm1004728862-271335882>