# Earth Observations From the Moon Surface Using EPIC-Like Camera and Multi-Slit Spectrometer

**Nick Gorkavyi** (SSAI/GSFC), **Nickolay Krotkov** (NASA/GSFC)**, Alexander Marshak** (NASA/GSFC)

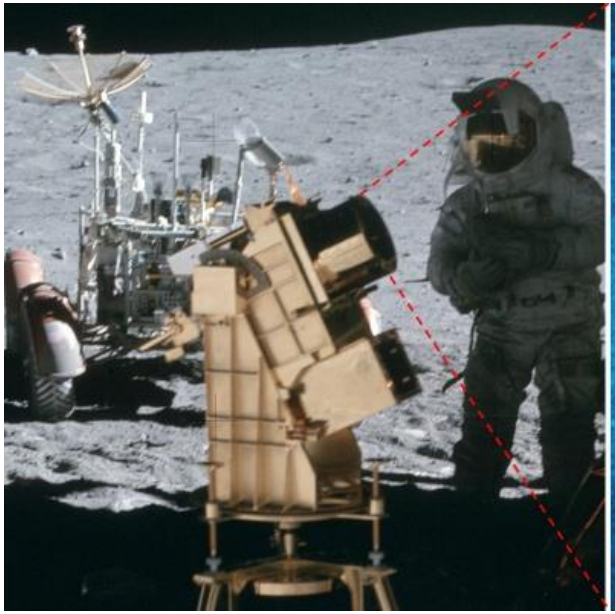
## Summary

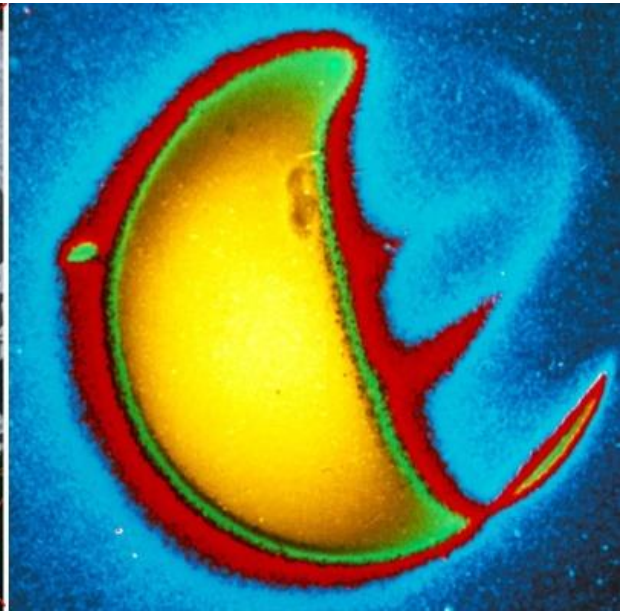
We propose to deploy a wide-angle camera and a multi-slit spectrometer on the Moon surface for whole Earth hyperspectral observations. These observations will complement DSCOVR/EPIC observations limited to near-backscatter directions for the full range of Earth phases. In addition, a wide-angle camera can be used as the first webcam on the Moon surface to provide continuous images of the Earth phases. The libration of the Moon in latitude and longitude causes the center of the Earth to move in the Moon's sky within the fixed angular field of view 13.4°× 15.8° with periods of ~27 days and 6 years. This apparent librational movement complicates observations of the Earth but will also act as a natural scanning mechanism for a fixed telescope mount. We propose to place a multi-slit spectrometer on the Moon surface on a fixed platform to take advantage of this lunar librational movement.

**AGU, December 16, 2022**

# Earth Observations From the Moon

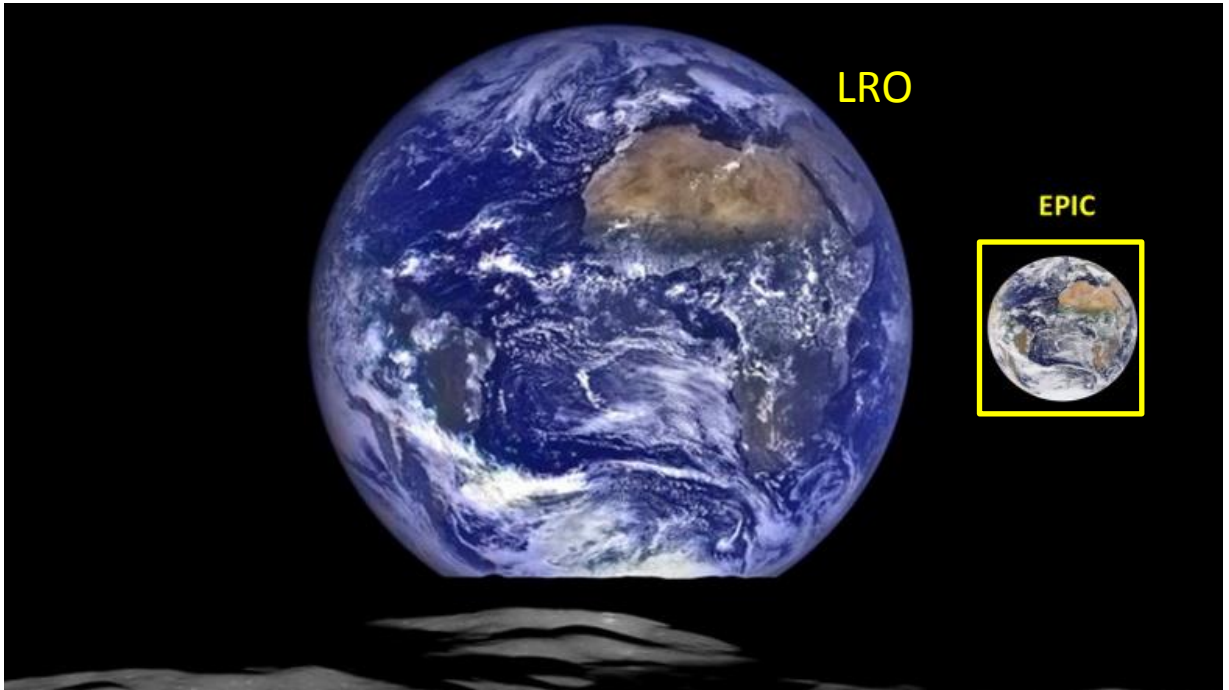
A Far-Ultraviolet Camera/Spectrograph was operated on the lunar surface during the Apollo 16 mission, April 1972 (NASA).





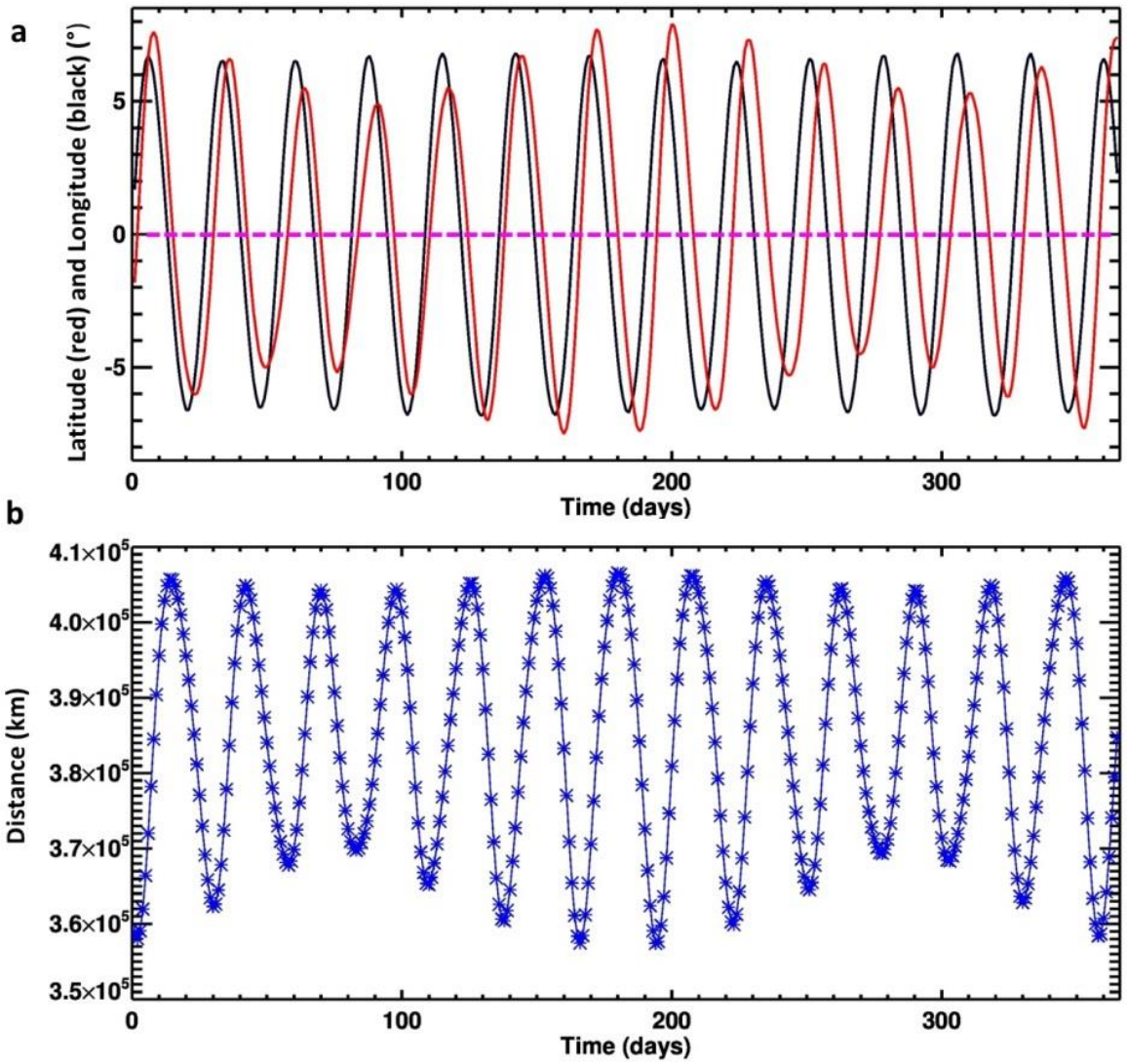
The Earth' UV photo (1304 angstroms) from the Moon *(NASA/*G. Carruthers et al.)

A unique view of Earth from the LRO's vantage point in orbit around the Moon, October 12, 2015 (NASA/GSFC/ Arizona Univ.)




Insert shows an image of the same part of the Earth taken by DSCOVR/EPIC on the same day as it would be seen from the Lagrange point.

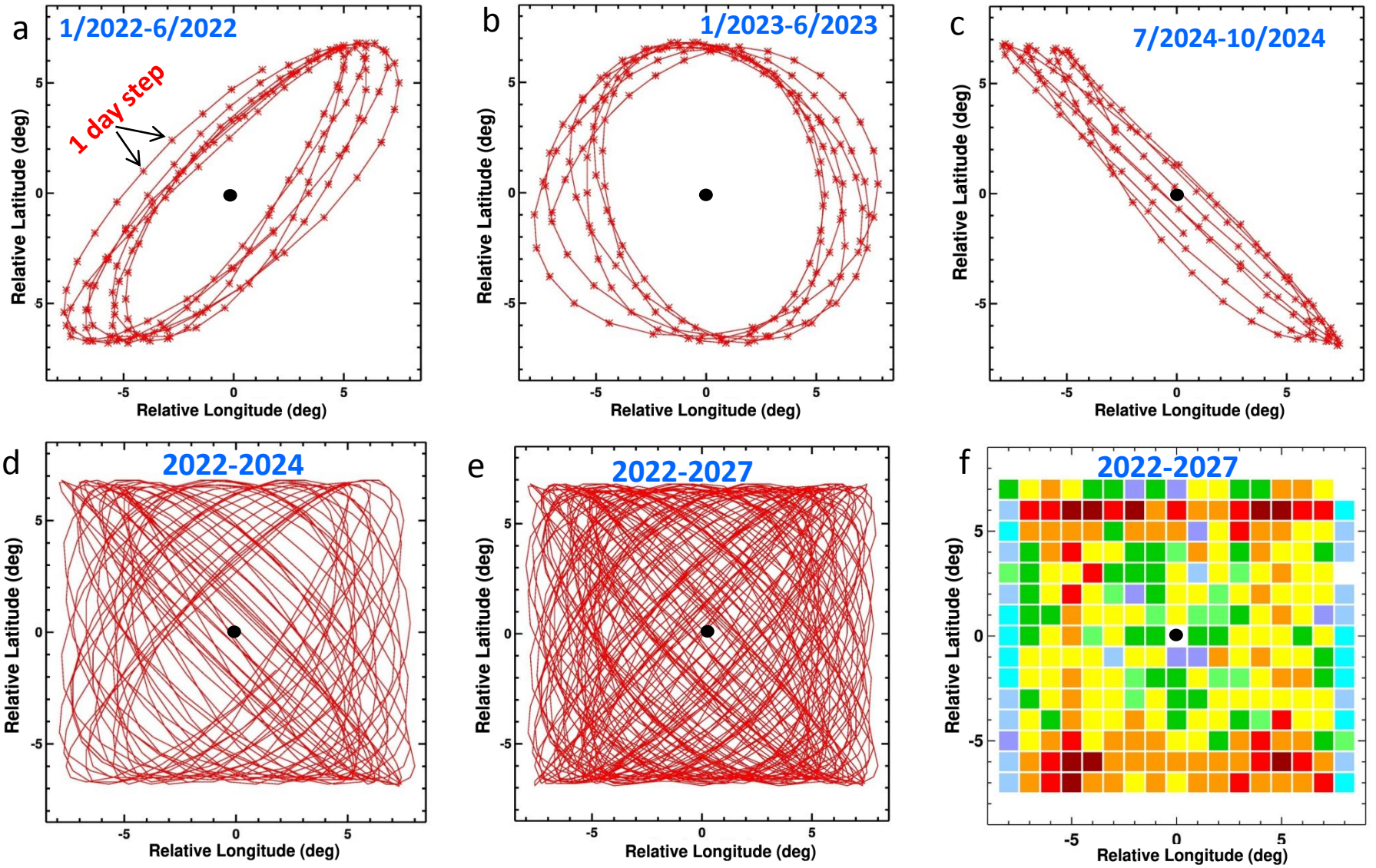
# Lunar librations and the Earth-Moon distance




**Variability of the Moon orientation and orbit during the 2022 starting from January 1, 2022 (data by *Espenak, 2021)*.**

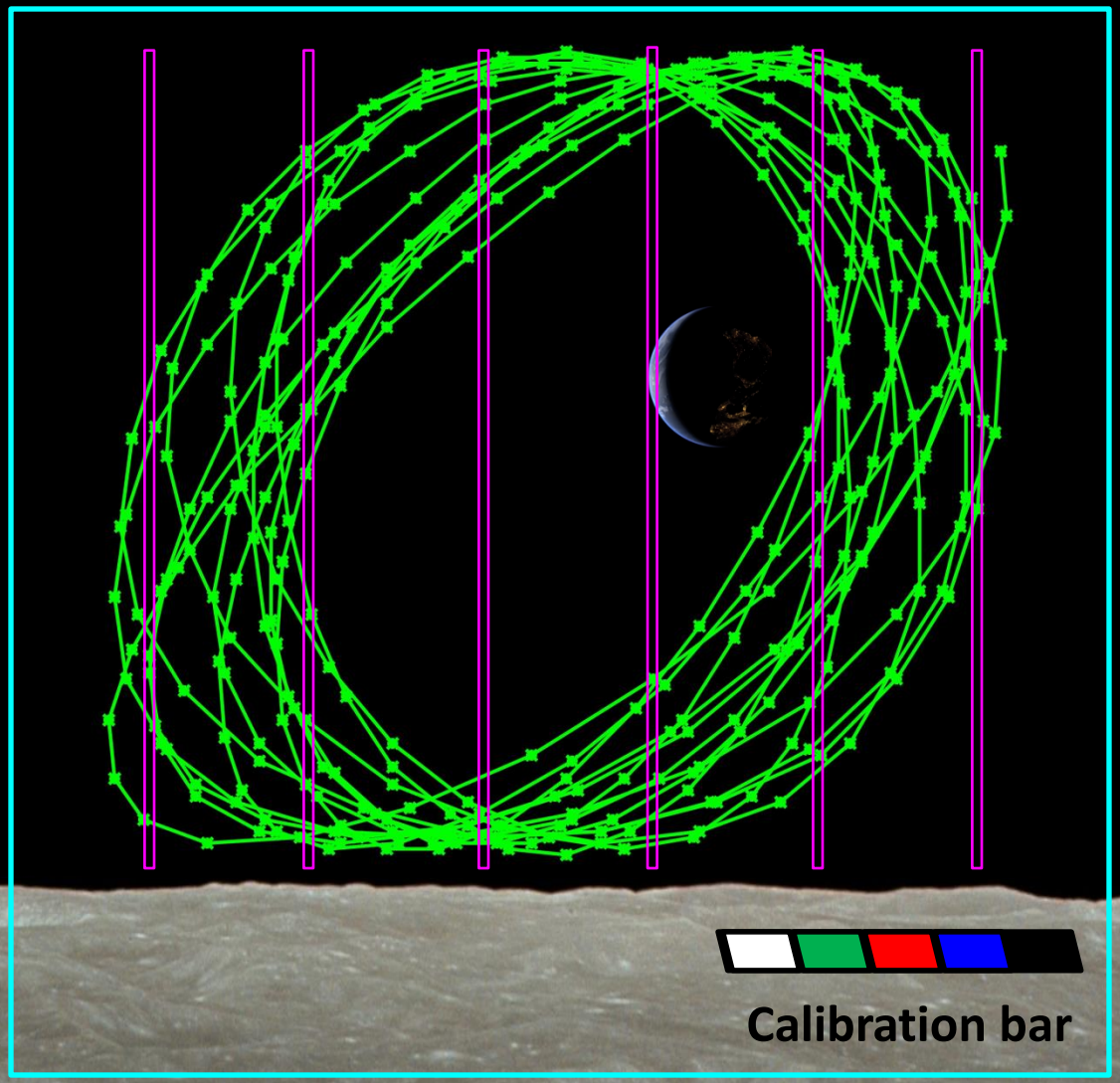
**(a) longitude libration (red) and latitude libration (black). The dashed line corresponds to the case of zero libration, that is, when the center of the visible lunar disk coincides with the zero point of selenographic longitude and latitude; (b) the Earth-Moon distance.**

# Librations of Earth in the Moon sky



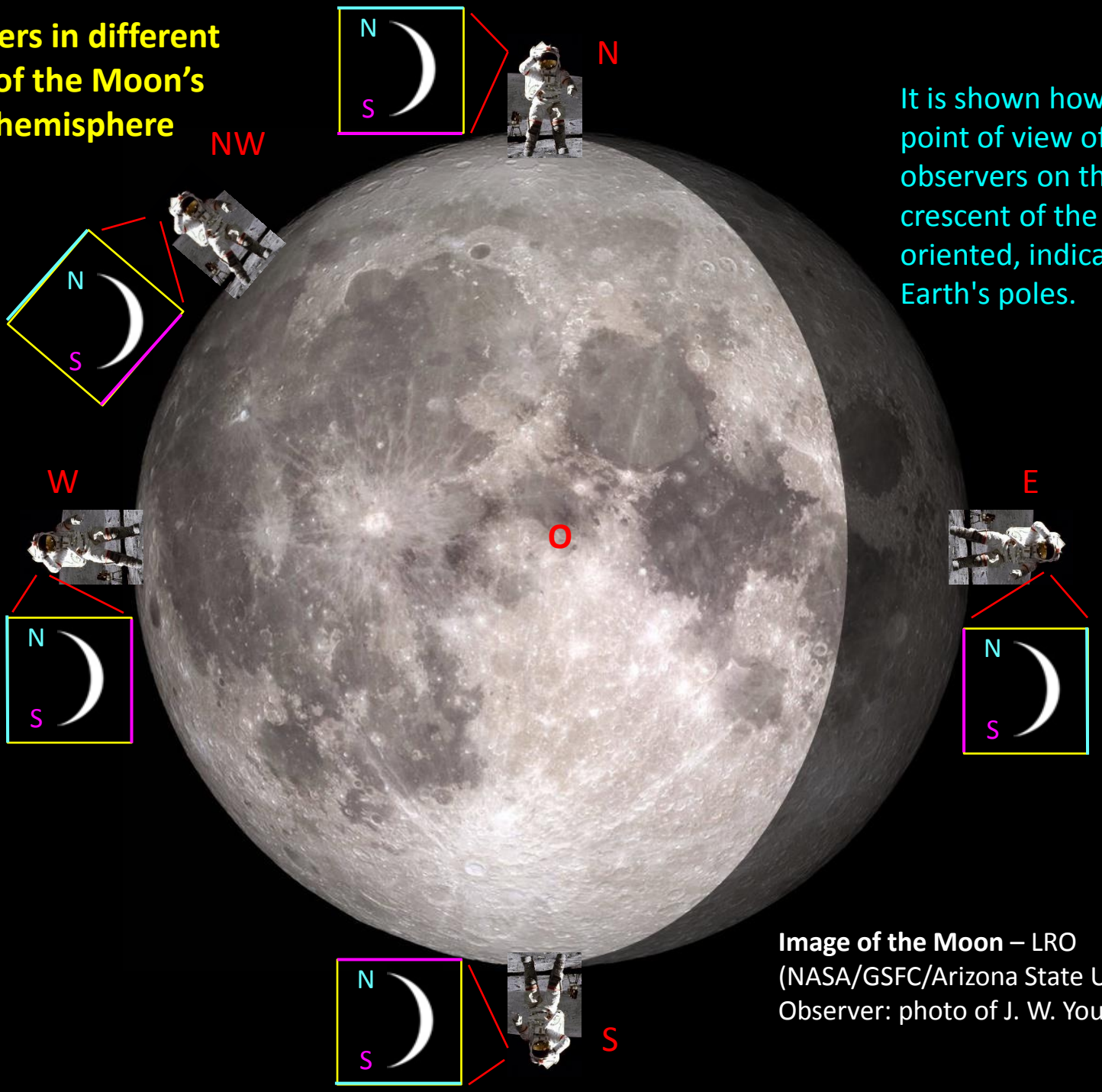

**Librations of Earth in the Moon sky (from North Pole of the Moon) during first 6 months 2022 (a) and 2023 (b); (c) July-September 2024; (d) 2022-2024 (3 years); (e) 2022-2027 (6 years or 2191 days = positions); (f) Statistics of the distribution of the 2191 positions of the center of the Earth for 6 years. $N$ - the number of entries of the center of the Earth into each 1°×1° grid' cell for this period. The black dot = zero librations.**

Positions of the Earth' center during 2026 (green line) from the South Pole of the Moon




**Blue square is ~18°-20° FOV of fixed mount camera. The violet lines are possible positions of slits of the spectrometer on a fixed platform. The calibration bar is used to calibrate color images. Lunar surface is from the photo taken by NASA/Apollo.**

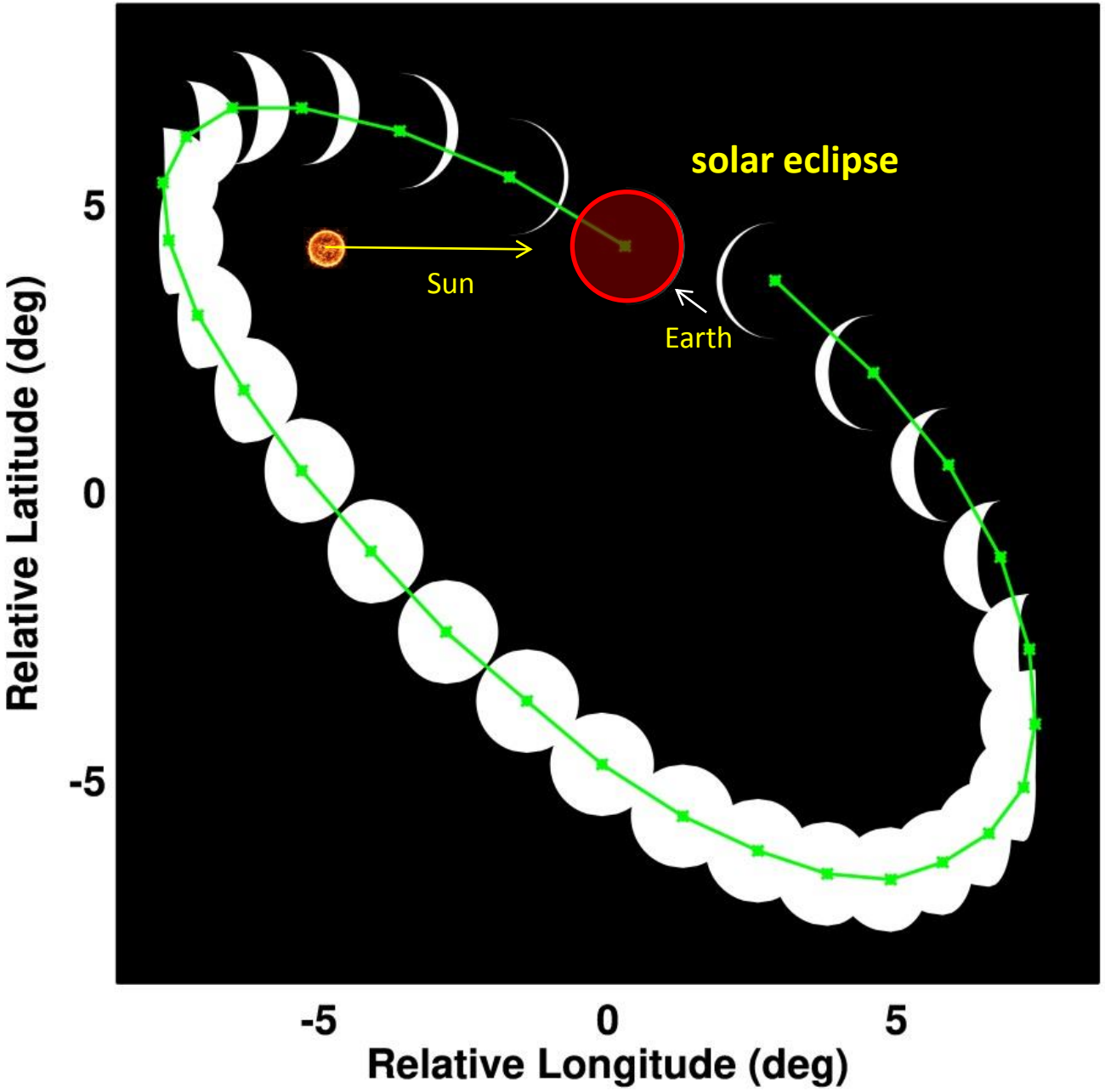
# Observers in different points of the Moon's visible hemisphere




It is shown how, from the point of view of different observers on the Moon, the crescent of the Earth is oriented, indicating the Earth's poles.

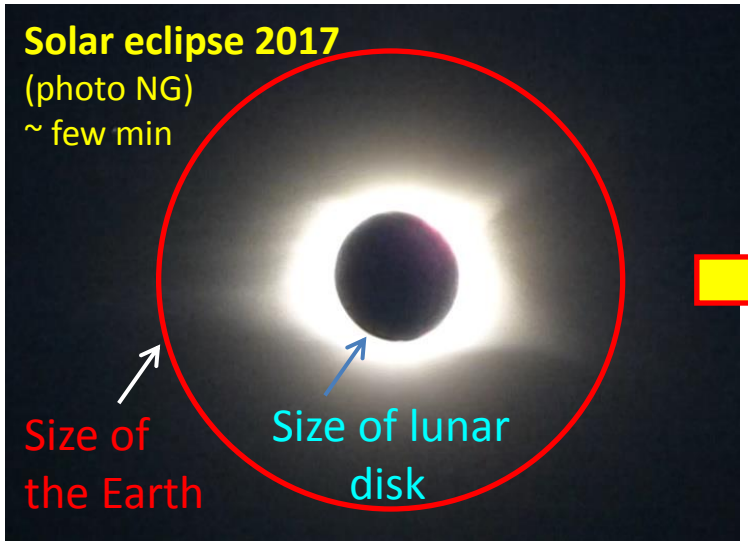
**Image of the Moon** – LRO (NASA/GSFC/Arizona State University).
Observer: photo of J. W. Young

# Position of Earth in the Moon sky and solar eclipse




**Relative position of the Earth' center due to lunar librations (green line) and Earth' phases during 28 days** (this sample – for June 15-July 12, 2022 for an observer located on the lunar North Pole).

# Observation from the Moon during total solar eclipses




**Observations of the lunar dust environment during total solar eclipses has a particular interest: the lunar dust glows from scattered sunlight under forward scattering conditions without saturation of the detector.**

*NASA's Scientific Visualization Studio*

Total solar eclipses on the Moon happen ~2 times a year when the Earth blocks the Sun and continue hours

# CONCLUSION

1. Due to lunar libration, the center of the Earth for an observer on the Moon moves in a rectangular area with dimensions of 13.4° × 15.8°.
2. The movement of the Earth in the sky of the Moon is characterized by quasi-periodicity with frequencies of ~27 days and 6 years. The rates of displacement of the Earth in the Moon sky reach two degrees per day.
3. Lunar libration must be taken into account when observing the Earth from the surface of the Moon and during Moon-Earth communications.
4. Observations of the lunar dust environment during total solar eclipses has a particular interest: the lunar dust glows from scattered sunlight.

**References:**

1. Marshak A. et al. **"Whole Earth imaging from the Moon South Pole (EPIC-Moon)",** WhitePaper #2054 in *Artemis III Science Definition Team Report*, 2020.
2. Gorkavyi N. et al. **"Earth Imaging From the Surface of the Moon With a DSCOVR/EPIC-Type Camera"** *Front. Remote Sens.* 2:724074. https://doi:10.3389/frsen.2021.724074 , 2021.
3. Boyd P. T. et al. **"EarthShine: Observing our world as an exoplanet from the surface of the Moon"** *J. Astr. Telesc. Inst. and Syst.*, 8(1), 014003, https://doi.org/10.1117/1.JATIS.8.1.014003, 2022.
4. Gorkavyi N., Krotkov N., Marshak A. **"Earth Observations from the Moon surface: dependence on lunar libration",** *Atmospheric Measurement Techniques, 2022,* https://amt.copernicus.org/preprints/amt-2022-158/