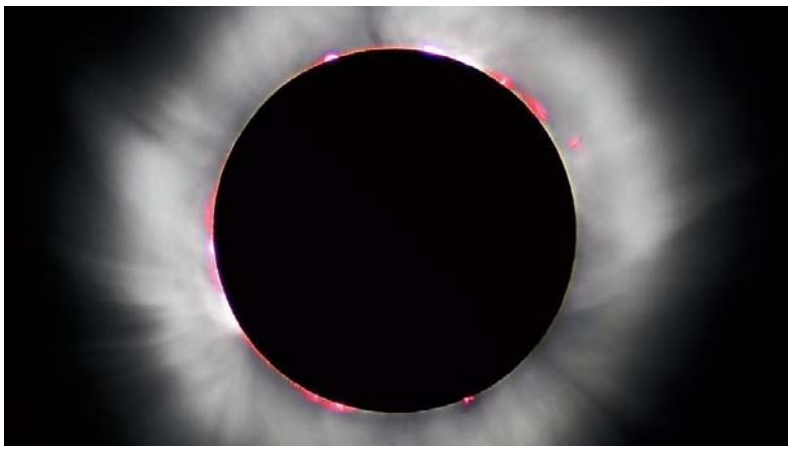
The Great American Solar Eclipse

Collection of weblinks on eclipse at https://physicsweb.creighton.edu/

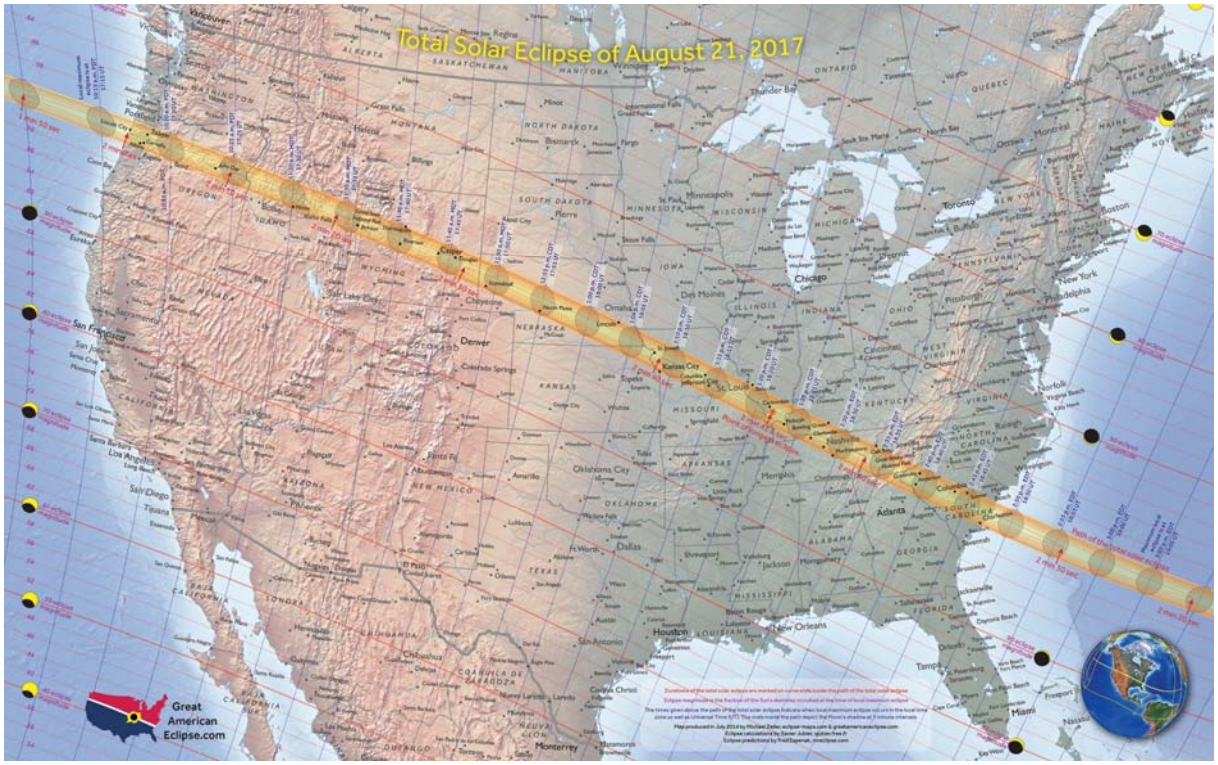
Overview:

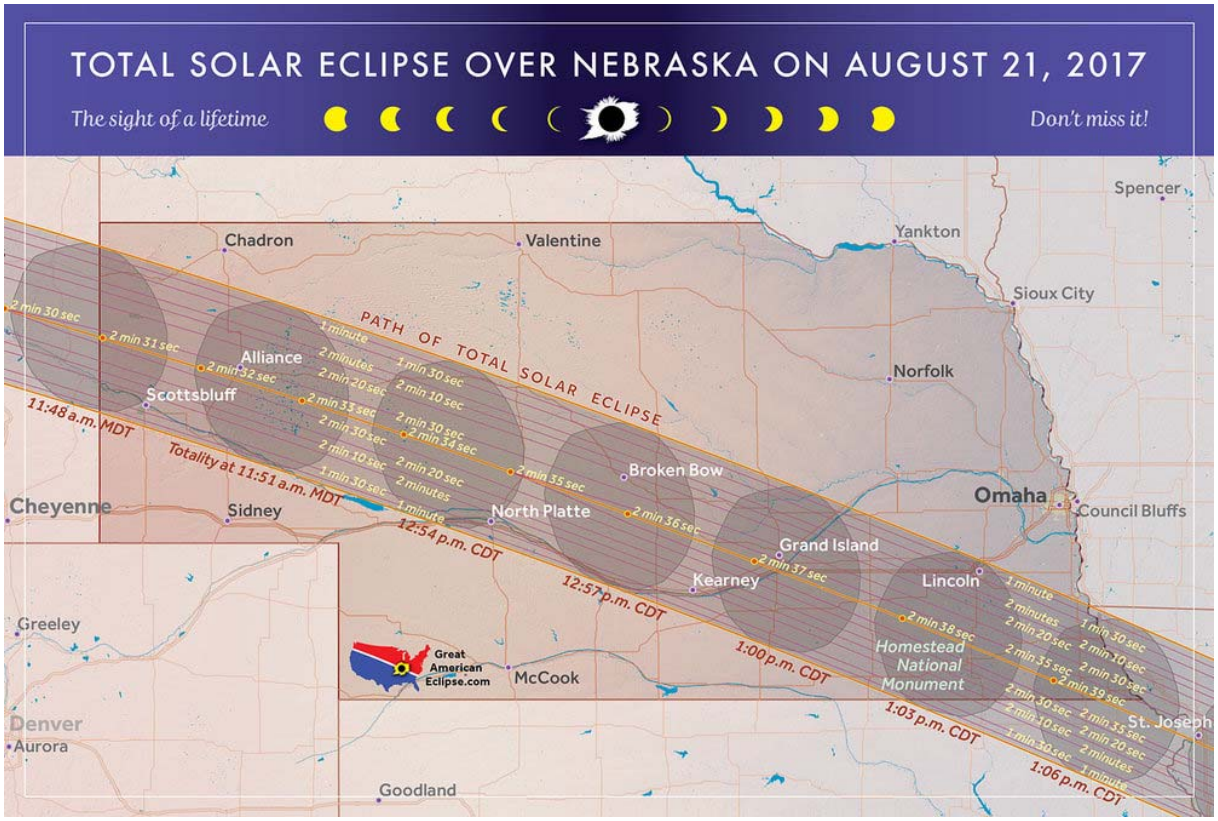
- What you can expect to see and where to see it.
- Why eclipses are so rare and spectacular to see (astronomy behind eclipses)
- How to SAFELY view the eclipse
- Assorted things that make eclipses really cool!



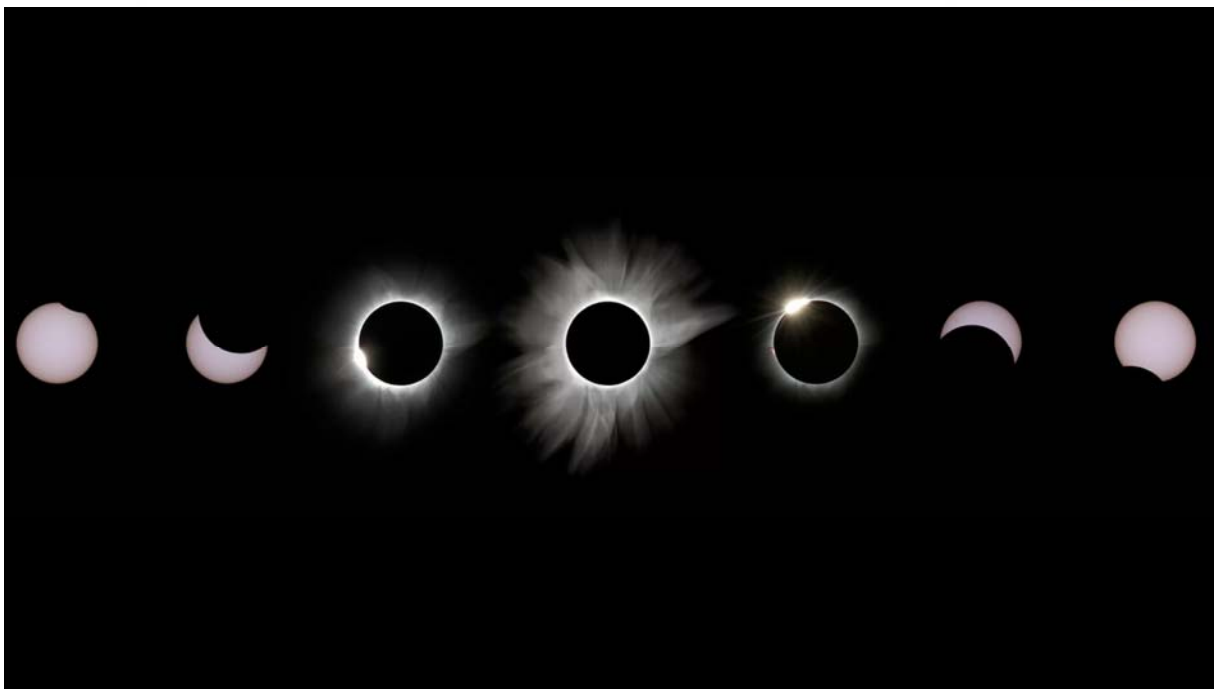
What will you see?

- It depends on WHERE you are viewing from and WHEN you are viewing.
- **Total Solar Eclipse**: visible ONLY within the ~70 mile wide path that will sweep across the U.S. from West to East (in ~90 minutes total)
- Duration of total eclipse <2.5 minutes





DIFFERENT PHASES OF A TOTAL SOLAR ECLIPSE

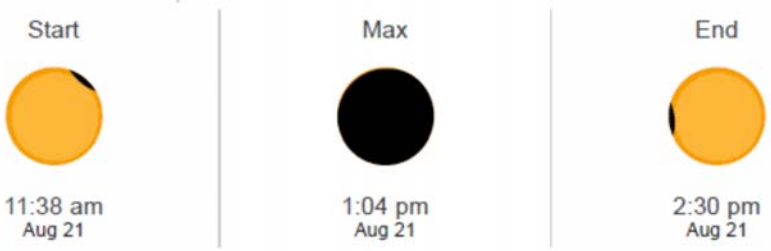


What will you see?
If you are NOT in path of Totality

- **Partial Solar Eclipse**: Everyone in the U.S. will see a partial eclipse of the Sun
- The closer you are to the "Path of Totality" the larger the % of the sun will be eclipsed at maximum

  - in Omaha, 98% of the sun will be eclipsed at maximum
- But, totality is an entirely UNIQUE experience

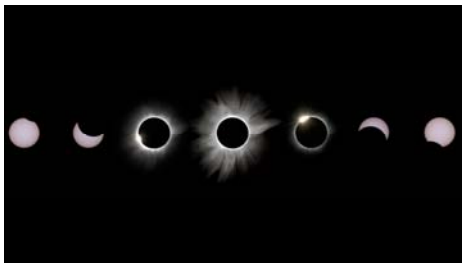
…it gets about 10,000 times darker when the moon covers the last 1 percent of the sun's surface!



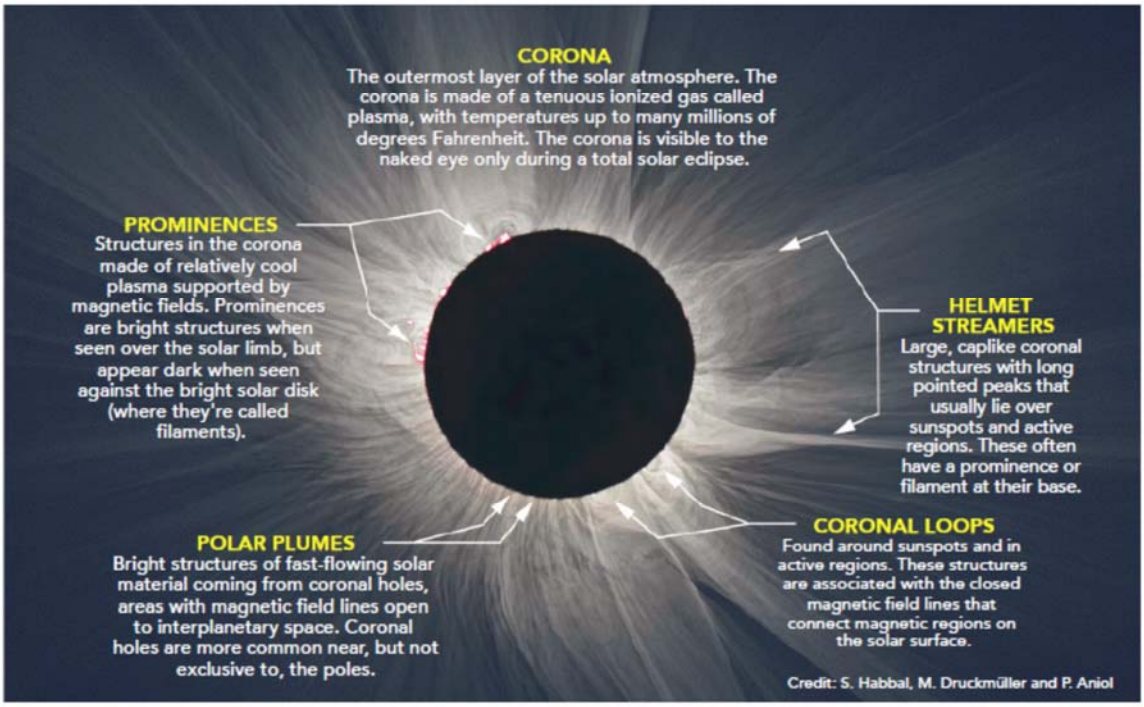
If you ARE viewing in the Path of Totality:
HIGHLY RECOMMENDED IF POSSIBLE

- Moon will gradually move in front of the Sun
- As totality approaches, you will see:

  - "Bailey's Beads": streams of sunlight gleaming through the cliffs and terrain of the Moon & "Diamond Ring Effect"
- **At totality: Solar Corona, sky darkens, stars appear, animals confused, Eerie light!**

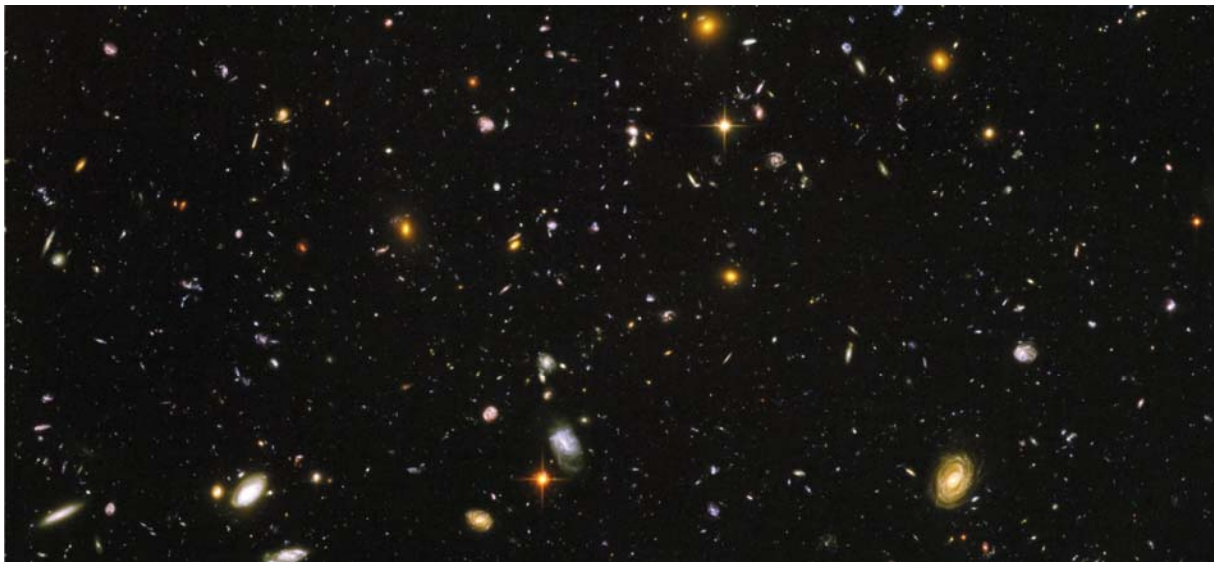


STRUCTURES IN THE SUN'S FAINT ATMOSPHERE VISIBLE DURING A TOTAL SOLAR ECLIPSE



What causes an eclipse: The Astronomy of Eclipses

Our Place in the Universe

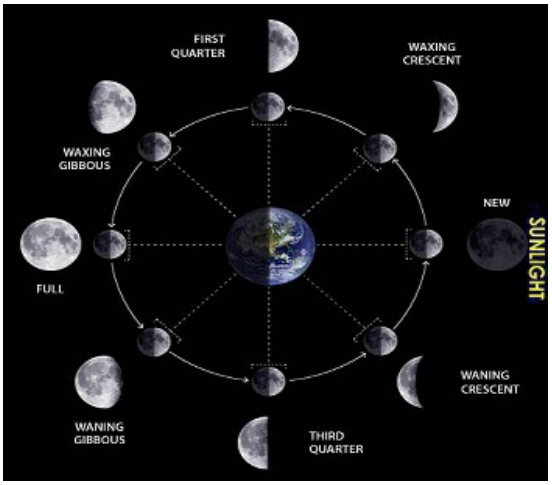


YouTube link to the video: https://www.youtube.com/watch?v=17jymDn0W6U

FIRST: The causes of Eclipses and Moon Phases are NOT the same

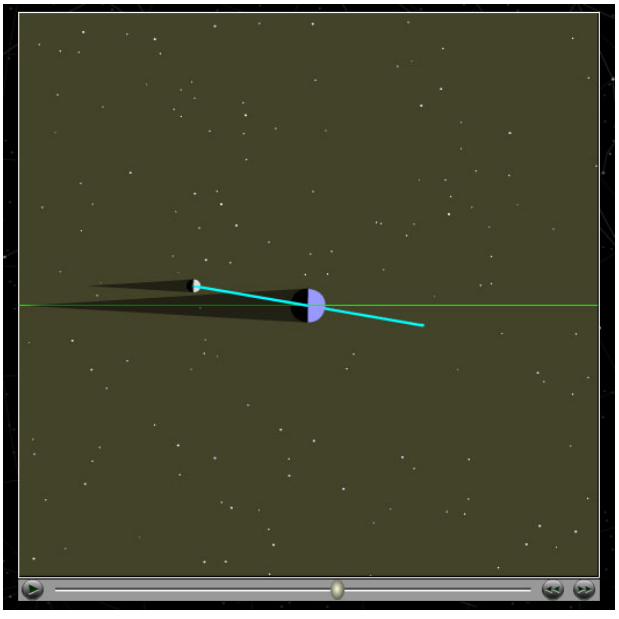
- MOON PHASES are due to relative position of Earth-Moon-Sun
- Moon phases go through a full cycle every ~28 days due to Moon's orbit around the Earth

- Half of the Moon is always lit up by sun (day) half dark
- We see a different fraction of that lit up part as it orbits around us

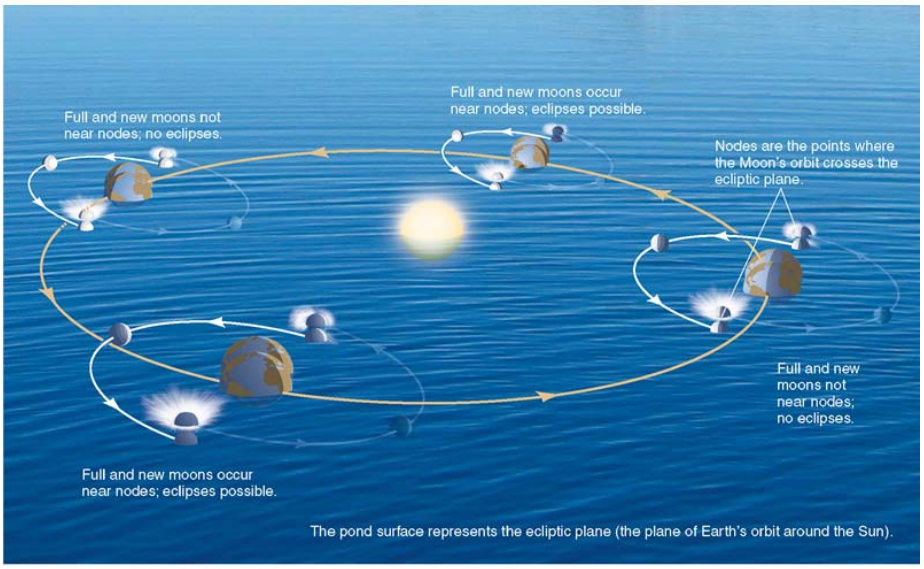


Eclipses

- The Earth & Moon cast shadows.
- When either passes through the other's shadow, we have an **eclipse**.
- Why don't we have an eclipse every full & new Moon?



- Moon's orbit tilted 5° to ecliptic plane
  - Crosses ecliptic plane only at the two **nodes**
  - Eclipse possible only when full/new occur near nodes



Solar Eclipses between 2011-2023

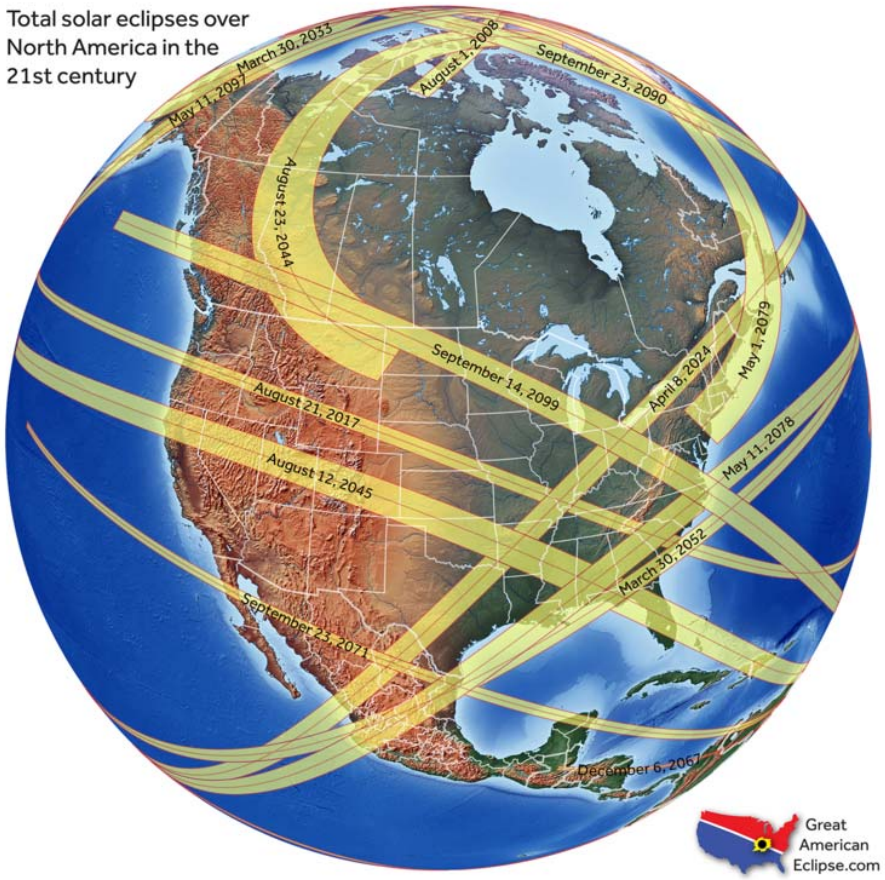
09531 2011 Jan 04 08:51:42 67 136 151 P t- 1.0627 0.8576 65N 21E 0
09532 2011 Jun 01 21:17:18 67 141 118 P -t 1.2130 0.6010 68N 47E 0
09533 2011 Jul 01 08:39:30 67 142 156 Pb t- -1.4917 0.0971 65S 29E 0
09534 2011 Nov 25 06:21:24 68 147 123 P -t -1.0536 0.9047 69S 82W 0
09535 2012 May 20 23:53:54 68 153 128 A -p 0.4828 0.9439 49N 176E 61 237 05m46s
09536 2012 Nov 13 22:12:55 68 159 133 T -n -0.3719 1.0500 40S 161W 68 179 04m02s
09537 2013 May 10 00:26:20 68 165 138 A pn -0.2694 0.9544 2N 175E 74 173 06m03s
09538 2013 Nov 03 12:47:36 68 171 143 H3 n- 0.3272 1.0159 3N 12W 71 58 01m40s
09539 2014 Apr 29 06:04:33 69 177 148 A- t- -1.0000 0.9868 71S 131E 0
09540 2014 Oct 23 21:45:39 69 183 153 P t- 1.0908 0.8114 71N 97W 0

09541 2015 Mar 20 09:46:47 69 188 120 T -t 0.9454 1.0445 64N 7W 18 463 02m47s
09542 2015 Sep 13 06:55:19 69 194 125 P -t -1.1004 0.7875 72S 2W 0
09543 2016 Mar 09 01:58:19 70 200 130 T -n 0.2609 1.0450 10N 149E 75 155 04m09s
09544 2016 Sep 01 09:08:02 70 206 135 A -n -0.3330 0.9736 11S 38E 70 100 03m06s
09545 2017 Feb 26 14:54:33 70 212 140 A n- -0.4578 0.9922 35S 31W 63 31 00m44s
09546 2017 Aug 21 18:26:40 70 218 145 T p- 0.4367 1.0306 37N 88W 64 115 02m40s
09547 2018 Feb 15 20:52:33 71 224 150 P t- -1.2116 0.5991 71S 1E 0
09548 2018 Jul 13 03:02:16 71 229 117 P -t -1.3542 0.3365 68S 127E 0
09549 2018 Aug 11 09:47:28 71 230 155 P t- 1.1476 0.7368 70N 174E 0
09550 2019 Jan 06 01:42:38 71 235 122 P -t 1.1417 0.7145 67N 154E 0

09551 2019 Jul 02 19:24:07 71 241 127 T -p -0.6466 1.0459 17S 109W 50 201 04m33s
09552 2019 Dec 26 05:18:53 72 247 132 A -n 0.4135 0.9701 1N 102E 66 118 03m40s
09553 2020 Jun 21 06:41:15 72 253 137 Am nn 0.1209 0.9940 31N 80E 83 21 00m38s
09554 2020 Dec 14 16:14:39 72 259 142 T n- -0.2939 1.0254 40S 68W 73 90 02m10s
09555 2021 Jun 10 10:43:07 72 265 147 A t- 0.9152 0.9435 81N 67W 23 527 03m51s
09556 2021 Dec 04 07:34:38 73 271 152 T p- -0.9526 1.0367 77S 46W 17 419 01m54s
09557 2022 Apr 30 20:42:36 73 276 119 P -t -1.1901 0.6396 62S 71W 0
09558 2022 Oct 25 11:01:20 73 282 124 P -t 1.0701 0.8619 62N 77E 0
09559 2023 Apr 20 04:17:56 73 288 129 H -n -0.3952 1.0132 10S 126E 67 49 01m16s
09560 2023 Oct 14 18:00:41 74 294 134 A -p 0.3753 0.9520 11N 83W 68 187 05m17s

Another Correction: The Moon doesn't move in a perfect circle around the Earth (slightly elliptical)

- During some eclipses, the moon is slightly further away and doesn't fully cover the Sun – "Annular Eclipse"
- TOTAL Solar eclipses are visible from somewhere on Earth every 1 – 2 years



Summary: Why am I excited about this eclipse….

- Striking visual and sensory experience!

  - the CROWN JEWEL of sky watching & most dramatic Natural phenomenon to observe

- Very RARE to see a total eclipse

- Gives a unique sense of our Natural World, Laws and forces of nature that shape our universe

  - appreciate the sheer awesomeness of the Universe and at the same time the incredible scientific achievements of humanity!

Viewing the Eclipse Safety
VERY IMPORTANT!

- Proper filters required if going to look directly at the sun at ANY TIME and ANYPLACE, except the “total eclipse phase”

Some Options for **Direct Viewing of the Sun**





Viewing the Eclipse Safety: VERY IMPORTANT!

- Most people will use **Solar Eclipse glasses**:
  - should not be able to see ANYTHING except the Sun
  - look for ISO number 12312-2
  - THESE ARE NOT TOYS!
  - wear them OUTSIDE of eyeglasses
- See links on Creighton University Physics website (American Astronomical Society has tested glasses from many vendors for safety)

Viewing the Eclipse Safety: VERY IMPORTANT!

More advanced filter viewing options::

- "Solar telescopes"

- regular night-sky telescopes with SAFE filters (made for the telescope) placed IN FRONT of the mirror/lens

Filters Always go IN FRONT of any lenses or mirrors

EYE SAFETY DURING AN ECLIPSE

It's NEVER safe to look directly at the sun, except when the sun is completely blocked during the period of a total eclipse known as *TOTALITY.*

1 PARTIAL ECLIPSE • GLASSES ON
The eclipse begins when the sun's disk is partially blocked by the moon. This partial eclipse phase can last over an hour.

2 DIAMOND RING • GLASSES ON
Shortly before totality, the crescent sun converges into a single brilliant "diamond" of sunlight as the last bit of the sun's bright disk shines along the edge of the moon, while the first glimpses of the faint corona create a "ring" around the moon.

3 BAILY'S BEADS • GLASSES ON
In the last little moment before totality, you may see the "diamond ring" break up into "beads" created as the sun's light shines through the low-lying valleys along the edge of the moon. These are called Baily's Beads.

4 TOTALITY • GLASSES OFF
Once the Baily's Beads disappear and the moon completely covers the entire disk of the sun, you may safely look at the eclipse without a solar filter. Be careful to protect your eyes again before the end of totality—the total eclipse may last less than a minute in some locations.

5 FINAL STAGES • GLASSES ON
A crescent will begin to grow on the opposite side of the sun from where the diamond ring appeared at the beginning. This crescent is the lower atmosphere of the sun, beginning to peek out from behind the moon and it is your signal to stop looking directly at the eclipse. ***Make sure you have safety glasses back on—or are otherwise watching the eclipse through a safe, indirect method—before the first flash of sunlight appears around the edges of the moon.***

Images 1, 2, 4, 5 Credit: Rick Fienberg, TravelQuest International and Wilderness Travel

Indirect Viewing

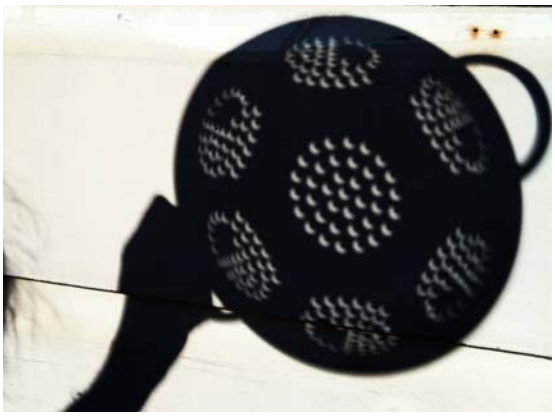
- Project image of sun through a “pinhole” (ie., a simple hole in a piece of paper):

- Simple:

- Or Fancy:

Indirect Viewing

- Projection of sun’s image through the spaces between leaves of a tree (or anything small holes!)



Photography of the Eclipse?

My recommendation: IF you are viewing in the Path of Totality, **during the brief special minutes of Totality**:

PUT YOUR PHONES AND CAMERAS AWAY

and EXPERIENCE THE EVENT

There will be many many many beautiful images of the eclipse online, taken with professional equipment and by professional photographers for you to enjoy, download, print, etc.

But even these will not capture the experience of observing it

Taking photos w/ smartphone

… But you might want to take pictures during PARTIAL ECLIPSE:

-- Buy a solar filter or use your eclipse glasses (NOT regular sunglasses) as a solar filter to cover your smartphone lens during the early part of the eclipse.

-- Use a tripod to keep your camera stable.

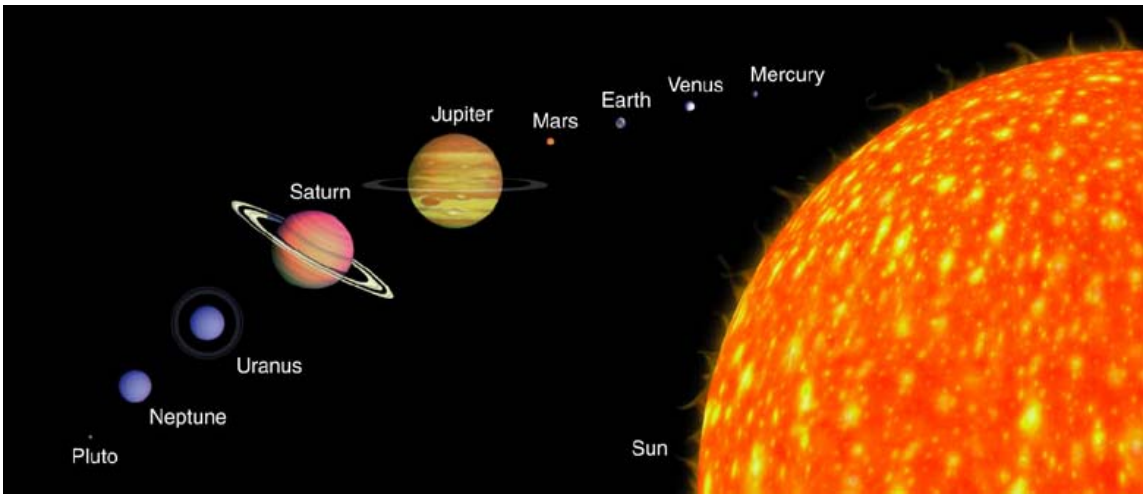
-- If you want to take pictures of the stuff going on around you during the eclipse, use a low light level setting or download a special app that lets you manually adjust exposure speed.

-- Practice! Take photos just after sunset during twilight to get an idea of what the light levels will be like during totality.

-- Shoot photos of the moon to learn how to manually adjust the focus on your camera.

-- Get real! Camera phones were meant for selfies and such. Don't expect amazing eclipse photos from your smartphone.

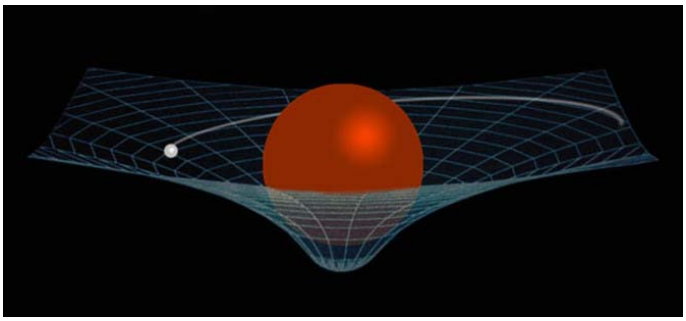
A cosmic coincidence: Consider the scale of the solar system

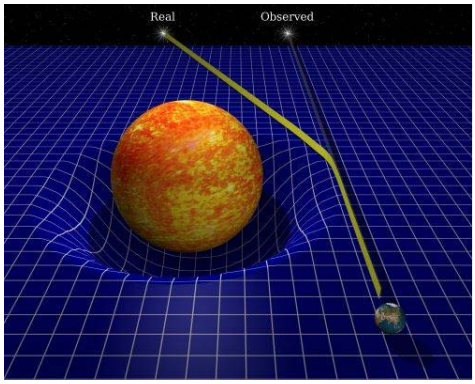


Sun and planets to scale

An Important Eclipse from History

- Confirming Einstein's General Theory of Relativity: The total solar eclipse of 1919

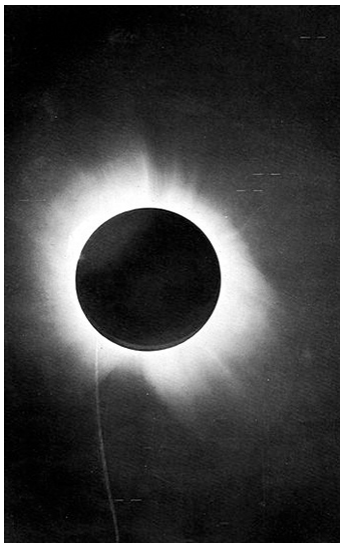




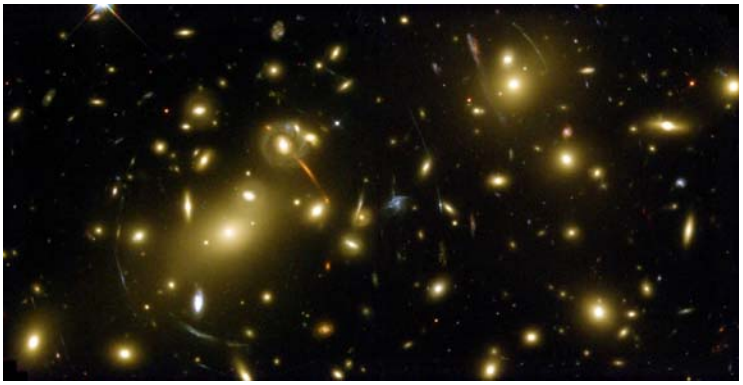
In 1915, Einstein proposed a revolutionary theory of gravity, space and time: Mass warps space, and warped space tells objects how to move

Confirming General Relativity

- The shift is VERY small:
  - the size of a quarter held ~2 miles away!
  - was detected by Arthur Eddington



- Now we see the warping of space on grand, cosmological scales (called "Gravitational Lensing")



First Picture of an Eclipse on the continent?

- http://www.astronomy.com/news/2017/08/total-eclipse-petroglyph

Recurrence of Eclipse Patterns: The Saros Cycles

The Saros arises from a natural harmony between three of the Moon's orbital periods:

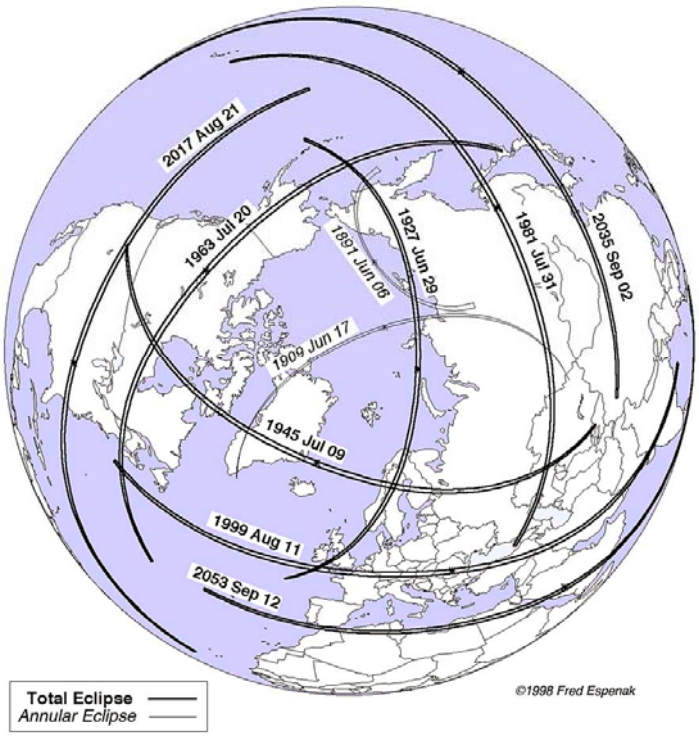
Synodic Month (New Moon to New Moon) = 29.530589 days
Anomalistic Month (perigee to perigee) = 27.554550 days
Draconic Month (node to node) = 27.212221 days

These three cycles match roughly every 6,585 days (or 18 + years)

Thus the eclipse path on the Earth's surface will be similar every 18+ years)

Saros Cycles

Some Past and Future Eclipses of Saros 145



Courtesy of "Totality - Eclipses of the Sun" by Littmann, Willcox and Espenak