



Enchanted Eclipse UNM 2023

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Dept. of Physics & Astronomy, UNM

Outline

- Whats up?
 - ‘Annular’ solar eclipse October 14th
- How it works – why do we get eclipses?
 - Geometry of eclipses
 - Location and frequency of solar eclipses
- Safety when viewing the Sun
- Where & when to observe the eclipse in Albuquerque
 - Clear view to the east – UNM program starting 8:30am
- See also eclipse.unm.edu

Safe viewing the Sun

Why is it dangerous to look at the Sun if it is mostly blocked?



Safe viewing

- At any time during an annular eclipse and a transit, parts of the photosphere is visible to the eye
- This light (6% of the total normal amount) is enough to damage your eyes!

Safety

- **NEVER look at the Sun directly during this annular eclipse!!!**
 - Sunglasses are NOT sufficient protection!!!
 - When any part of the Sun's photosphere is showing, it can burn your retina very quickly
- Use protective equipment:
 - Viewers/Eclipse shades: special glasses, filters designed to dim the sun light
 - Make sure viewer is rated for looking at the Sun
 - Solar viewers can be bought online, will be handed out at the UNM Campus Observatory event
 - A #14 or higher rated welding helmet/welding glass also considered safe

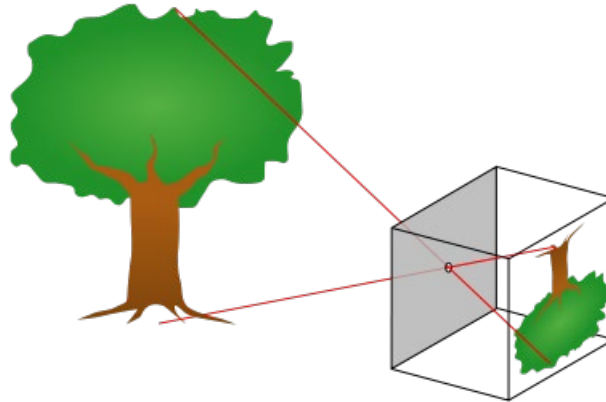
Safe viewing

- To use your eclipse shades:
 - Make sure there are no holes & scratches
 - Turn away from the Sun, hold viewer in front of your eyes turning to the Sun. Keep viewer up until you've turned away from the Sun again.



Safety cont.

- Pinhole cameras:
 - Make your own set that cast an image of the Sun onto a screen.
 - Make sure you only look at the screen, do not look through the pinhole to the Sun itself!

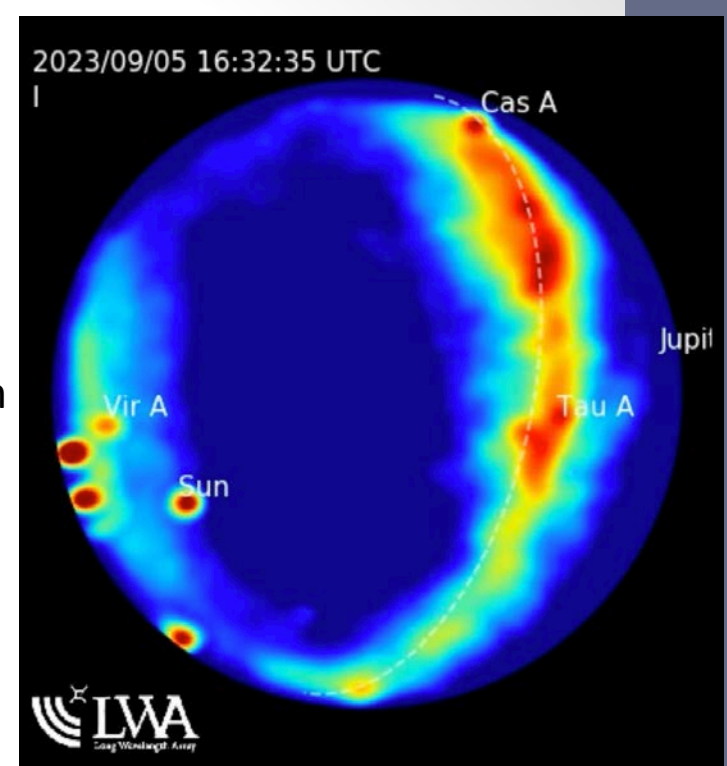


Other Ways to view the Sun

In the Radio with the Long Wavelength Array

- ° A new type of telescope
- ° Works from 3 – 88 MHz
- ° Operated by UNM for the National Science Foundation and Air Force Research Laboratory
- ° Watch it yourself in real-time at:

<http://www.phys.unm.edu/~lwa/lwatv.html>



LWA1



Other Ways to view the Sun



Live updates from various web sites

<https://www.timeanddate.com/live/eclipse-solar-2023-october-14>

Various nifty animations of what will happen:

<http://shadowandsubstance.com/>

<https://www.timeanddate.com/eclipse/map/2023-october-14>

<https://solarsystem.nasa.gov/eclipses/home/>

UNM Events

- October 14th at Johnson Field and in PAIS at UNM
 - Talks starting at 8:50am, free eclipse viewers and activities on Johnson field starting at 8:30am
- Eclipse starts at 9:13am, annularity (maximum eclipse is from 10:34 to 10:39am) end of eclipse at 12:09pm

- Talks in PAIS room 1100:

8:50am Welcome

9:00am Solar Physics

9:30am High Energy Views of the Sun

10:00am Solar Eclipses Optical and Radio

10:35am Annularity

11:00am History of Eclipses

11:30am Eclipses on Other Worlds

12:00pm End

Presenter

Greg Taylor (UNM)

Stephen White (AFRL)

Fred Baganoff (MIT)

Greg Taylor (UNM)

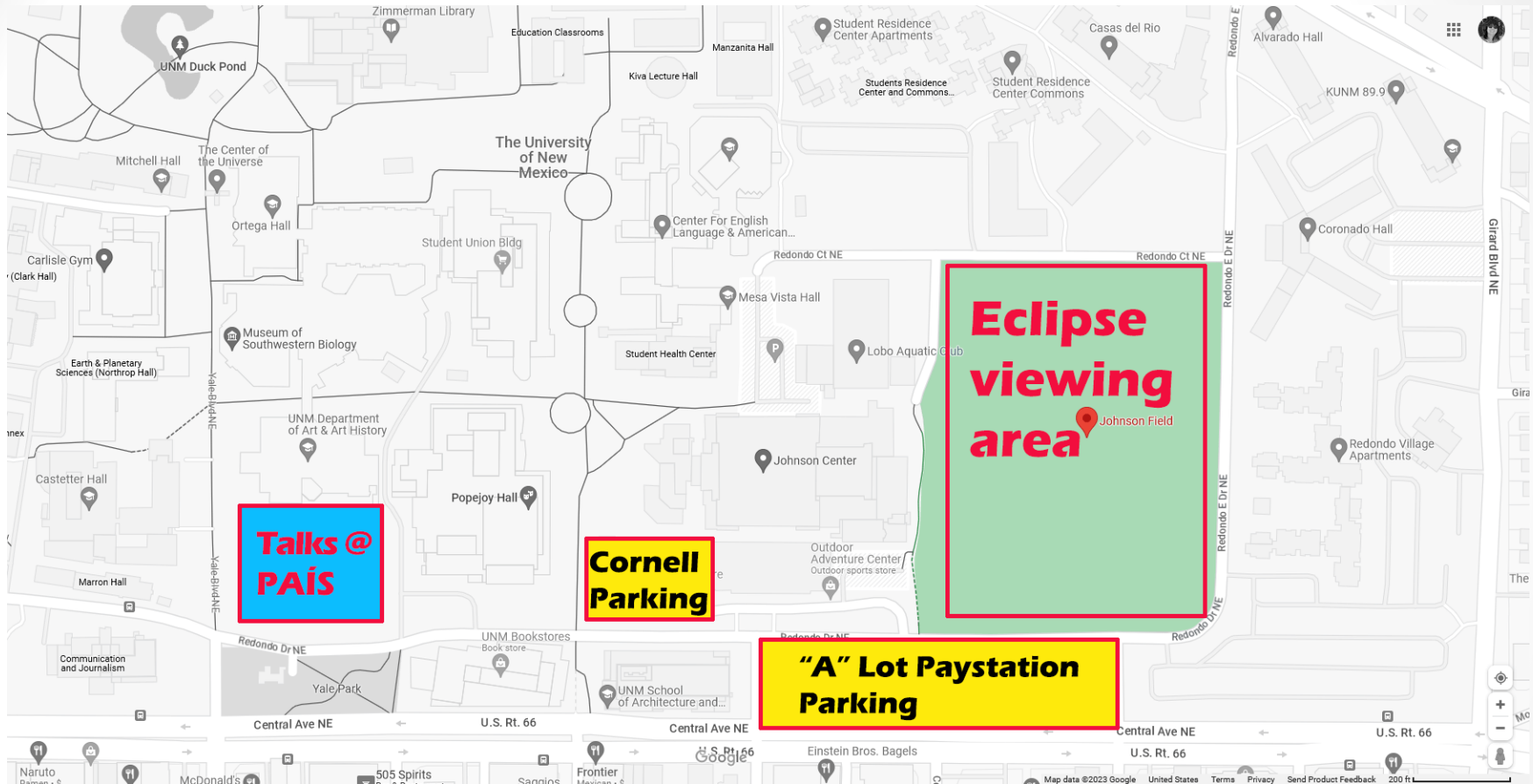
Sun

Kylar Greene (UNM)

Mallory Harris (UNM)

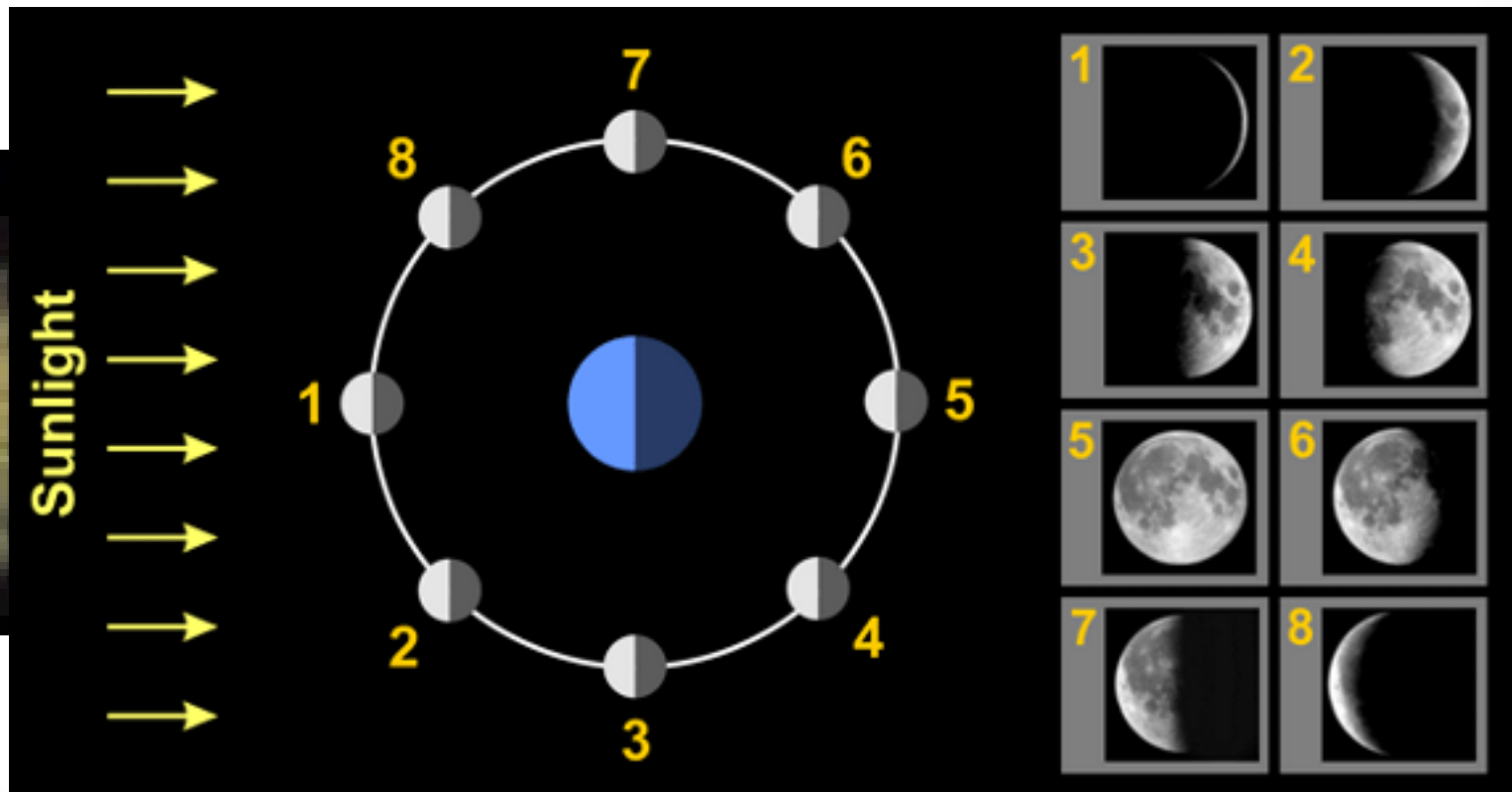
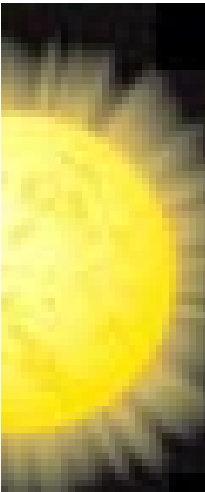
Note: a live image of the Sun will be projected alongside the talks

Activities at UNM on October 14th



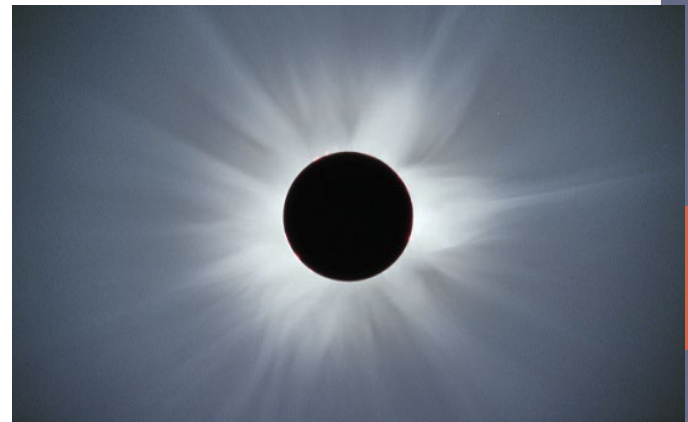
Eclipse background:

- Moon phases:
 - When the Moon is *new* it passes between the Earth and the Sun
 - When it is *full* it is in the opposite position in it's orbit



Solar & Lunar Eclipses

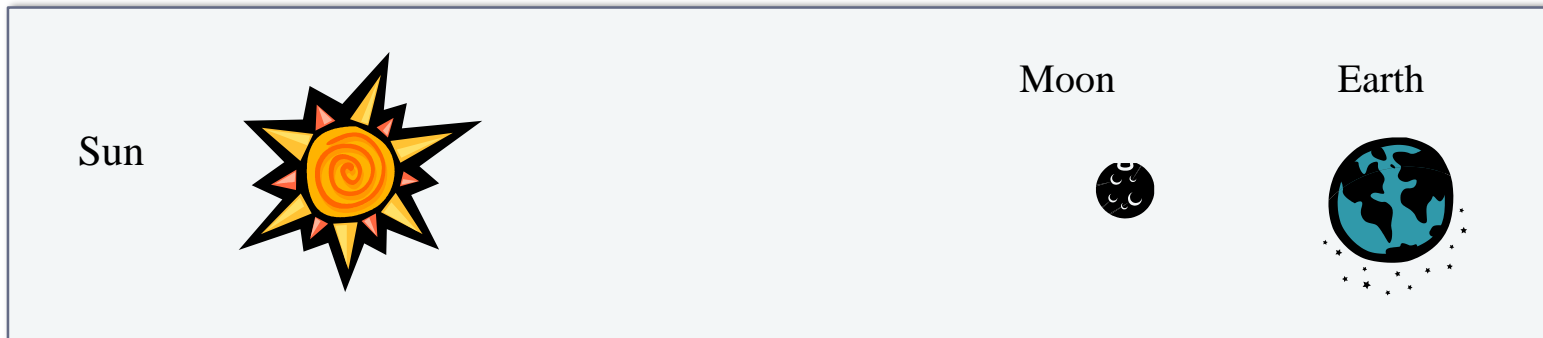
- When 3 objects fall in a direct line, blocking the view of each other, an eclipse occurs
- When the Earth's shadow falls on the Moon, we call it a lunar eclipse.
- When the Moon's shadow falls on the Earth, we call it a solar eclipse.



- **Lunar eclipse:** When the Earth passes directly between the Sun and the Moon.



- **Solar eclipse:** When the Moon passes directly between the Sun and the Earth.

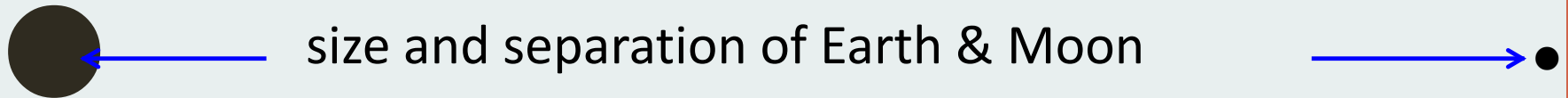


Sizes of Sun, Earth and Moon

- The Moon is $\sim 1/4$ of Earth's diameter
- The Sun is $\sim 400x$ bigger than the Moon, but $\sim 400x$ farther away

➡ The Sun and the Moon have about the same angular size!

- The Sun is $\sim 100x$ the size of the Earth

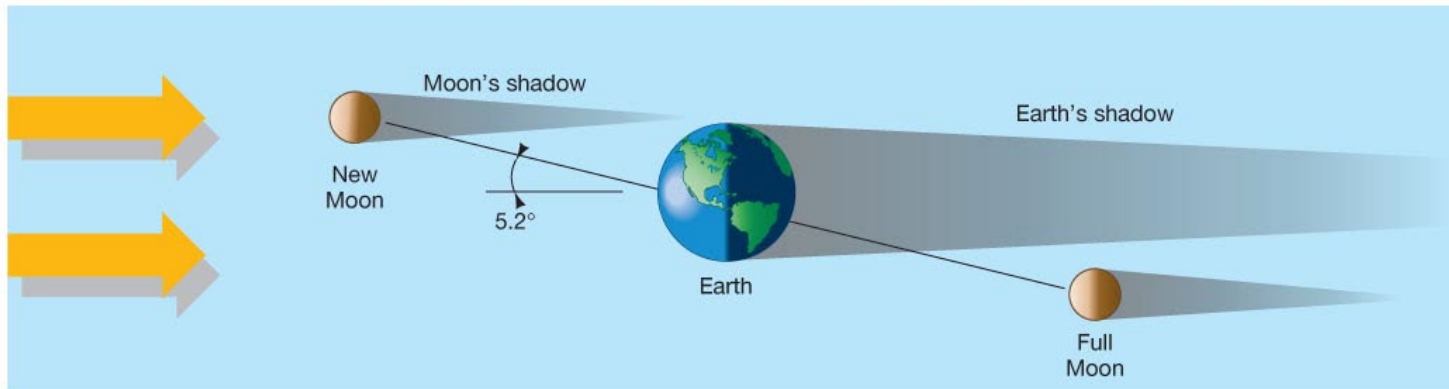


Size of the Moon

- The angular size of the Moon varies from 29.37 to 33.52 arcmin
- The distance between the Earth and the Moon varies by up to 13% during each orbit
- If the Moon's angular size is larger than the Sun's, a total eclipse can occur
- If the Moon's angular size is smaller than the Sun's, an annular eclipse can occur (more later)
- ...Don't wait too long: the Moon moves 4cm farther away each year, so in 700 million years there will be no more total eclipses!

Frequency of eclipses

- There are 2-5 lunar/solar eclipses respectively each year, but most are not *total*.
- OK, why don't we get an eclipse *every* New or Full Moon?
 - The Moon's orbit is tilted by about 5deg with respect to the Earth's orbit around the Sun.



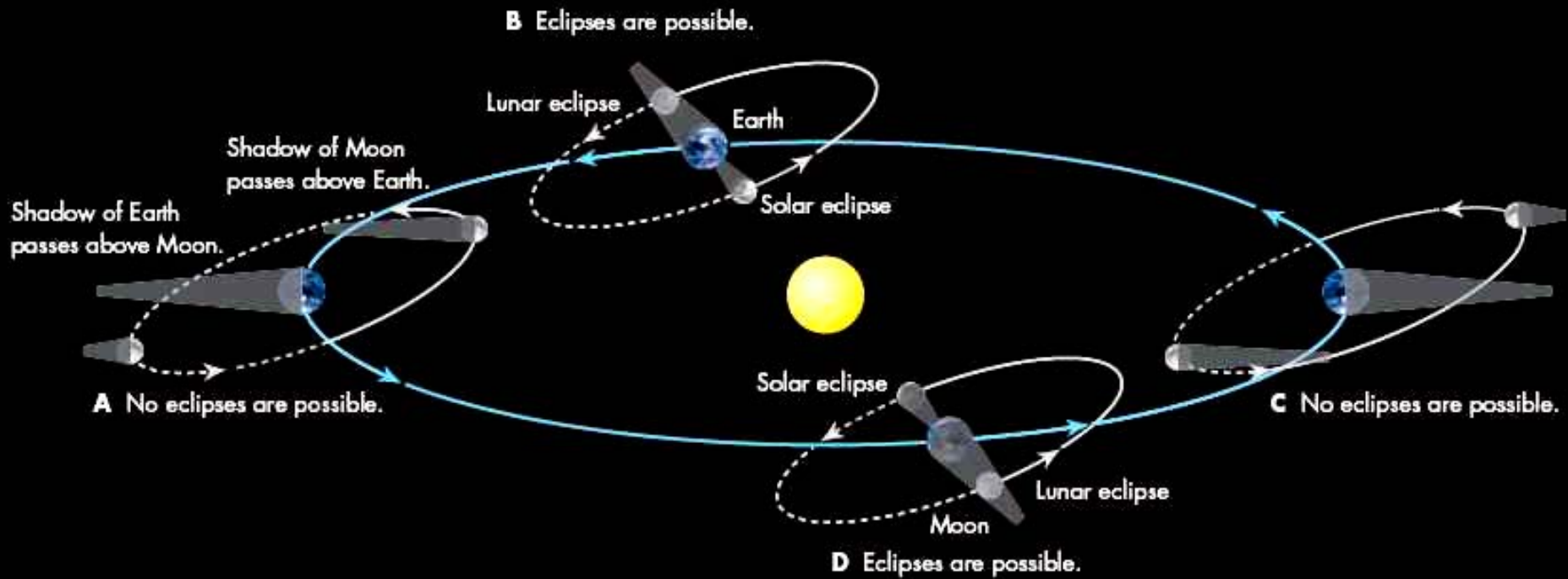
(b) Side view

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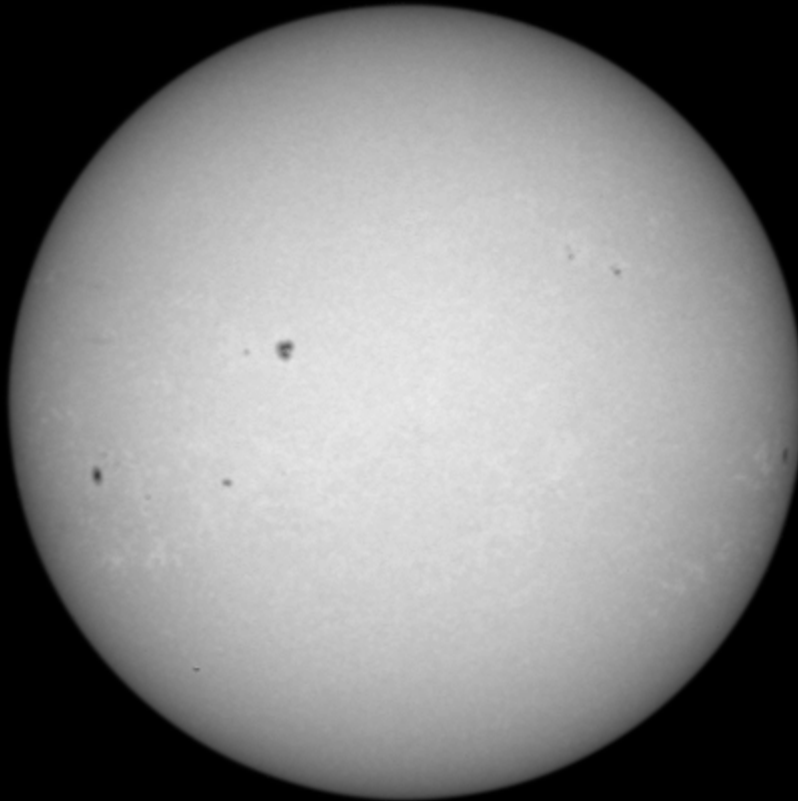
- If the Moon is within about 1° of the Earth's orbital plane (*the ecliptic*) while it is New or Full, we see eclipses

Eclipse Seasons

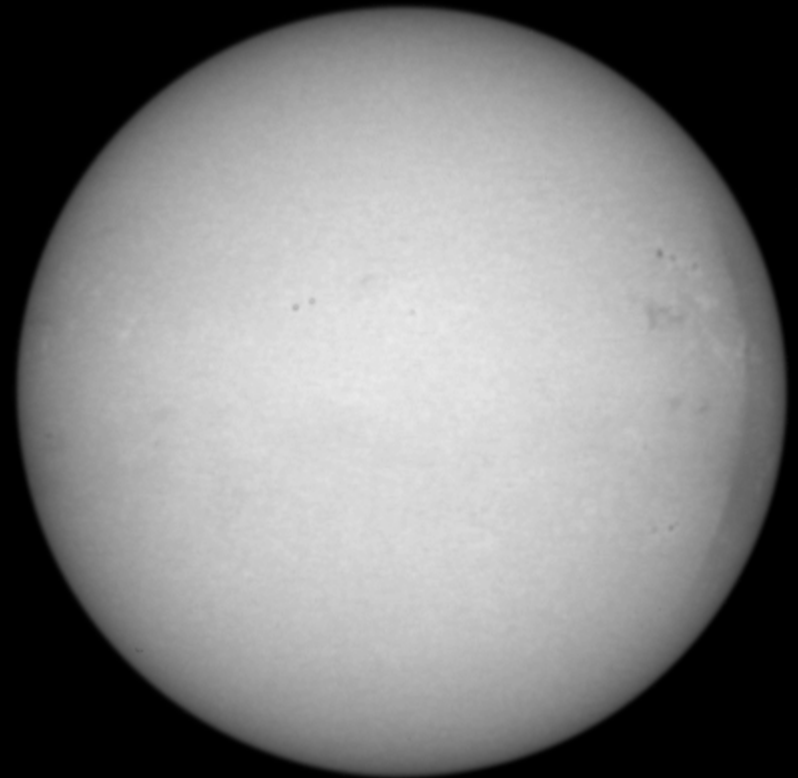
- Because the tilt of the Moon's orbit maintains about the same orientation in space, eclipses occur during two month-long periods, about 6 months apart.



The Sun in January vs July



1992/01/23 05:57:16.000



1992/07/21 14:39:43.000

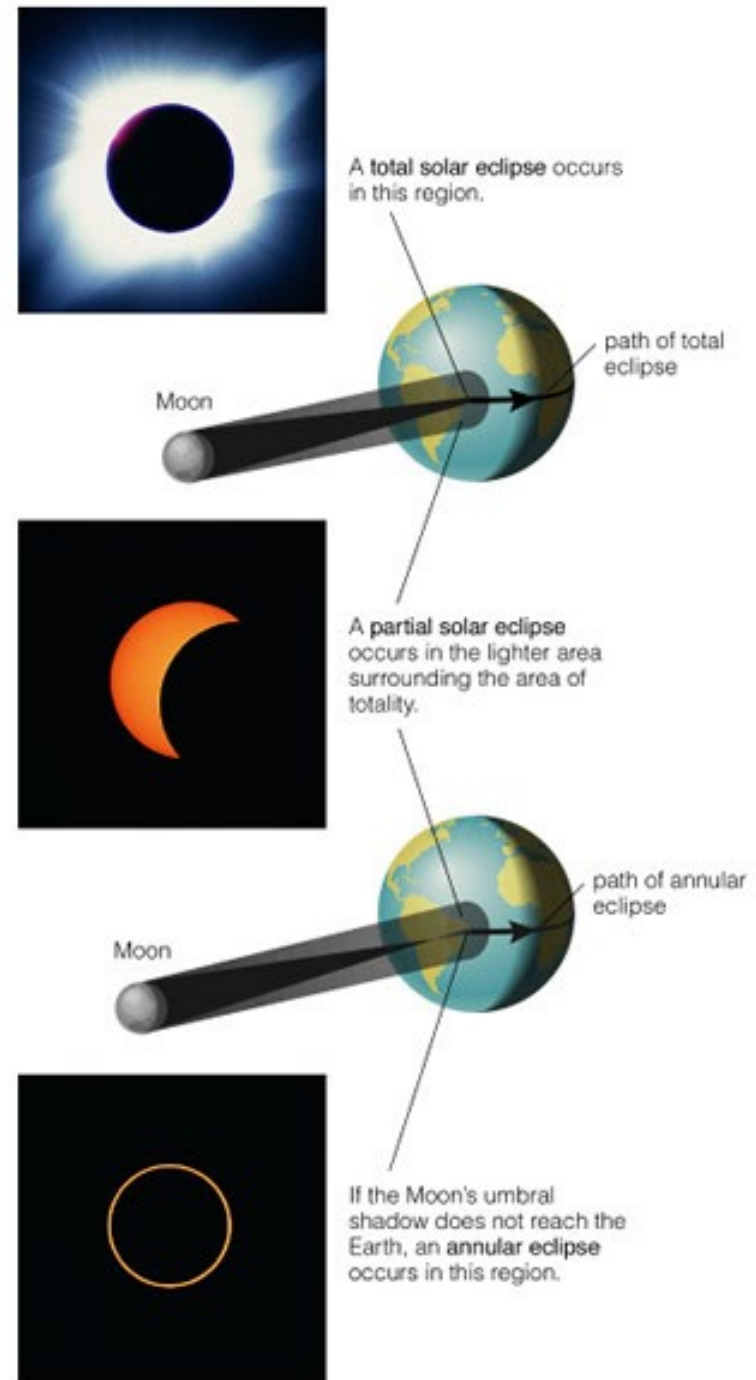
Types of Solar Eclipses

As mentioned earlier, the size of the objects involved in the shadowing are important for the appearance of eclipses, causing different types of eclipses.

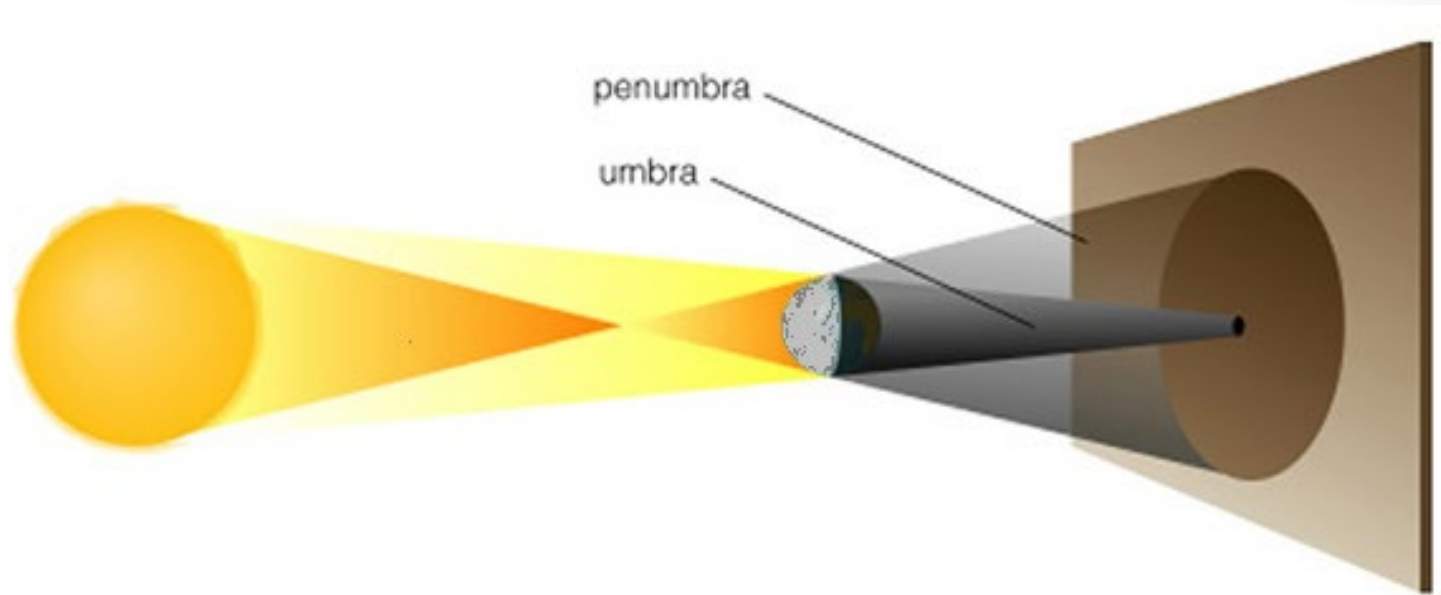
- Because Earth's orbit isn't exactly a circle the size of the Sun changes a little during the year
- The Sun's angular diameter is 32.7 arcmin on Jan 3, and 31.6 arcmin on July 4 (changes by 3.4%)
 - We can only have a total solar eclipse when the Moon is larger (angle) than the Sun
 - The duration depends on how much larger.

Types of Solar Eclipses

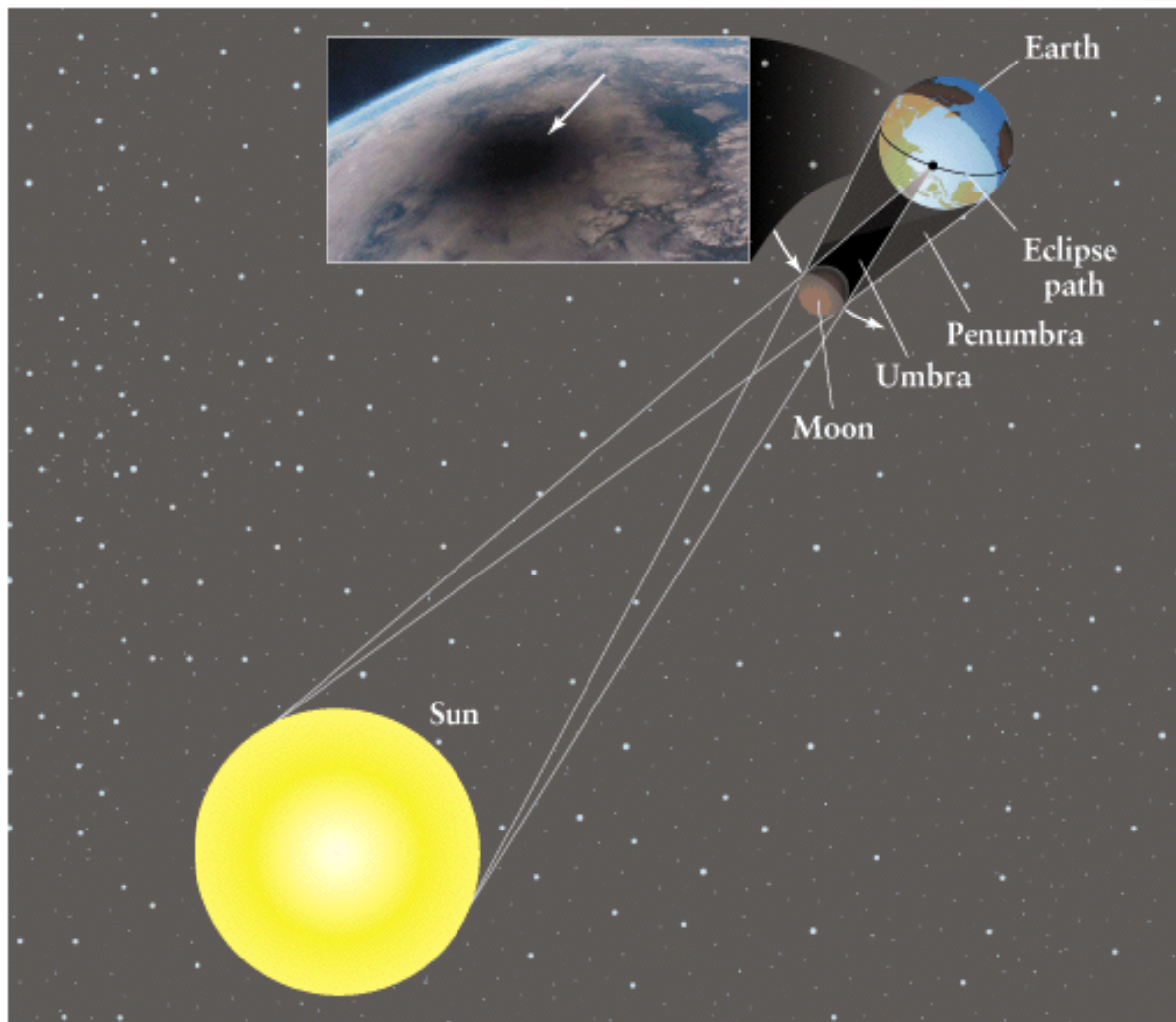
- If the Moon's angular size is larger than the Sun's it can cause a *total eclipse*.
- In a *partial eclipse* the Moon doesn't cover the Sun completely
- If the Moon is too small but passes directly in front we call it an *annular eclipse*.



Umbra & Penumbra

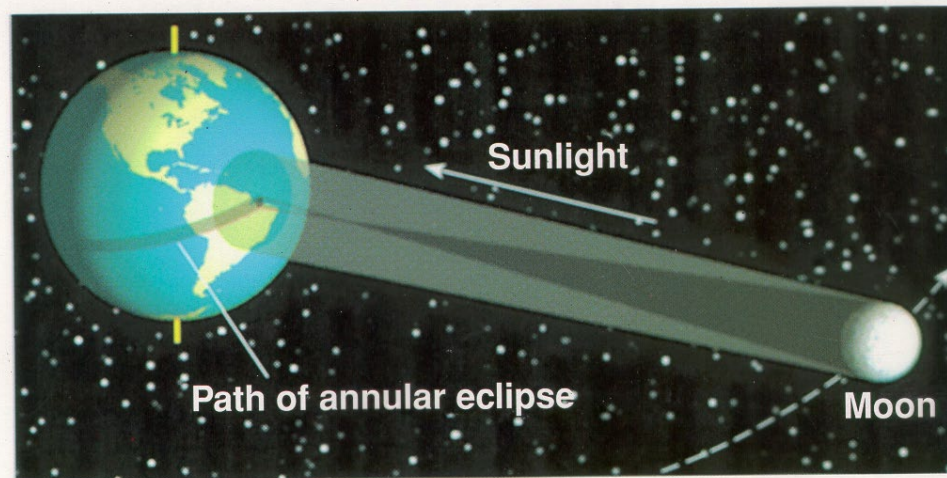
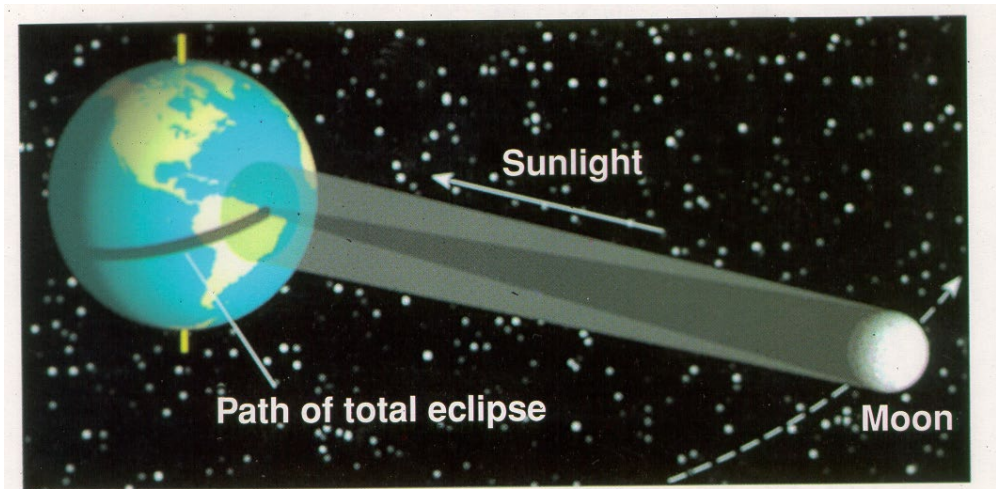


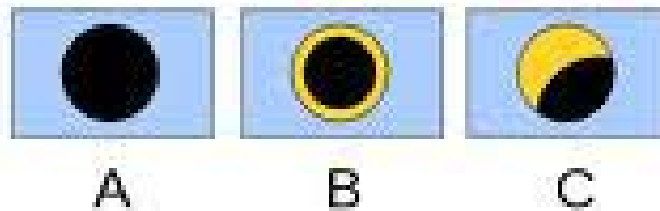
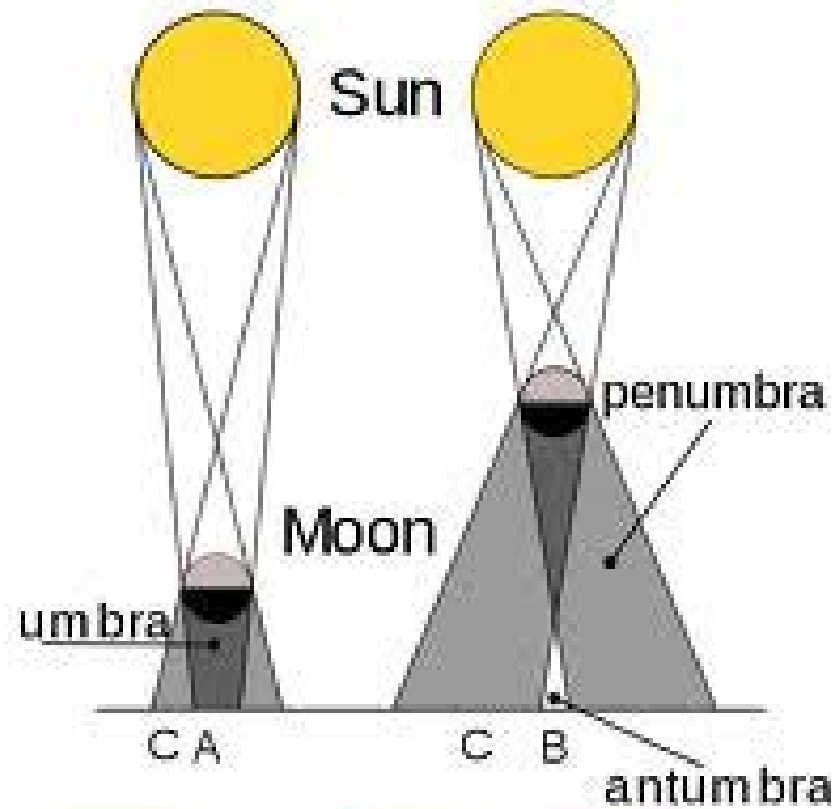
- Shadows have two parts
 - Umbra is the darkest part, where Sun is completely blocked
 - Penumbra is not as dark, since some of the Sun's light gets by



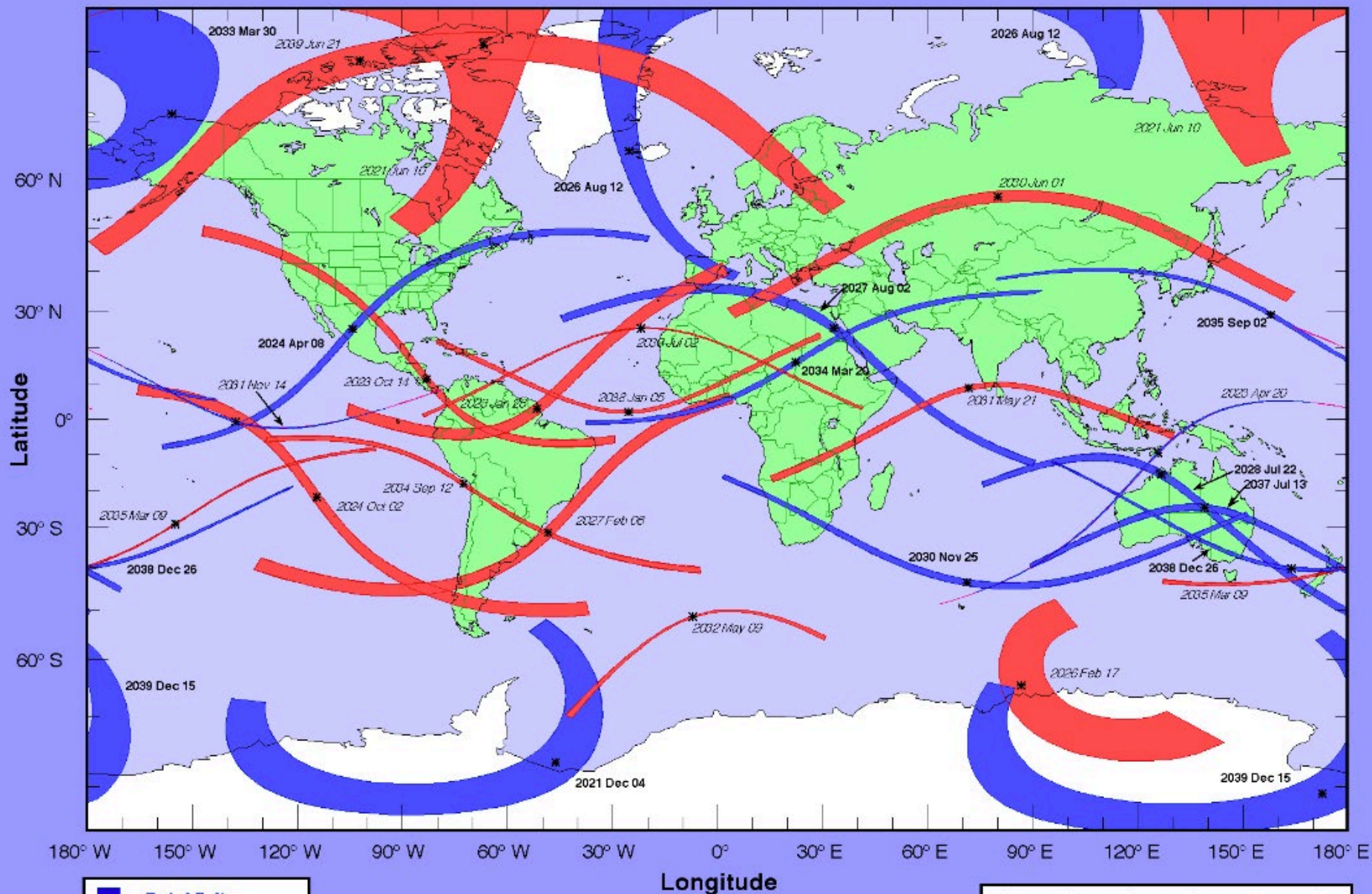
- The Umbra determines the path of totality, and Penumbra partial eclipses.

Total vs. Annular eclipses

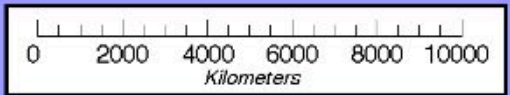




Total and Annular Solar Eclipse Paths: 2021 –2040



- Total Eclipse
- Annular Eclipse
- Hybrid Eclipse





ABOVE THE
CLOUDS

RING OF FIRE SOLAR ECLIPSE

OCTOBER 14, 2023



Annular Eclipse



- During an annular eclipse solar beams turn into rings of light
 - Look at the rays of light beneath a leafy tree
 - Use your fingers to create a waffle pattern



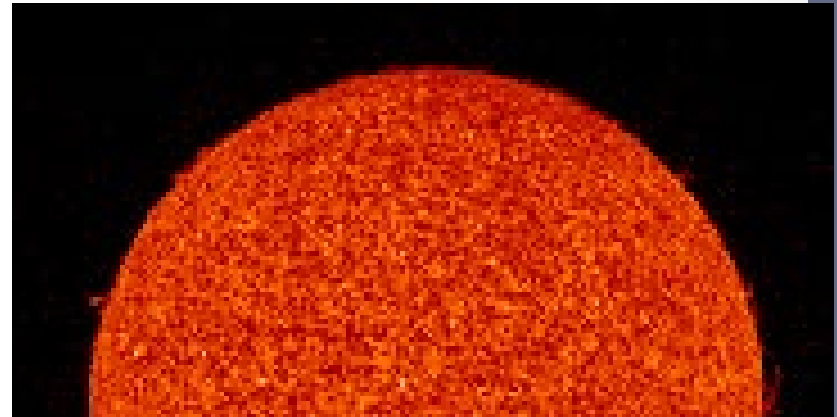
Photosphere

- $T=5,800$ K, depth 400km
- The yellow “surface” we see
- Looks like a surface because visual-wavelength photons cannot move far in an ionized gas with this high density
- It has MUCH higher surface brightness than outer parts of Sun



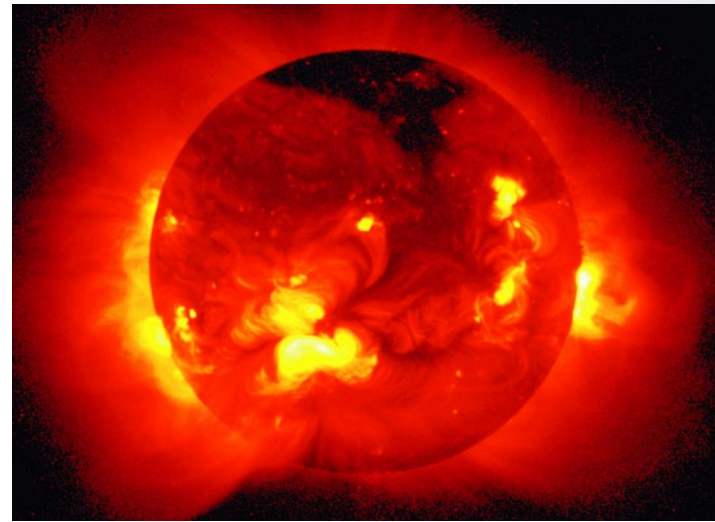
Chromosphere

- $T=1-5 \times 10^4$ K, depth 2500km
- A thin layer above the photosphere where most of the Sun's UV light is emitted
- Top: UV image of the Sun light emitted from neutral Helium at 20,000K
- Bottom: Visible light image of the Sun during a total solar eclipse



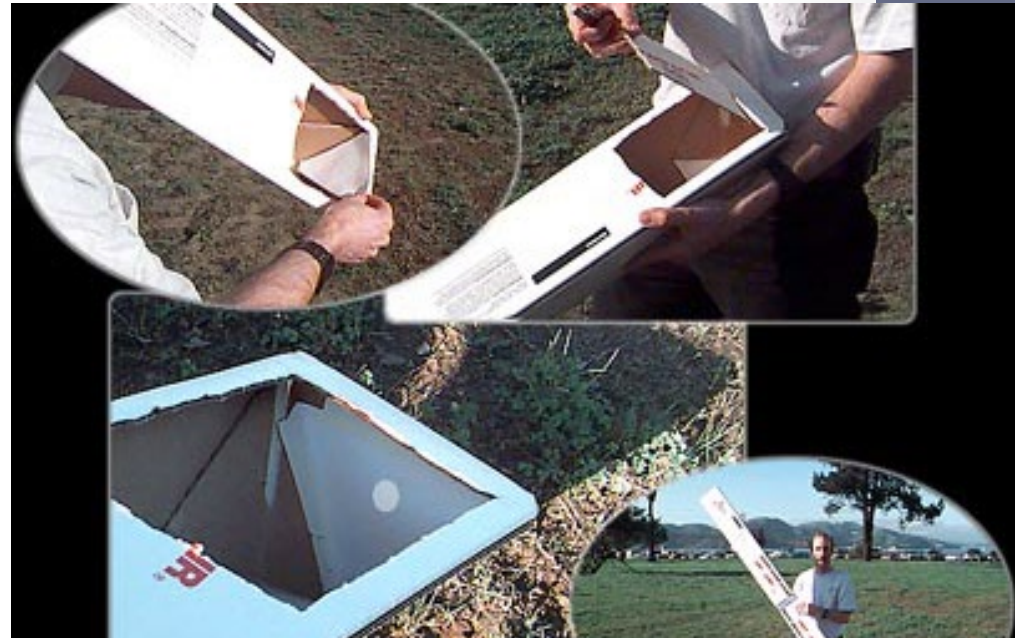
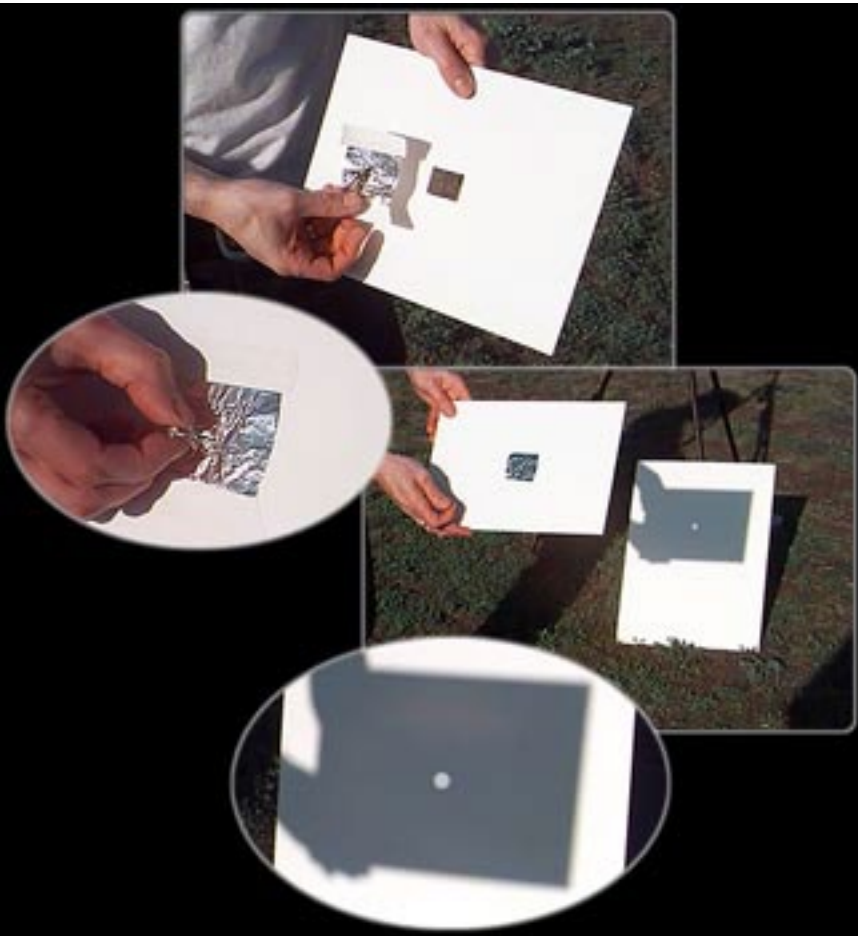
Corona

- $T=2 \times 10^6$ K, depth 600,000km
- Very hot, thin gas which surrounds the Sun.
- Top: X-ray image (YOHKOH telescope)
- Bottom: Visible light image during a total solar eclipse





Pinhole cameras



<http://eclipse.unm.edu/>

More lectures

- Astronomy on Tap, TBD