TNU 2025 Summer School
08/08/2025

POLARIZATION OF THE MOON

Lab 4 : (Langrenus Project)

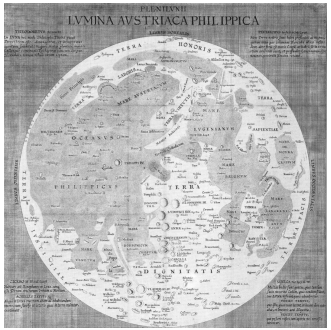
Instructor: Dr. John Hoang (Hoang Kim Dinh)

Outline

1. Introduction
2. Features of the Moon
3. Instruments
4. Moon Data
5. Problem
6. Data Analysis
7. Our Results
8. Future plan

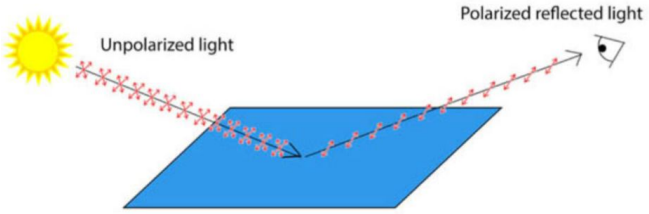
About the moon 🌝

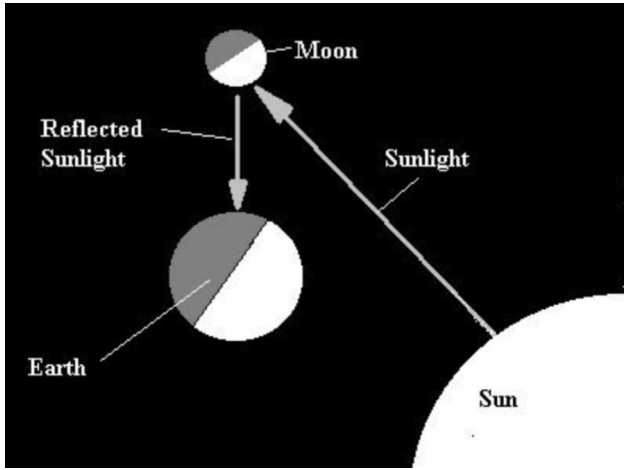
- The only natural satellite the Earth has.
- We want to map the surface of the moon in a similar way to Earth.
- Will help us to understand how the moon formed and why it is orbiting the earth.
- This is why we are observing the moon and studying the features on the surface.



How Does the Moon Polarize Light?

- Light is a transverse wave, and that means the light waves oscillate on many axes.
- When the light is incident on a surface, such as the moon, the light waves are absorbed by the surface and scattered by the dust and rocks.
- The resulting light waves only oscillate in one direction.
- The degree of polarization depends on the phase of the moon.
- This means that we must express the degree of polarization in terms of the phase angle of the moon.





Features we are mapping 🌝

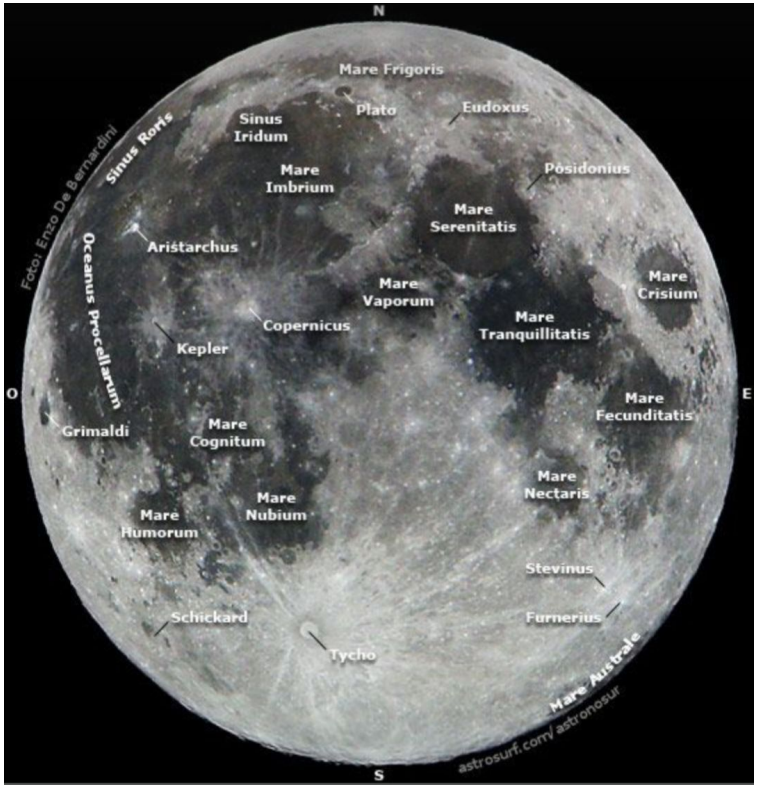
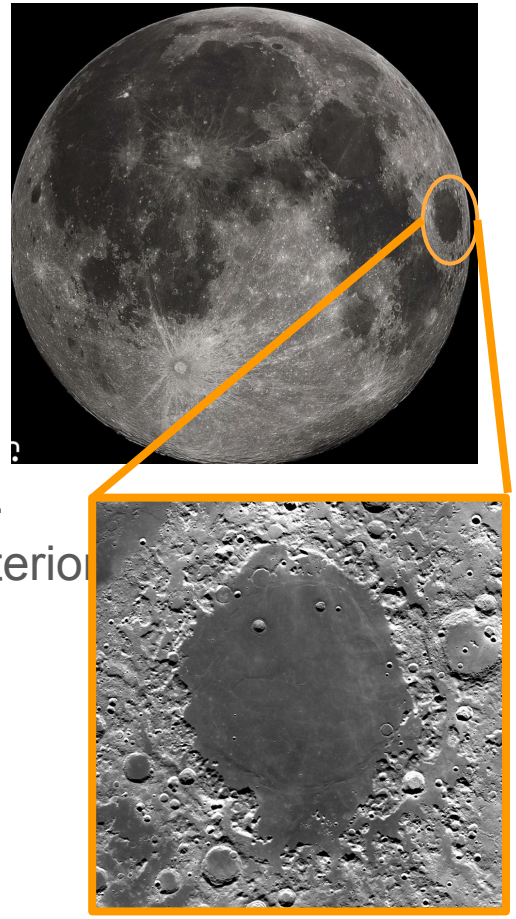


Fig: AstroNosur. (n.d.). *Mapa lunar*. Astrosurf. http://www.astrosurf.com/astronosur/luna_mapa.htm

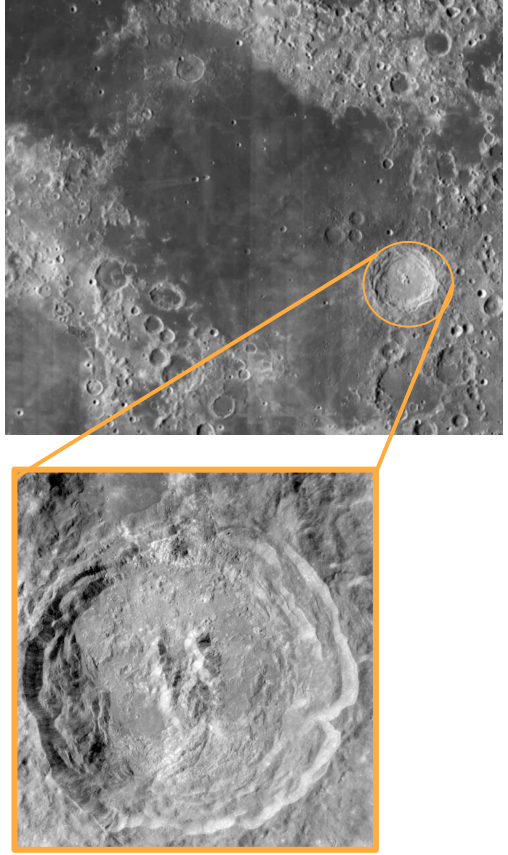
Mare Crisium 🌝

- Name: Sea of Crisis.
- Age: ~ 3.92 - 3.85 billion years ago.
- Formed: Ancient volcano filled with lava.
- Area: ~ 176,000 km^2.
- Shape:has a flat floor with a ring of wrinkles ridges.
- It also has 3 large craters on the floor: Picard, Swift, Peirce.
- Picard is normal impact crater, bowl shaped with several interior ridges and hills.



Langrenus Crater 🌝

- Astronomer Michael Van Langren (one of the first people to draw a lunar map).
- Age: ~3.2- 1.1 billion years ago.
- Diameter: 132 km.
- Depth: 2.7 km
- Shape: a large central peaks in the middle of its surface.
- Observed: a higher albedo so it appears brighter.
- The crater floor has many boulders.



Wikipedia contributors. (2025, July 30). *Langrenus (crater)*. In *Wikipedia, The Free Encyclopedia*. Retrieved August 8, 2025, from https://en.wikipedia.org/wiki/Langrenus_(crater)

Outline of our Project 🌝

- Calculate the **Degree of Linear Polarization** and understand how that changes from day to day.
- Equation we are using:

$$DoLP = \frac{\sqrt{(I_{0^0} - I_{90^0})^2 + (I_{45^0} - I_{135^0})^2}}{\frac{1}{2}(I_{0^0} + I_{90^0} + I_{45^0} + I_{135^0})} \quad (1)$$

- It gives the intensity at each polarisation angle.
- Intensity can be measured for each angle and can be used to calculate DoLP.
- We will plot a graph using these values.

(1) Venkatesulu, E., & Shaw, J. A. (2024). Polarization images of the Moon as a function of the lunar phase. *Optics Express, 32*(14), 24275–24292.https://opg.optica.org/oe/fulltext.cfm?uri=oe-32-14-24275&id=552277

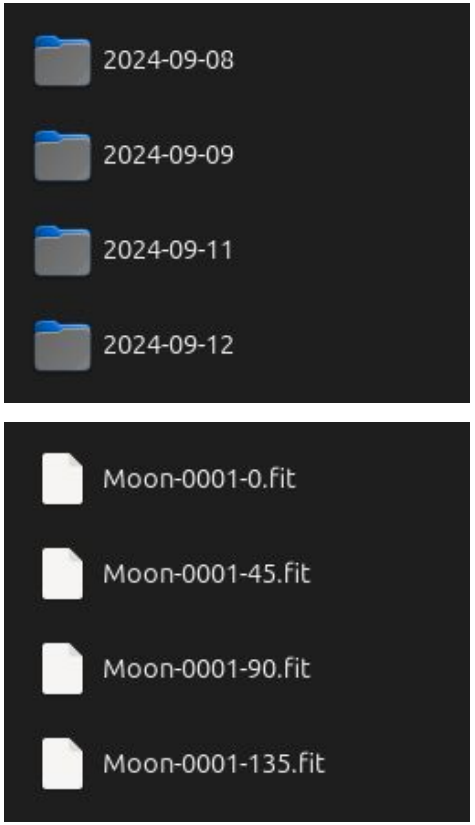
Quy Nhon Observatory

Telescopes utilised in QNO🌝

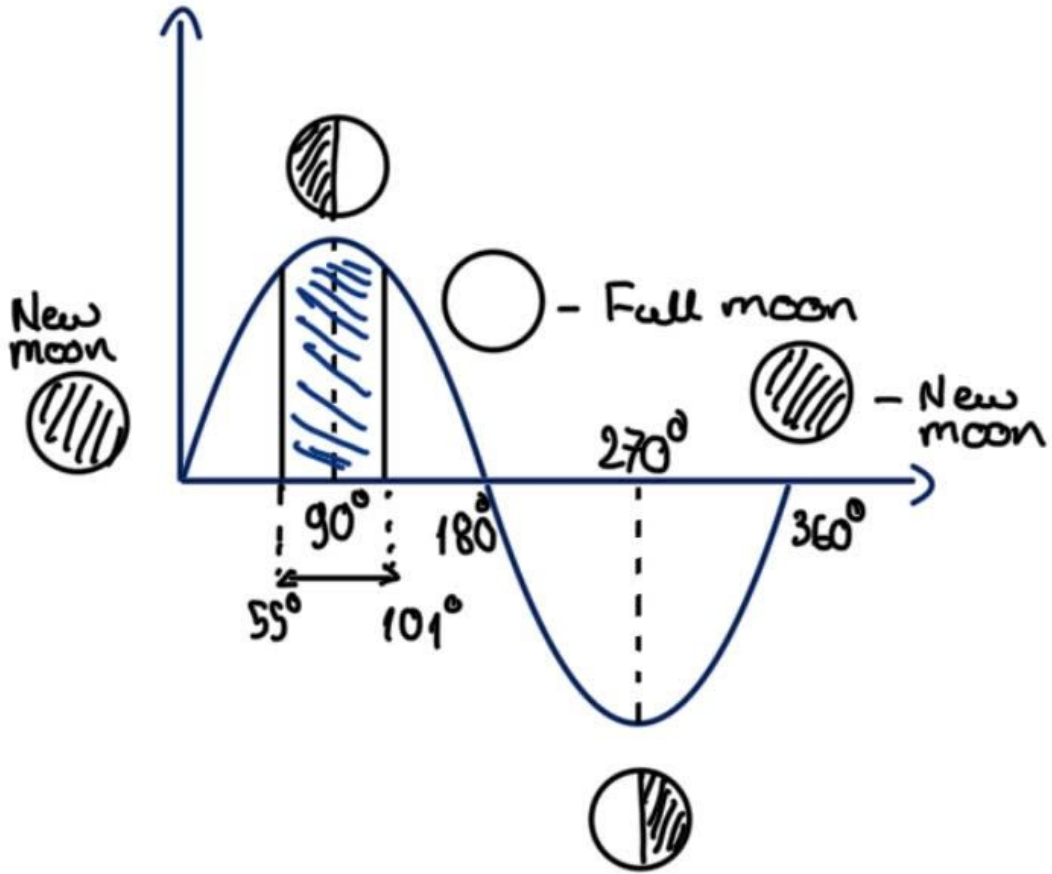
CDK600 Telescope

L-600 Mount

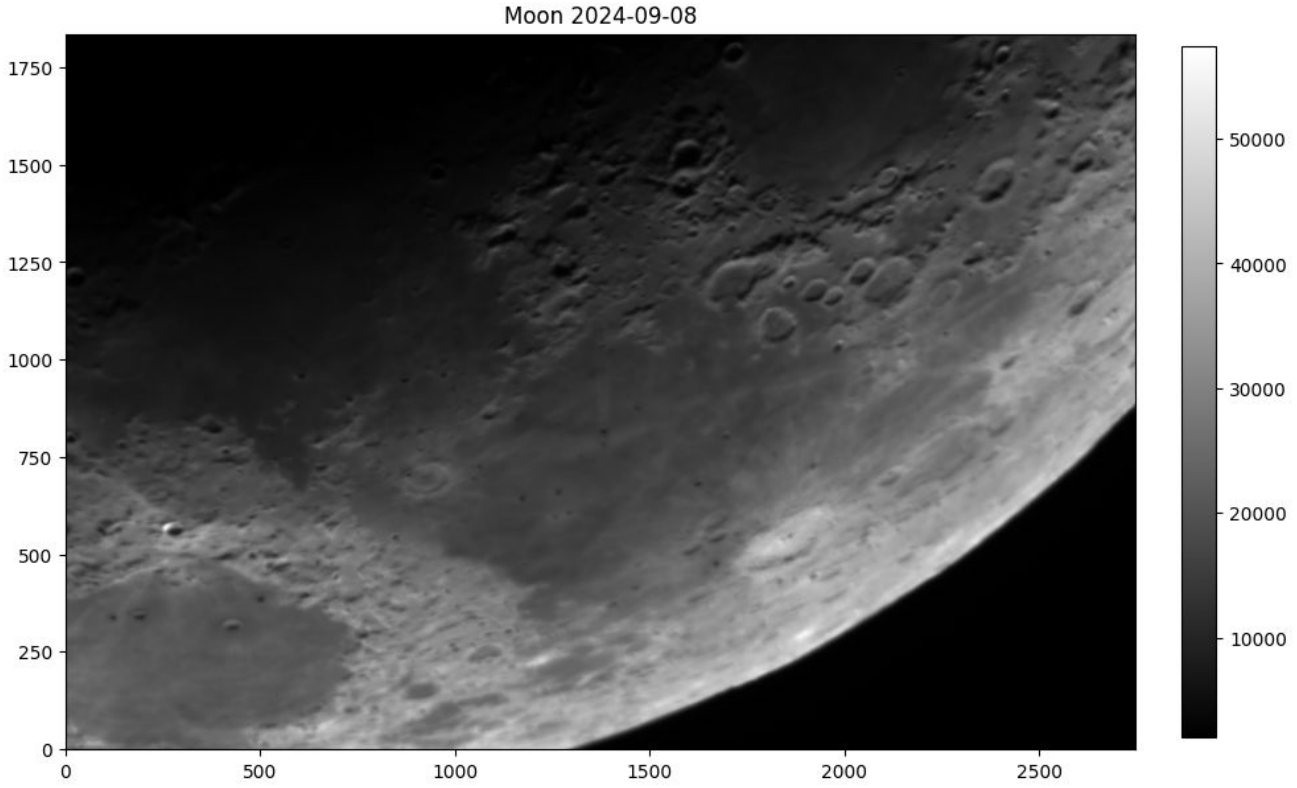
Data



Quy Nhon Observatory data.

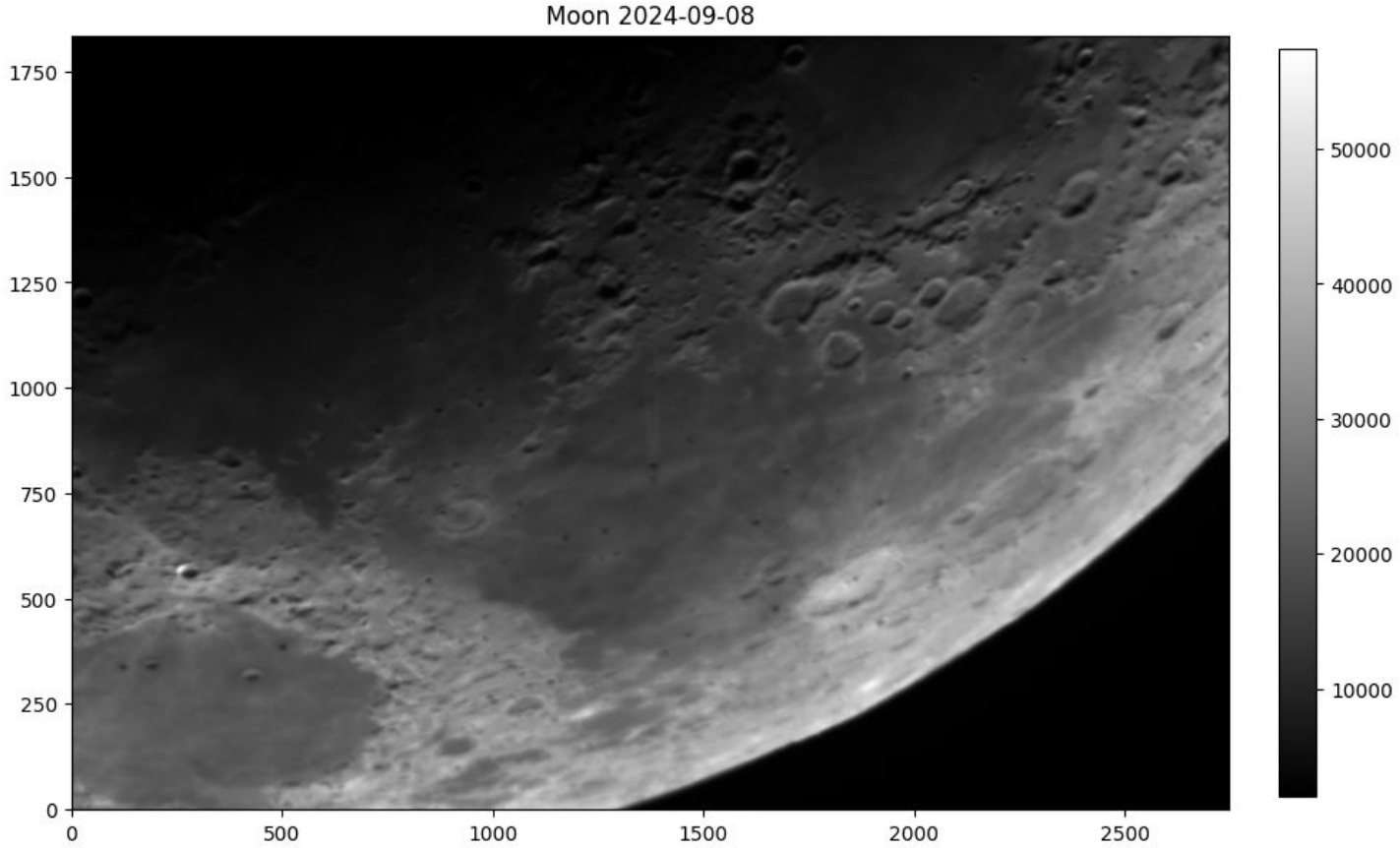

New moon
- Full moon
- New moon
270°
90°
180°
360°
55°
101°

Raw Data🌝


Moon 2024-09-08
1750
1500
1250
1000
750
500
250
0
0
500
1000
1500
2000
2500
50000
40000
30000
20000
10000

200,000 stacked images of the moon’s details 🌝

Djudjic, D. (2022, August 31). *Two photographers and over 200,000 photos made this 174-megapixel photo of our Moon*. DIY Photography. Two photographers and over 200,000 photos made this 174-megapixel photo of our Moon


Moon 2024-09-08
1750
1500
1250
1000
750
500
250
0
0
500
1000
1500
2000
2500
50000
40000
30000
20000
10000

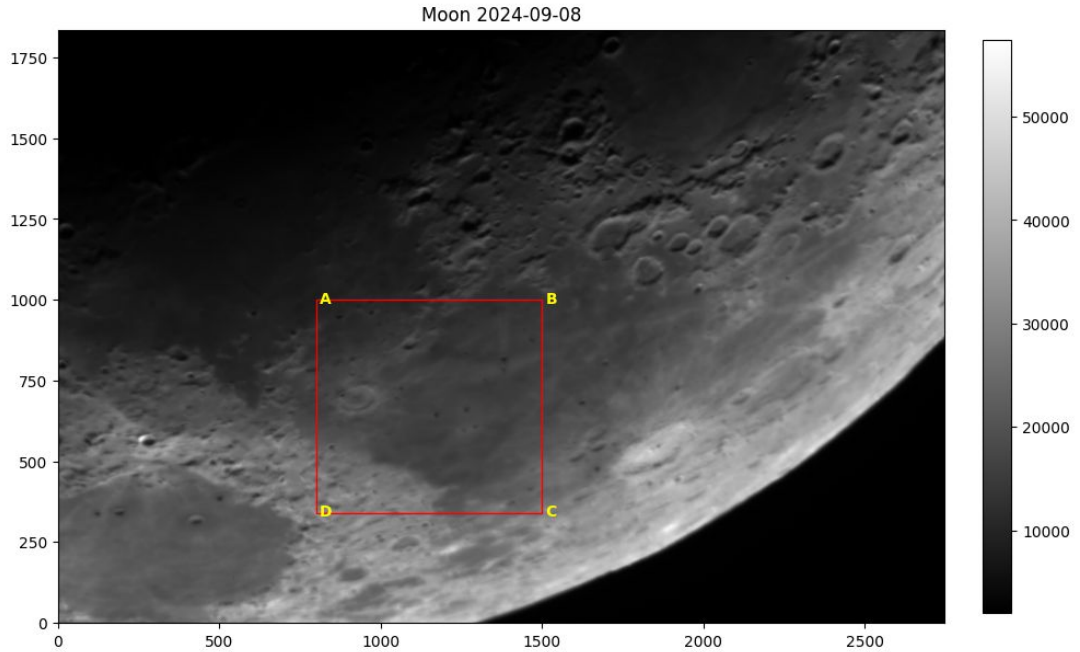
Survey the Features 🌝

Create a box to focus on a specific region.

Normalization:

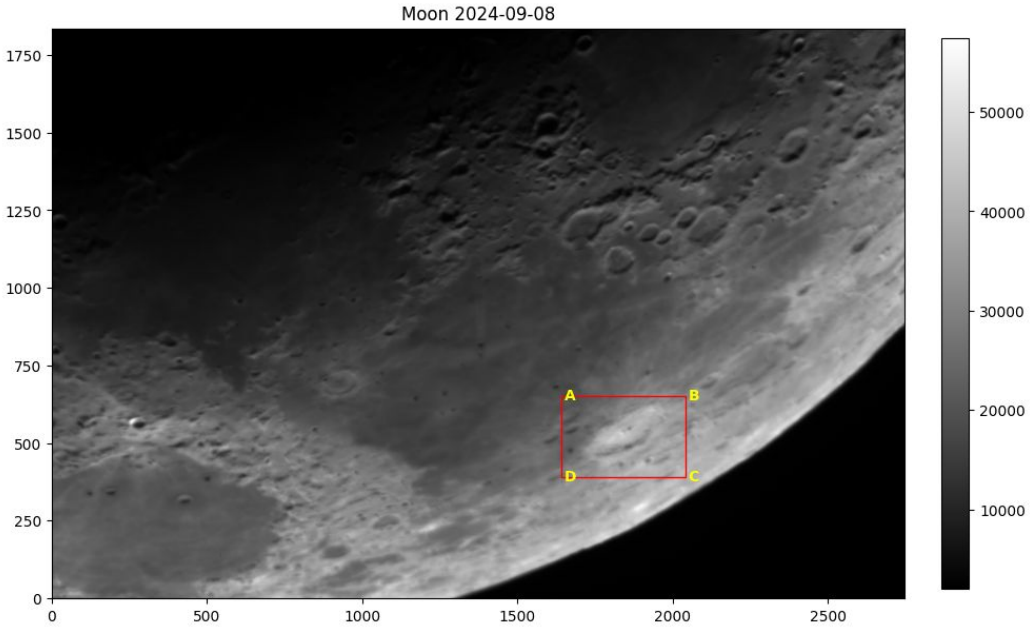
Calculate the total intensity (**i)** within box (i.e., the sum of all pixel intensities inside the box) and divide it by area of the polygon (**A)**.

$$I'_{moon} = \frac{i_{polygon\,1}}{A_{polygon\,1}} \quad \text{(Intensity per pixel)} (2)$$



Survey the Features🌝

Focus the box on the research features (Langrenus Crater, Mare Crisium) by finding their pixel coordinates.



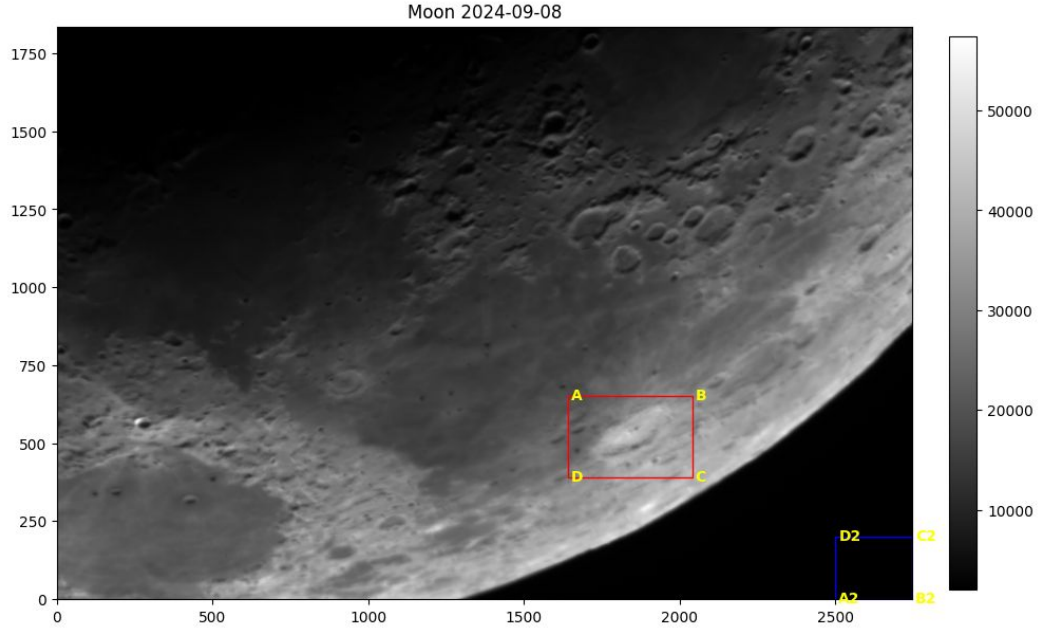
Adjustment of Light Contamination 🌝

Draw a second box to find the total intensity in a dark region:

$$I'_{dark} = \frac{i_{polygon\,2}}{A_{polygon\,2}} \text{ (Intensity per pixel)} (3) \ ,$$

We adjust for more accurate of the Moon's intensity.

$$I = I'_{moon} - I'_{dark} \quad (4)$$

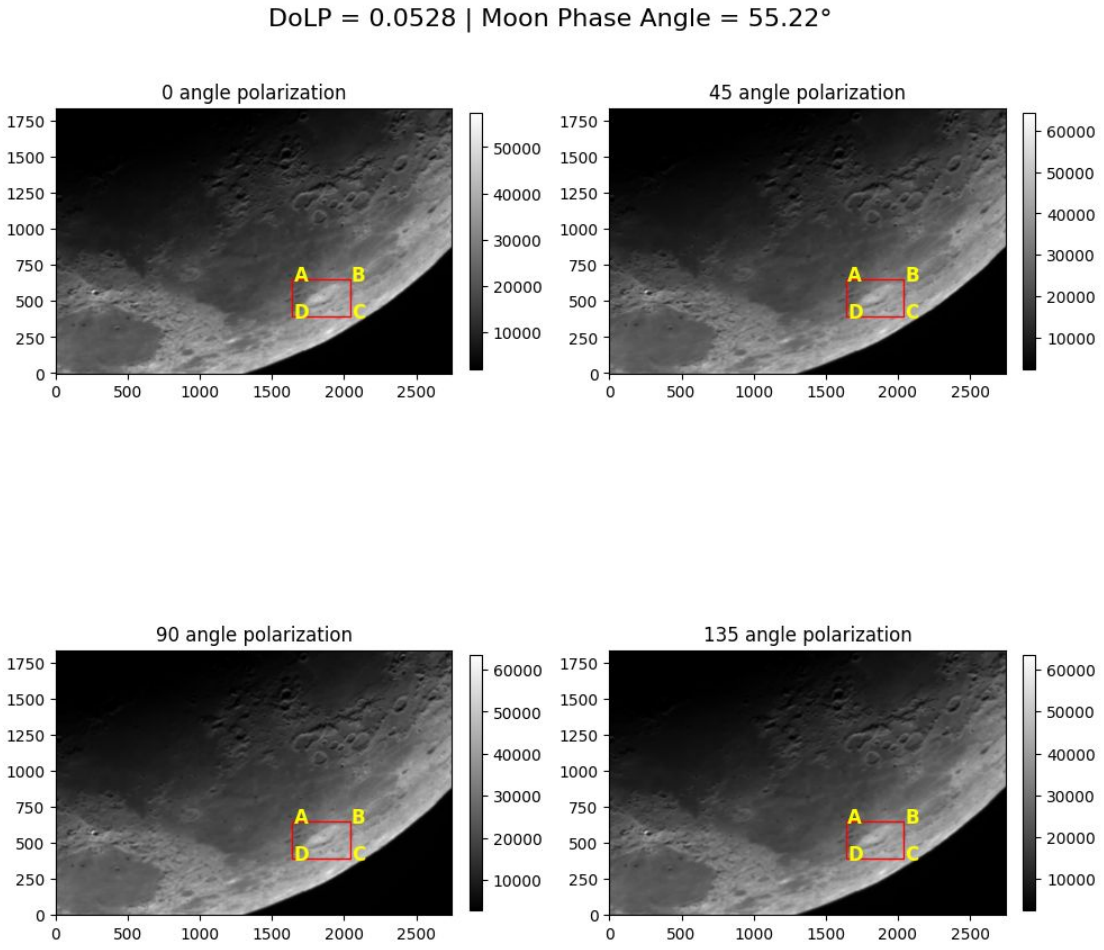


DoLP for 4 Angles

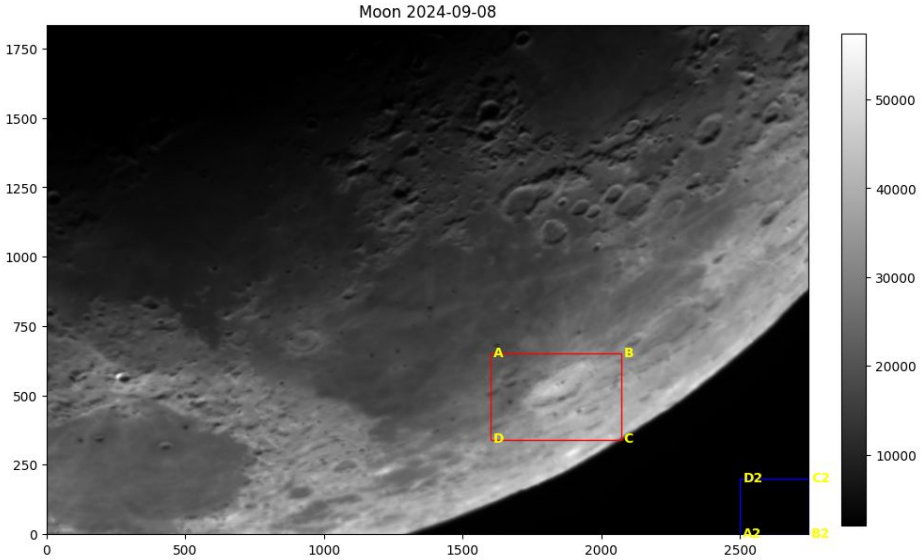
Perform the same process for all 4 polarization angles to obtain I_0,I_{45},I_{90},I_{135}.

Then DoLP:

$$DoLP = \frac{\sqrt{(I_{0^0} - I_{90^0})^2 + (I_{45^0} - I_{135^0})^2}}{\frac{1}{2}(I_{0^0} + I_{90^0} + I_{45^0} + I_{135^0})}$$



Langrenus Crater DoLP

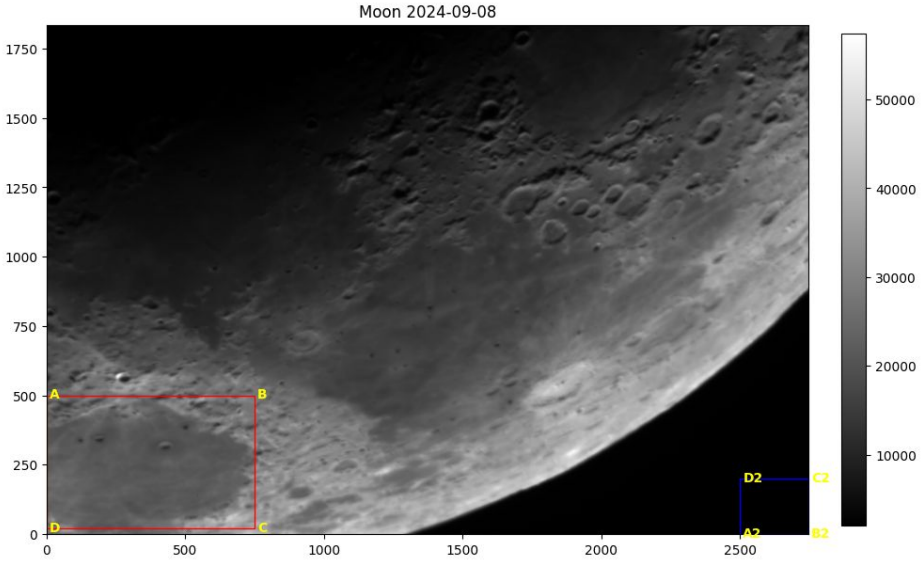


$$I = I'_{moon} - I'_{dark}$$

$$DoLP = \frac{\sqrt{(I_{0^0} - I_{90^0})^2 + (I_{45^0} - I_{135^0})^2}}{\frac{1}{2}(I_{0^0} + I_{90^0} + I_{45^0} + I_{135^0})}$$

```
Intensity in main polygon:
  I0   = 17610.65115151515
  I45 = 19768.273454545455
  I90  = 21020.394943722942
  I135 = 19659.20858874459
Intensity in polygon 2:
  I0   = 2231.9436437246964
  I45 = 2653.338947368421
  I90  = 3014.0275303643725
  I135 = 2622.808744939271
Intensity after adjustment
  I0   = 15378.707507790454
  I45 = 17114.934507177033
  I90  = 18006.36741335857
  I135 = 17036.39984380532
--------------DoLP-------------
DoLP
0.07784936396372463
----------Phase angle-------------
Angle 0°:
  DATE-OBS (Vietnam time): 2024-09-08T10:54:36.30
...
Angle 135°:
  DATE-OBS (Vietnam time): 2024-09-08T10:55:00.38
  Phase angle of the Moon: 55.22°
```

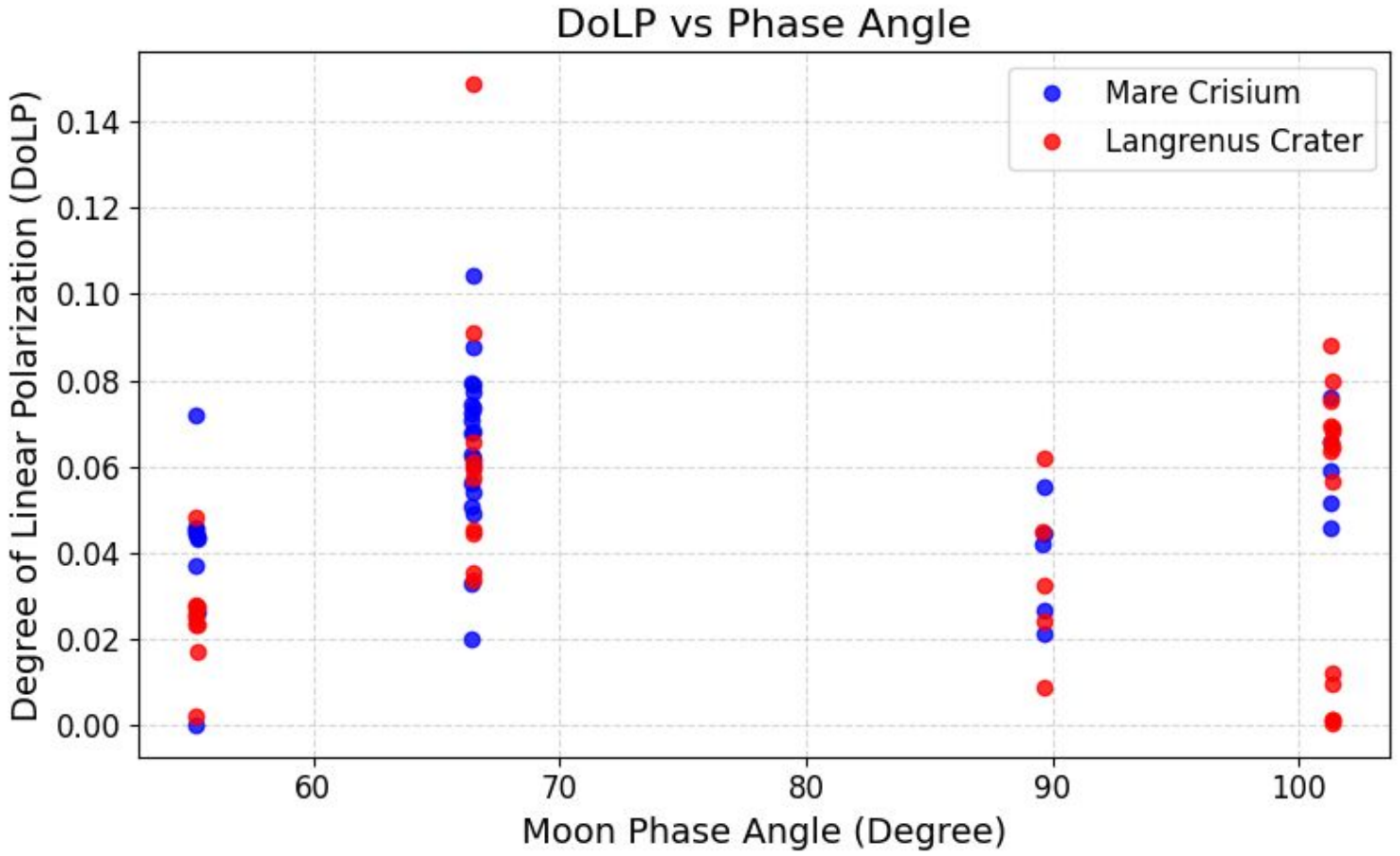
Mare Crisium DoLP 🌝



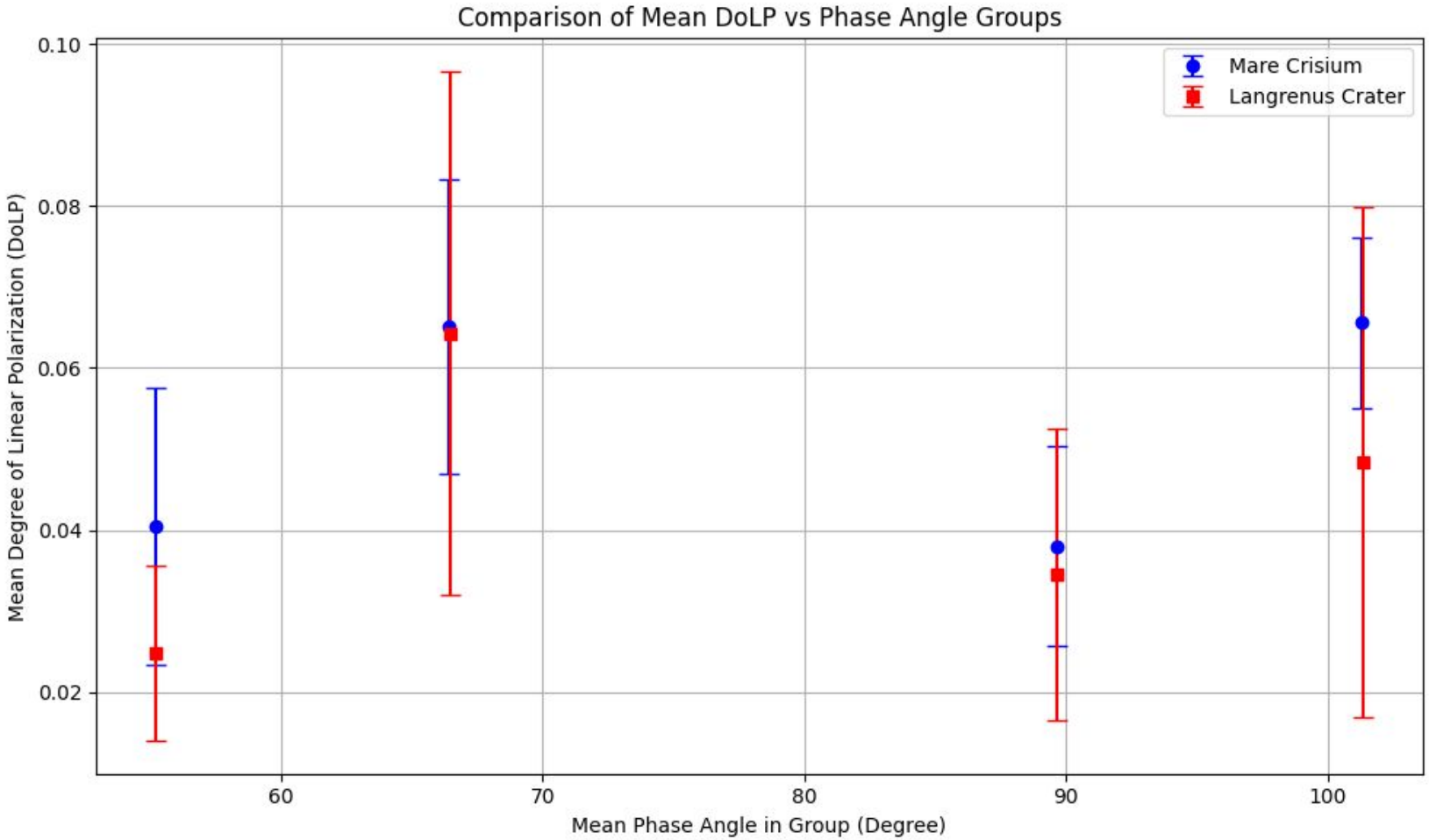
$$I = I'_{moon} - I'_{dark}$$

$$DoLP = \frac{\sqrt{(I_{0^0} - I_{90^0})^2 + (I_{45^0} - I_{135^0})^2}}{\frac{1}{2}(I_{0^0} + I_{90^0} + I_{45^0} + I_{135^0})}$$

```
Intensity in main polygon:
  I0   = 23602.13191111111
  I45 = 26120.066844444445
  I90  = 27410.02808888889
  I135 = 25886.85937777778
Intensity in polygon 2:
  I0   = 2231.9436437246964
  I45 = 2653.338947368421
  I90  = 3014.0275303643725
  I135 = 2622.808744939271
Intensity after adjustment
  I0   = 21370.188267386417
  I45 = 23466.727897076024
  I90  = 24396.000558524516
  I135 = 23264.05063283851
--------------DoLP-------------
DoLP
0.06557172029484766
----------Phase angle-------------
Angle 0°:
  DATE-OBS (Vietnam time): 2024-09-08T10:54:36.30
...
Angle 135°:
  DATE-OBS (Vietnam time): 2024-09-08T10:55:00.38
  Phase angle of the Moon: 55.22°
```


DoLP vs Phase Angle
Mare Crisium
Langrenus Crater
Degree of Linear Polarization (DoLP)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
60
70
80
90
100
Moon Phase Angle (Degree)

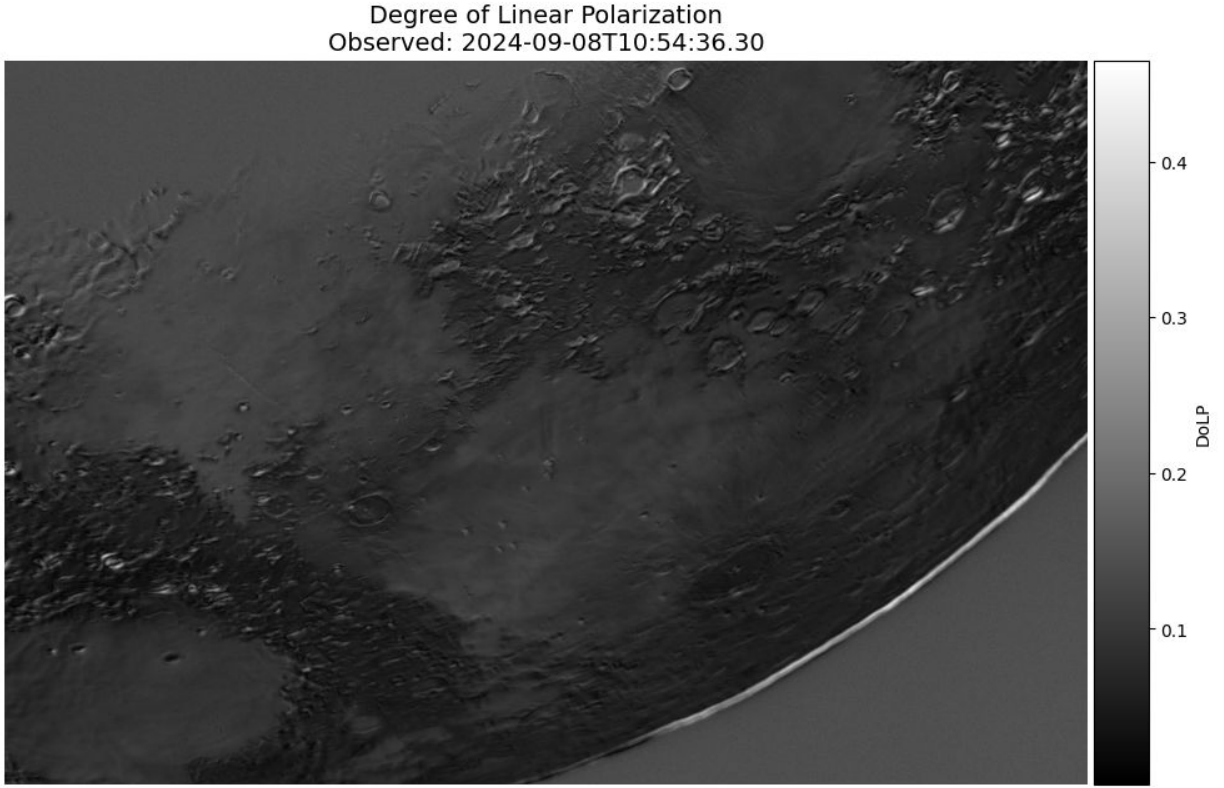
Our Results


Comparison of Mean DoLP vs Phase Angle Groups
Mare Crisium
Langrenus Crater
Mean Degree of Linear Polarization (DoLP)
0.10
0.08
0.06
0.04
0.02
60
70
80
90
100
Mean Phase Angle in Group (Degree)

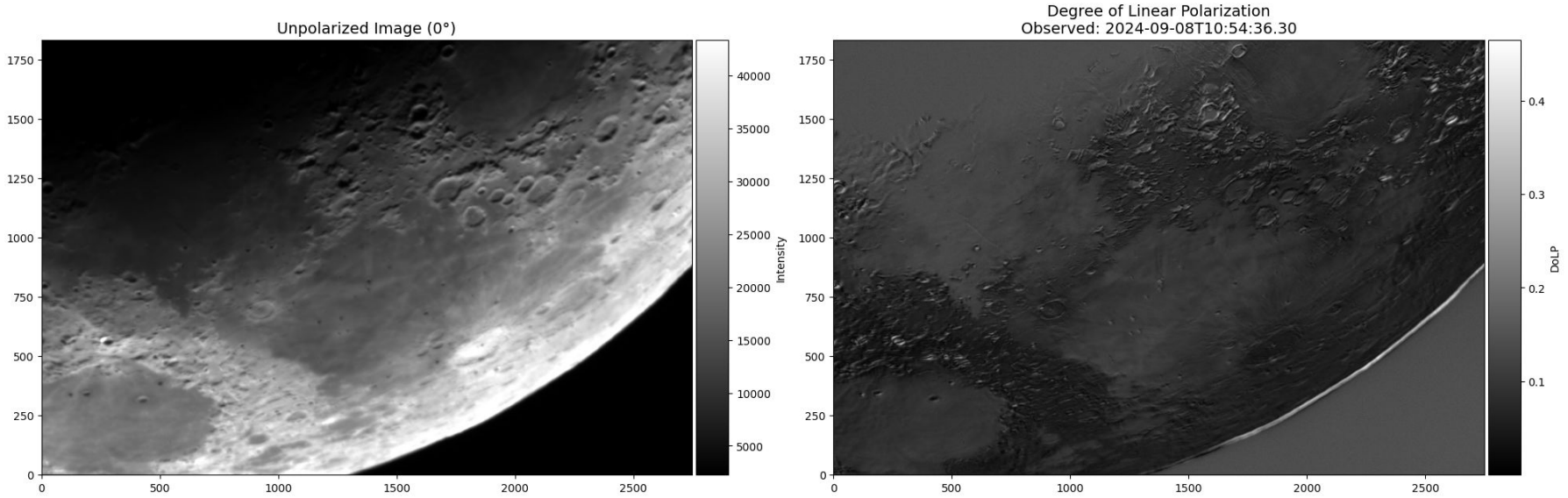
Our Results

Polarized light map of the Moon 🌝

Instead of using the box to survey a specific region, we calculate all DoLP of all pixel intensities.

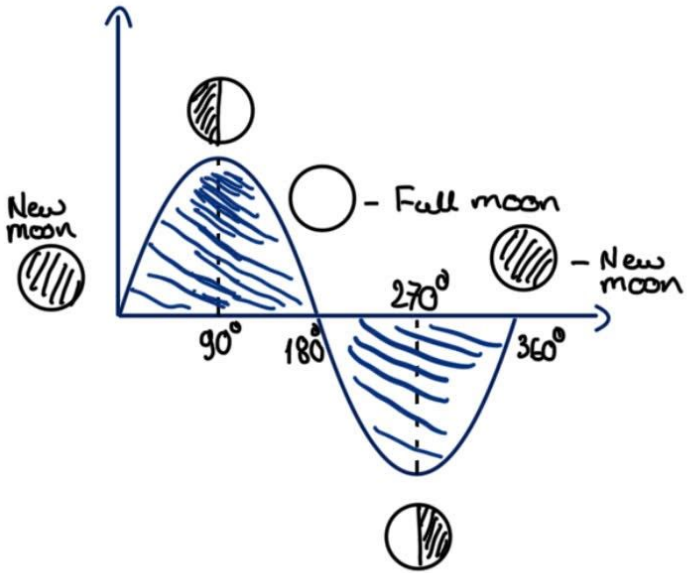


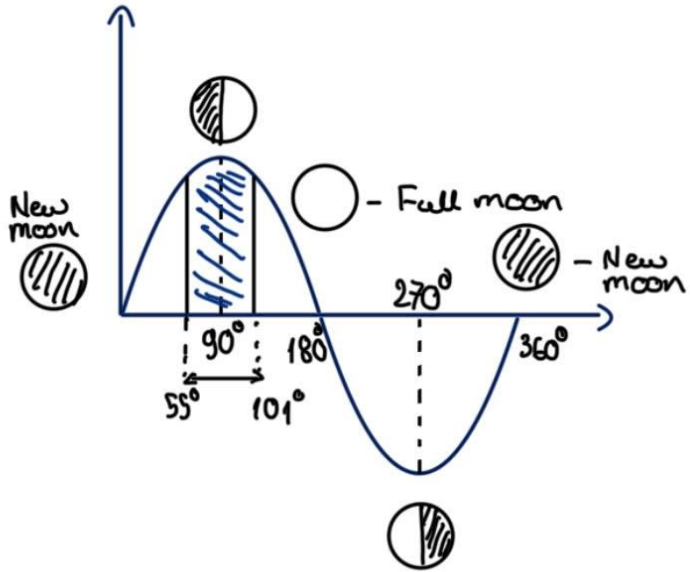
Polarized light map of the Moon 🌝



Future plan

Future plan





Moon phases

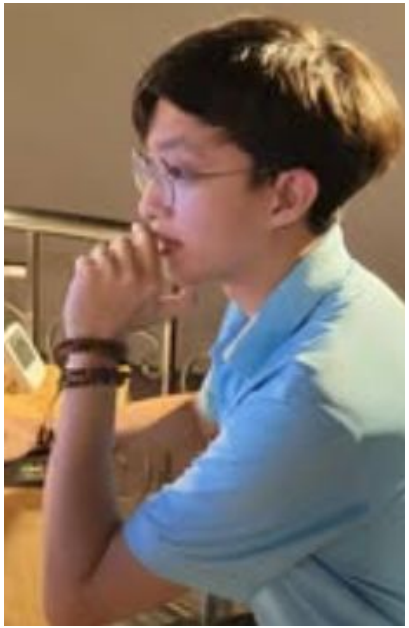
Future plan

- Collect and process data from the entire lunar region throughout all phases of the moon.
- The expansion of our study regions enables us to survey and acquire further data regarding the **DOLP** of various features on the lunar surface.
- We can determine properties of the surveyed surface such as its roughness, the type of material etc.

Conclusion

1. The polarization on the moon
2. The polarization of lunar features
3. Knowing how to process polarization data on the moon
4. Calculate the degree of linear polarization

Special Thanks to



Mr.Dong

Quy Nhon Observatory

Mr.Tue

Quy Nhon Observatory

Mr.Thuy

Quy Nhon Observatory

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Advisor

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THANK YOU FOR BE …


Merci
Kiitos
Cảm ơn
Děkuji
Danke
Takk
Dank je
Gracias
Obrigado
THANK YOU
Ευχαριστώ
감사합니다
תודה
ขอบคุณ
Teşekkür ederim
ありがとう
Salamat
Tack
धन्यवाद
Asante
Спасибо
谢谢
شكراً
Ngiyabonga
धन्यवाद