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Science and Technology Facilities Council

Introduction to Astronomy

And the science of the Islamic Calendar

Dr Emma L Alexander

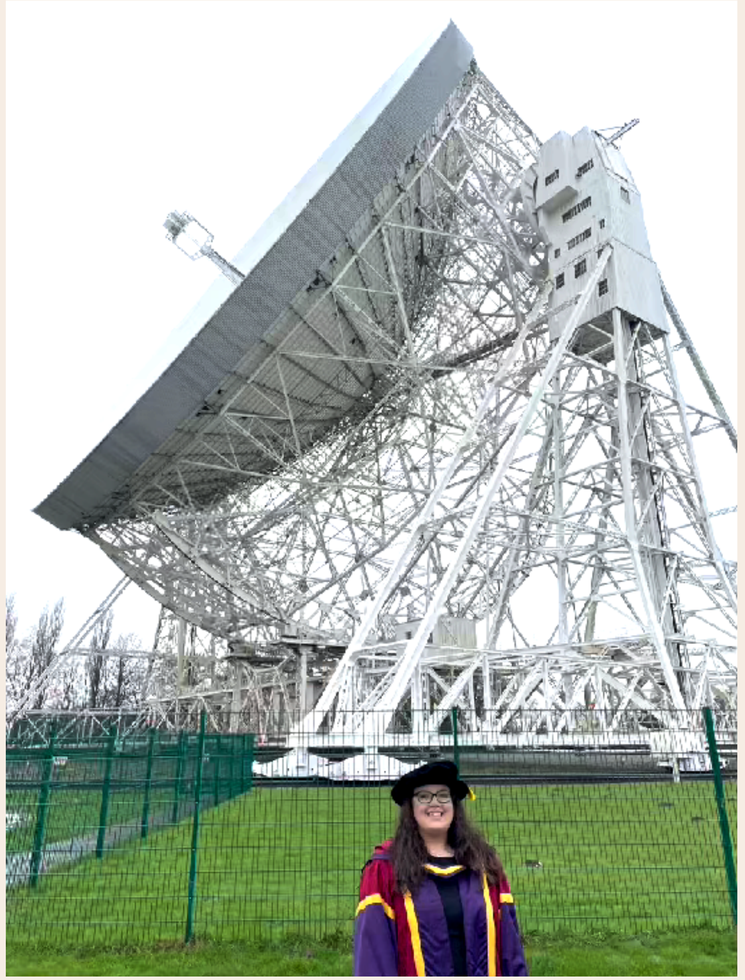
Session overview

- **Our place in the Universe**
  - The Sun, Earth, Moon & beyond
  - Science of the lunar cycle
- **Crescent Visibility**
  - Physical principles
  - Explanation of visibility maps
- **Observing the Universe**
  - Learning your way around the sky

Introduction

My background

- Joined my local astronomical society (York) as a teenager.
- Undergraduate degree in Physics with Astrophysics (University of Manchester).
- PhD in Astrophysics from Jodrell Bank Centre for Astrophysics (UoM), specialising in Radio Astronomy (2022).
- Currently: postdoctoral Research Fellow here at Leeds, researching our Milky Way galaxy with radio telescopes.



Introduction

Why my personal interest in Moonsighting?

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Our Place in the Universe

Dr Emma L Alexander

A sense of scale

Much of astronomy deals in very large numbers. It's okay to be boggled by them!

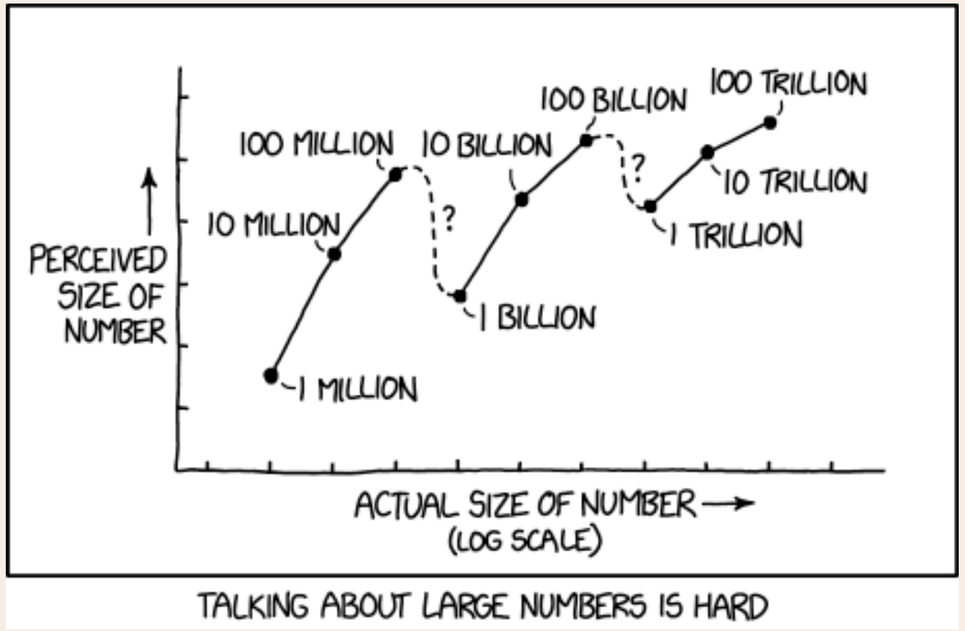
Start counting 1,2,3… every second. How long until you get to 1 million?

11.6 days

How about 1 billion seconds?

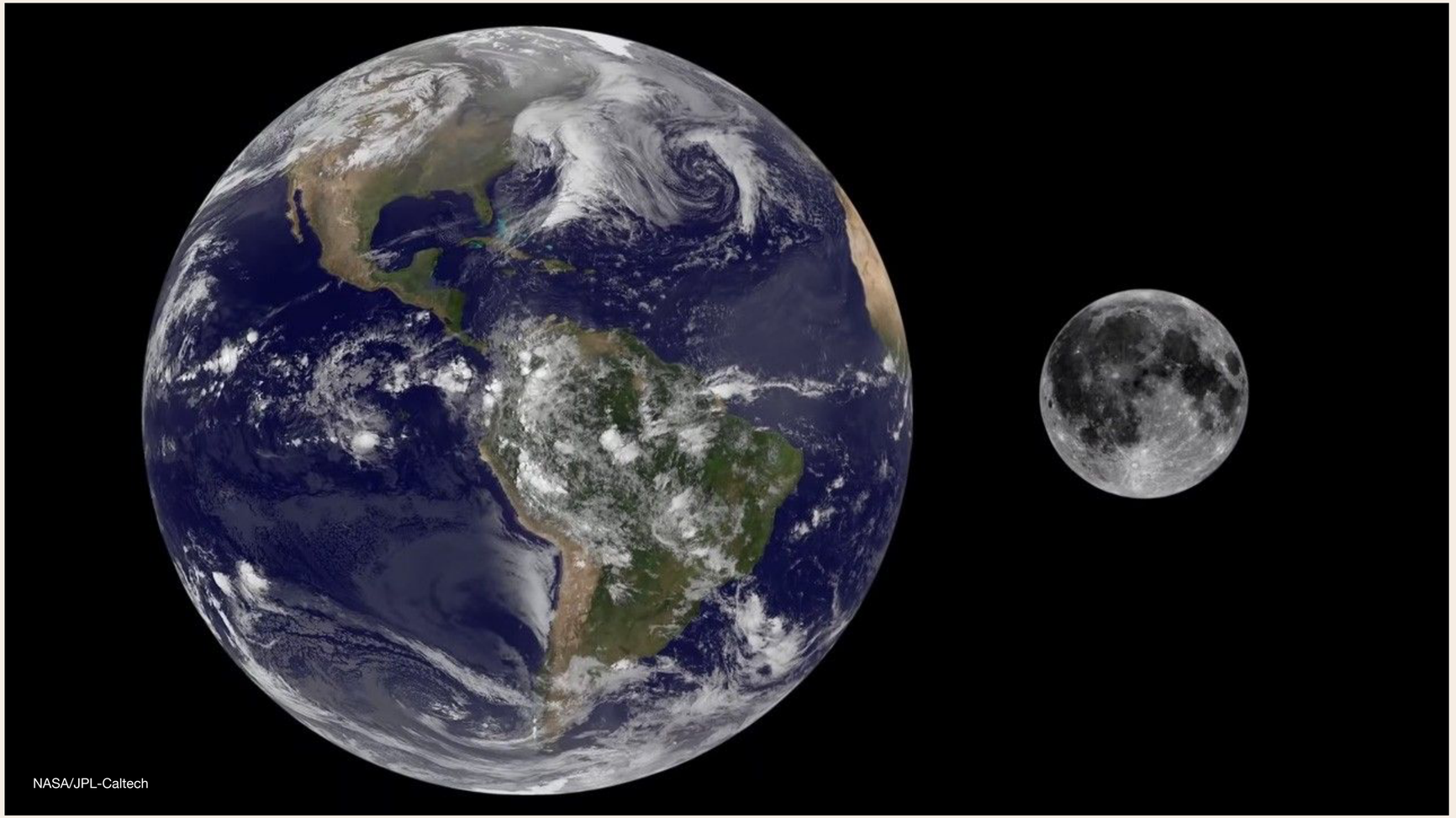
32 years

https://xkcd.com/2091/



TALKING ABOUT LARGE NUMBERS IS HARD

A sense of scale

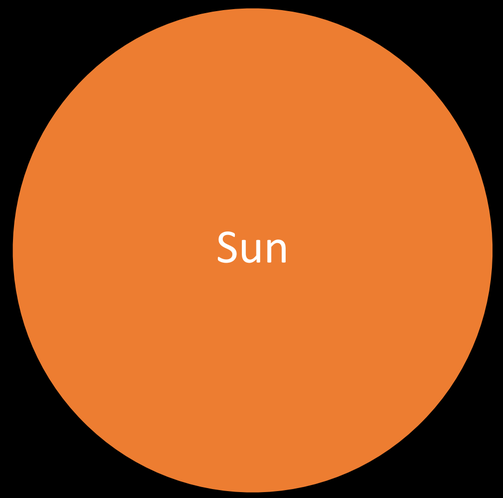


The Moon is roughly 4x smaller than the Earth in diameter

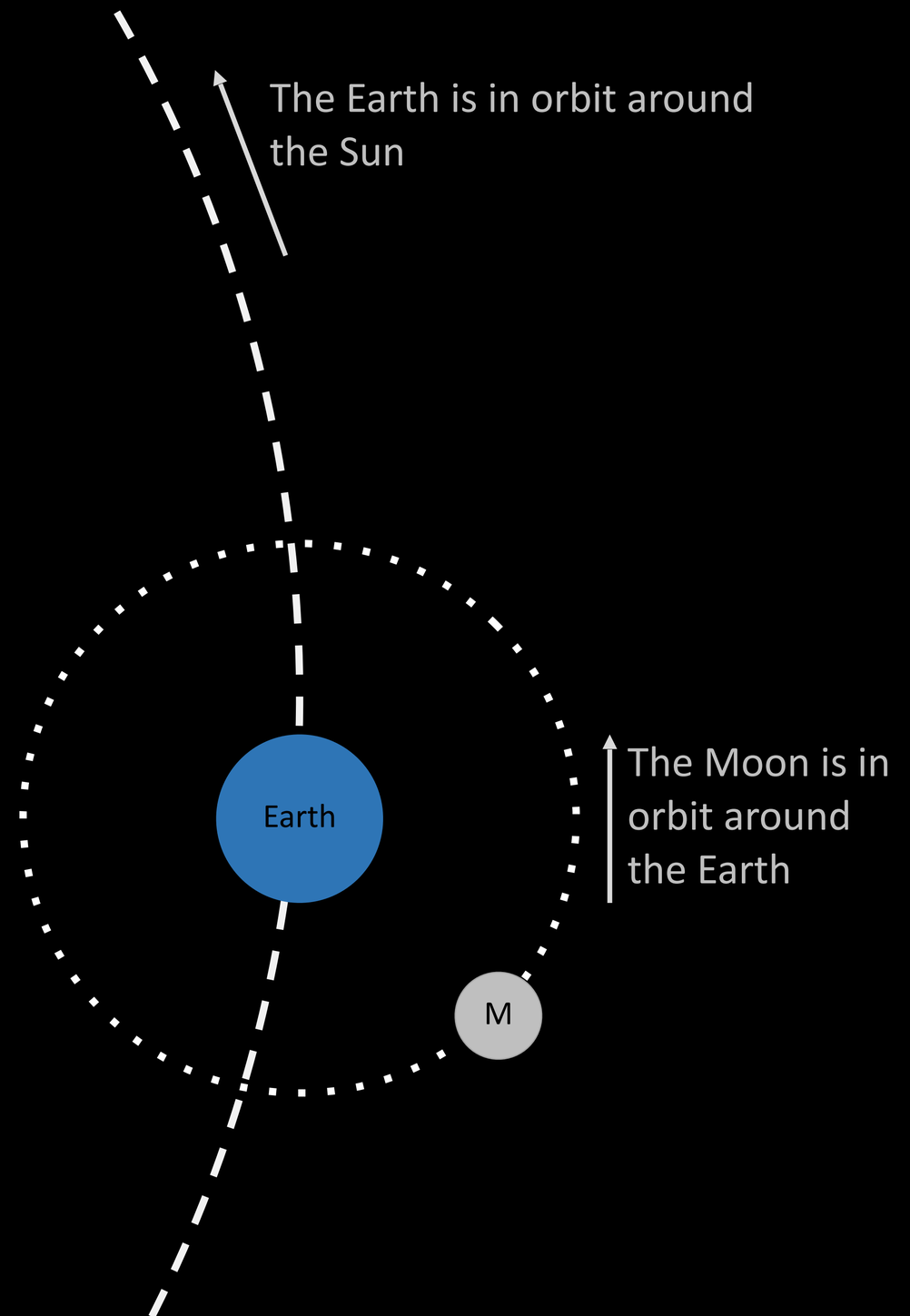
What about this image is incorrect?

A sense of scale

Sun, Earth, Moon

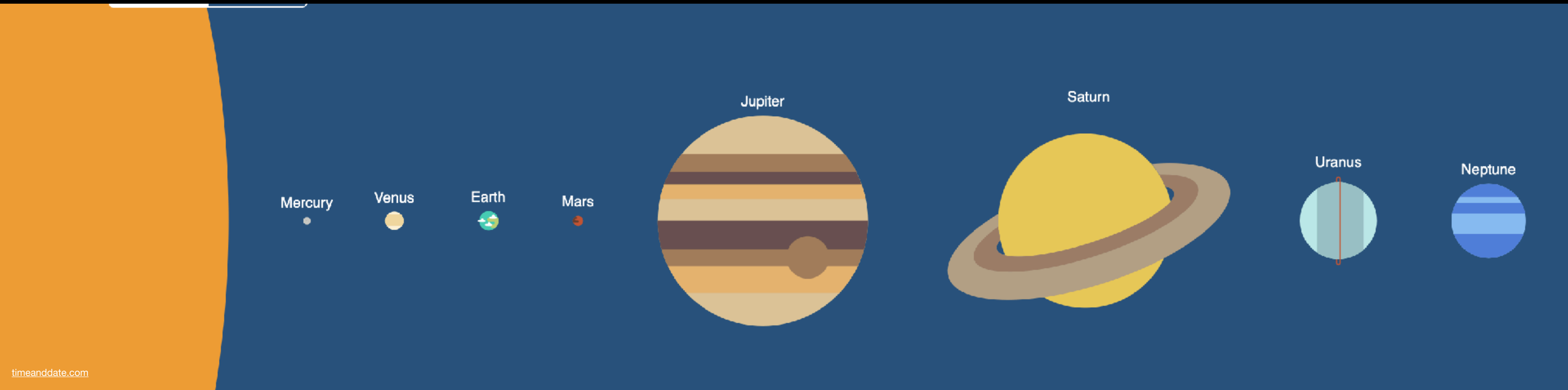


Not to scale!

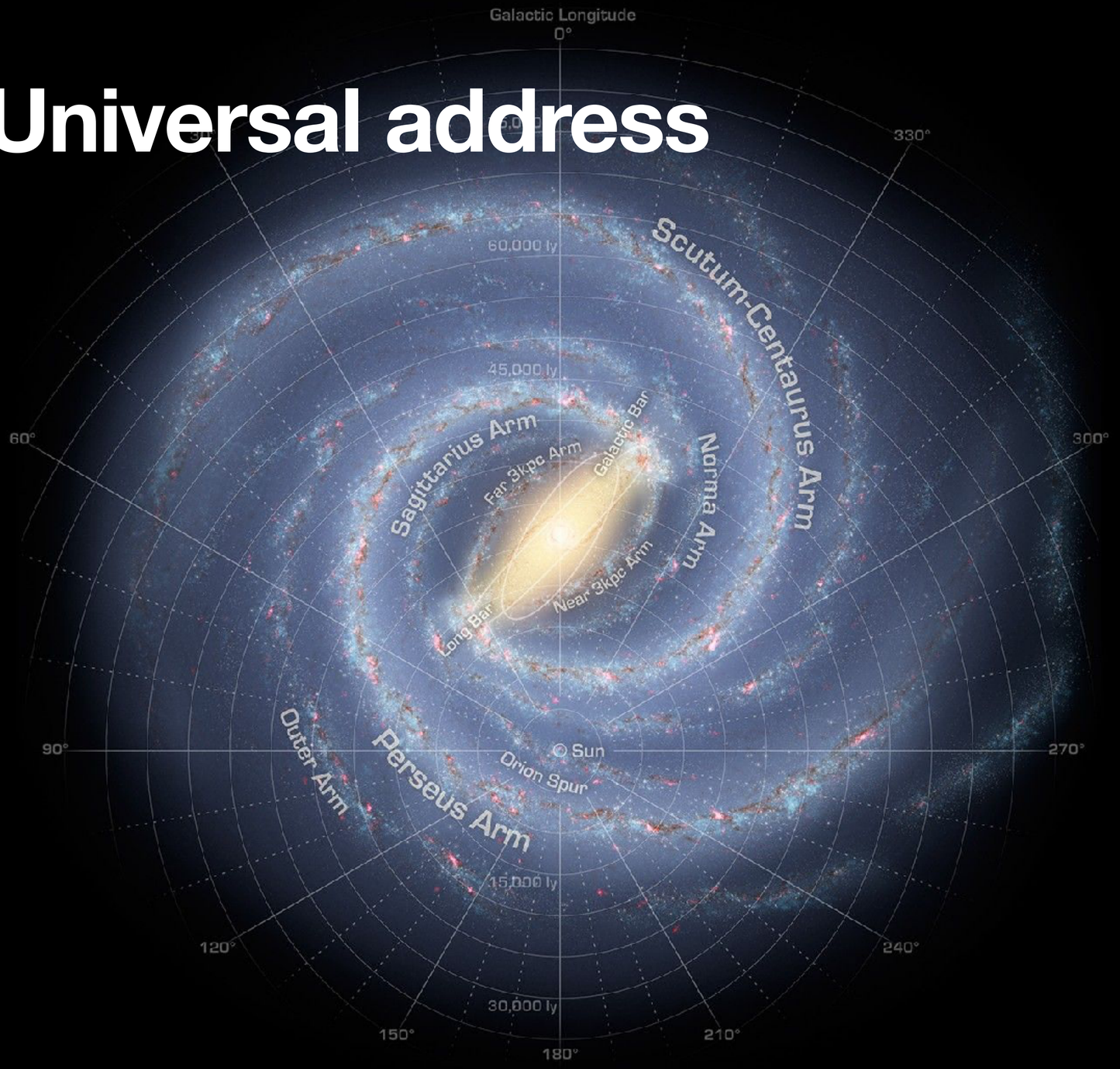


Our Universal address

- All planets in our Solar System orbit the Sun
- Some of them have moons of their own
- The image shows their sizes to scale (but not the distances)



Our Universal address



- The Sun is just one of many stars in our Milky Way Galaxy.
- Our Galaxy is just one of many in the Universe!

NASA/JPL-Caltech/R. Hurt (SSC/Caltech)

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Lunar phases

Dr Emma L Alexander


9 days of the Moon
Manchester, UK
Single frames
Sony DSC HX60v
30x optical zoom
The line between light and dark is called the *terminator*

Phases of the Moon

Waxing: *more* Moon is lit next night

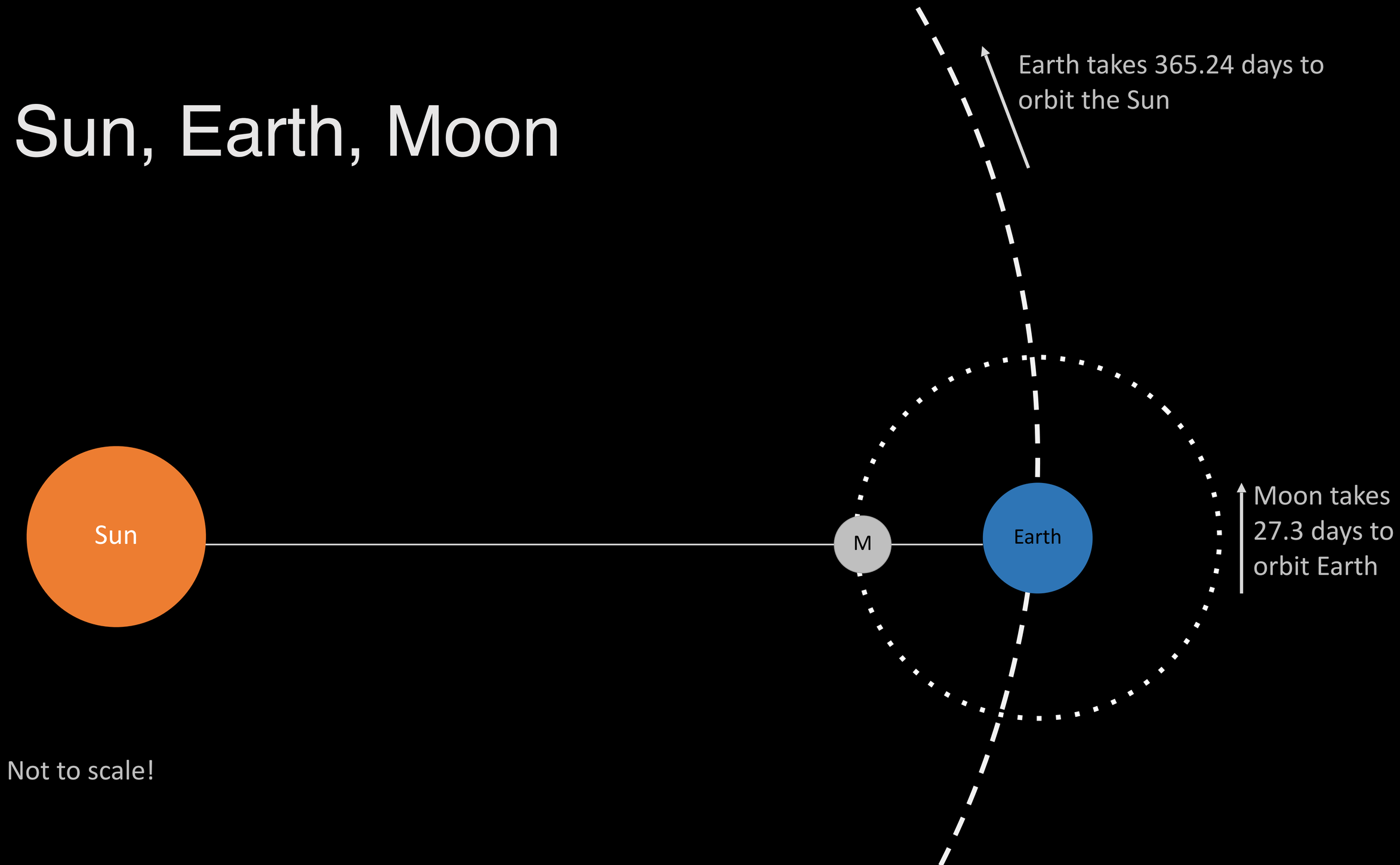
Waning: *less* Moon is lit next night

Crescent: see *less* than half Moon lit

Gibbous: see *more* than half Moon lit

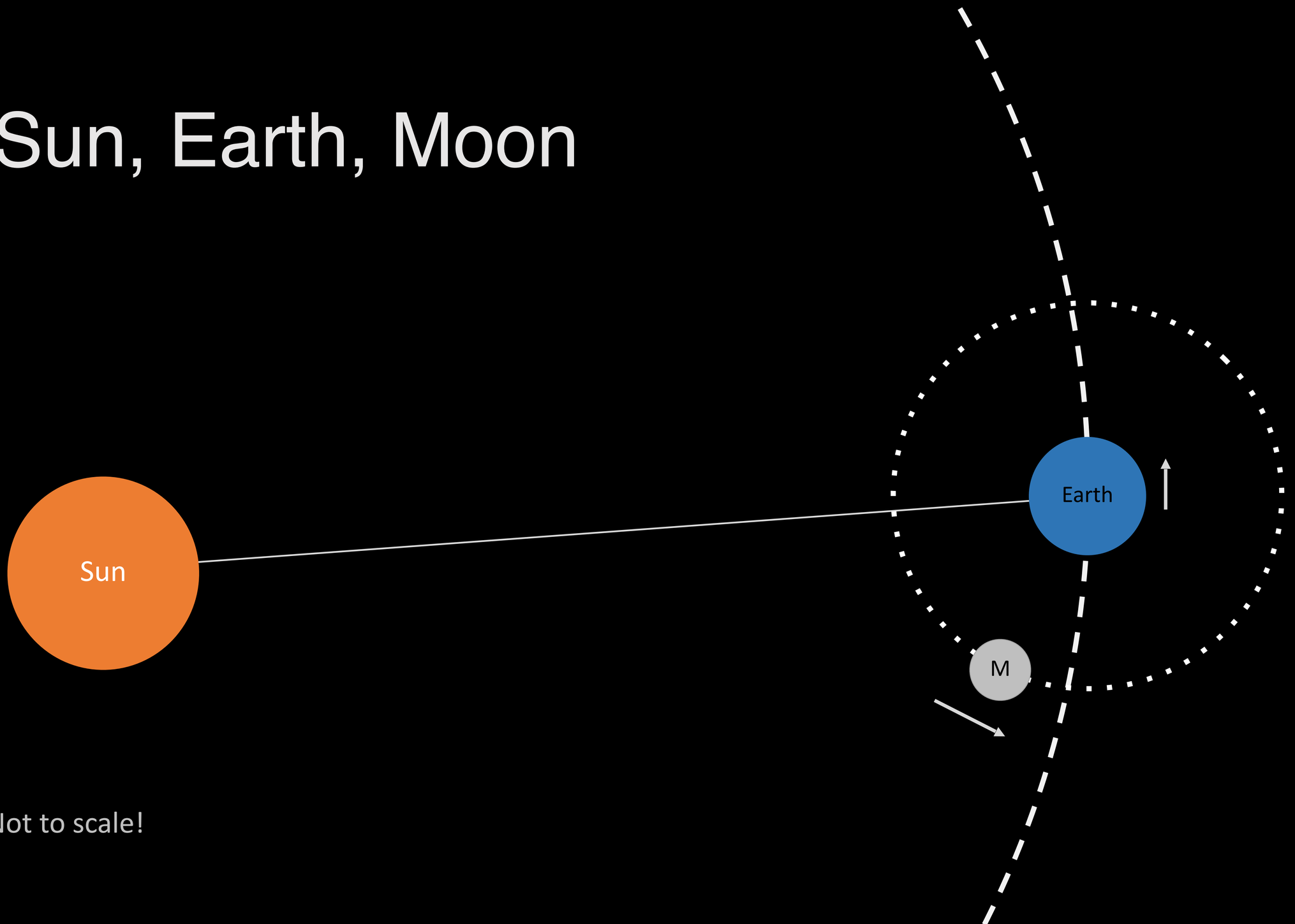
Quarter: half and half (either ¼ or ¾ through the cycle)

Sun, Earth, Moon



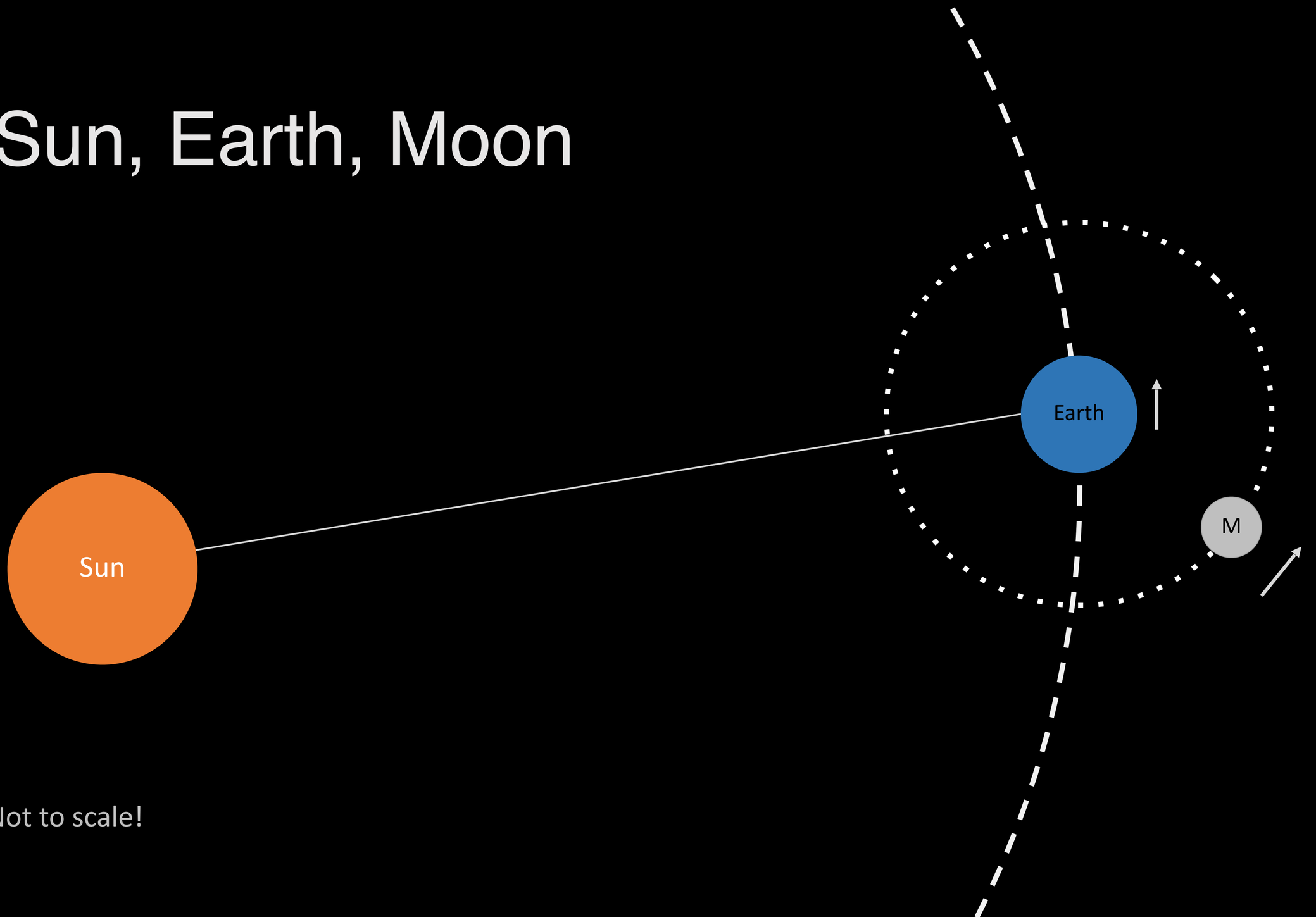
Not to scale!

Sun, Earth, Moon



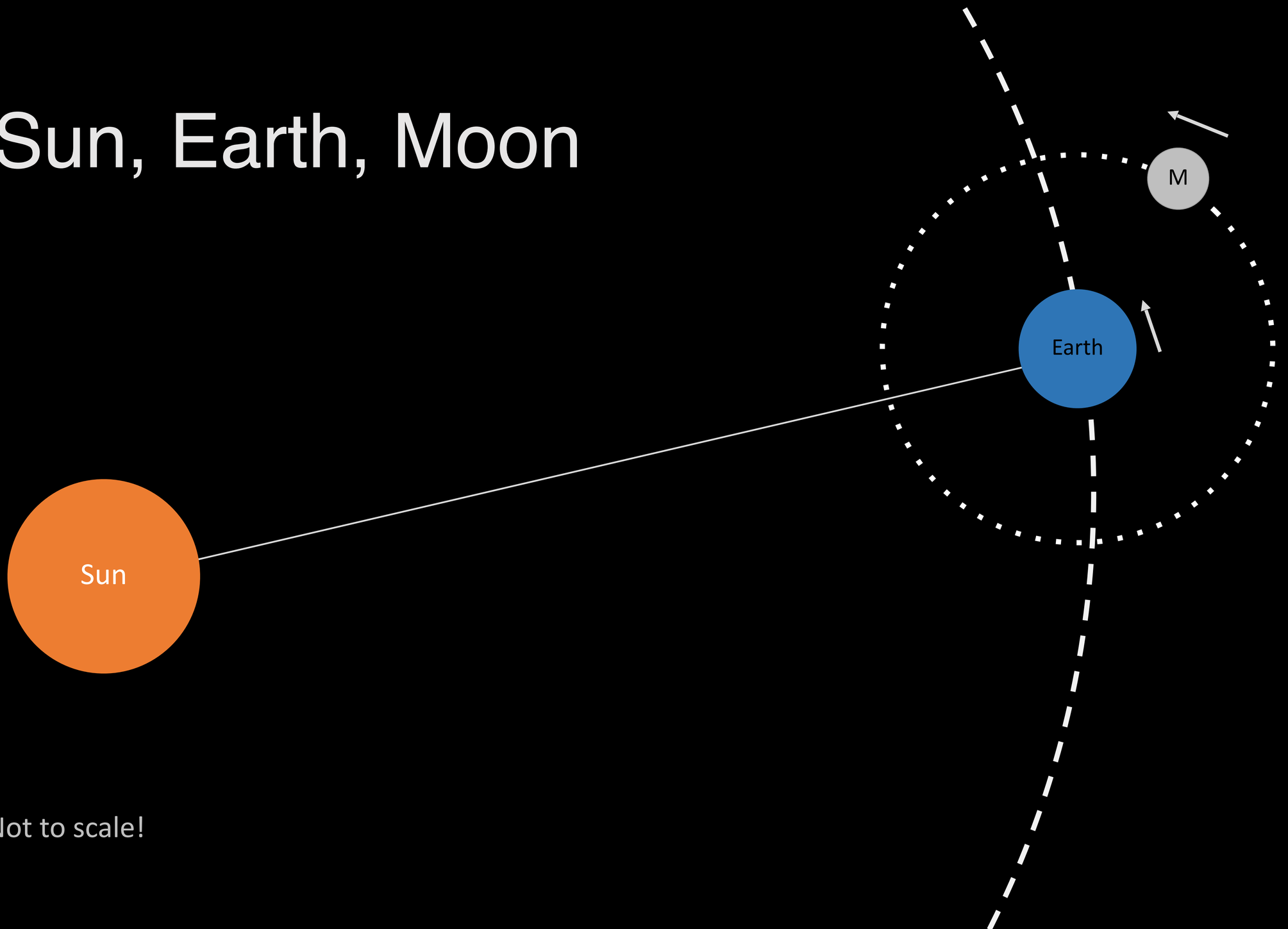
Not to scale!

Sun, Earth, Moon



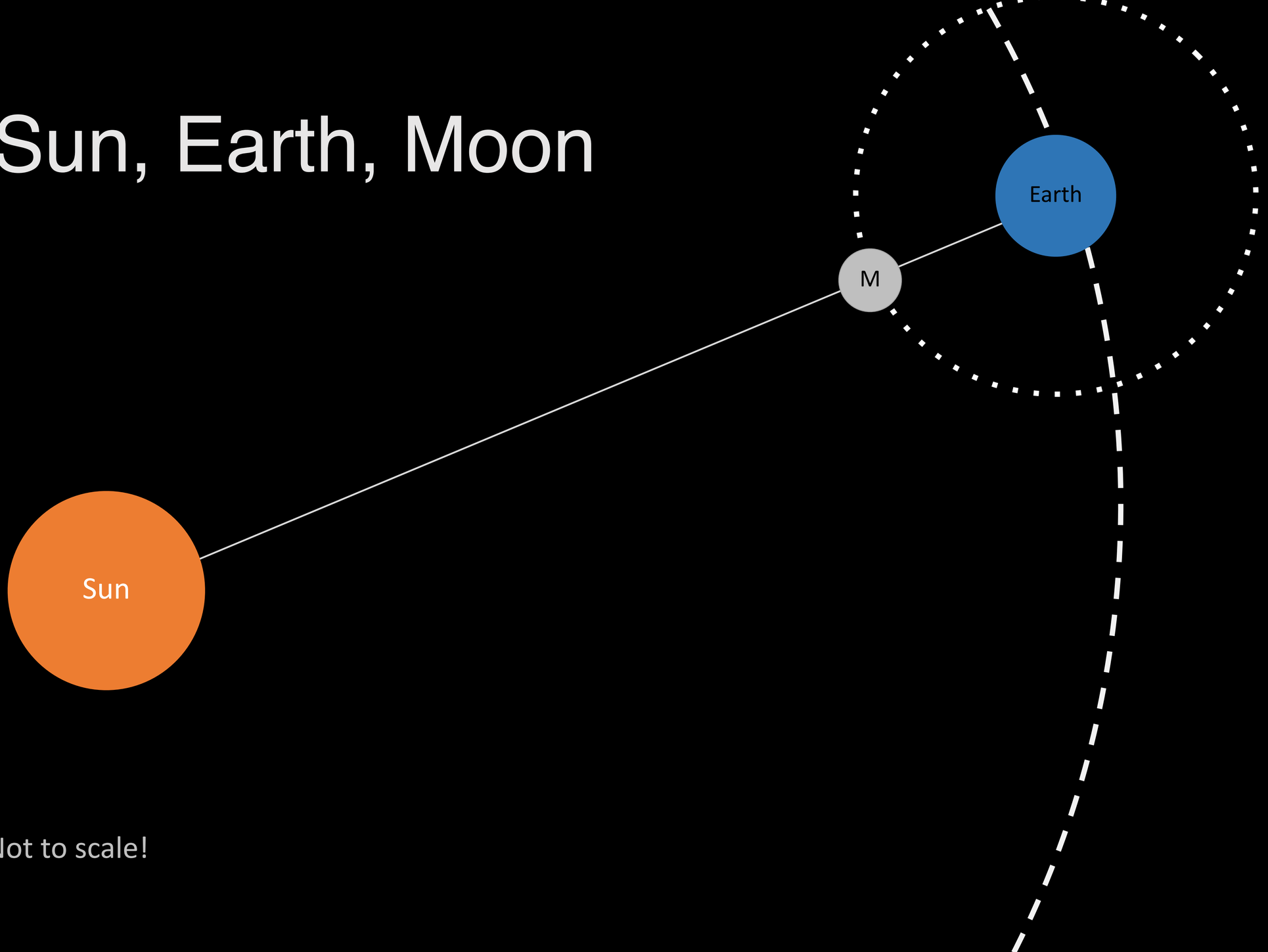
Not to scale!

Sun, Earth, Moon



Not to scale!

Sun, Earth, Moon



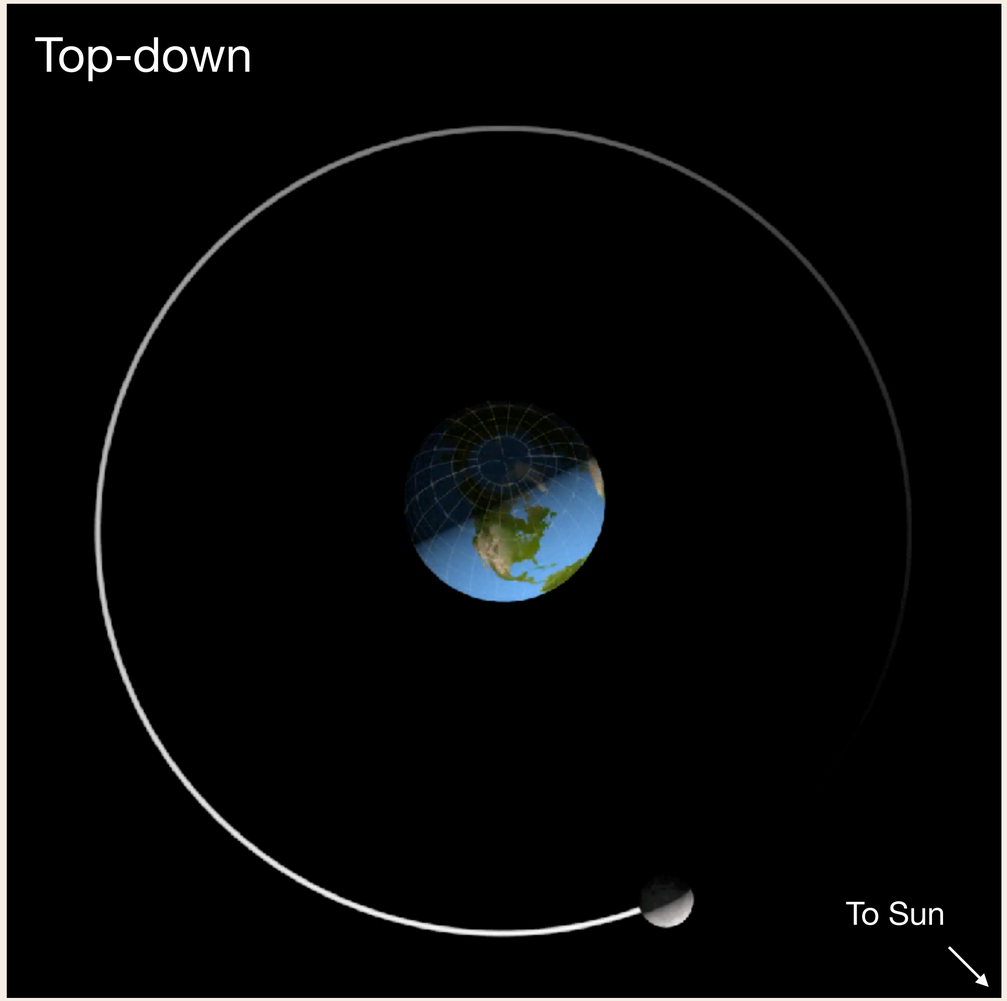
Not to scale!

The Sun, Moon, and Earth all line up again after 29.5 days

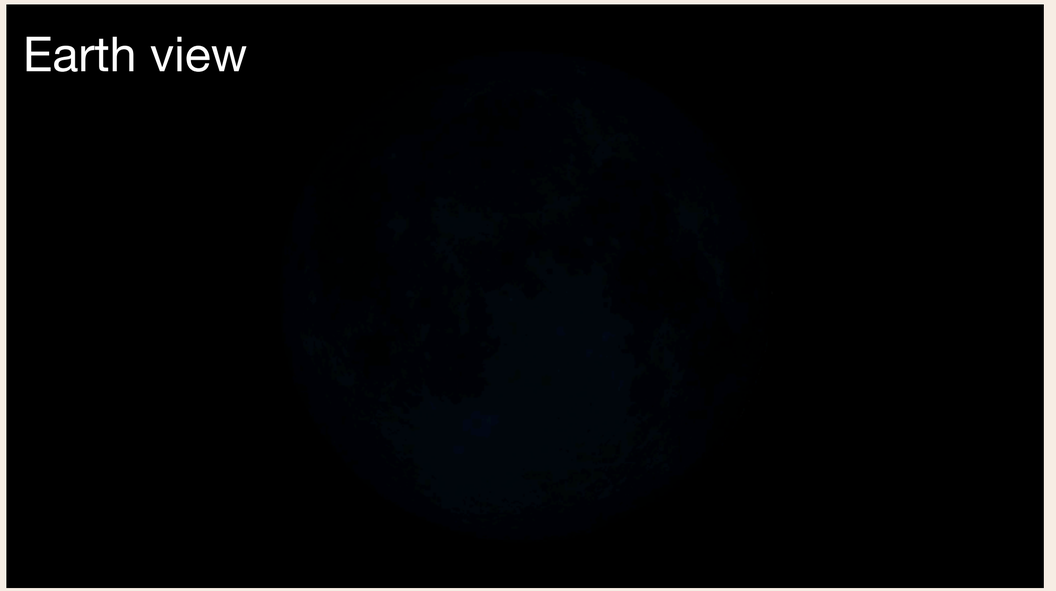
This is why Islamic lunar months are either 29 or 30 days long

Note that the Moon has to travel around more than 360 degrees before it becomes New again!

Overview



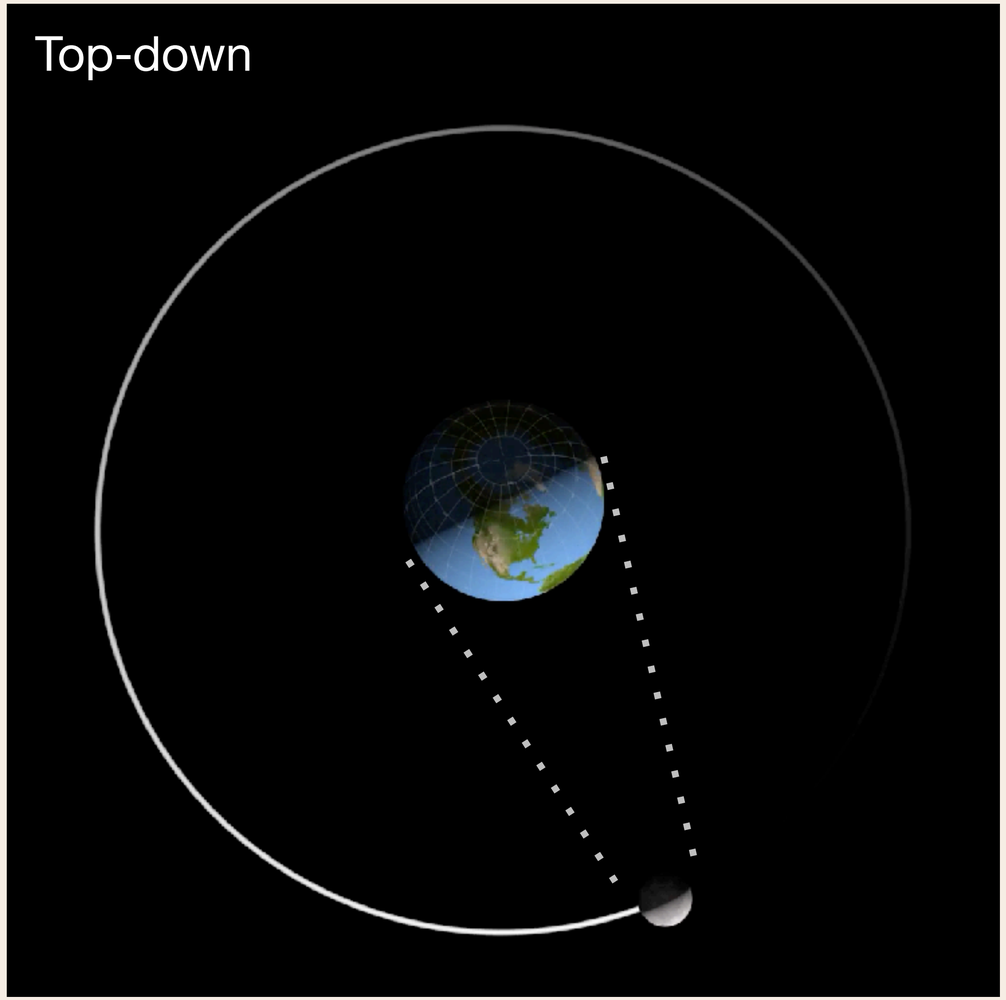
- The Moon does not produce its own light
- The light we see from the Moon is reflected Sunlight
- Half of the Moon is always lit by the Sun, no matter how it looks to us

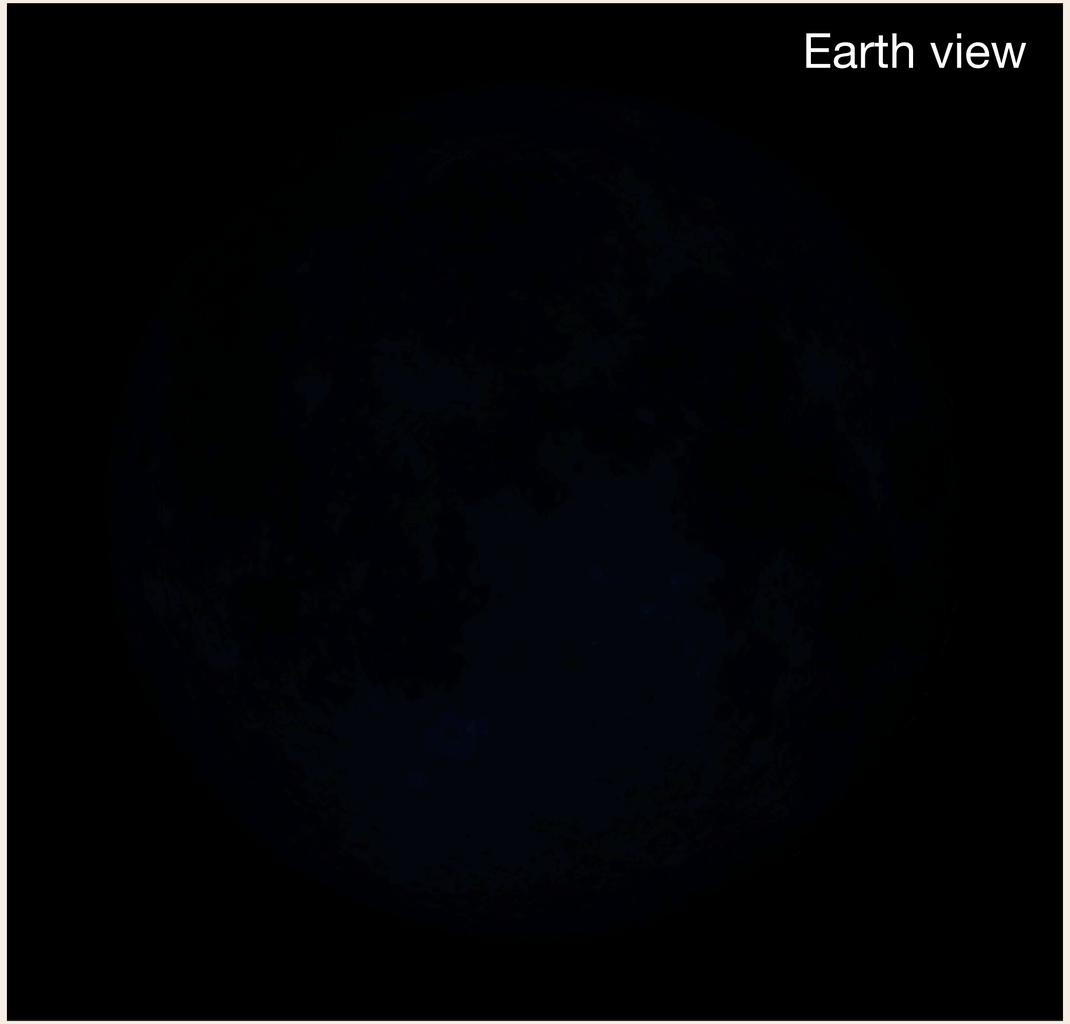


Videos credit NASA's Scientific Visualization Studio

https://www.youtube.com/watch?v=wz01pTvuMa0

New Moon

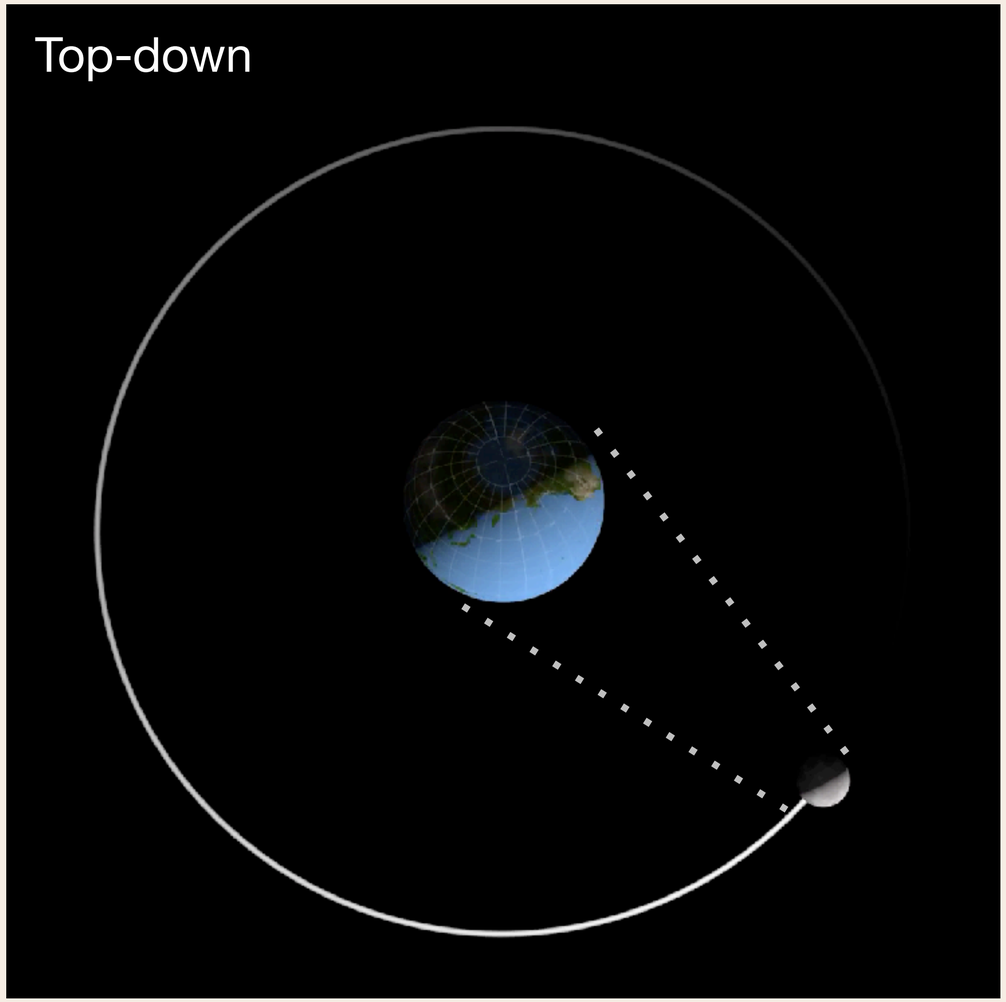




Images credit NASA's Scientific Visualization Studio

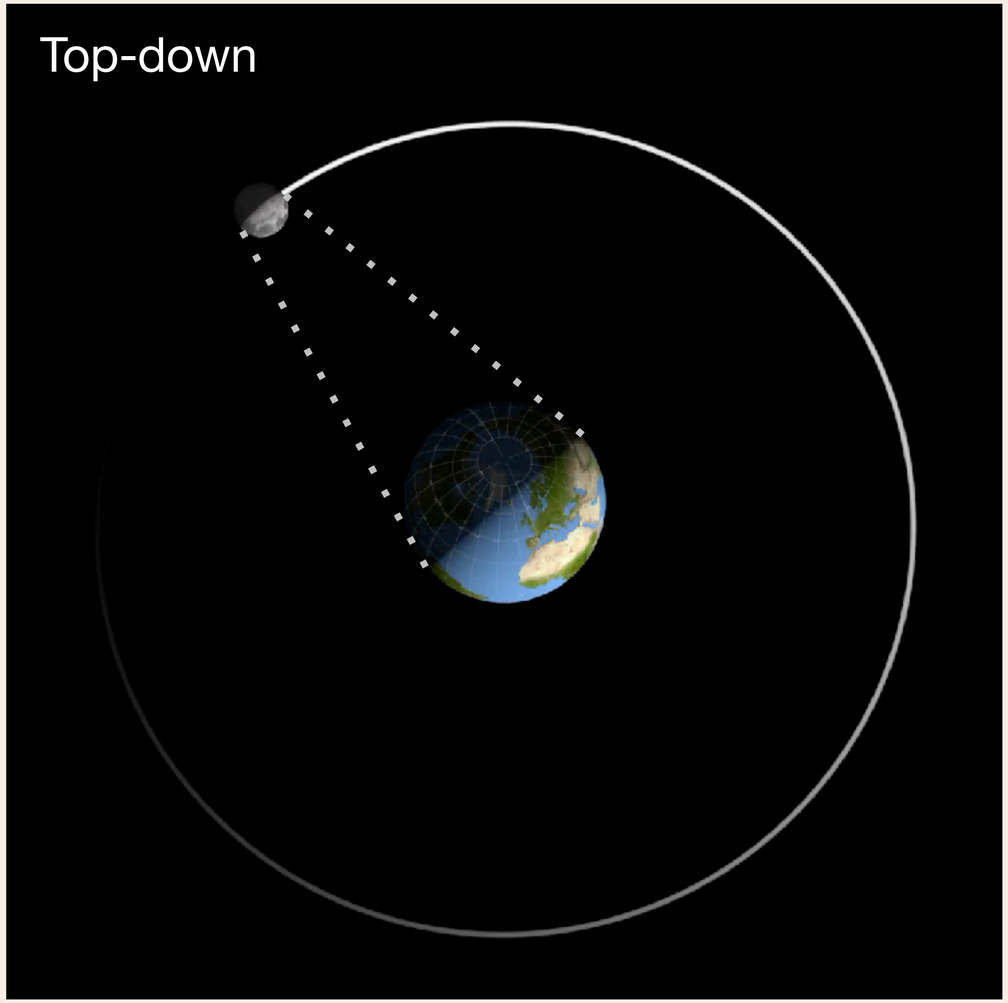
New Crescent

- Different to a New Moon!!
- Occurs the day afterwards

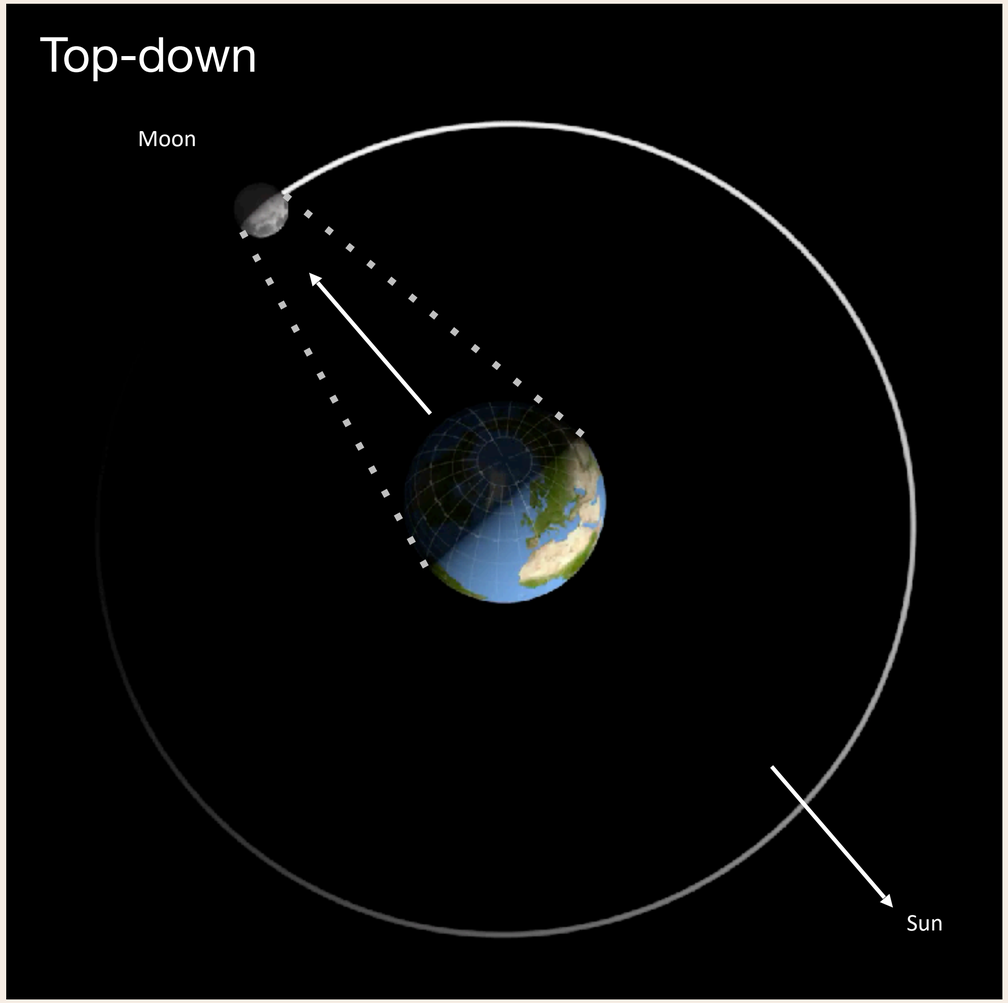


Images credit NASA's Scientific Visualization Studio

Full Moon



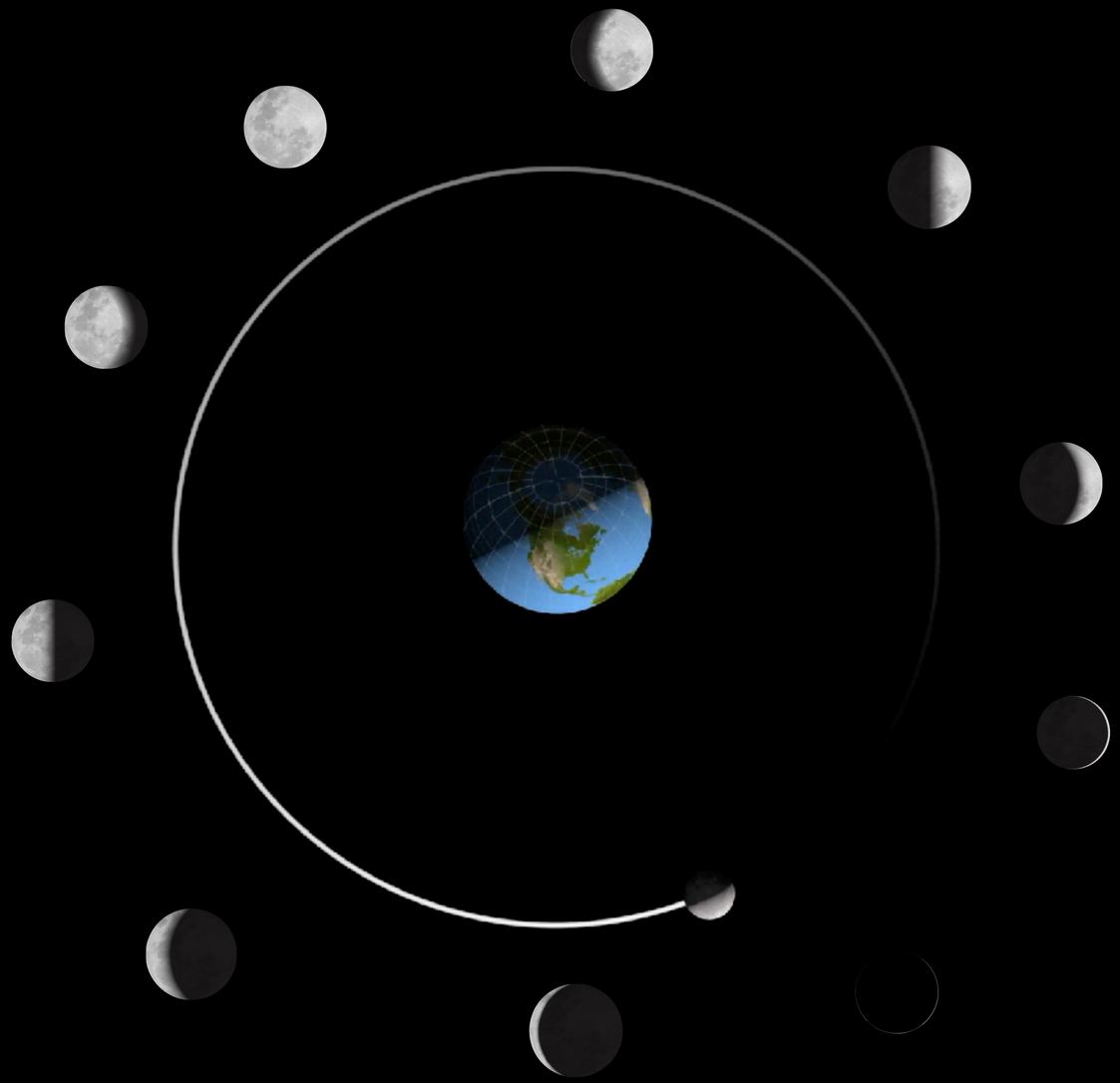
Full Moon



The New Moon is NOT the New Crescent

1 day later

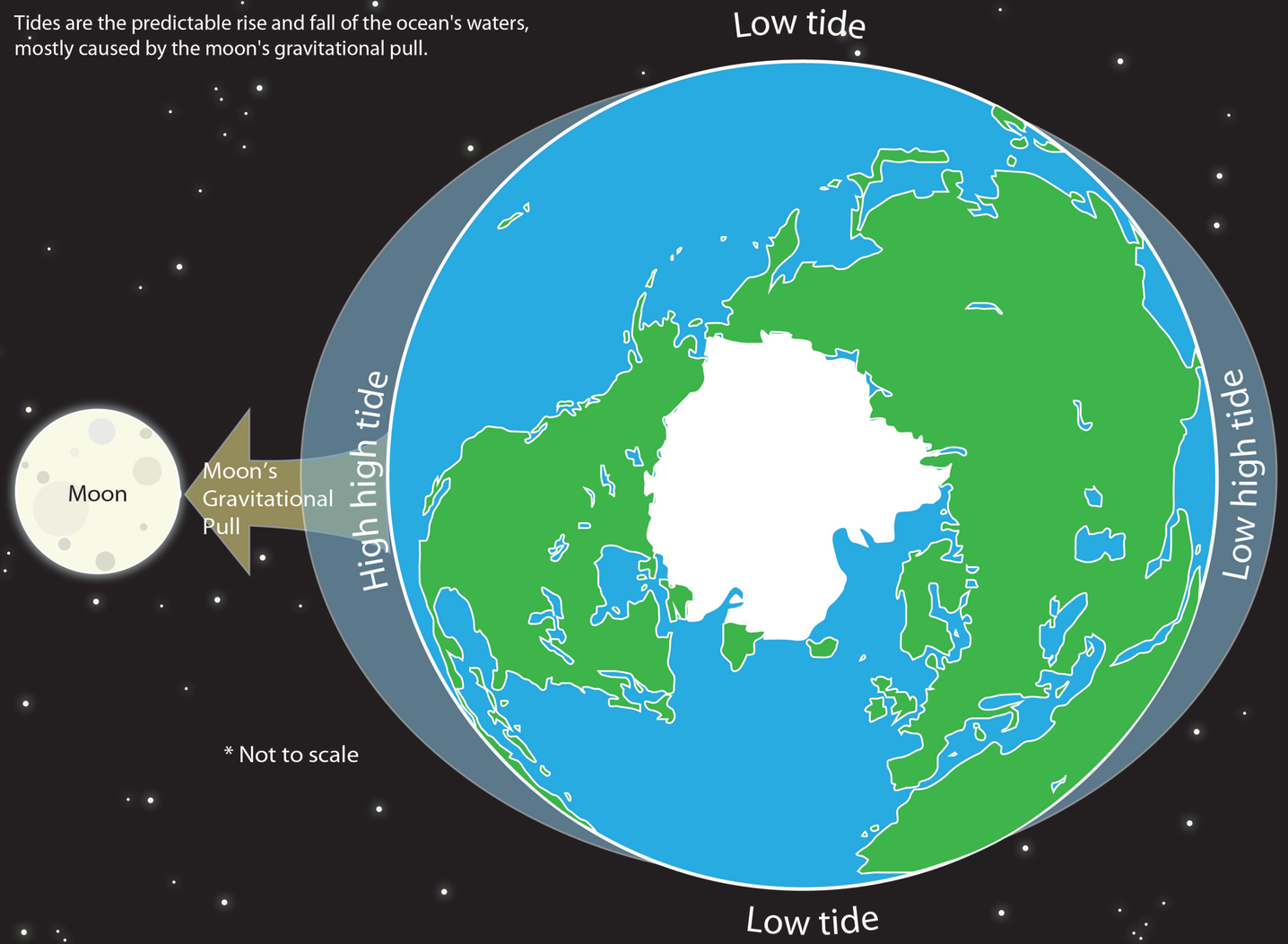
Astronomically impossible to see by eye

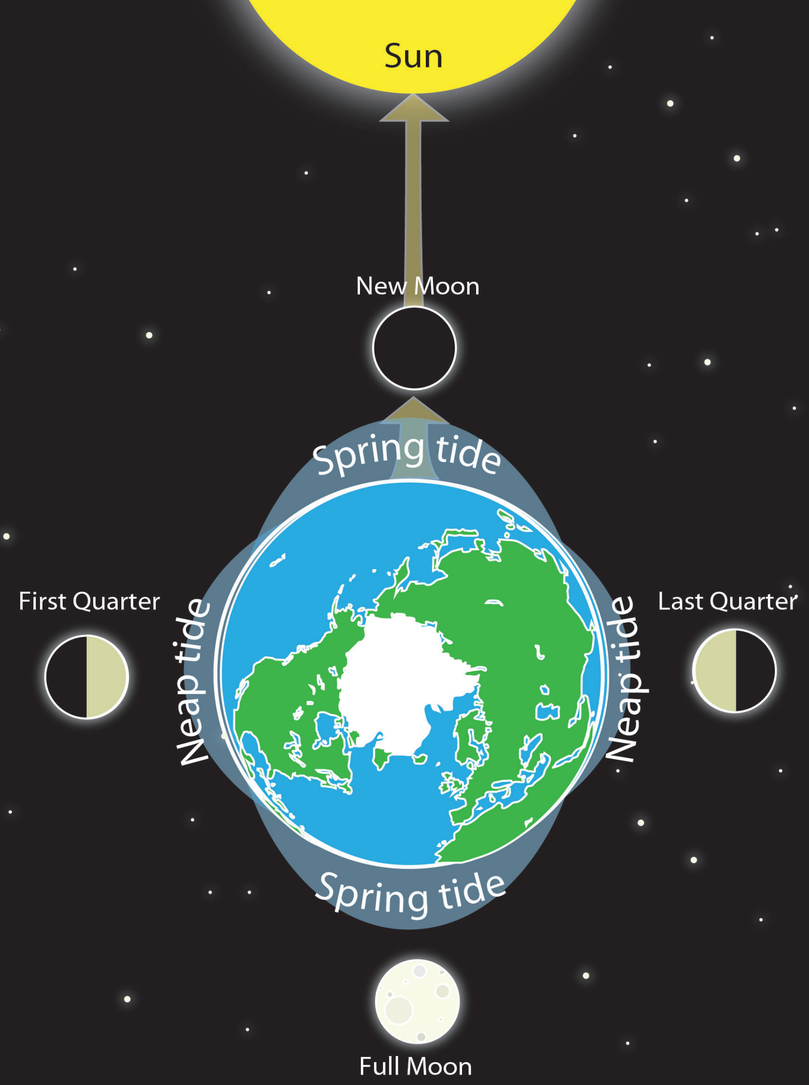


View from Earth

Earth's Tides

Tides are the predictable rise and fall of the ocean's waters, mostly caused by the moon's gravitational pull.





Adding the Sun into the Equation

When the sun and moon align, their combined gravitational forces create **spring tides**.

When the sun and moon are not aligned, and are at right angles to each other in relation to Earth, their gravitational forces work against each other to create **neap tides**.

NATIONAL GEOGRAPHIC

Questions

Discuss in groups

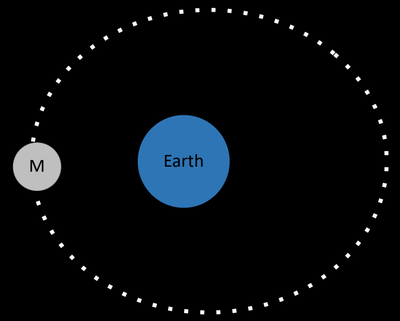
Approximately what time of day or night might you expect to see a full Moon rising?

Why don’t we get solar and lunar eclipses every month?

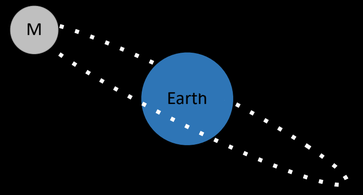
Would it be possible to follow a lunar calendar on another planet?

Why does the Moon “wobble”?

- The Moon’s orbit isn’t a perfect circle.

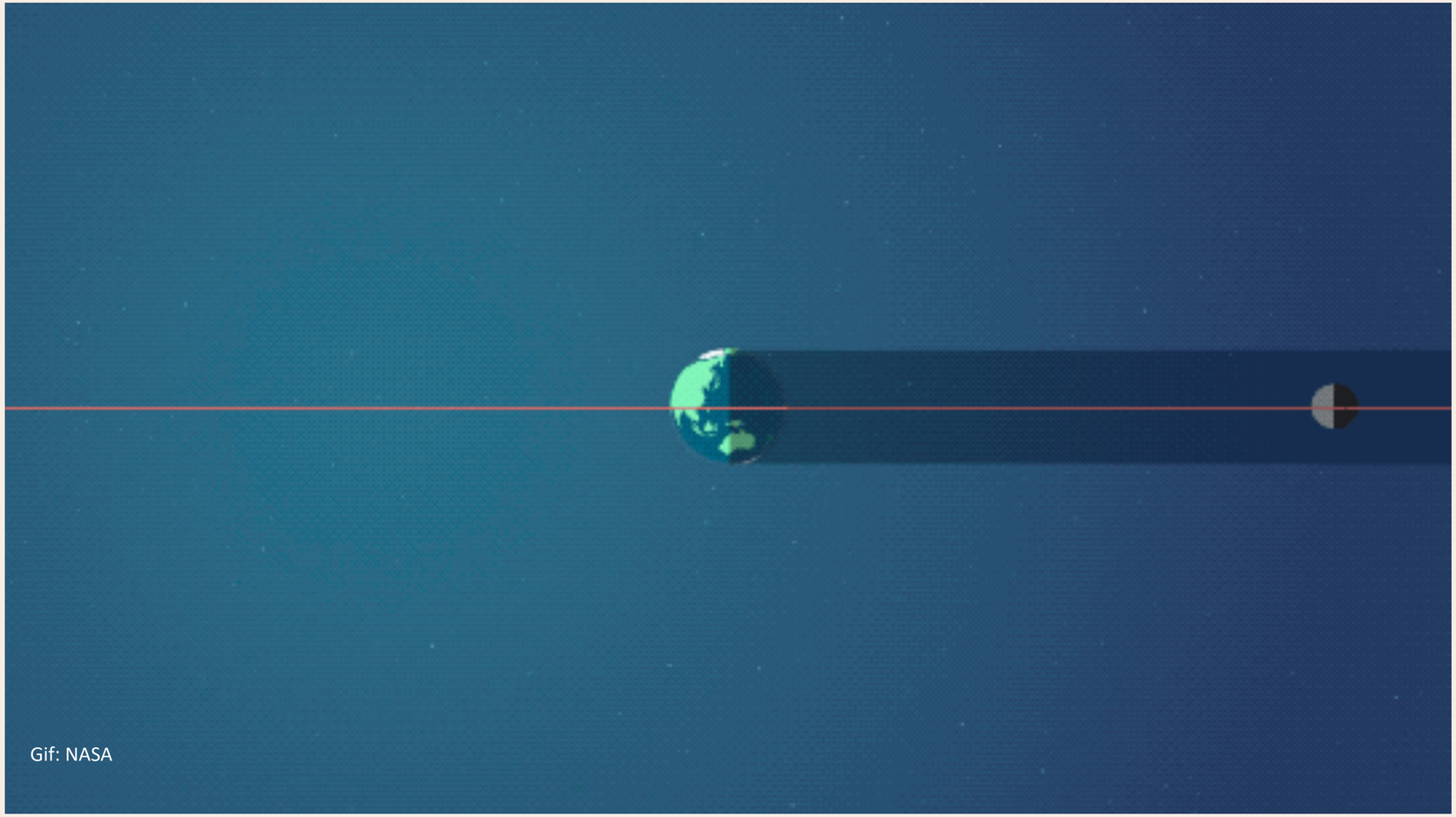


Top view



Side view

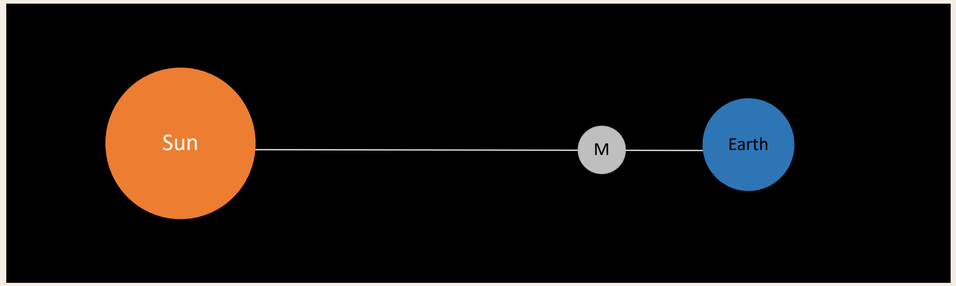
Tilted lunar orbit



Gif: NASA

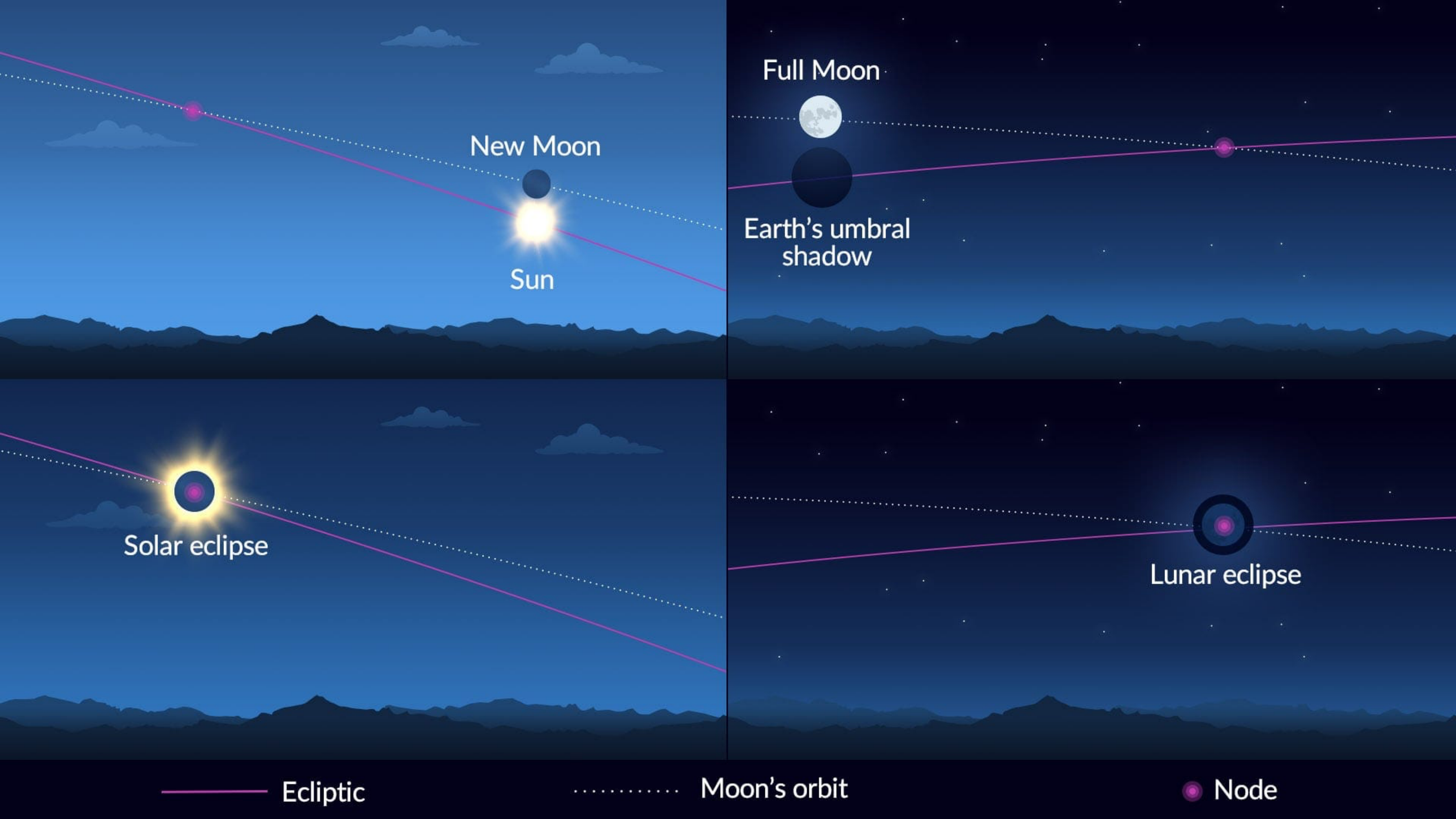
Solar eclipse

- Only happen when Sun, Earth, and Moon line up exactly!
- The Sun is blocked by the Moon.
- Always occurs during new Moon phase.



Lunar eclipse

- Only happen when Sun, Earth, and Moon line up exactly!
- The Moon is blocked by the Earth.
- Always occurs during full Moon phase.


New Moon
Sun
Full Moon
Earth's umbral shadow
Solar eclipse
Lunar eclipse
Ecliptic
Moon's orbit
Node

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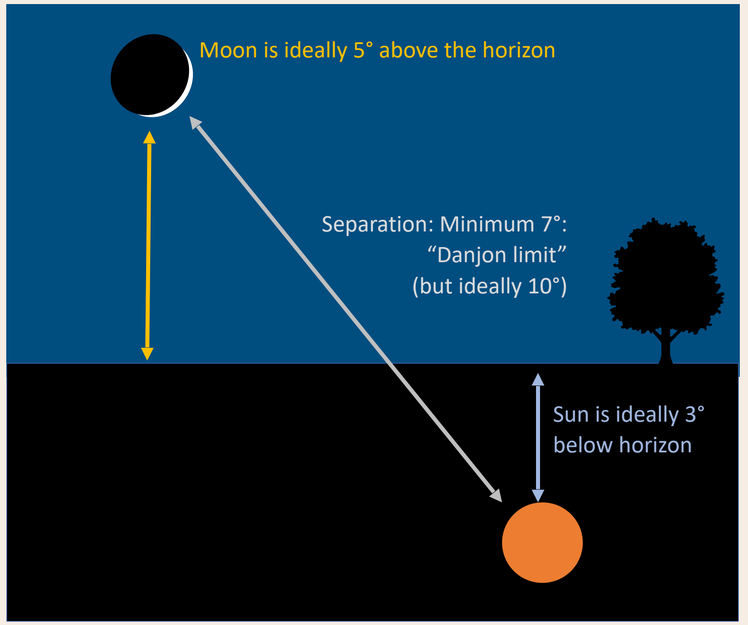
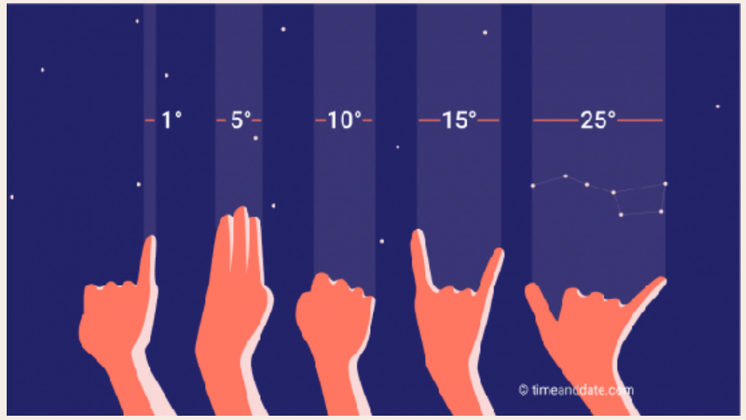
Crescent Visibility

Dr Emma L Alexander

New Crescent Visibility

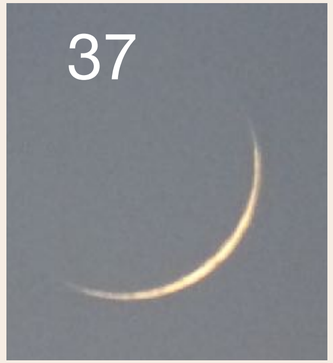
- Approx 7 degree separation for a crescent to form (“Danjon limit”)
- Moon and Sun are at a 10 degree separation about 18 hours after the New Moon; so realistic to see crescent the day after a New Moon (not the day of).
- A degree is a measure of distance on the sky.



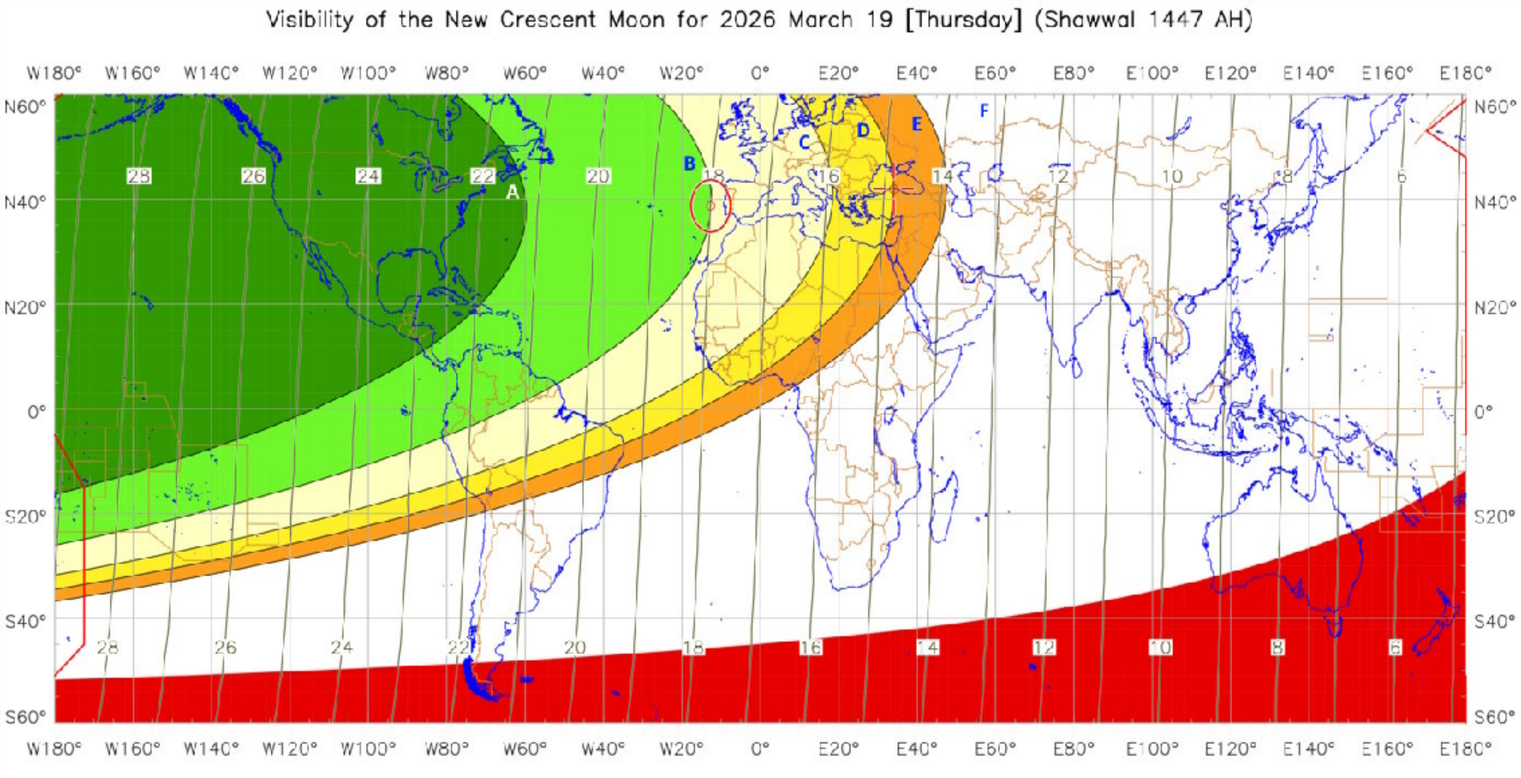


Age of Moon

- How long after the moment of New Moon
- Often measured in hours or days.
- Corresponds with a percentage (full Moon = 100%)



Visibility maps



A: Easily visible to the unaided eye

B: Visible under perfect conditions

C: Visible to unaided eye after found with an optical aid

D: Only visible with an optical aid

E: Not visible with a conventional telescope

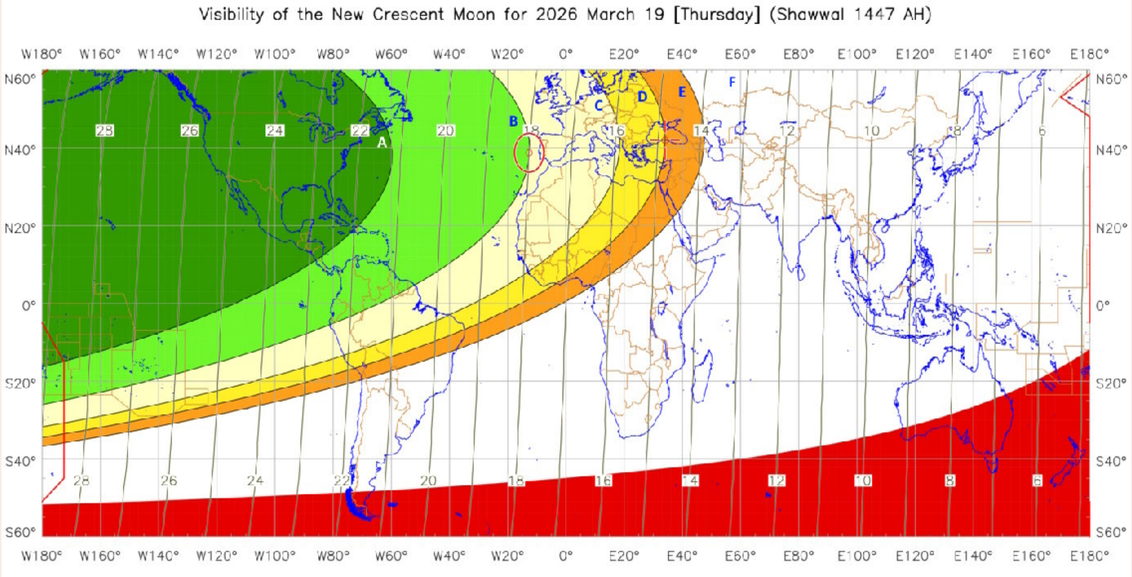
F: Below Danjon limit

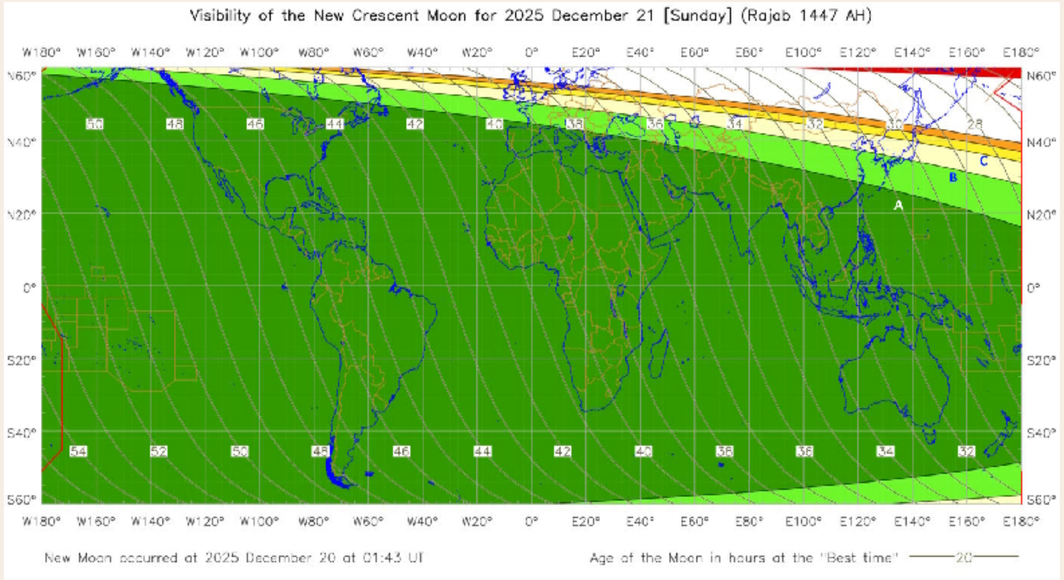
Red: moonset before sunset

Further West means Moon is “older” at location’s sunset time. Crescent gets thicker and brighter and is moving apart from the Sun in the sky = more easily visible.

Visibility maps

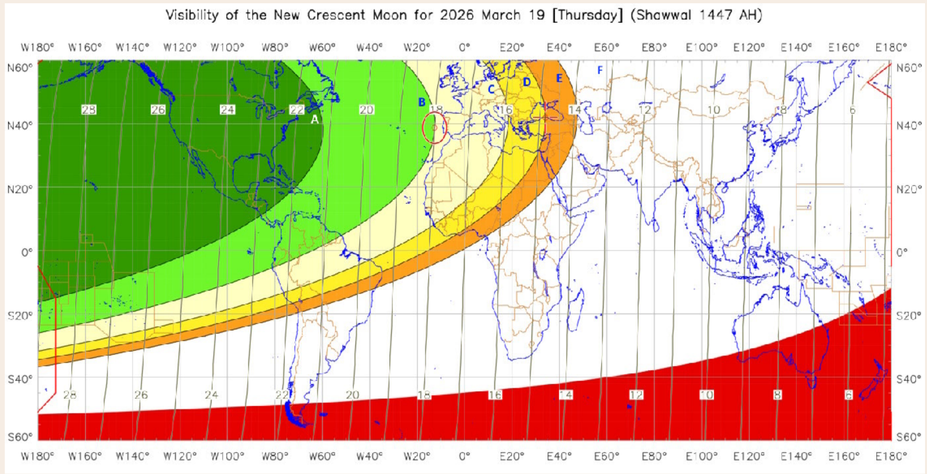
Change every month





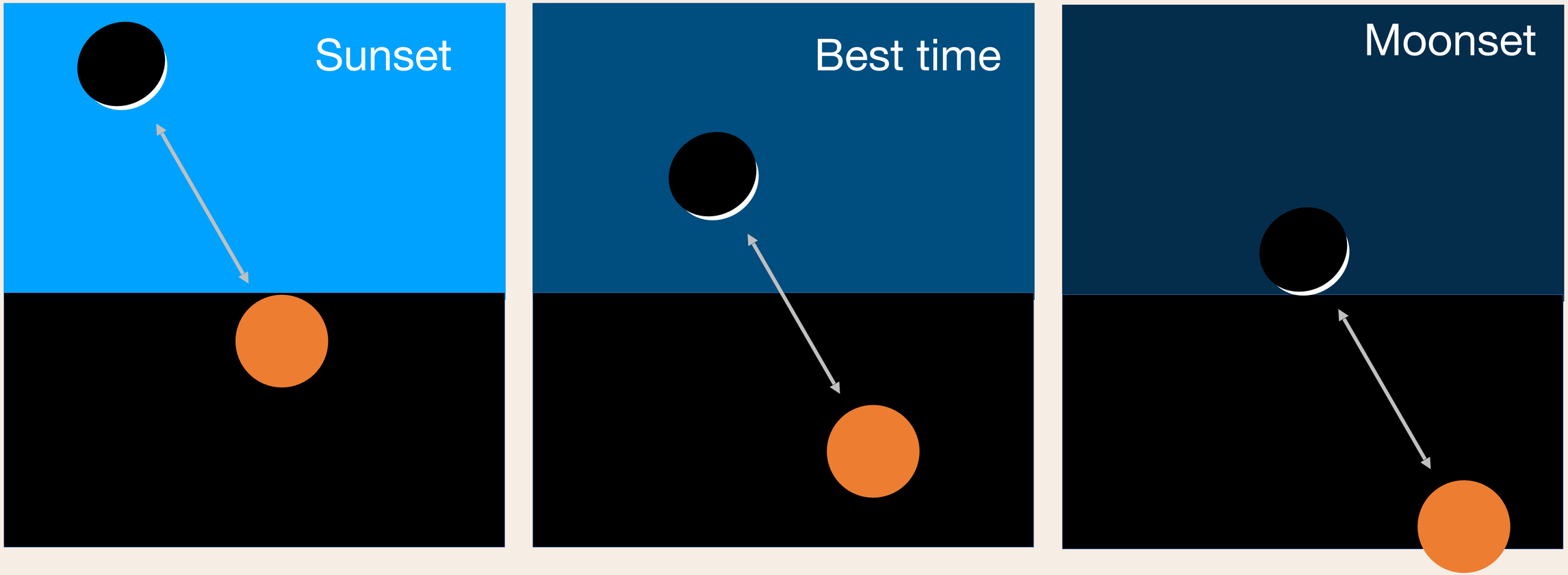
Origin of visibility maps

- Based on scientific analysis of a dataset of Moonsightings: when the Moon was seen by eye, by optical aid, or not at all.
- Use this to categorise likelihood of seeing future Moons (visibility maps)



NAO Technical Note No 69
A Method for Predicting the First Sighting of the New Crescent Moon
by BD Yallop

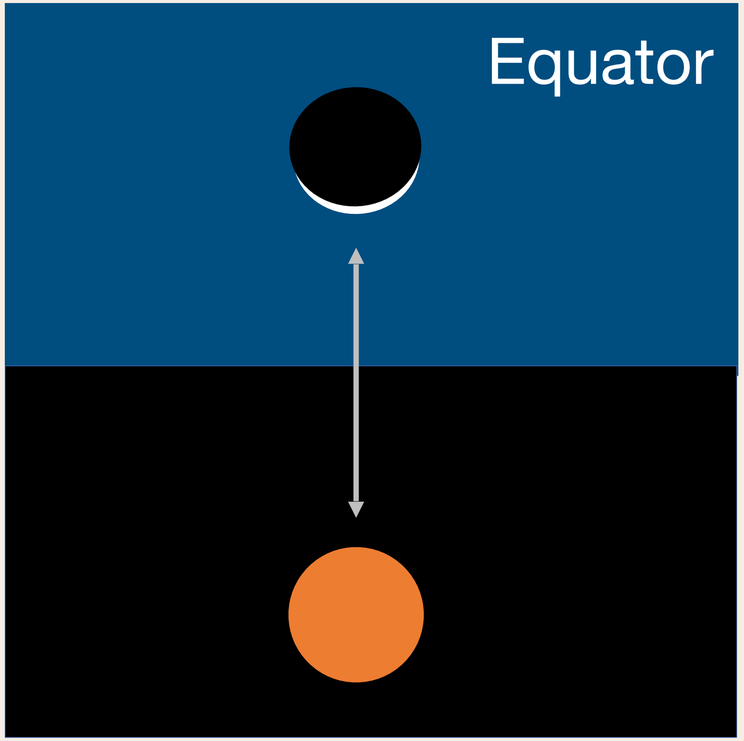
“Best time”

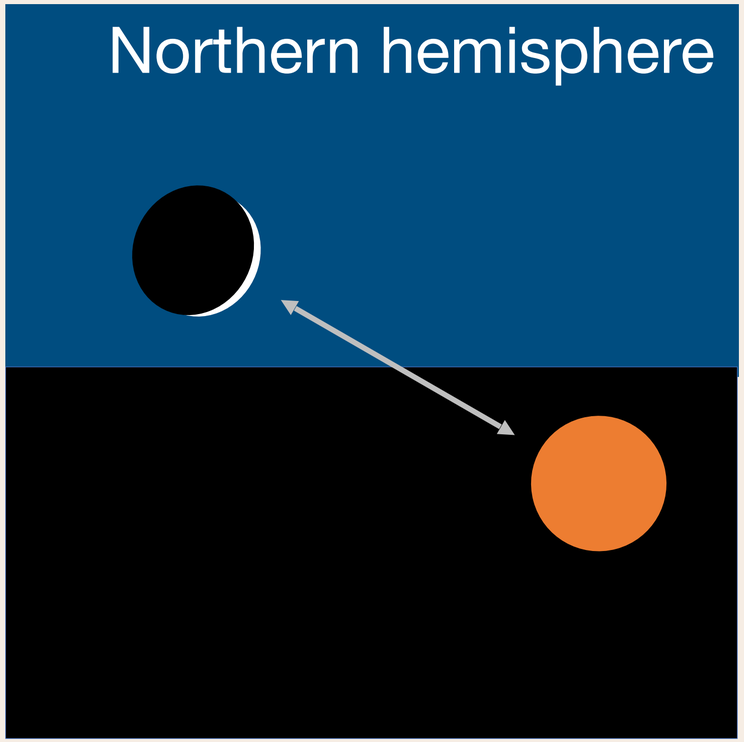


Balance between moon altitude and sky brightness

Effect of latitude

Why a younger Moon can be seen nearer the equator

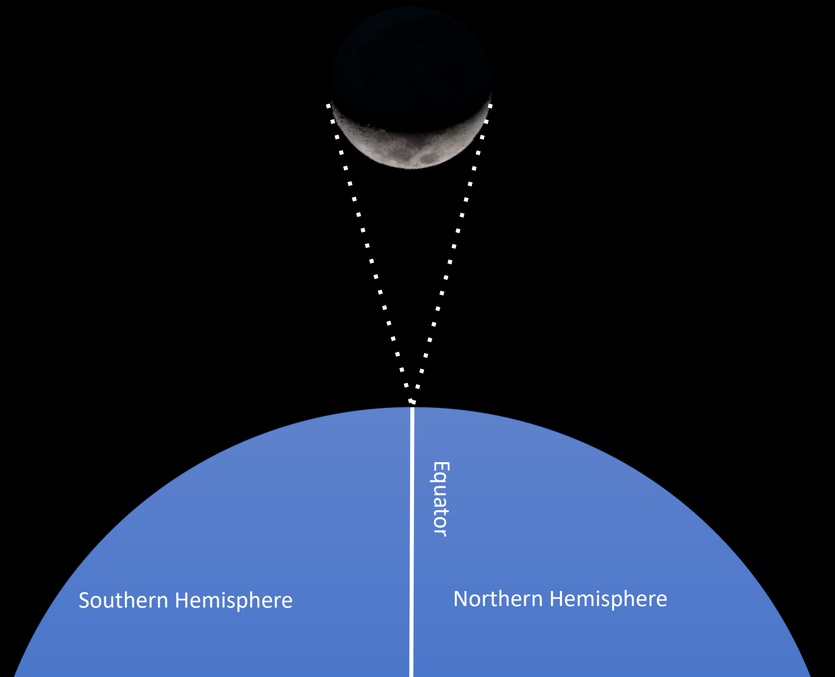




Same elongation, difference vertical separation

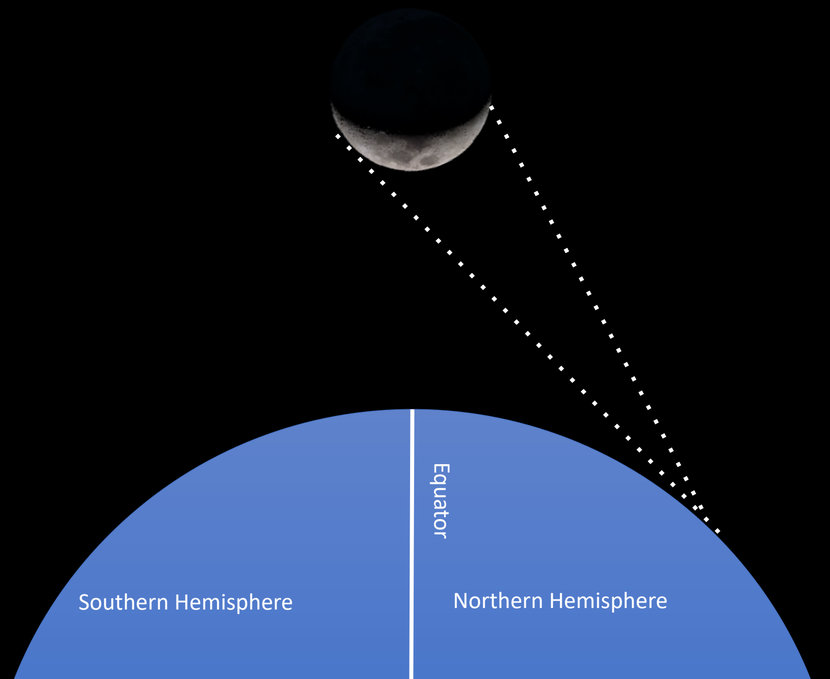
Views around the world

Equator



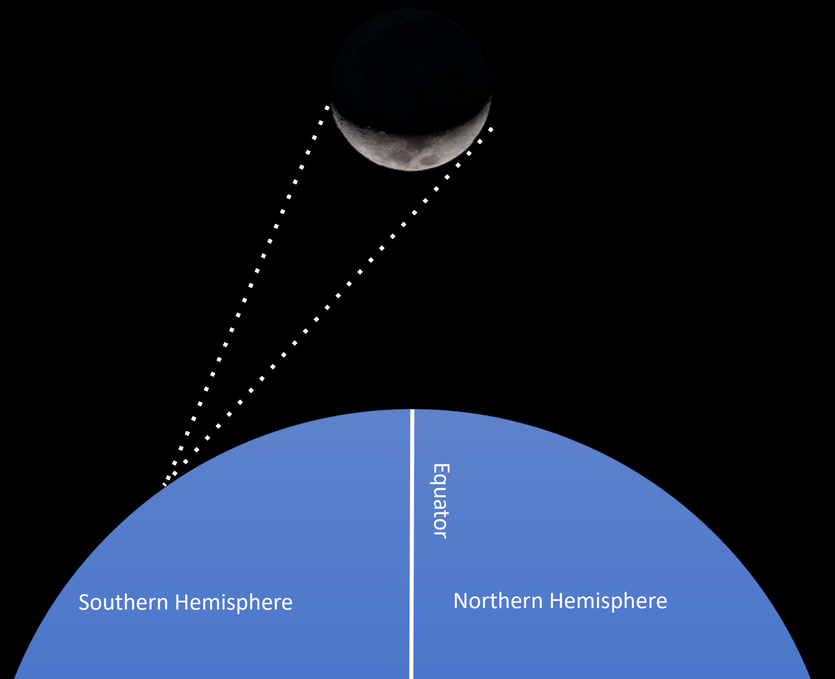
Views around the world

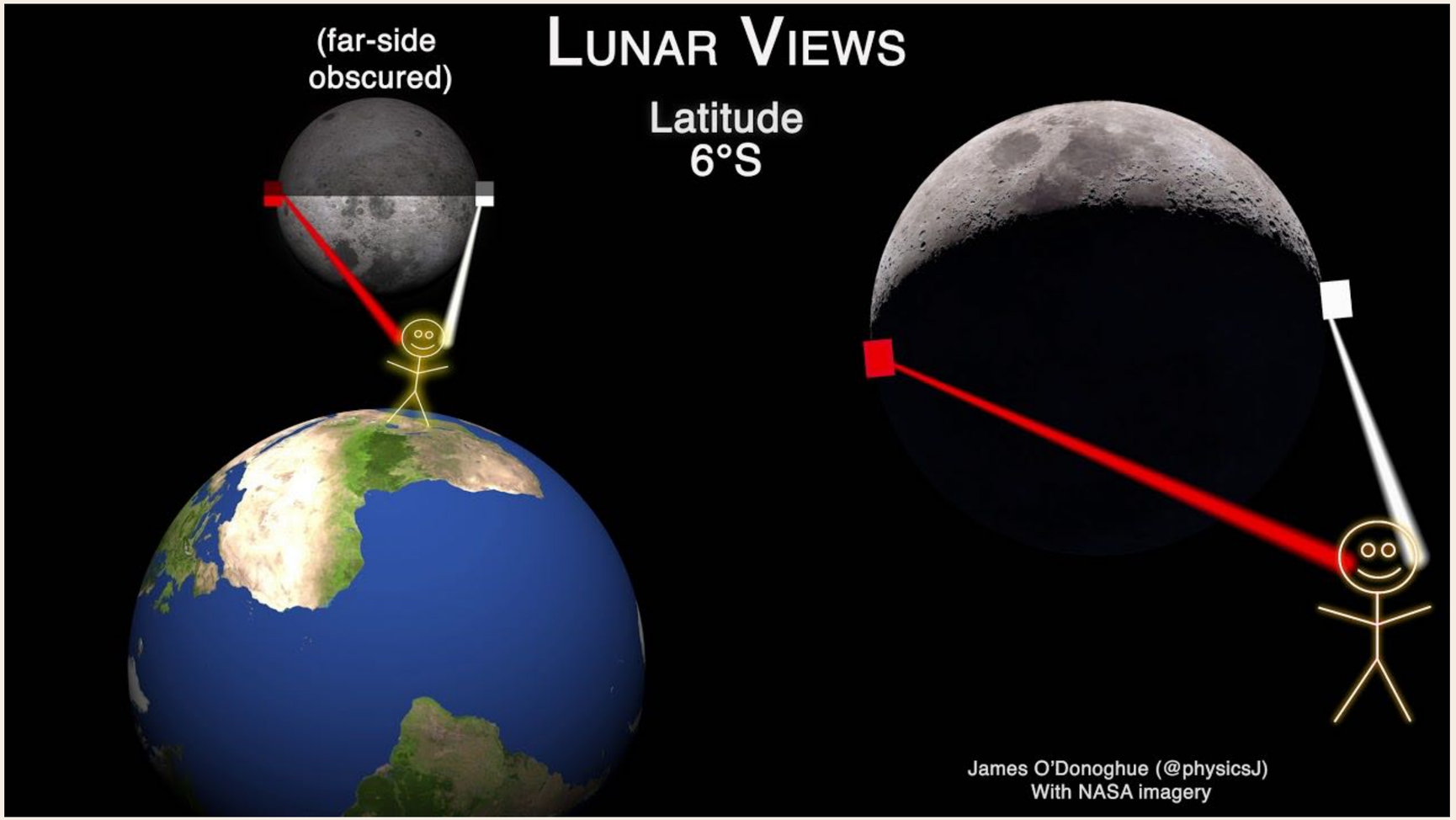
Northern Hemisphere



Views around the world

Southern Hemisphere




(far-side
obscured)
LUNAR VIEWS
Latitude
6°S
James O'Donoghue (@physicsJ)
With NASA imagery

Moon appears upside down in Southern Hemisphere!

Sydney, Australia
July 2018

Questions

Discuss in groups

Why do we have a “best time” to see the Moon? Why can we still see it either side of this time?

Why are visibility maps different for each month?

How could you determine where you are on Earth by seeing the Moon? How can you use this to verify photos you see?

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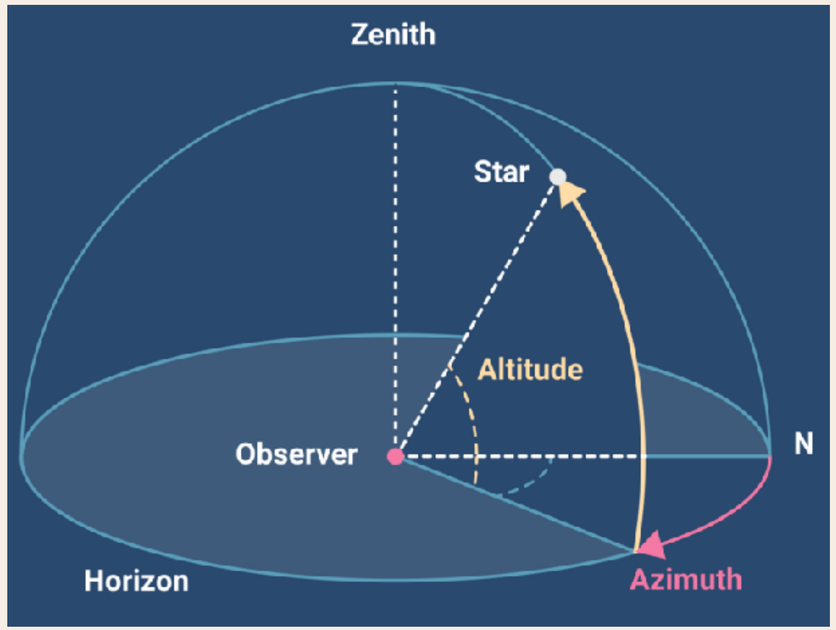
Observing the Universe

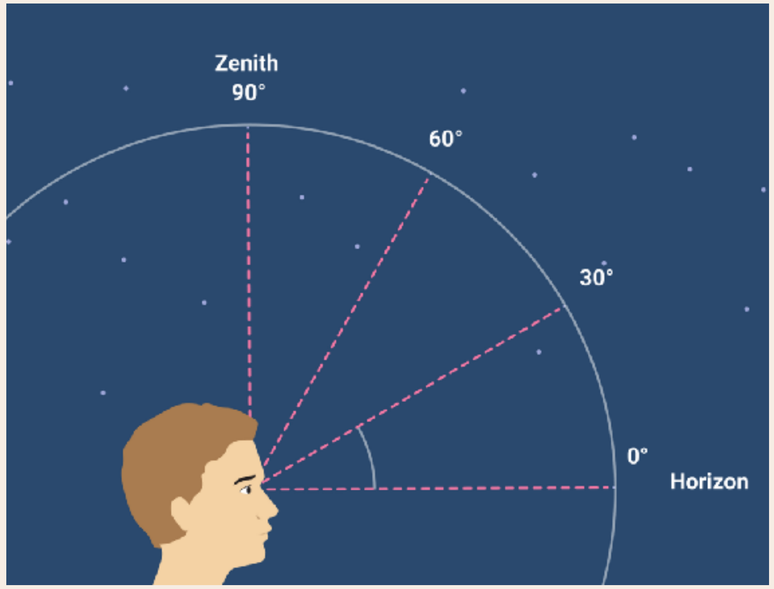
Dr Emma L Alexander

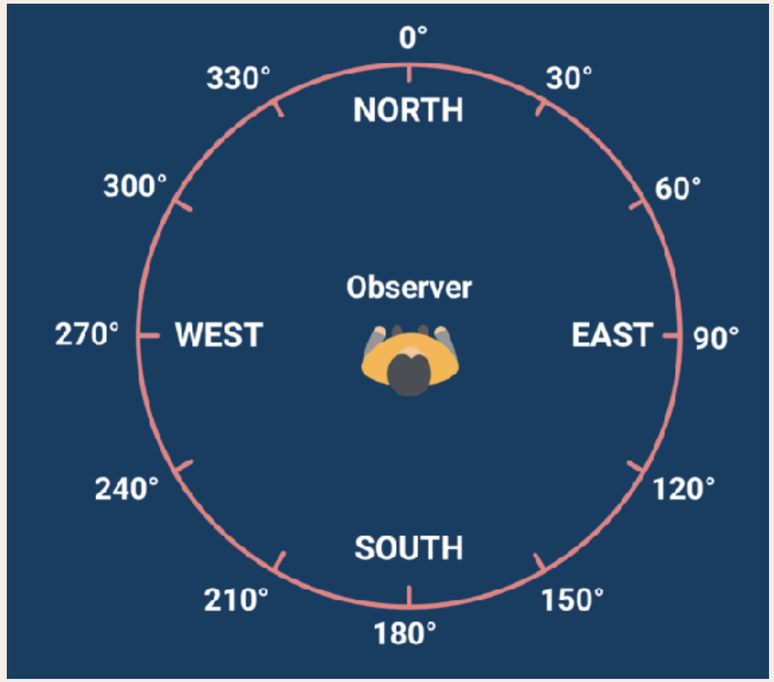
Astronomical coordinate systems

Images from timeanddate.com

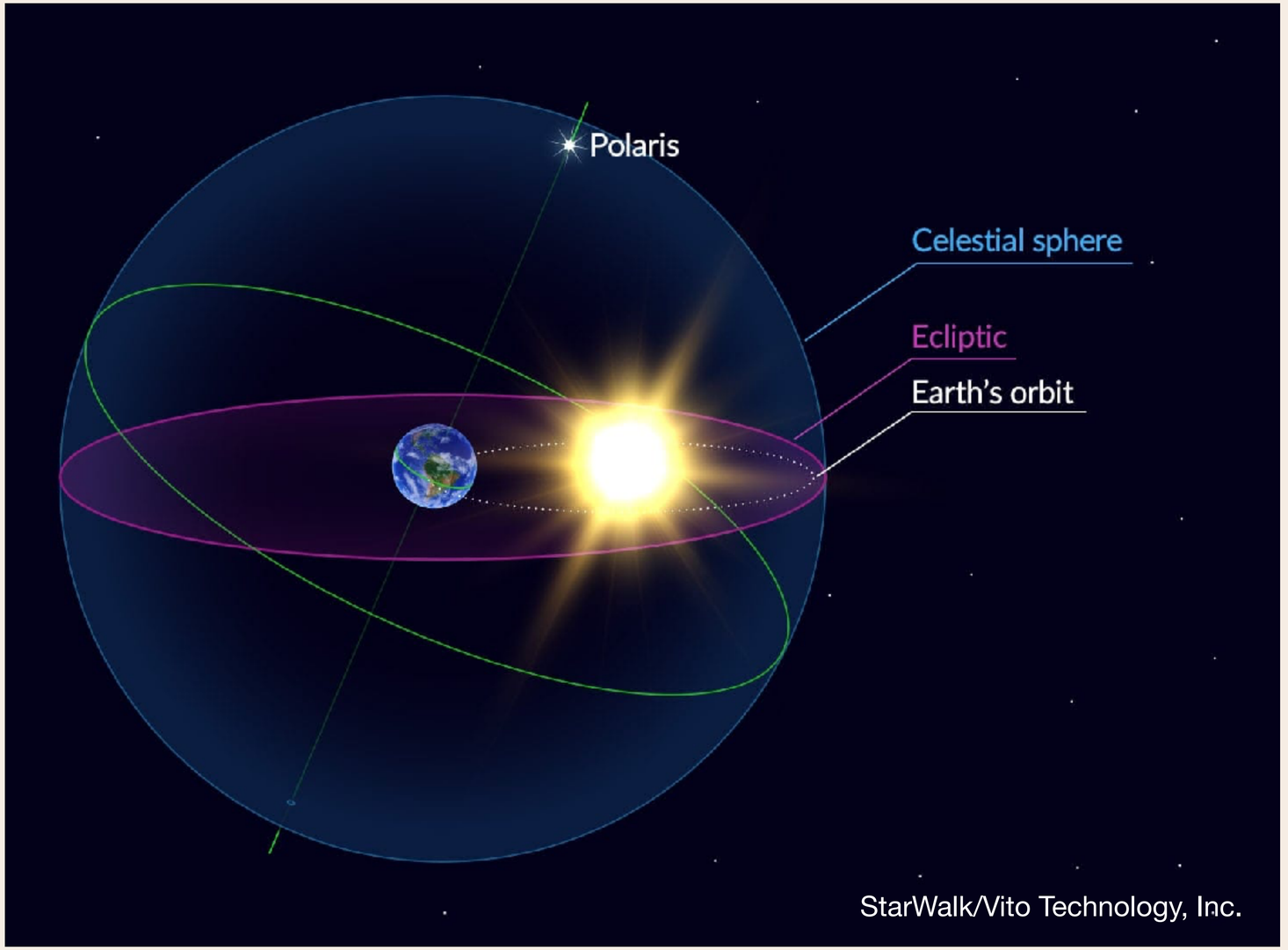
Zenith سمت الرأس (samt al-raʾs)

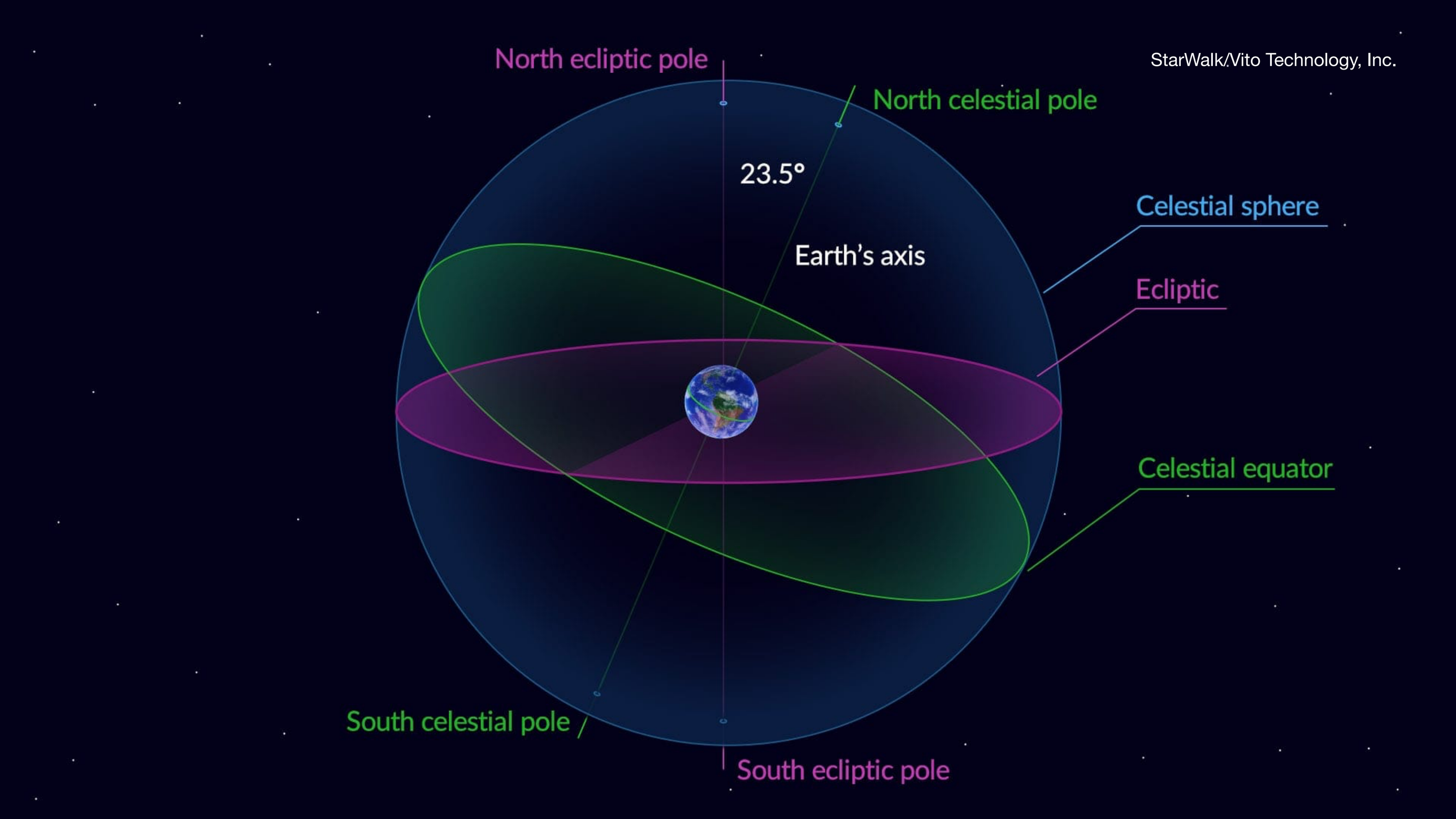






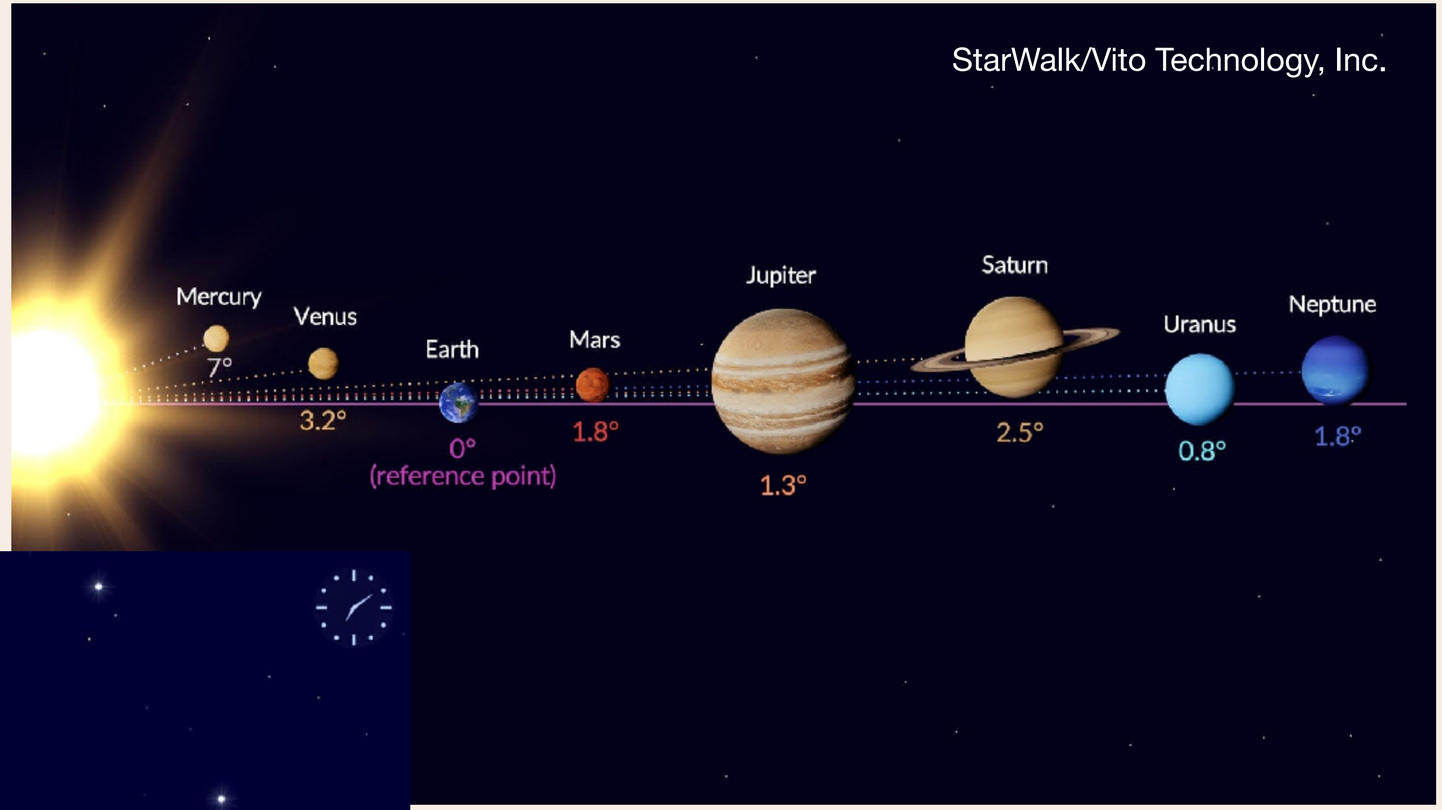
Other coordinate systems

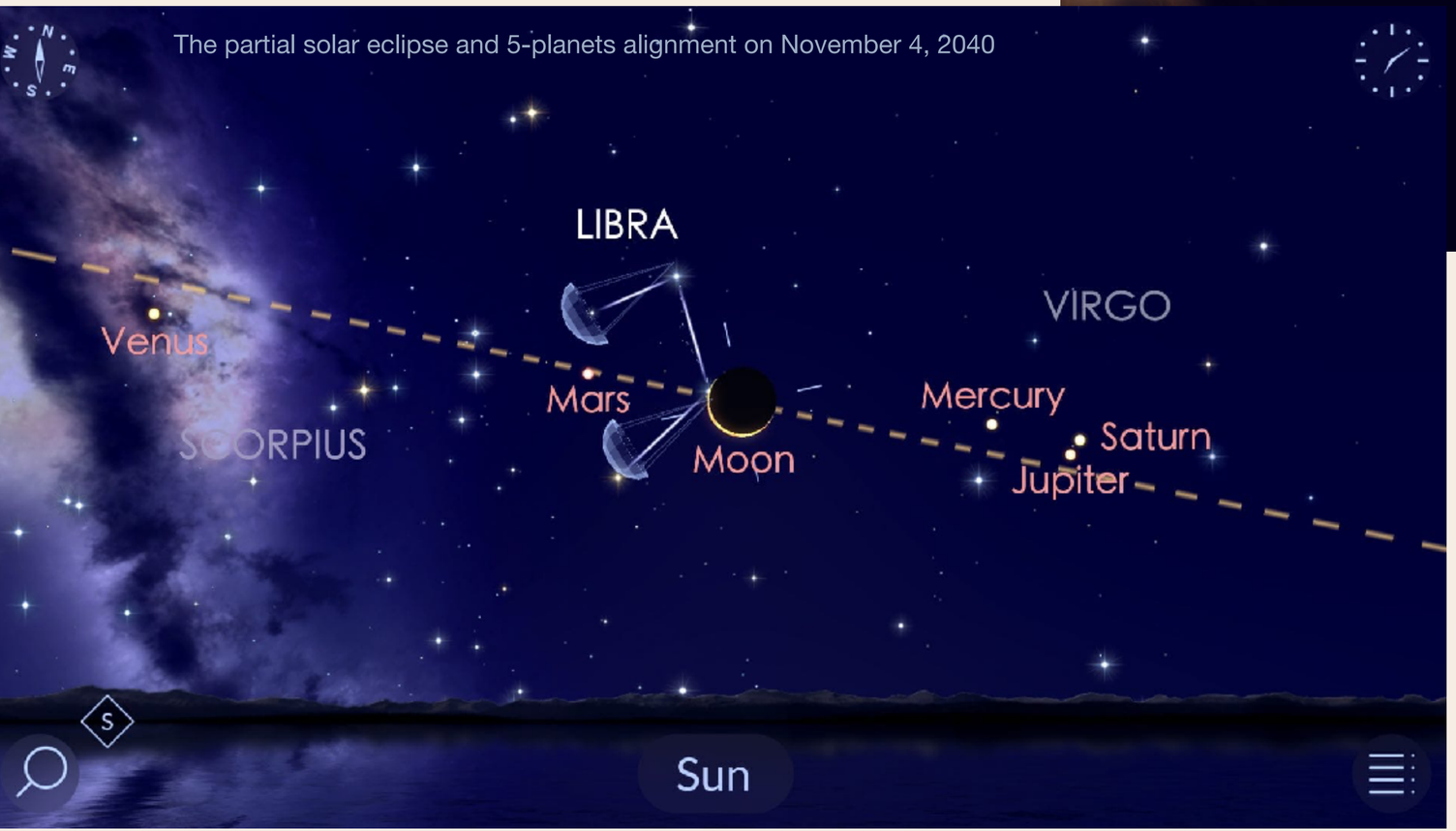




StarWalk/Vito Technology, Inc.

Ecliptic


StarWalk/Vito Technology, Inc.
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
7°
3.2°
0°
(reference point)
1.8°
1.3°
2.5°
0.8°
1.8°


The partial solar eclipse and 5-planets alignment on November 4, 2040
LIBRA
VIRGO
Venus
Mars
Moon
Mercury
Saturn
Jupiter
SCORPIUS
Sun

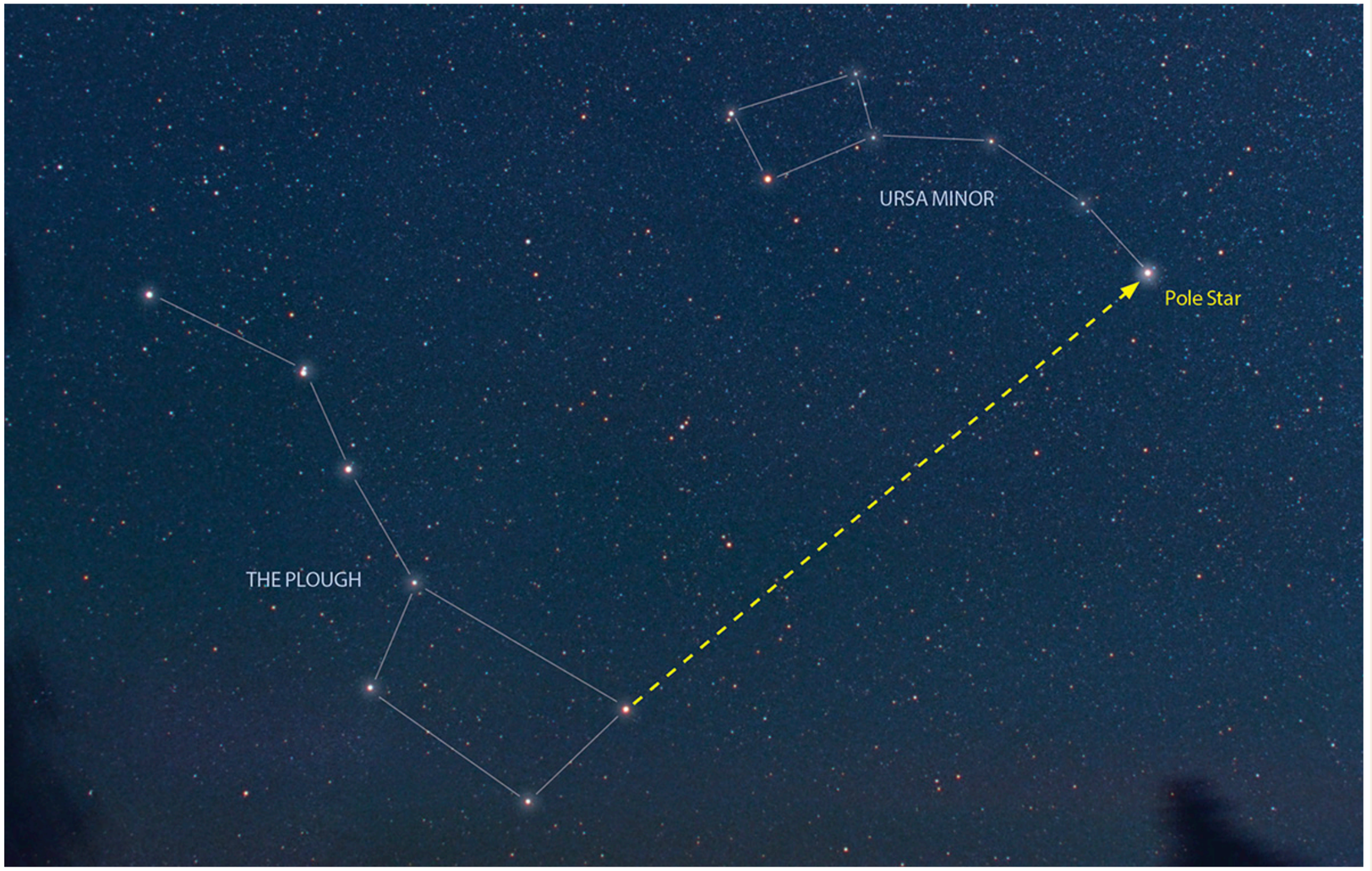
Nebula vs Galaxy

Cluster vs constellation

Constellations

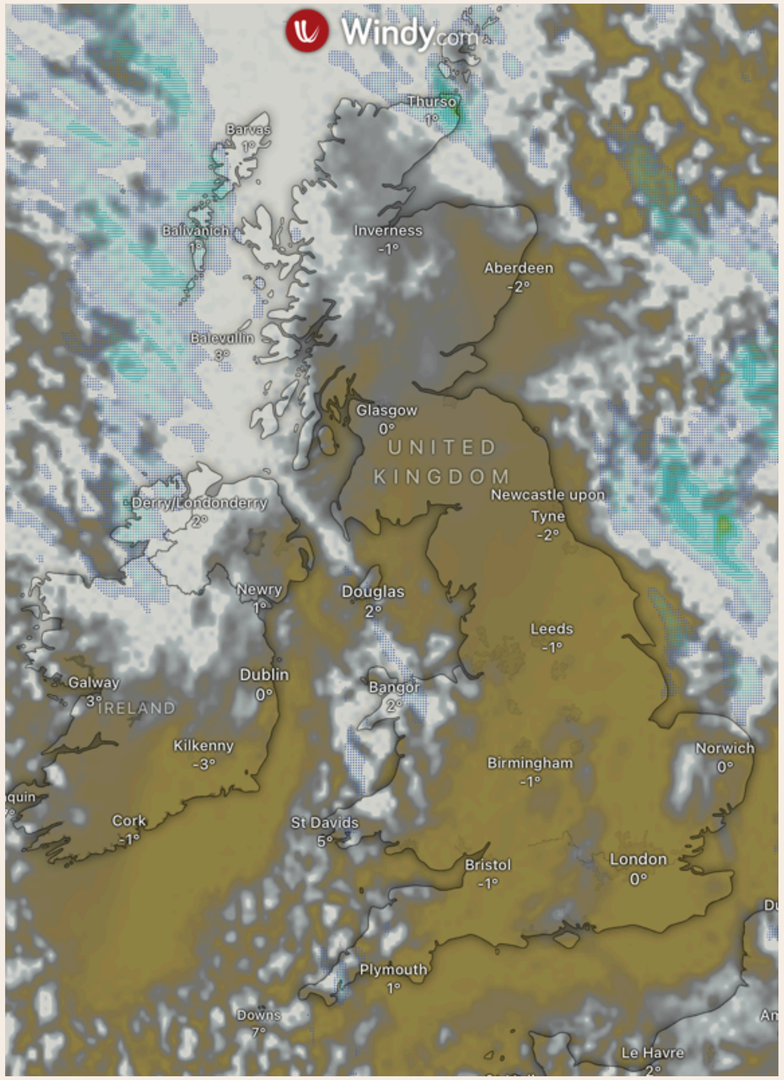
Florian Winkler

The North Star



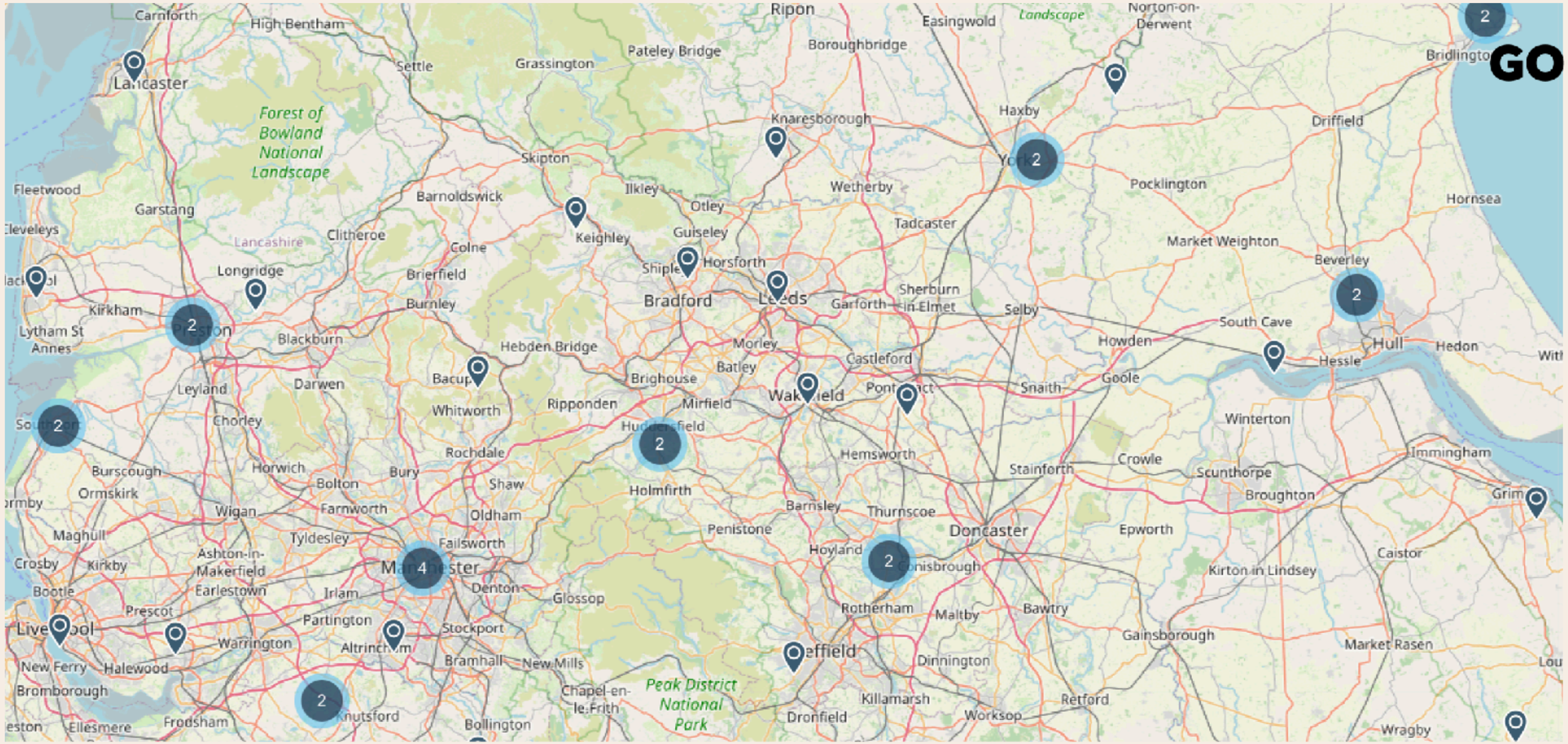
Astronomers vs clouds

- Cloud height
- Cloud moverment
- Cloud direction



Find your local society!

GO STARGAZING



https://gostargazing.co.uk/events-map/

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Q&A

- Discuss questions on your tables!

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Happy Stargazing!
Happy Moongazing!

Dr Emma L Alexander