Solar Eclipse 101

Rob Hendricks

Presented at the Beaufort Branch Library on July 26, 2017

What we will cover

1. Introductions/expectations?
2. What is an eclipse?
   - Eclipses, transits and occultations
   - The difference between a Lunar eclipse and a solar eclipse
   - How does an eclipse happen?
3. What can I expect to see?
4. Eclipses in history
5. Why are eclipses important to us today?
6. So.. what will we see from Beaufort?
7. How to view the eclipse

Who am I?

- Forester by trade
- Long time interest in astronomy
- Seen three total eclipses and a few partials

My Objective

- Further interest in science

Who are you?

Will our dogs need to be protected?

2016_Eclipse

What is an eclipse?

- When an **astronomical object is temporarily** obscured by–
  - Passing into the shadow of another body, or
  - Having another body pass between it and the viewer.
- Solar eclipse -- Moon in front the sun -- partial/total
- Lunar eclipse --Earth in front of the sun (seen from Earth) – partial/ total
- Other commonly observed "eclipses"
  - Planetary eclipses e.g. Jupiter
  - Stars in other solar systems
  - Asteroid/moon occultations
  - Transits

Labels all depend on where you're standing, tradition, size of the objects, or the location of your space ship

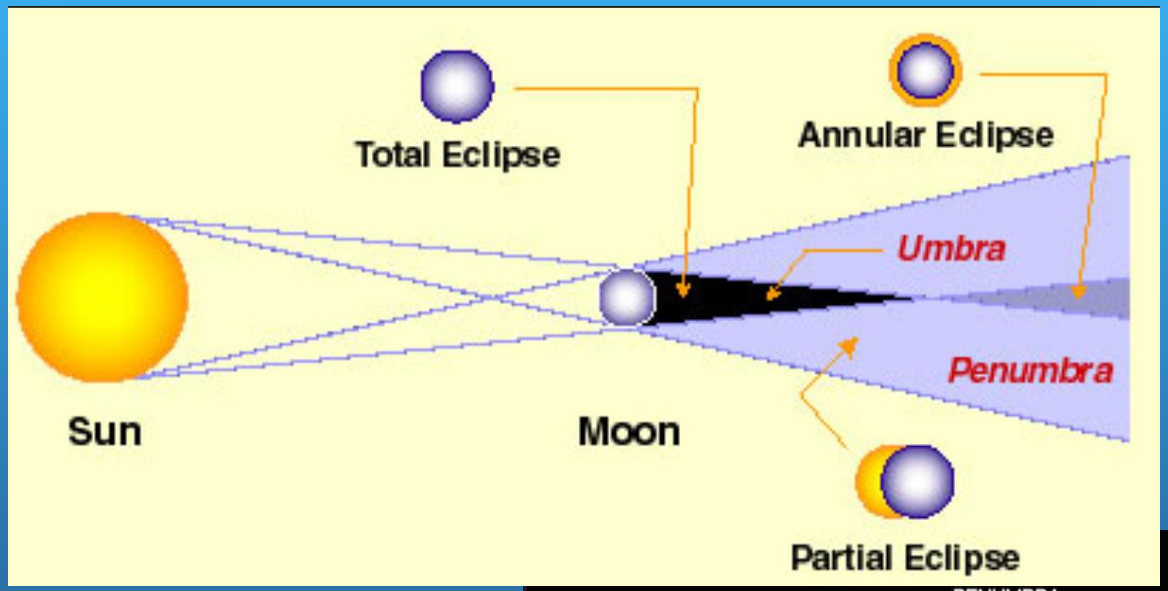
Standing on Earth

- Eclipses refer to the moon, sun and moon plus shadows on planets
- The words transit and occultation are specialized eclipse terms

Dispelling the Mystery

It's nothing but a shadow!

Different kinds of shadows -- eclipses

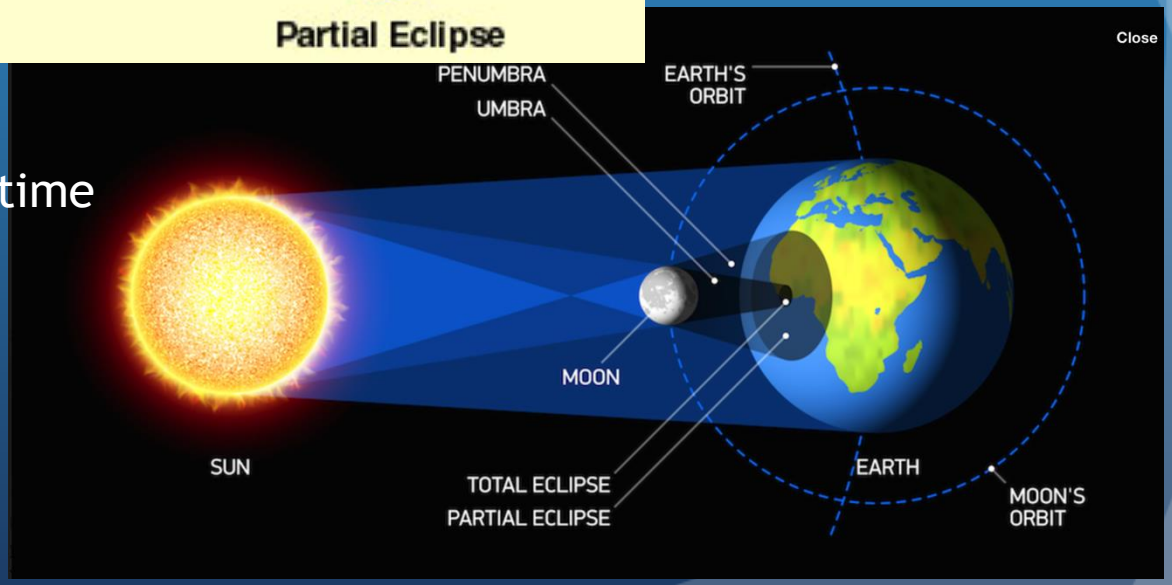


Total,
Partial,
Annual

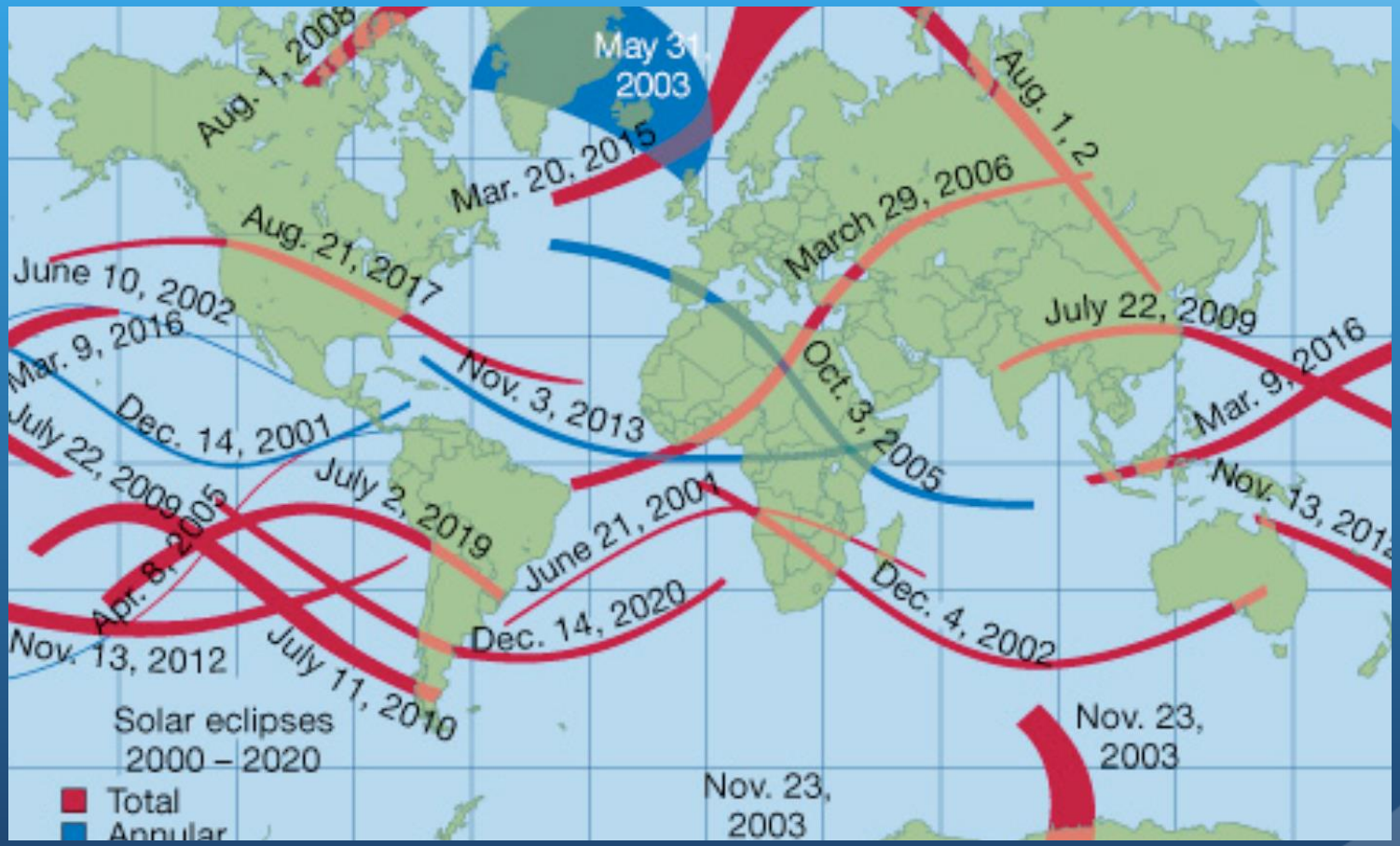
Solar eclipses happen during a new moon – daytime

½ of 1% of the earth is under the path of the totality shadow

Every 18 months – not rare

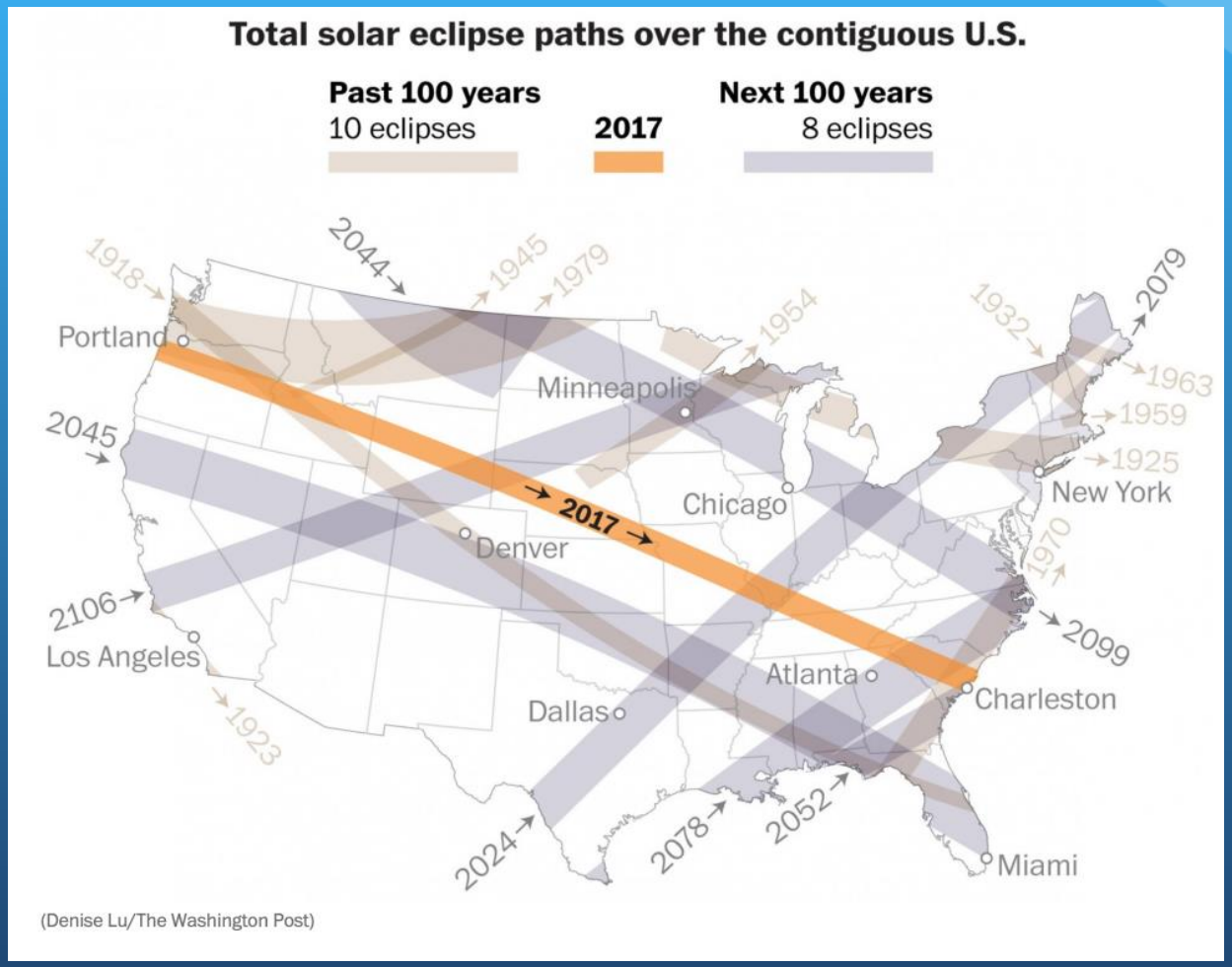


Recent and future Solar totality tracks



Most are over water!

Totality tracks in the U.S.

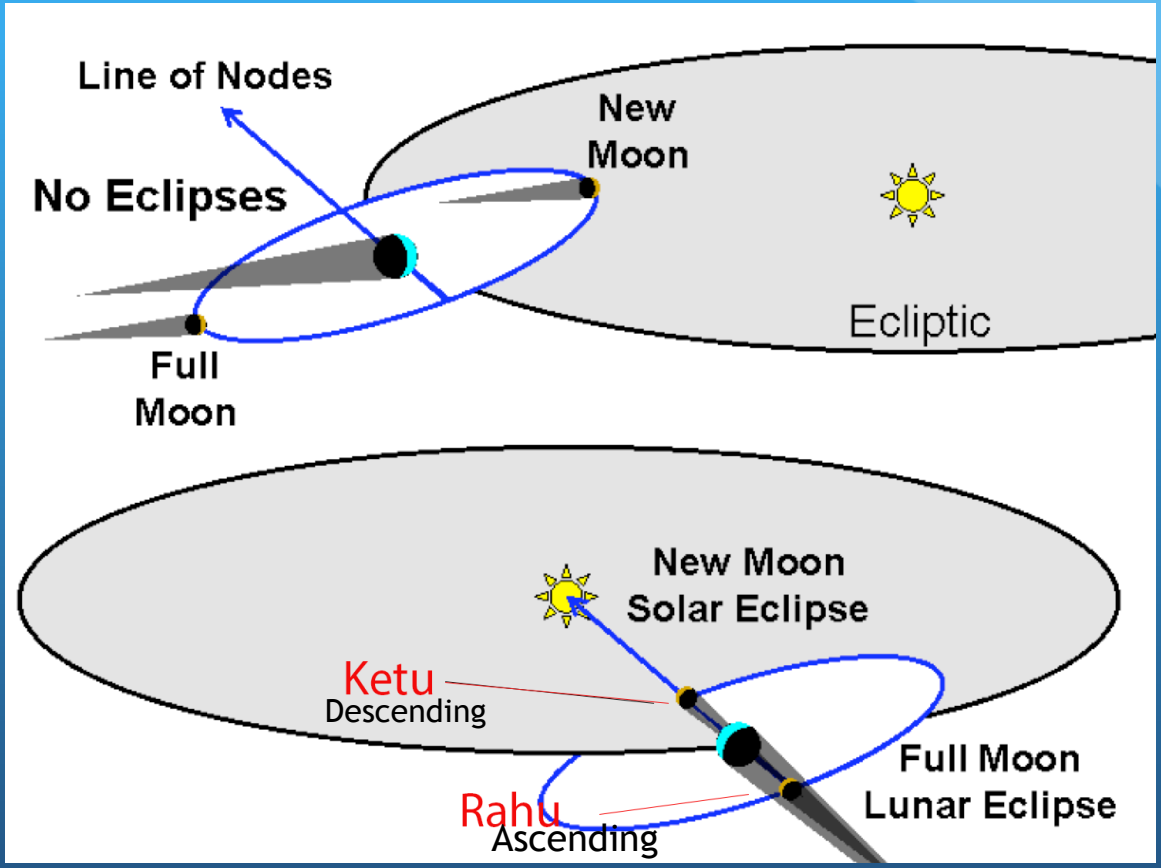


Notice the width of the tracks

70 miles wide running at 2,000 MPH

First entirely U.S. solar eclipse since the American Revolution

Why not every month?



Moon's elliptic must cross Sun's elliptic, called ascending and descending nodes

Hindu sacred texts call these nodes Rahu and Ketu

Interesting footnote

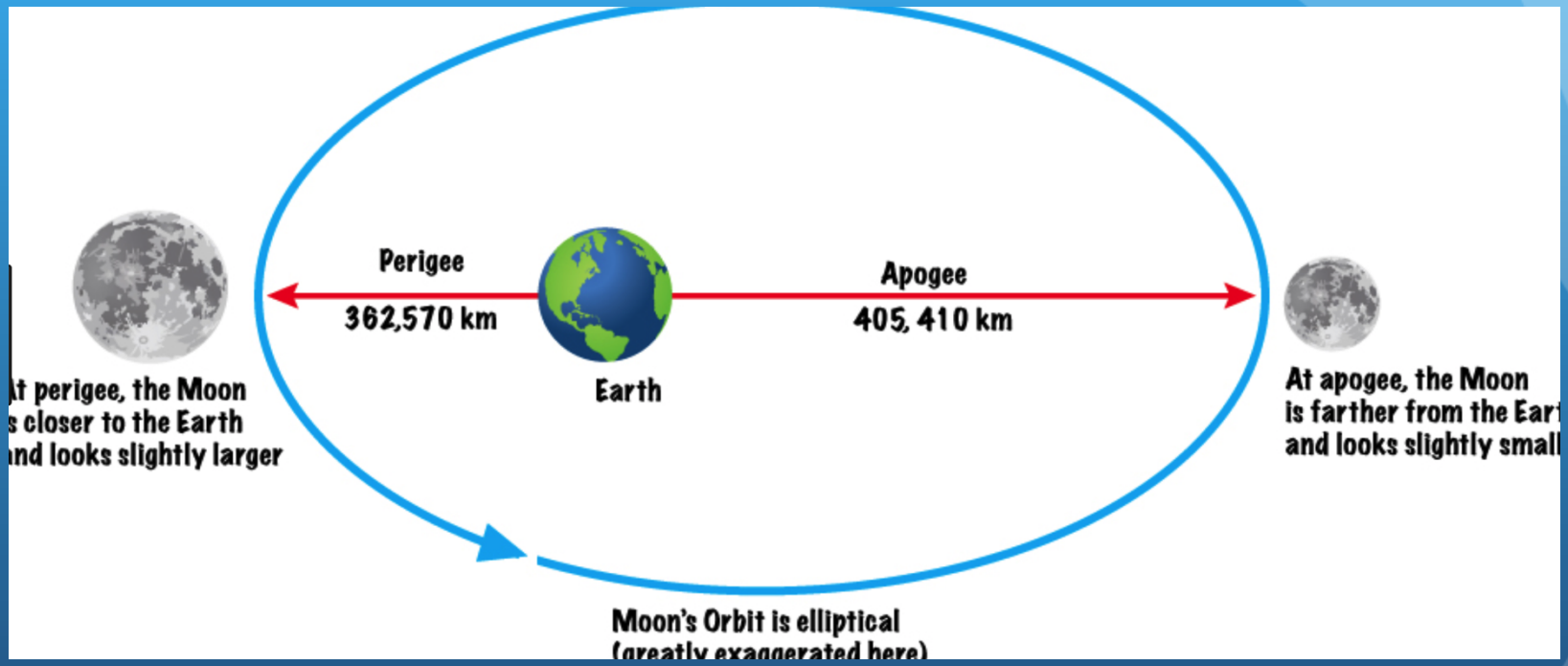
- Rahu and Ketu are 2 gods, or houses
- These intersections of Earth and Moon's orbits (nodes) create areas of electromagnetic disturbance
- The line between the nodes form the Hindu karmic axis

  --Indicates the types of karmas to be experienced for each person.

  --Areas of life that you will focus on, or strive for perfection

Rahu eating the sun

Why do we have annular eclipses, “fat” or narrow tracks?



The moon’s orbit is not circular

Size of cone depends of noon’s distance from Earth

The moon is receding from the earth, distant future no total eclipses

What's the difference between an eclipse of the moon and an eclipse of the sun?

- Lunar eclipses are more common
- Lunar eclipses are seen at night
- Solar eclipse's are seen during the day
- Total solar eclipses are much more spectacular events

The American Astronomical Society -- "the most gorgeous natural wonder you will ever see.

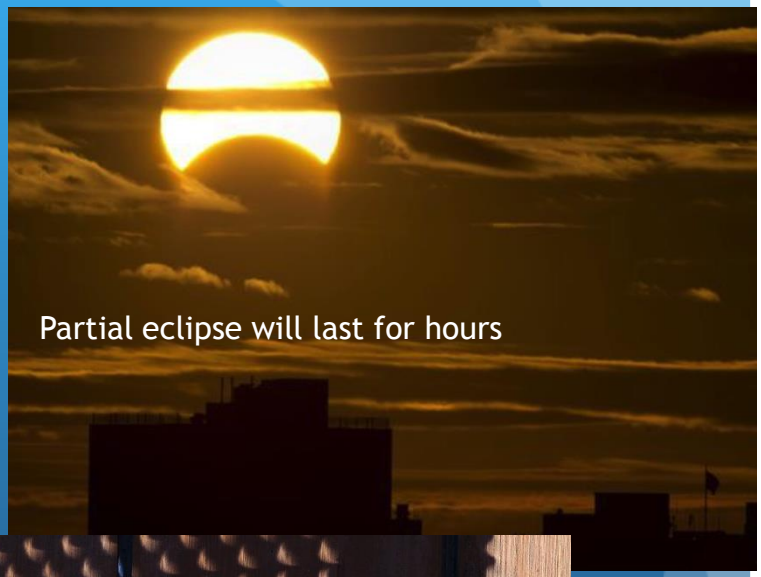
If it strikes you hard enough, you will never be the same."

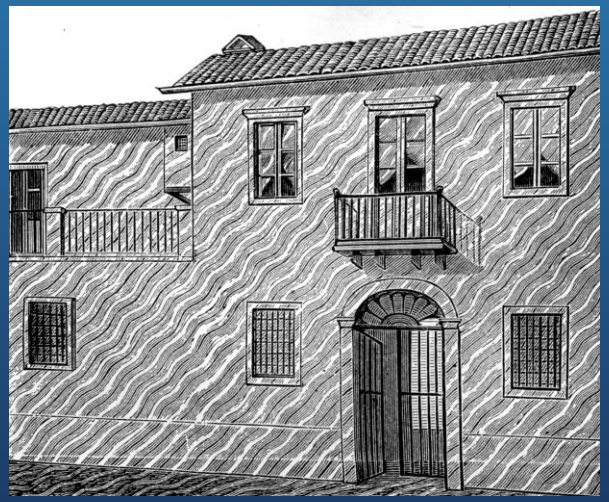
Get on with it—

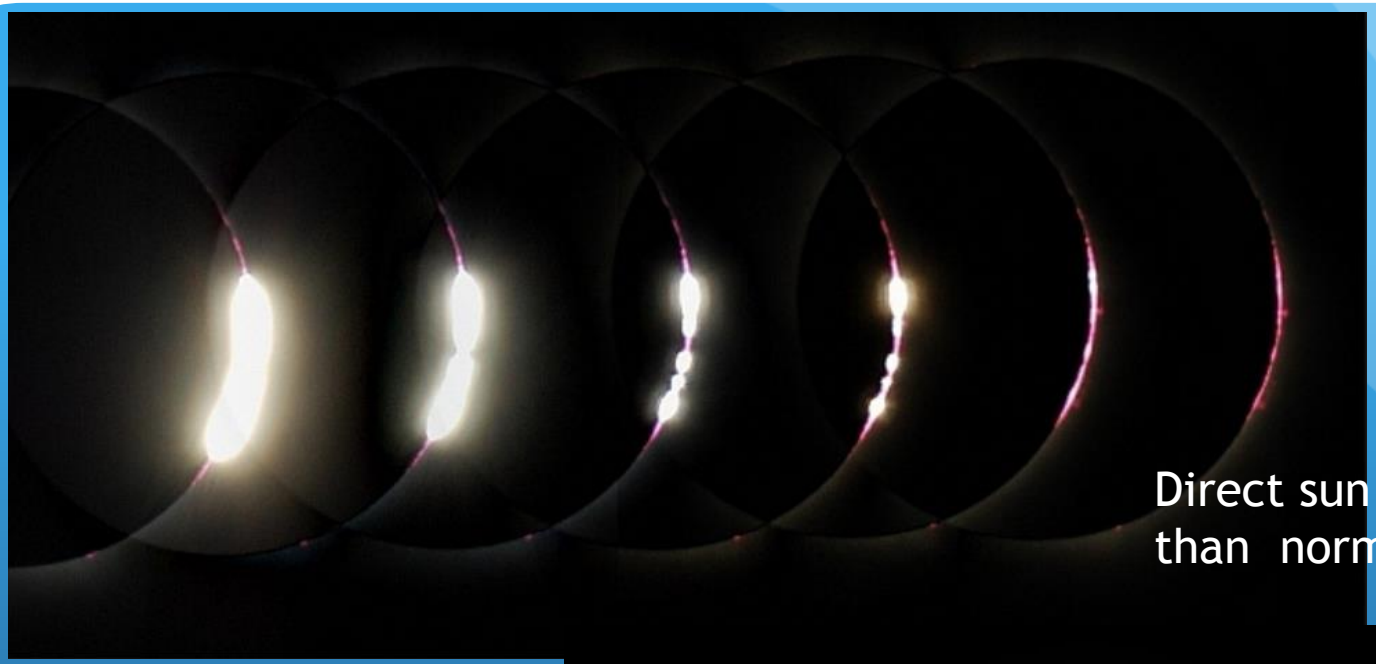
What will we see???

Eclipse of the sun - what we'll see

--Growing odd mystical light -- partial eclipse
--On a mountain top see the approaching shadow
--Feel the temperature drop
--Wind?
--Sharp shadows and pin hole camera effects
--Shadow bands
--Baily's Beads
--The Diamond ring
--The Sun's corona!!







Baily's Beads

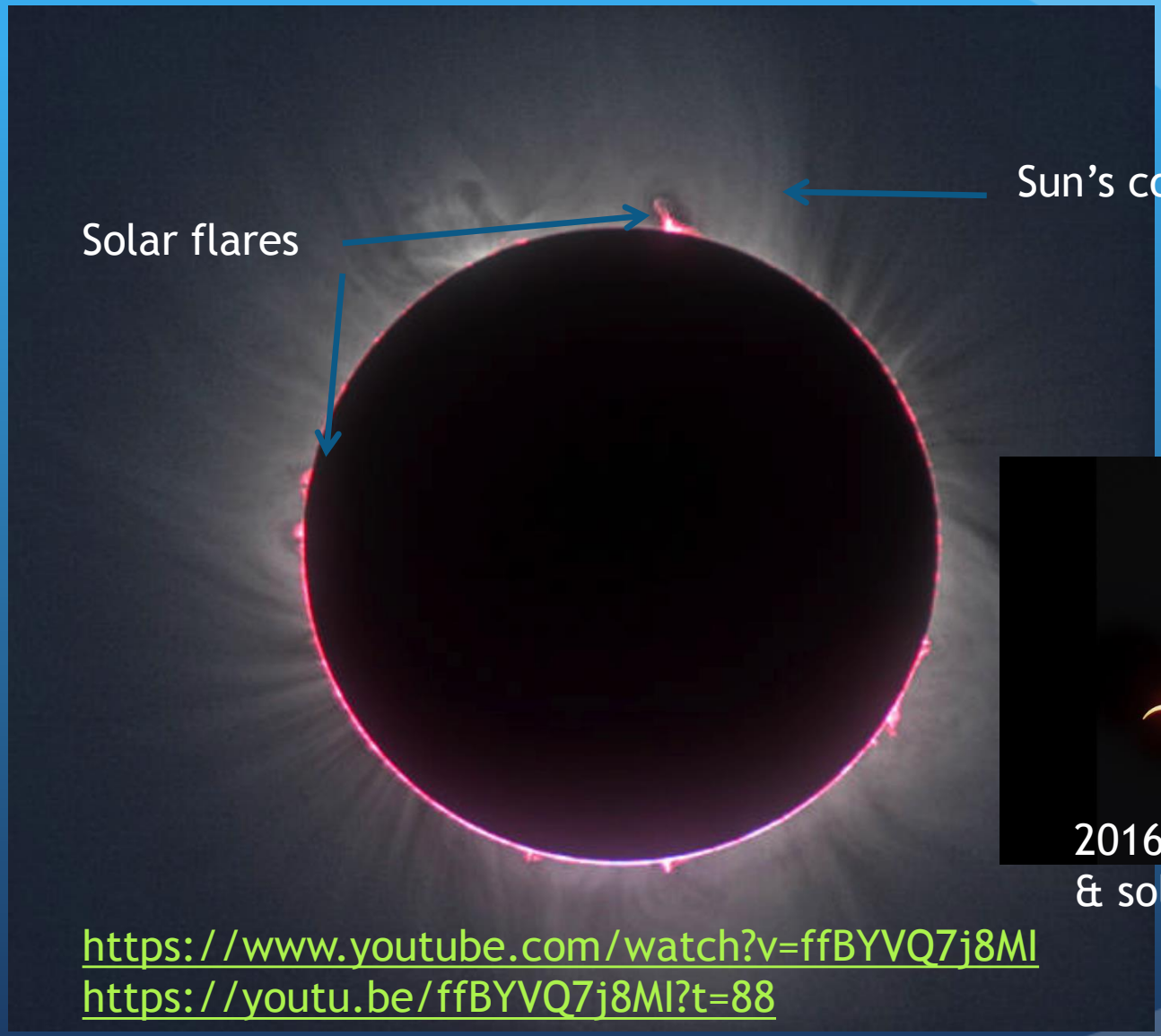
Direct sun is million of time
than normal objects!

Sun coming through the moon's valleys
- just before totality

The Diamond Ring

Coinkidink: The sun and moon are the same size because the sun is 400 X moon's size but 400X further away

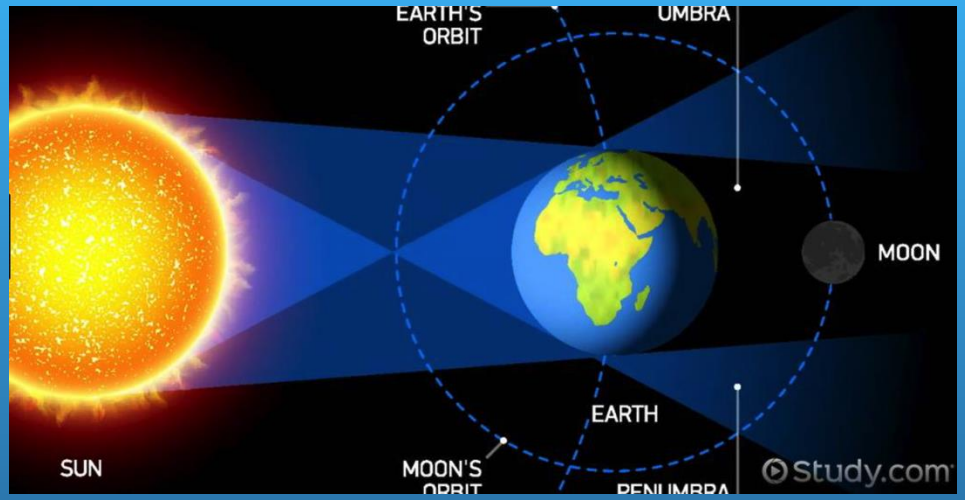
Totality!

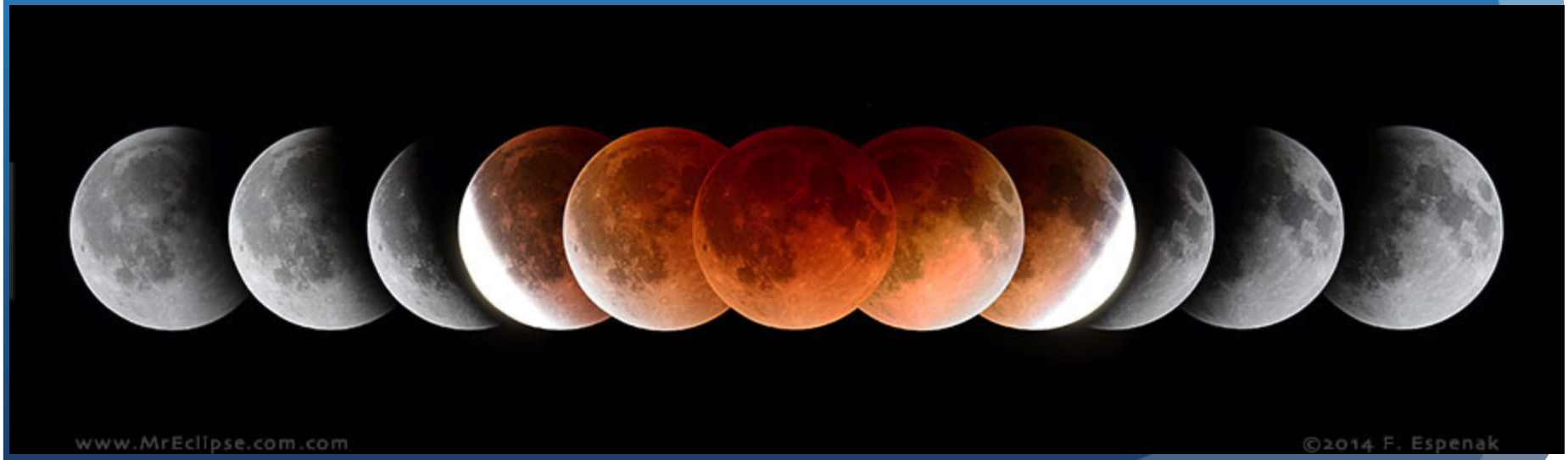


2016 -- my picture, 50 mm & solar filter

https://www.youtube.com/watch?v=ffBYVQ7j8MI
https://youtu.be/ffBYVQ7j8MI?t=88

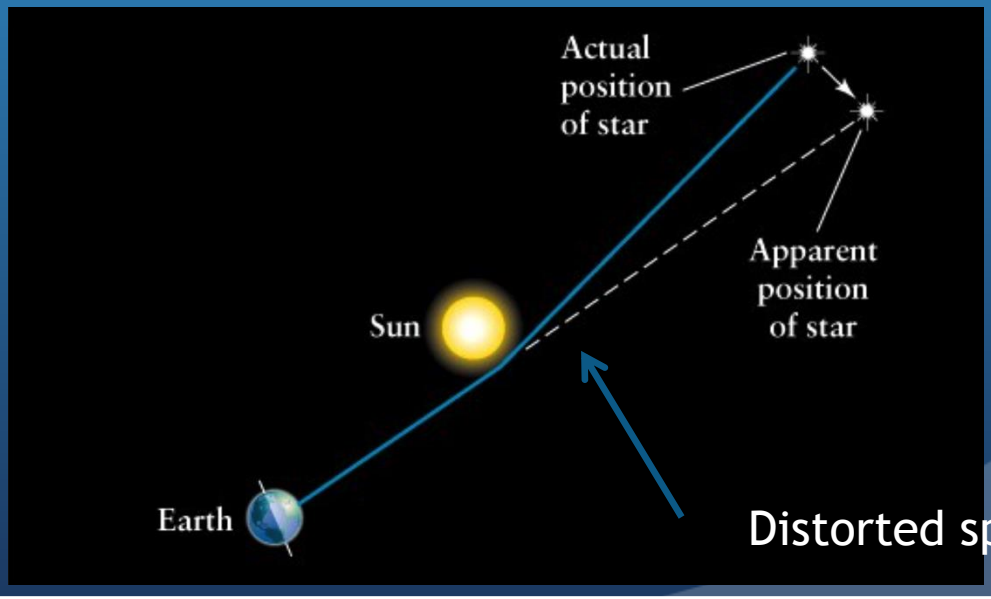
Eclipse of the moon





Importance of eclipse science

- Understanding:
- The Sun's corona – Solar weather, satellite communication, power grids, cell phones
- The Moon's orbit
- The Earth's ionosphere
- First proof of Einstein's theory of Relativity
- Etc.



Distorted space/time

Importance of Lunar eclipse science

A little eclipse history

In many cultures, the solar eclipses involved mythical figures eating the sun or angry or quarreling gods

- e.g. Rahu
- Homer, 1178 BC-- and the Sun has perished out of heaven, and an evil mist hovers over all."
- **Old Testament, Amos 763 BC --** "On that day, says the Lord God, I will make the sun go down at noon and darken the earth in broad daylight."

Also great ancient understanding

Pliny, 50 AD -- "Consequently inhabitants of the East do not perceive evening eclipses of the Sun and Moon, nor do those dwelling in the West see morning eclipses, while the latter see eclipses at midday later than we do.. . . this was because the curve of the globe discloses and hides different phenomena for different localities."

Eclipses, transits and occultations

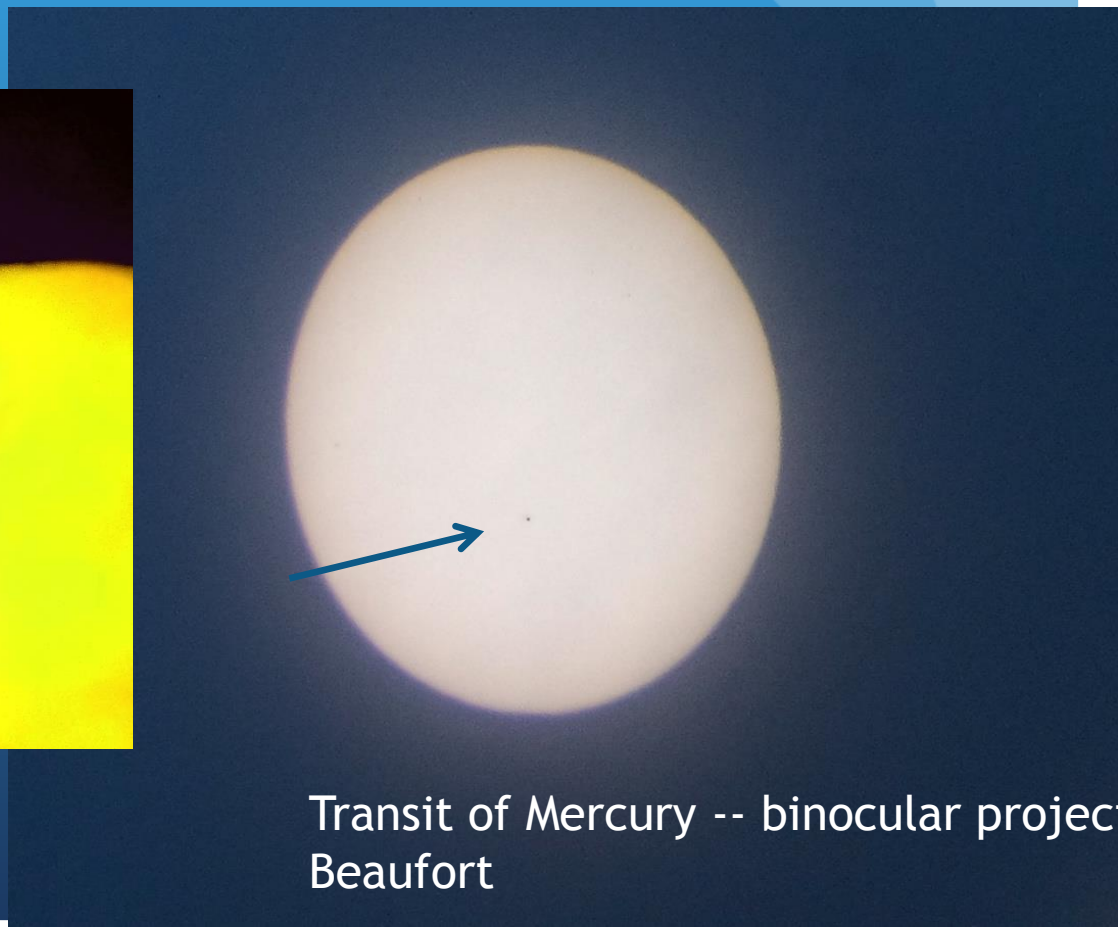
- There are also “eclipses” of stars, moons, planets, asteroids -- all fascinating and useful to science
- Word “eclipse” used arbitrarily or not at all.

Jupiter -- multiple solar eclipses/transits viewed from Earth.

Timing of Jupiter’s eclipses, and “apparent” delays, allowed calculation of the speed of light

Transit

- To pass across or through e.g. transit of Venus or Mercury



1769--Famous transit of Venus -- Captain James Cook

Mission – determine the size of the solar system

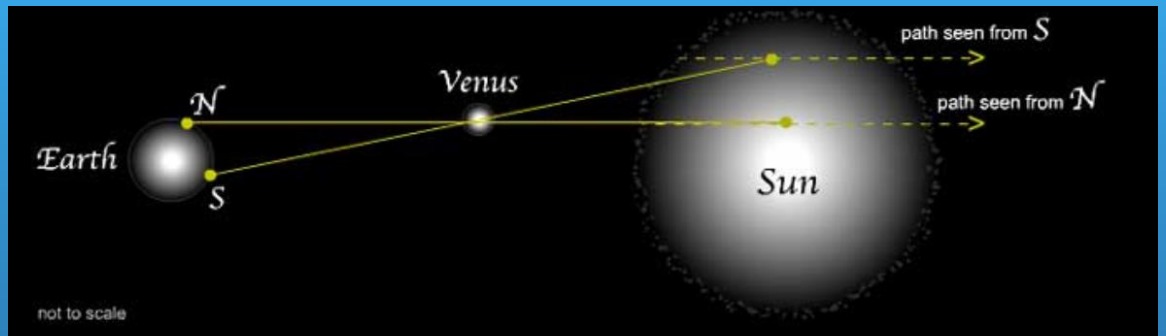
--1769

--Three year voyage

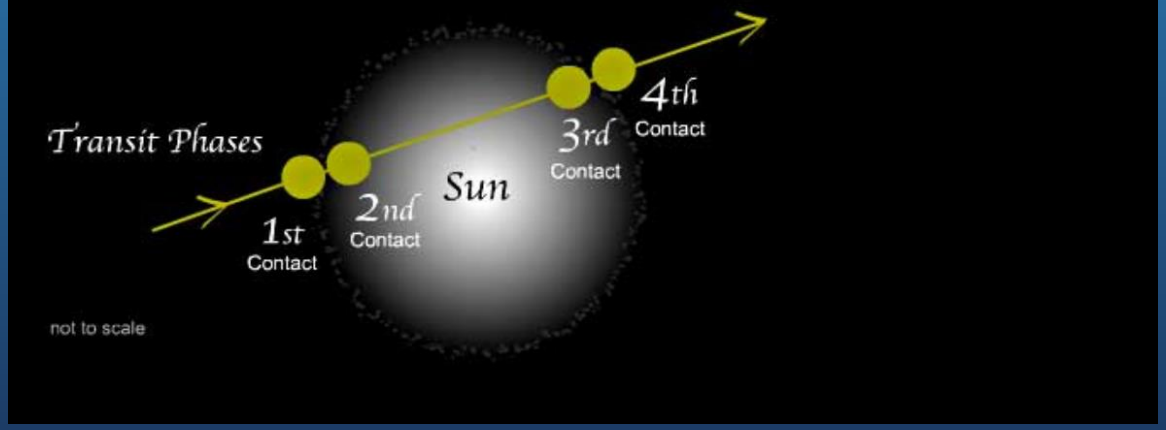
--Island of Tahiti

--Cultural heritage of the South Pacific

Until the transit of Venus, science only knew the relative distance between the planets, measures as a % of the distance to the sun. Distance to the sun was “1”.



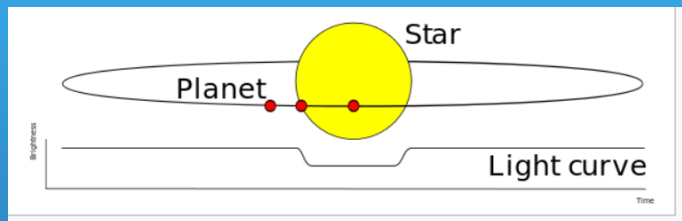
Because we see the Sun as a circle, these two different paths will have different lengths. Halley proposed that an easy way to measure the difference between the lengths of these two paths would be to time the transits, using the four phases of the transit—the first, second, third, and fourth contacts—as indicators.



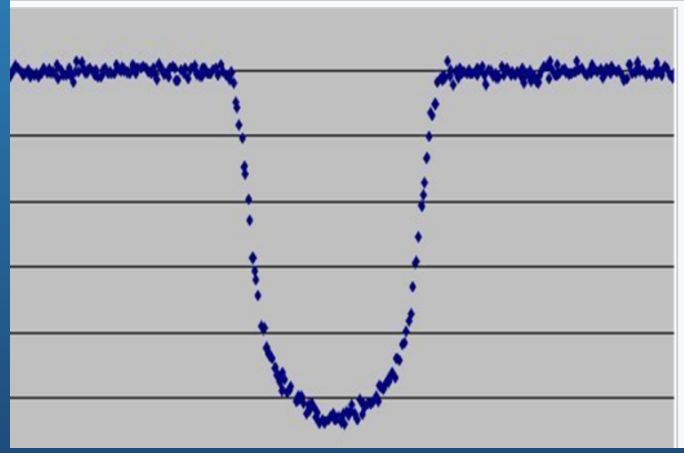
Multiple observers measure the timing of Venus’ passage across the Sun.

Use trig to figure it out.

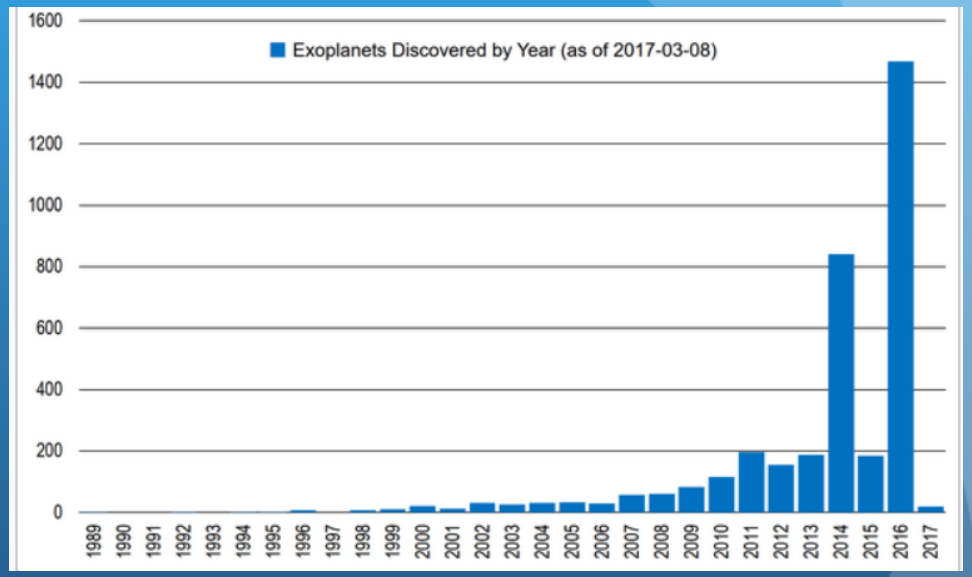
Transits of stars – discoveries of new solar systems/planets



Transit method of detecting extrasolar planets. The graph below the picture demonstrates the light levels received over time by Earth.



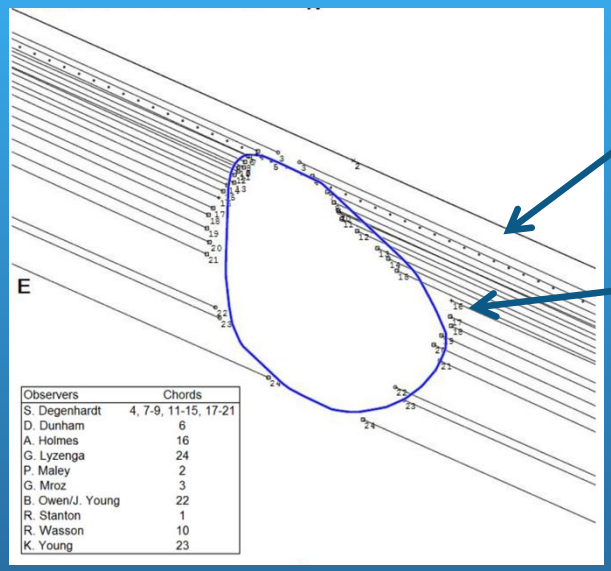
Growing no. of discovered planets



Light change detected by sensitive photon sensors – e.g. digital cameras

Occultation -- occurs when a solar-system body passes in front of a more distant object (star)

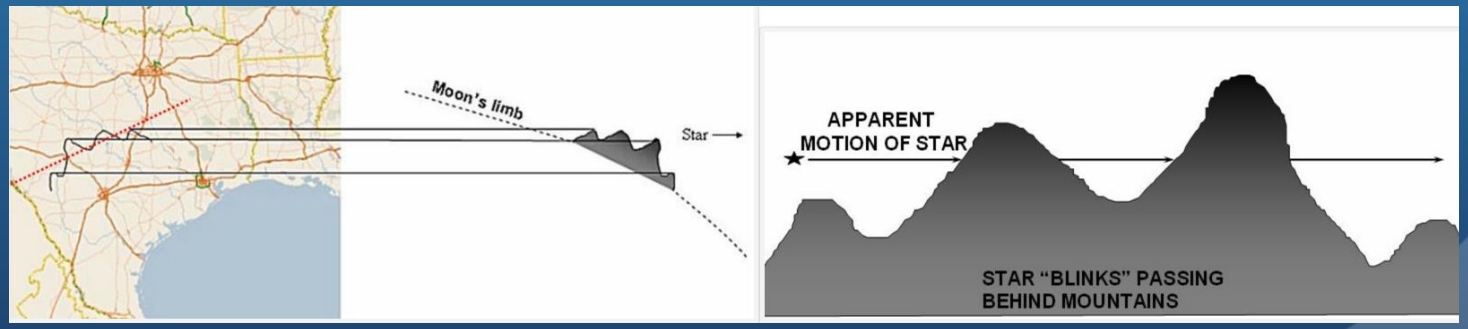
Determining an asteroid's speed, distance, location and shape



Observed background star track

Time star disappears

Different lines are different angles to Earth observers



Measuring the height of Lunar Mountains

So…what can I see from Beaufort?

You will see a partial eclipse, unless you travel

How to view the eclipse – common sense/equipment?

- Do not look at the partial eclipse with out solar viewers!
- It is OK to look at the total eclipse -- after and before Baily's Beads
- Sun filters on cameras, binoculars and telescopes!!!
- "The faculty of sight cannot resist it (the Sun's rays), which can inflict a painful injury. If one continues to look at it, one's sight becomes dazzled and dimmed, so it is preferable to look at its image in water and avoid a direct look at it, because the intensity of its rays is thereby reduced . . . Indeed such observations of solar eclipses in my youth have weakened my eyesight." al-Biruni, *Kitab Tahdid* (1025)

Equipment

--Your brain -- common sense!
--Pinhole projector
--Binocular projector
--Solar screen on all cameras, binoculars and telescope
--Filters attenuate the sun to 1/1000 of 1% of full intensity

--Baader Planetarium has moved beyond Mylar and designed a specialty "solar safety film", which is a high-strength polymer metallized on both sides.

When’s the last time you looked at the Milky Way?