

2017 Solar Eclipse



Presentation to
Oregon State Legislature
Senate Committee on Education

Jim Brau
University of Oregon
June 6, 2017

2017 Solar Eclipse

First
Total Solar Eclipse
in North America
since 1979



<https://eclipse.gsfc.nasa.gov>

Phases of the Eclipse

Salem
Aug 21
9:05 am

| \Leftarrow 2 minutes of Totality \Rightarrow |
10:17 am 10:18 am 10:19 am

11:37 am



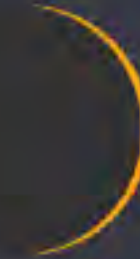
First Contact
Edge of the Moon starts to overlap the edge of the Sun. The eclipse begins.



Second Contact
The Moon covers the entire disk of the Sun. Total eclipse begins.



Totality
Max phase of a Total Solar Eclipse. The Sun is completely covered.



Third Contact
The Moon starts moving away. Parts of the Sun's disk reappear.



Fourth Contact
The Moon stops covering the Sun. The eclipse ends.

Credit: <https://www.timeanddate.com>

August 21, 2017
10:16:19 a.m. PDT

Center 44°51'44"N, 124°33'56"W, 0m
Duration 1m 58.2s
Sun Alt, Az 38.7°, 115.1°
Moon L, B, C 5.28°, -0.16°, 21.87°



Total Eclipse Visualized by Ernie Wright (NASA)

Types of Solar Eclipse



August 21
will be
a Total Eclipse



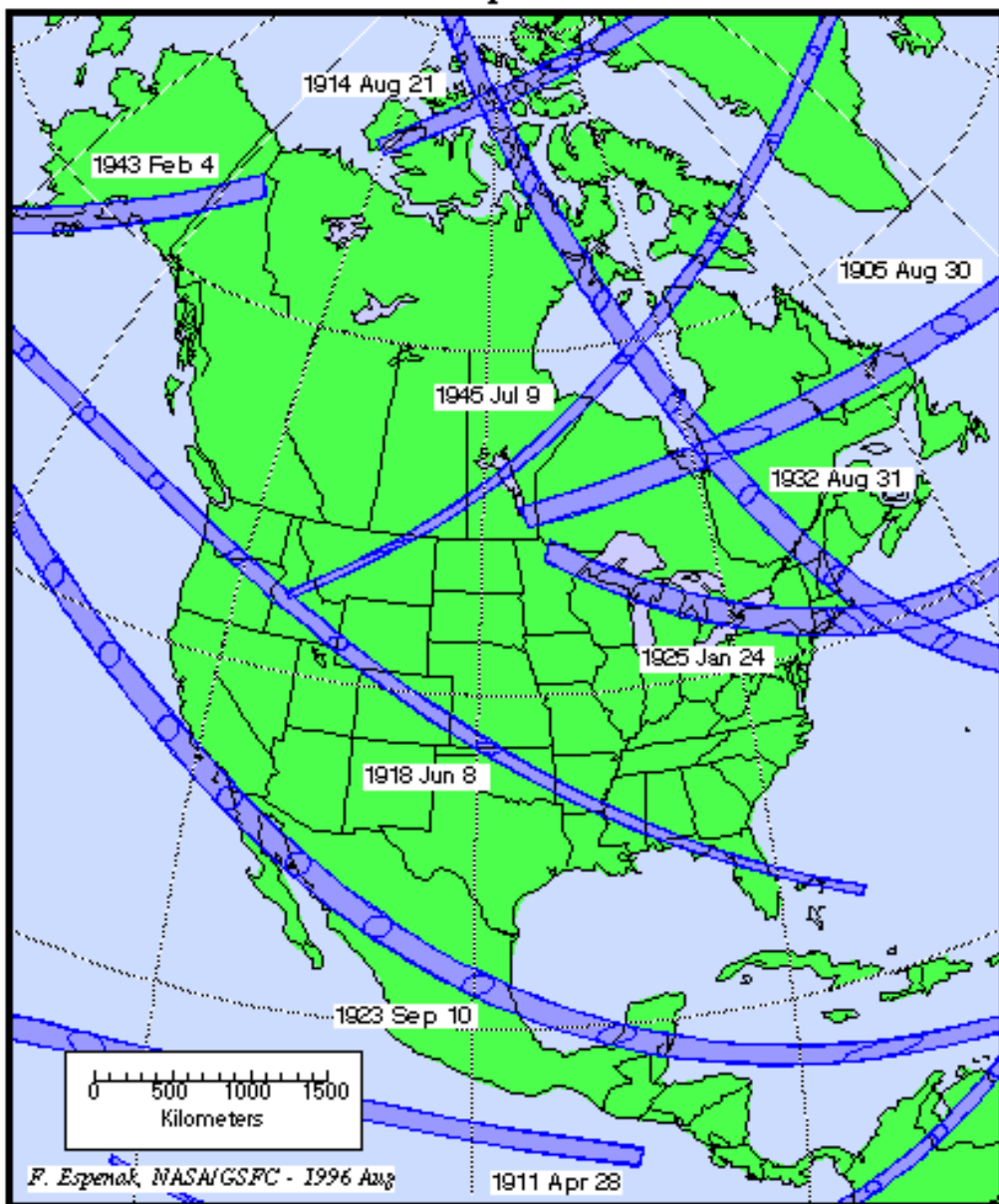
Annular
Eclipse
May 20, 2012



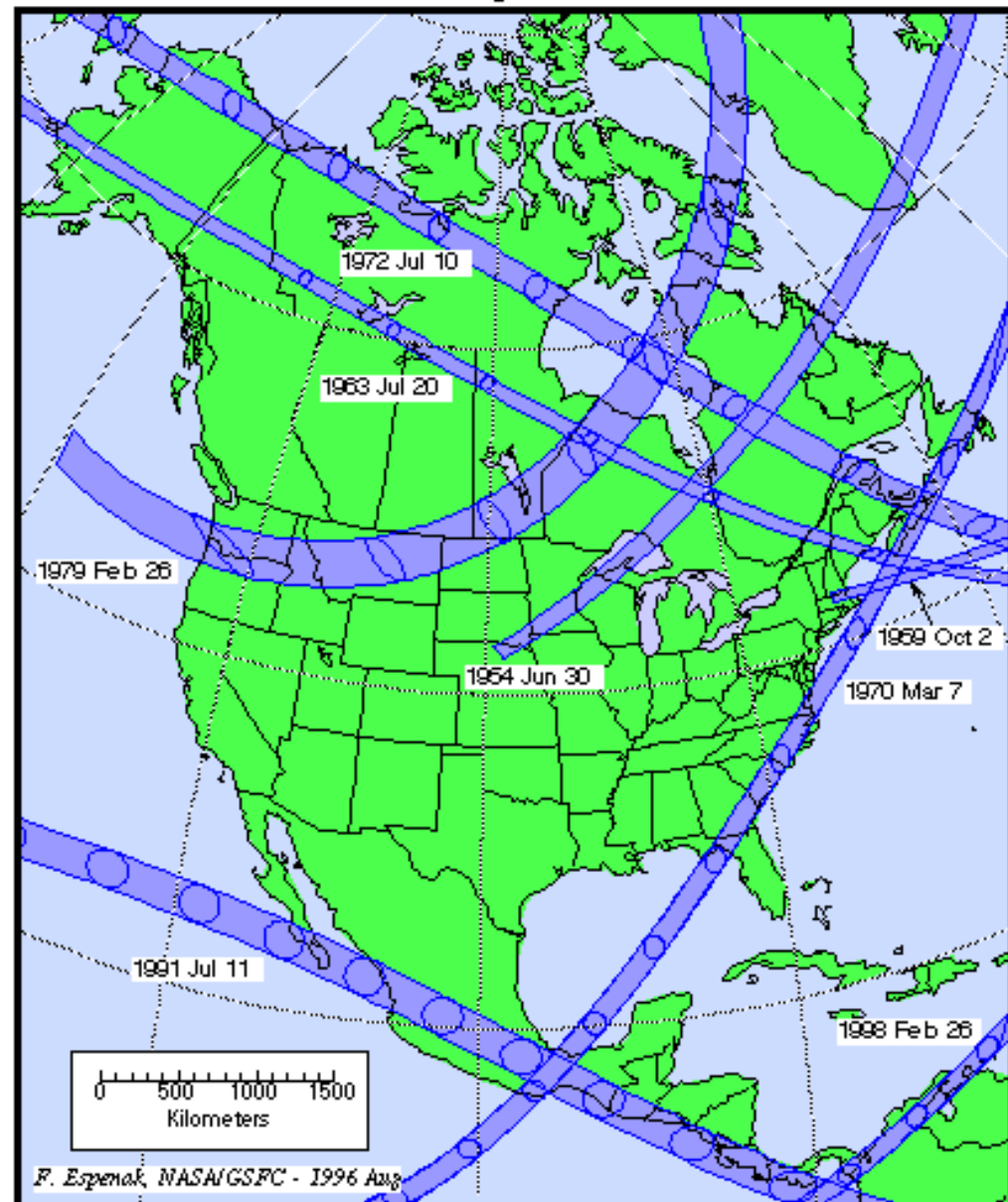
Partial
Eclipse
October 23, 2014

https://en.wikipedia.org/wiki/Solar_eclipse

Total Solar Eclipses: 1901 - 1950



Total Solar Eclipses: 1951 - 2000



<https://eclipse.gsfc.nasa.gov/SEmap/SEmapNA.html>

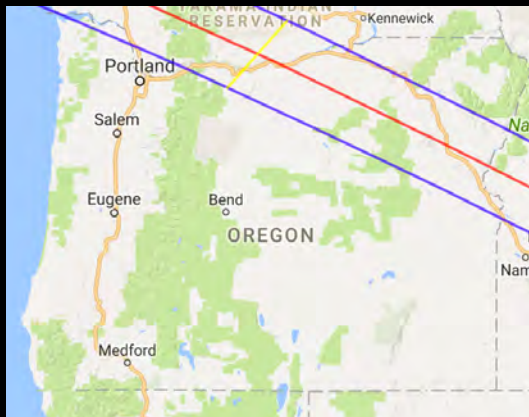
Total Solar Eclipses over Oregon in Last 150 Years



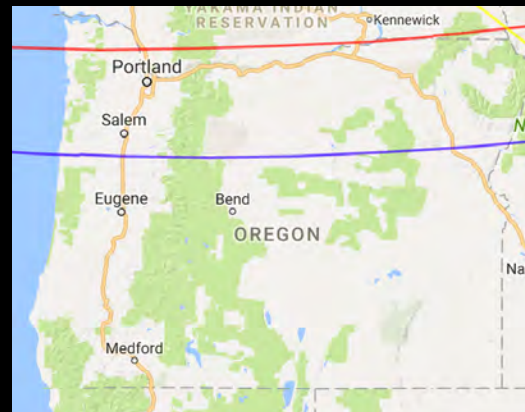
Jul 18, 1860



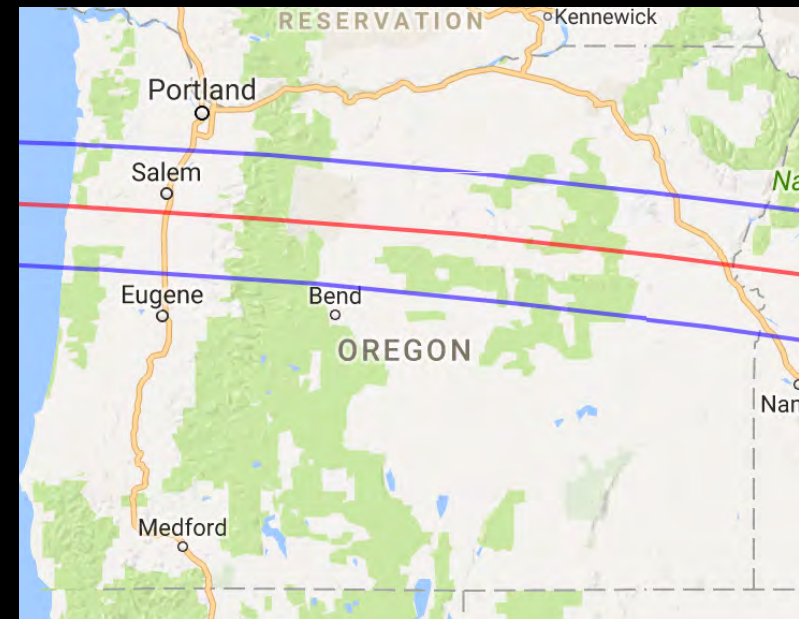
Jan 1, 1889



Jun 8, 1918



Feb 26, 1979



Aug 21, 2017

<https://eclipse.gsfc.nasa.gov>

June 8, 1918

- Last Total Solar Eclipse to cross US from Pacific to Atlantic

DENVER POST—FIRST IN EVERYTHING

THOUSANDS POINT GLASSES AT SUN TO WATCH ECLIPSE

MAP SHOWING PATH of TOTAL ECLIPSE of the SUN ACROSS the UNITED STATES, JUNE 8, 1918.

TOTAL ECLIPSE OF THE SUN, MAY 28, 1900, PHOTOGRAPHED AT WADESBORO, N.C. BY THE YERKES OBSERVATORY.

Police Enforce Quiet So Astronomers at University May Make Priceless Observations—Movies to Be Taken—Throngs Seek Vantage Points.

AMERICANS PUSH GERMANS BACK IN

June 8, 1918

Total Solar Eclipse

- Last Total Solar Eclipse to cross US from Pacific to Atlantic
- Congress made special appropriation of \$3,500 for US Naval Observatory to observe and study eclipse
 - equivalent to \$824,000 *economic power* in 2017
 - <https://www.measuringworth.com/uscompare/relativevalue.php>
- After considering many sites, Naval Observatory team chose Baker City, OR for observations
 - **expected good weather**
 - higher altitude of Sun
 - longer duration of totality



Credit: Princeton Univ.
Art Museum

Popular Astronomy.

Vol. XXVII, No. 1.

JANUARY, 1919.

Whole No. 261

THE NAVAL OBSERVATORY ECLIPSE EXPEDITION, JUNE 8, 1918.

JOHN C. HAMMOND.

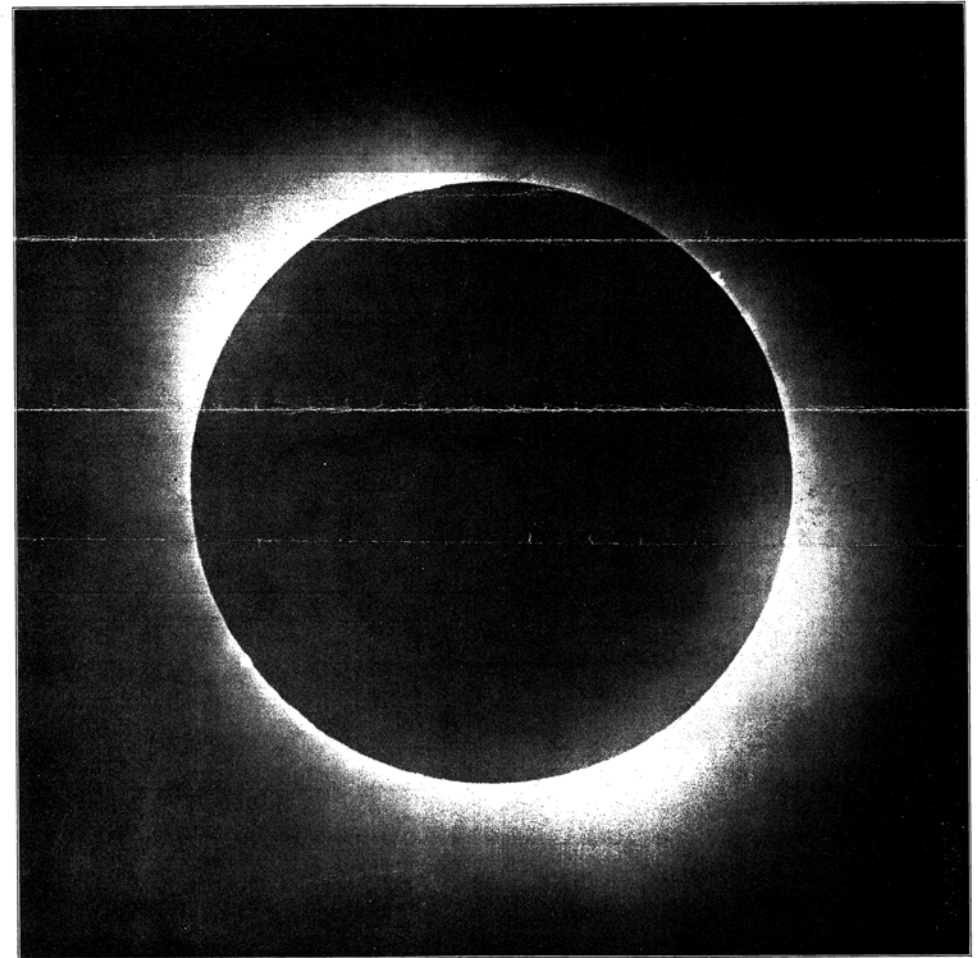
(Communicated by Rear Admiral T. B. Howard, USN., Ret., Superintendent.)

The observation of the total solar eclipse of June 8, 1918, by the Naval Observatory was made possible by a special appropriation of \$3500 by Congress. After considering various sites, it was decided to locate at Baker, Oregon. The weather conditions were likely to be good at Baker in June; also the altitude of the sun at the time of eclipse was greater and the duration of totality longer than at points farther east.

All the preparations were made during the winter of 1917-18 and the car containing the apparatus left Washington on April 11. The advance party consisting of astronomer J. C. Hammond, Assistants C. C. Wylie and W. A. Conrad of the Naval Observatory, and Dr. S. A. Mitchell, Director of the Leander McCormick Observatory of the University of Virginia, arrived at Baker on April 29. They were joined on May 1 by Professor L. G. Hoxton of the University of Virginia. These five members of the expedition set up and adjusted the various instruments. They were aided in this work by a party of six men sent from the Receiving ship at Puget Sound, Washington. This party consisted of Patrick Welsh, Chief Quartermaster, N. R. F., W. L. Veale, CM 1C, U. S. N., G. J. Pehling, MM 2C, N. R. F., and H. H. Herrick, Carl Krummel and F. Oleson, seamen U. S. N. These men reported on May 5 and remained until the instruments were all repacked for shipment back to Washington after the eclipse.

Baker is a thriving city of 9000 inhabitants, situated in the Powder river valley between two mountain ranges, the Blue or Elkhorn range on the west and the Powder river or Eagle Mountains on the northeast. Its altitude is about 3400 feet and the region is devoted chiefly to mining, lumbering, stock and fruit raising. Very comfortable quarters for the party were secured at the Hotel Antlers. Through the kindness

PLATE I



No. 4. TOTAL SOLAR ECLIPSE, JUNE 8, 1918
U. S. Naval Observatory Eclipse Expedition, Baker, Oregon. Taken with a 65-foot camera. Exposure 15 seconds.
POPULAR ASTRONOMY, No. 261.

- Report of US Naval Observatory team member John C. Hammond

Courtesy Maria Mitchell Observatory
Provided by NASA Astrophysics Data System

Jim Brau

June 6, 2017

Report of US Naval Observatory Team Total Solar Eclipse of June 8, 1918



Credit: Princeton Univ. Art Museum



Credit: Princeton Univ. Art Museum



Aerial view of Baker City in 1918

Report of US Naval Observatory Team Total Solar Eclipse of June 8, 1918

On the morning of June 8 the sky was entirely overcast. The limb of the sun could just be seen with the equatorial. About noon it began to clear somewhat. At the time of first contact there was a thin cloud over the sun but the contact was easily observed. As totality approached there were clear patches of sky near the sun and the clouds were moving in such a way that it seemed certain that the sun would be in a clear space during totality. This expectation was not realized, however, as a light cloud covered the sun during totality. Five minutes afterward, the sun was in a clear space. The seeing was very steady and the photographs, while they do not show the fainter and out extensions of the corona, give fine representations of the inner corona and prominences.



Credit: Princeton Univ. Art Museum

Report of US Naval Observatory Team Total Solar Eclipse of June 8, 1918

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with the equatorial.

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the corona, give fine representations of the inner corona and prominences.

We hope for better
weather this time!



Univ. Art Museum

1918 and 2017



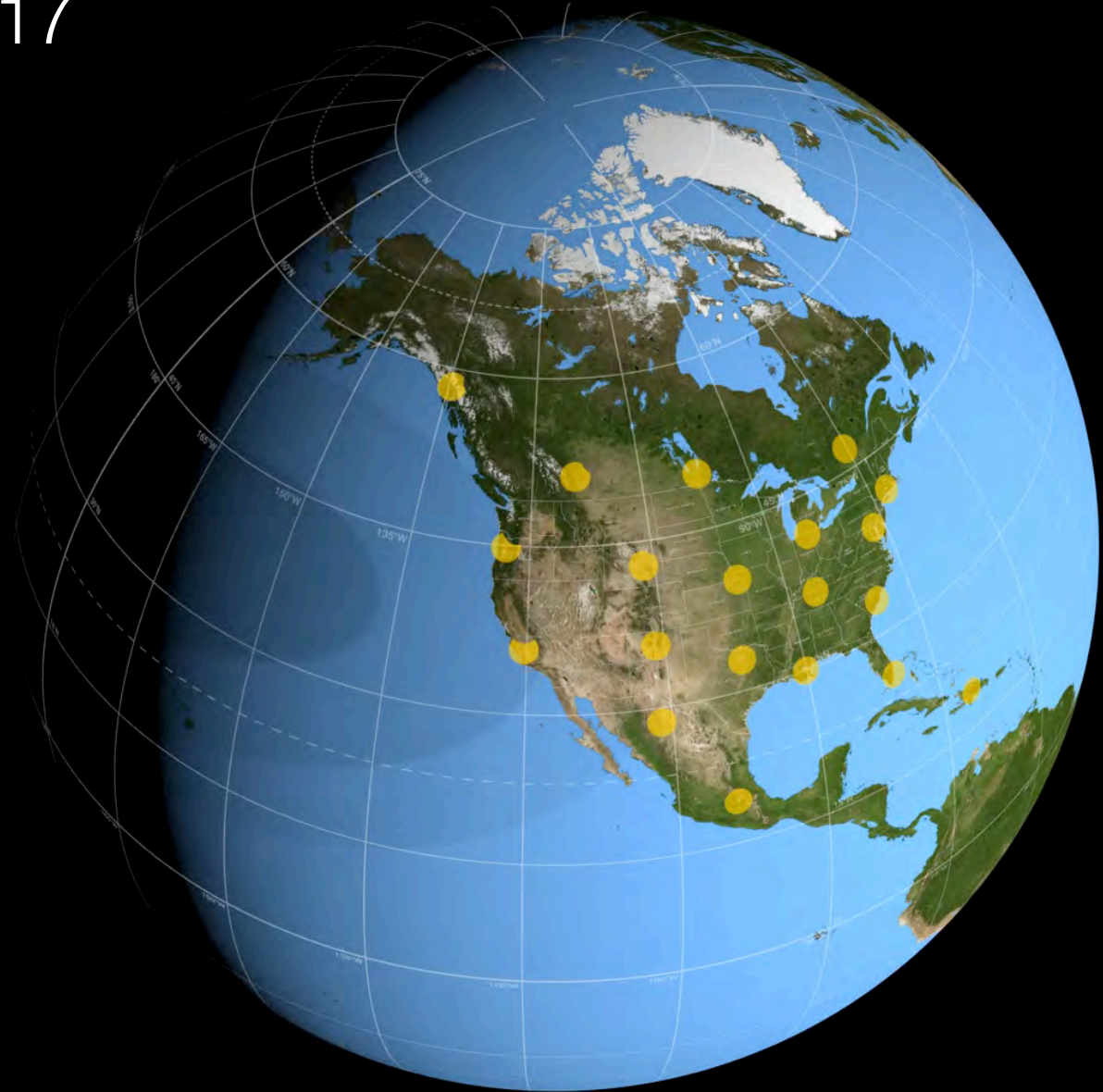
June 8, 1918

August 21, 2017

Last Total Solar Eclipse to cross US from Pacific to Atlantic was in 1918

Map adapted by NationalEclipse.com from original at eclipse.gsfc.nasa.gov. Map copyright Google, INEGI. Eclipse predictions courtesy of Fred Espenak, NASA/Goddard Space Flight Center.

August 21, 2017



Monday, August 21, 2017
Time Center 09:25:40 a.m. PDT
Duration
Sun Altitude

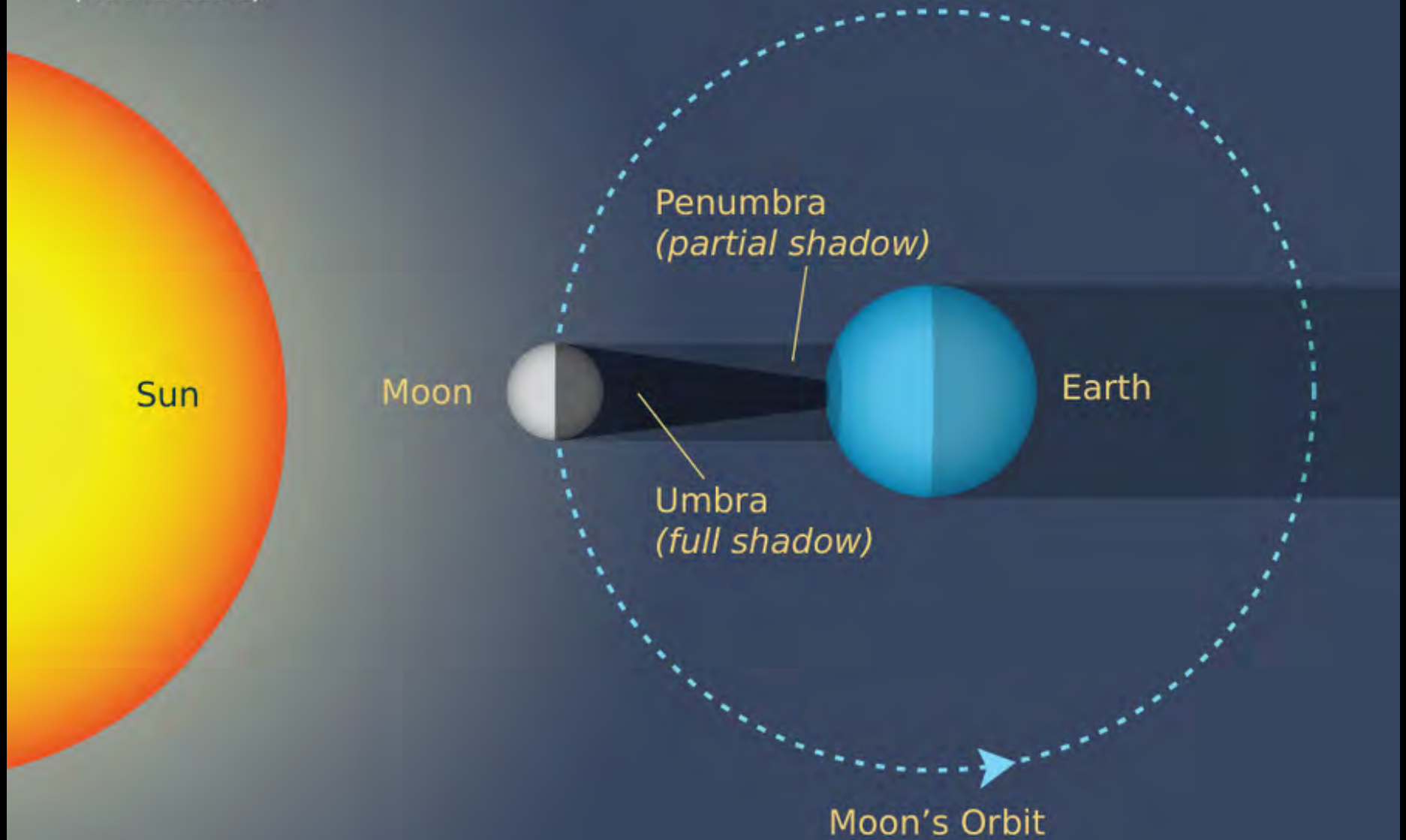
<https://www.nasa.gov/>

Jim Brau

June 6, 2017

Anatomy of a Solar Eclipse

(Not to scale)



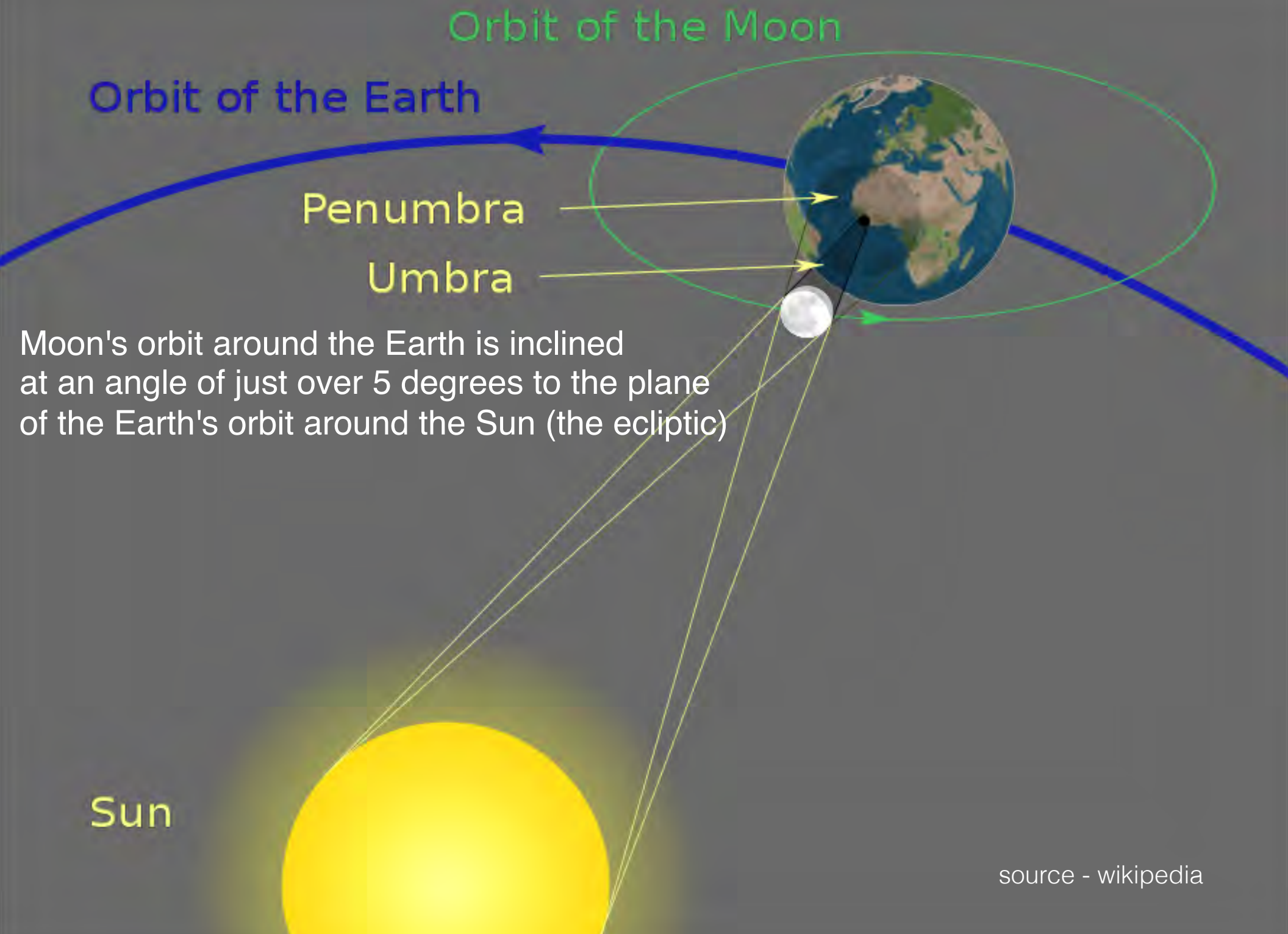
Credit: <http://www.astroasheville.org>

Awesome Totality



There are some phenomena that can only be seen during totality.

Credit: <https://www.timeanddate.com>



Orbit of the Moon

Orbit of the Earth

Penumbra

Umbra

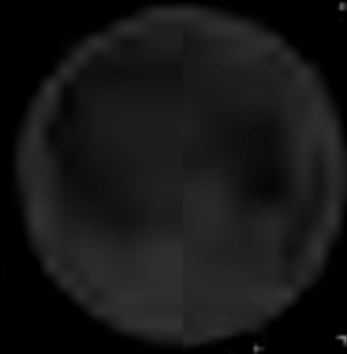
Moon's orbit around the Earth is inclined at an angle of just over 5 degrees to the plane of the Earth's orbit around the Sun (the ecliptic)

Sun

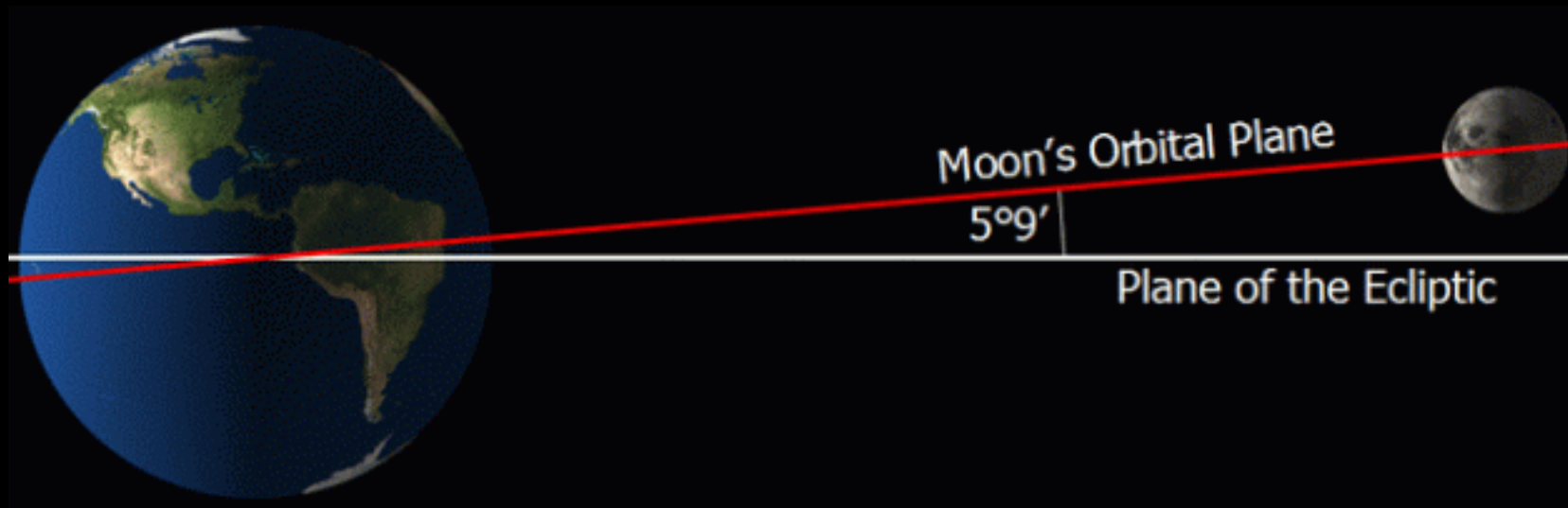
Why don't we have a solar eclipse every month?



Why don't we have
a solar eclipse every month?



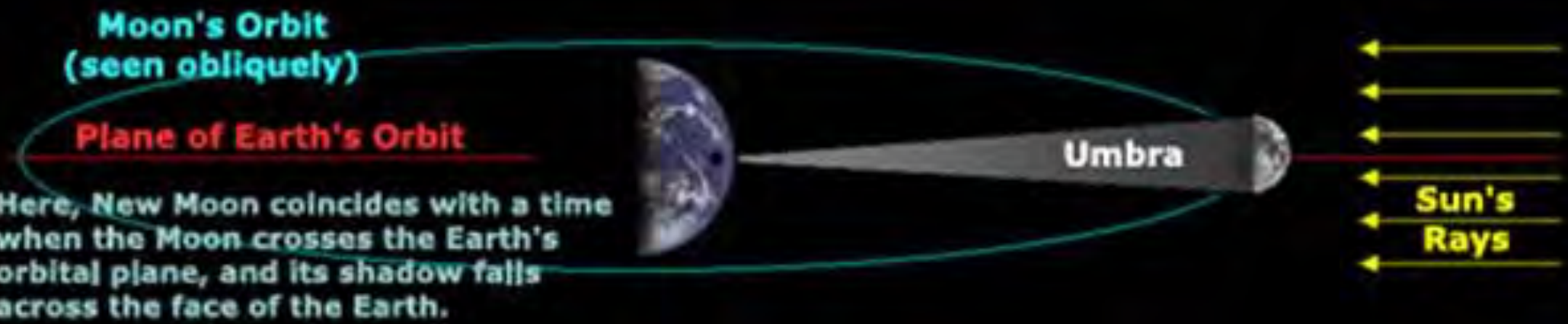
http://phys23p.sl.psu.edu/phys_anim/astro/indexer_astroC.html



- <http://rasyonalist.org>



In most months of the year the moon's orbit is not aligned to make eclipse.



When moon's orbit is aligned the moon can make an eclipse.

- <http://www.math.nus.edu.sg>

How frequently does Moon align for solar eclipse

Location	Most recent totality	Next scheduled Totality	Number of years between eclipses
Anchorage, Alaska	1943, Feb. 4	2399, Aug. 2*	456.5
Atlanta, Ga.	1778, June 24	2078, May 11	299.5
Boston, Mass.	1959, Oct. 2	2079, May 1	119.6
Calgary, Alberta	1869, Aug. 7	2044, Aug. 23	175.0
Chicago, Ill.	1806, June 6*	2205, July 17	399.1
Dallas, Texas	1623, Oct. 23	2024, April 8	401.5
Denver, Colo.	1878, July 29	2045, Aug. 12	167.0
Halifax, Nova Scotia	1970, March 7	2079, May 1	109.1
Hamilton, Bermuda	1532, Aug. 30**	2352, Feb. 16	819.5
Honolulu, Hawaii	1850, Aug. 7	2252, Dec. 31	402.4
Houston, Texas	1259, Oct. 17**	2200, April 14	940.5
Las Vegas, N.V.	1724, May 22	2207, Nov. 20	483.5
Los Angeles, Calif.	1724, May 22	3290, April 1	1565.9
Mexico City, Mexico	1991, July 11	2261, Dec. 22	270.4
Miami, Fla.	1752, May 13*	2352, Feb. 16	599.8
Montréal, Quebec	1932, Aug. 31*	2024, April 8*	91.6
New Orleans, La.	1900, May 28	2078, May 11	178.0
New York, N.Y.	1925, Jan. 24*	2079, May 1	154.3
Phoenix, Ariz.	1806, June 16	2205, July 17	399.1
St. Louis, Mo.	1442, July 7**	2017, Aug. 21*	575.1
San Francisco, Calif.	1424, June 26**	2252, Dec. 31	828.5
Seattle, Wash.	1860, July 18	2645, May 17	784.8
Toronto, Ontario	1142, Aug. 22**	2144, Oct. 26	1002.2
Washington, D.C.	1451, June 28**	2200, April 14	748.8
Winnipeg, Manitoba	1979, Feb. 26	3356, Sept. 16	1377.6

Once in several centuries for a given location

- <http://www.space.com>

How frequently does Moon align for solar eclipse

- Most calendar years have 2 solar eclipses somewhere on Earth.
- The maximum number of solar eclipses that can take place in the same year is 5, but this is rare.
- According to NASA calculations, only about 25 years in the past 5,000 years have had 5 solar eclipses.
 - The last time this happened was in 1935, and the next time will be in 2206.

Viewing the Eclipse

It is not safe to view the eclipse directly during partiality.

During partiality special glasses rated for solar viewing should be used.



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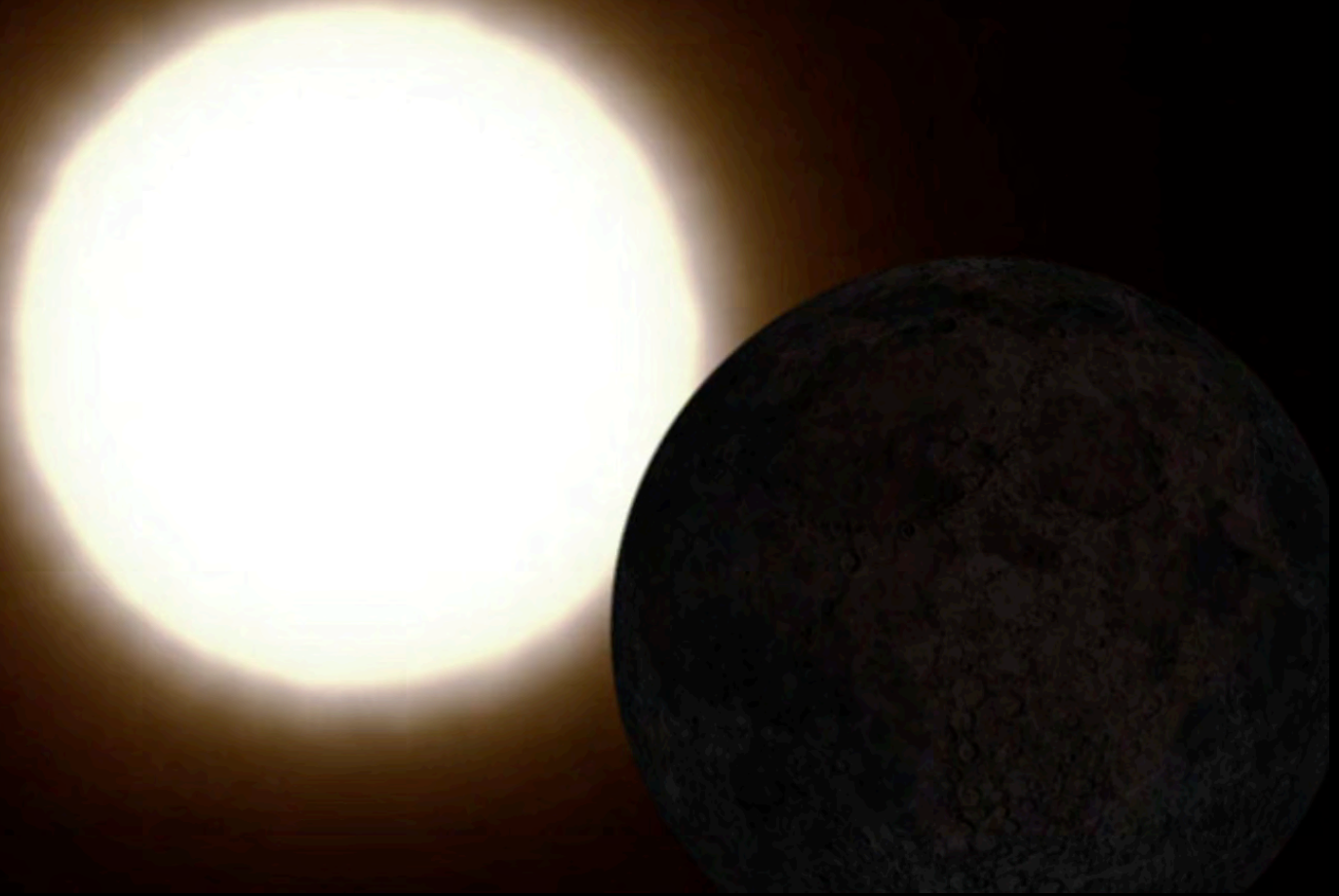
It is safe to observe the eclipse directly when the Sun's photosphere is completely covered by the Moon, and not before or after totality. (for about two minutes in 2017)

During this period, the Sun is too dim to be seen through filters.

The Sun's faint corona will be visible, and the chromosphere, solar prominences, and possibly even a solar flare may be seen.

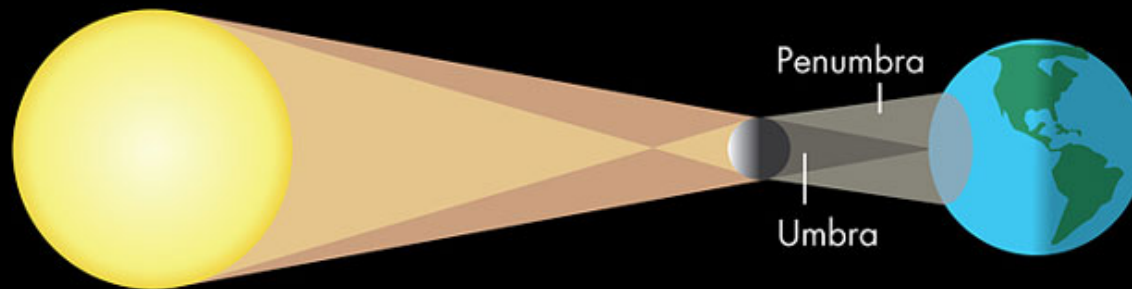
Totality occurs only very briefly - about 2 minutes for 2017
Eclipse viewed from Salem.

Coincidence of Angular Sizes Resulting in Total Solar Eclipse



Coincidence of Angular Sizes Resulting in Total Solar Eclipse

- Sun's distance is about **400 times** the distance to the moon.
 - 93,000,000 miles vs. 238,900 miles
- Sun is about **400 times** larger.
 - 864,576 mile vs. 2159 mile diameters
- A remarkable coincidence responsible for total solar eclipse.



stardate.org

NOT TO SCALE

Why Do We Have This Coincidence? - Theory of Origin of Moon

When the earth formed 4.5 billion years ago, other smaller planetary bodies were also growing.

Scientific evidence suggests one of these hit earth late in earth's growth process, blowing out rocky debris.

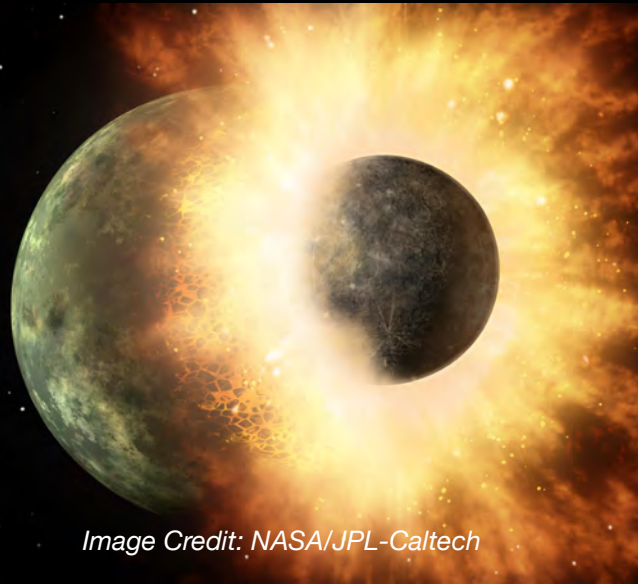


Image Credit: NASA/JPL-Caltech



The Giant Impact, as pictured in a painting by William K. Hartmann on the cover of Natural History Magazine in 1981.
Copyright William K. Hartmann

Planetary Sciences Institute
<https://www.psi.edu/eпо/moon/moon.html>

Why Do We Have This Coincidence? - Theory of Origin of Moon

When the earth formed 4.5 billion years ago, other smaller planetary bodies were also growing.

Scientific evidence suggests one of these hit earth late in earth's growth process, blowing out rocky debris.

A fraction of that debris went into orbit around the earth and aggregated into the moon.

As time passed, the moon drifted to the current orbit where it can nearly perfectly block the sun's rays.



The Giant Impact, as pictured in a painting by William K. Hartmann on the cover of Natural History Magazine in 1981.
Copyright William K. Hartmann

Planetary Sciences Institute
<https://www.psi.edu/eпо/moon/moon.html>

Today Moon Is Still Drifting Away from Earth



- 4 cm/year (about 1.5 inches/year)
- Distance will change by 10% in one billion years
 - 1 % in 100,000,000 years
- Solar eclipses will continue for a long time!

A Few Scientific Connections

- Observe and measure solar atmosphere
 - Corona
- Test general relativity
 - Measure bending of starlight
- What about neutrinos from the Sun?

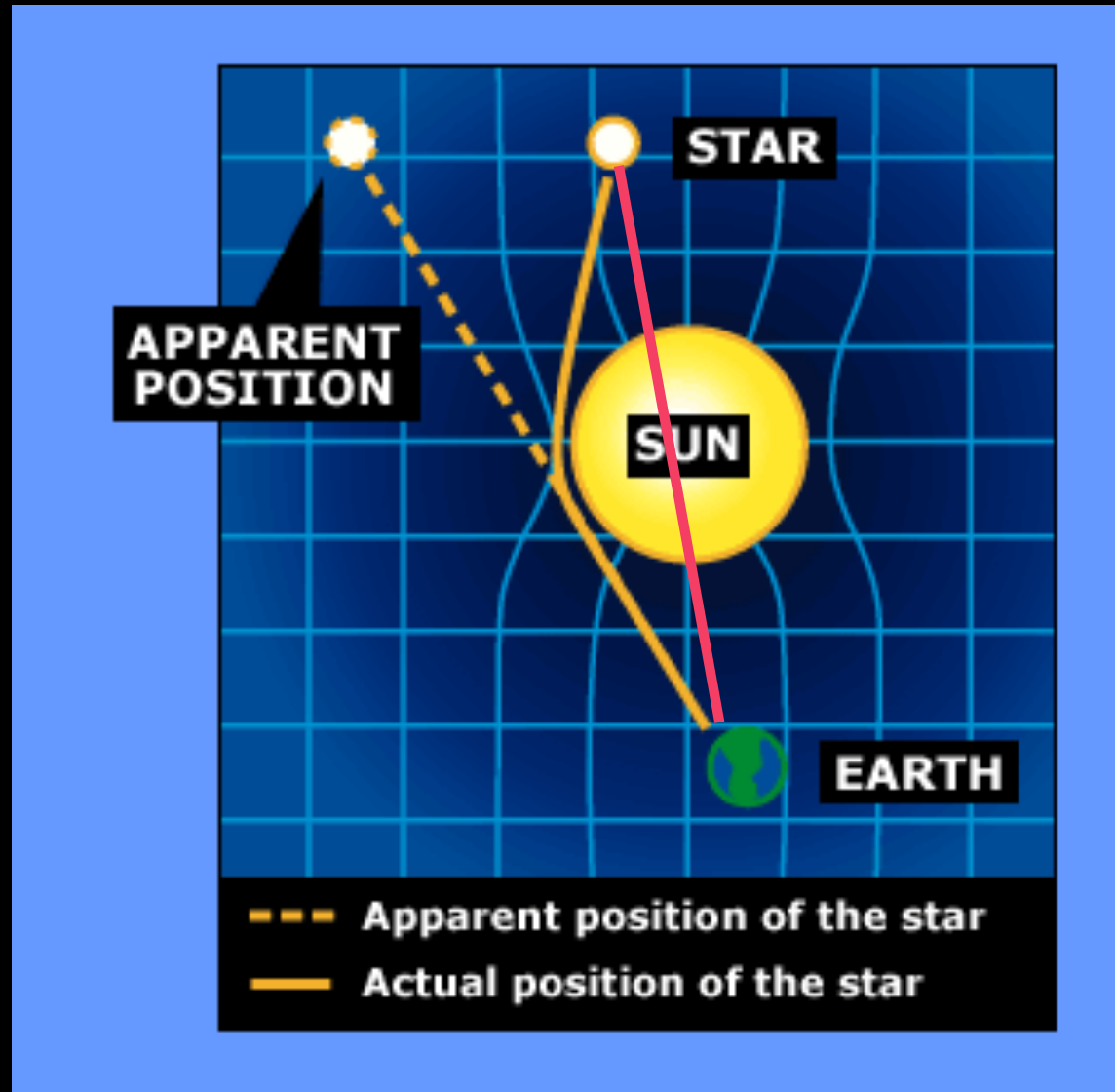
Measure Solar Atmosphere or Corona

- Corona is very hot (more than 1,000,000 K) but very diffuse.
- Before modern instrumentation became available, corona was studied during total eclipses.

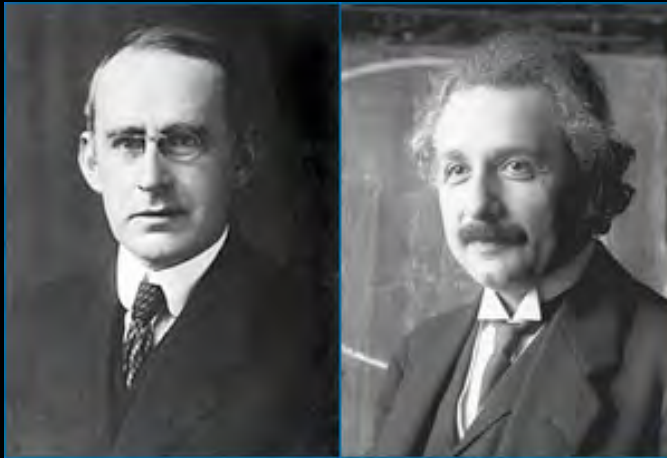


Credits: M. Druckmüller

Test General Relativity

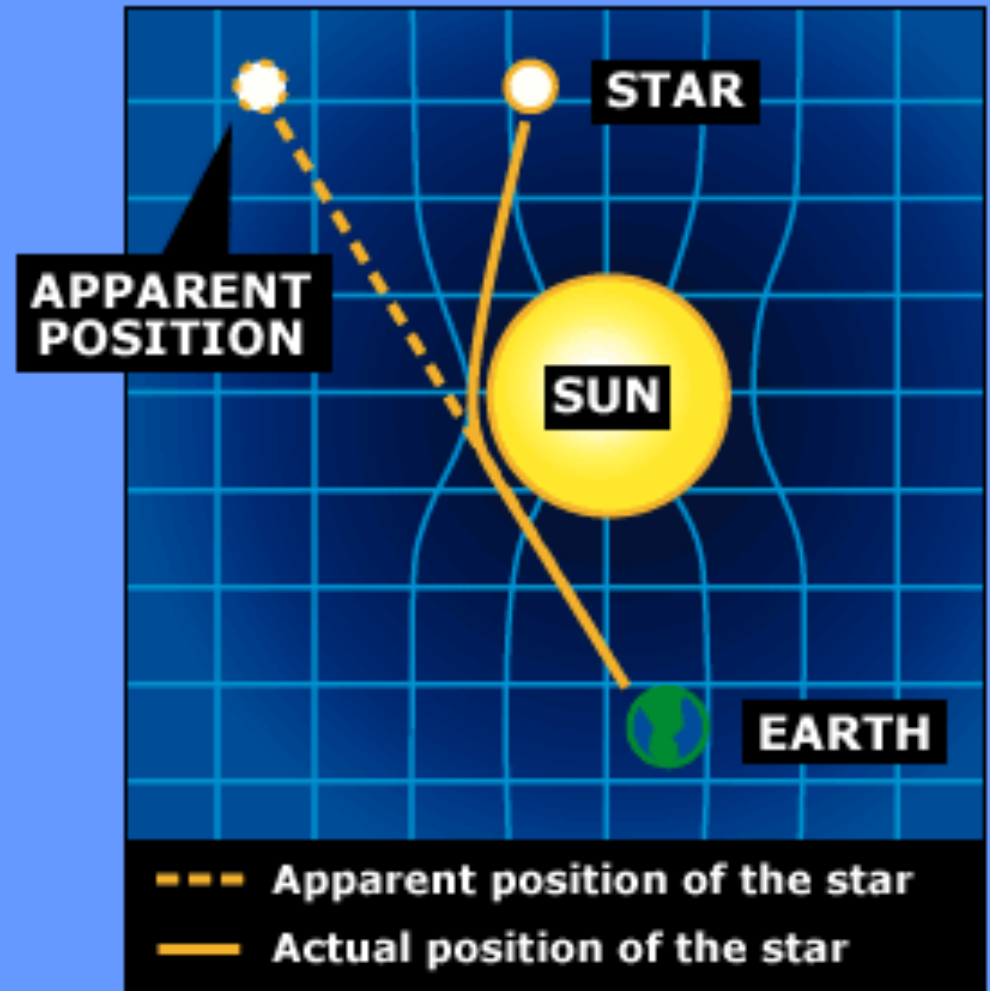


Test General Relativity

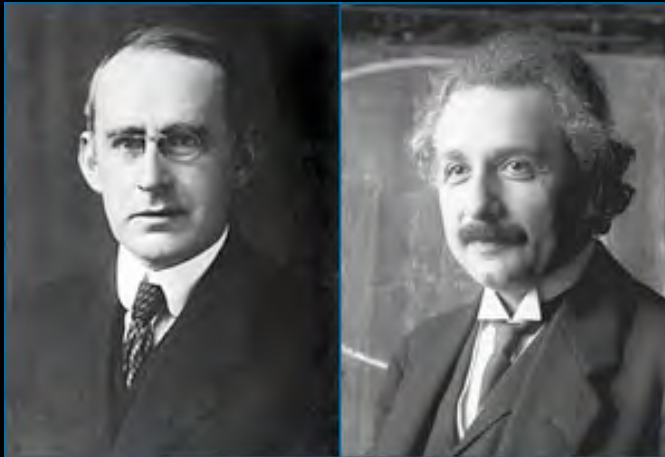


1915 - Einstein's General Relativity - new theory of gravity - predicts bending of light by gravity

May 29, 1919 - Eddington leads expedition to test bending of starlight during TOTAL SOLAR ECLIPSE



Test General



1915 - Einstein's General Relativity - new theory of gravity - predicts bending of light by gravity

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Credit: Illustrated London News, 22 November 1919

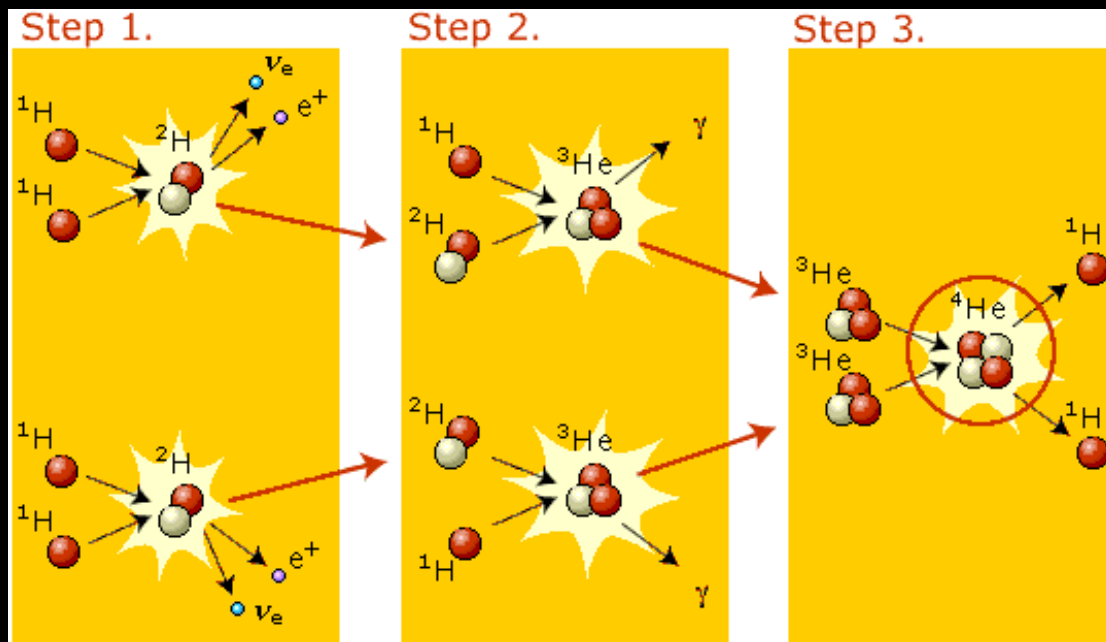
Power of the Sun



- The release of energy in the Sun results from thermonuclear reactions in which light elements (such as hydrogen) are fused into heavier elements (such as helium).
- The temperature at the center of the Sun, where these reactions are primarily at work, is 15,000,000 Kelvin (or 27,000,000 Fahrenheit).
- The power released in the sun is 4×10^{26} Watts.
- As a consequence 1400 Watts are incident per square meter on Earth.

Neutrinos from the Sun

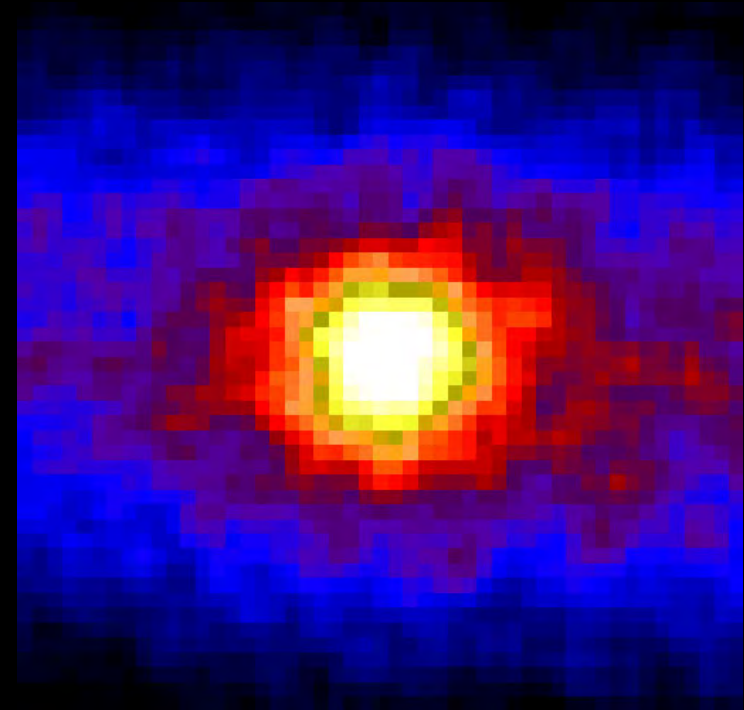
- Nuclear reactions in the Sun produce its energy and also produce neutrinos.



<https://www.nobelprize.org/>

Neutrinos from the Sun

- Nuclear reactions in the Sun produce its energy and also produce neutrinos.
- Almost all of the released energy goes into the Sun's thermal radiation, but a small fraction goes into neutrinos.
- The neutrino image of the Sun is visible underground and will (in principle) be unaffected by the Solar Eclipse.



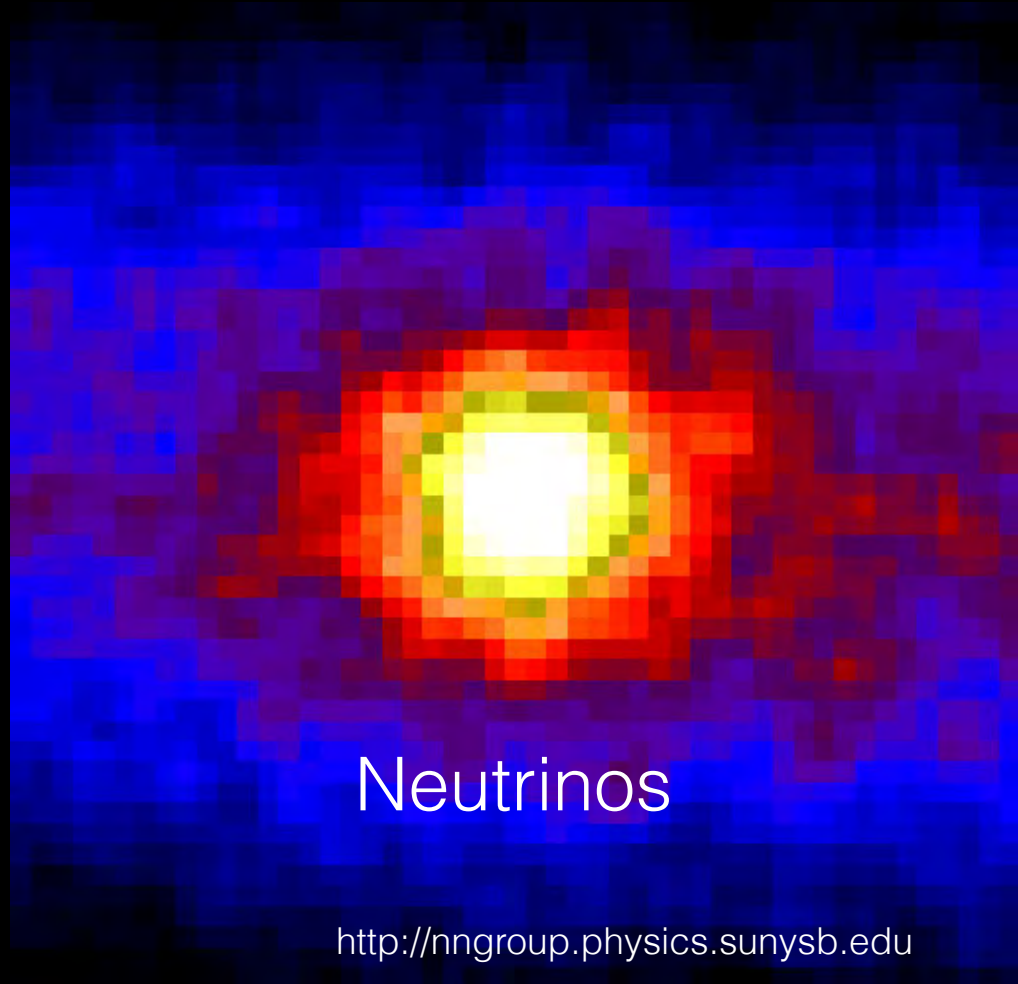
<http://nngroup.physics.sunysb.edu>

Image of Sun Before Eclipse



Visible Light

<http://www.solarham.net>



Neutrinos

<http://nngroup.physics.sunysb.edu>

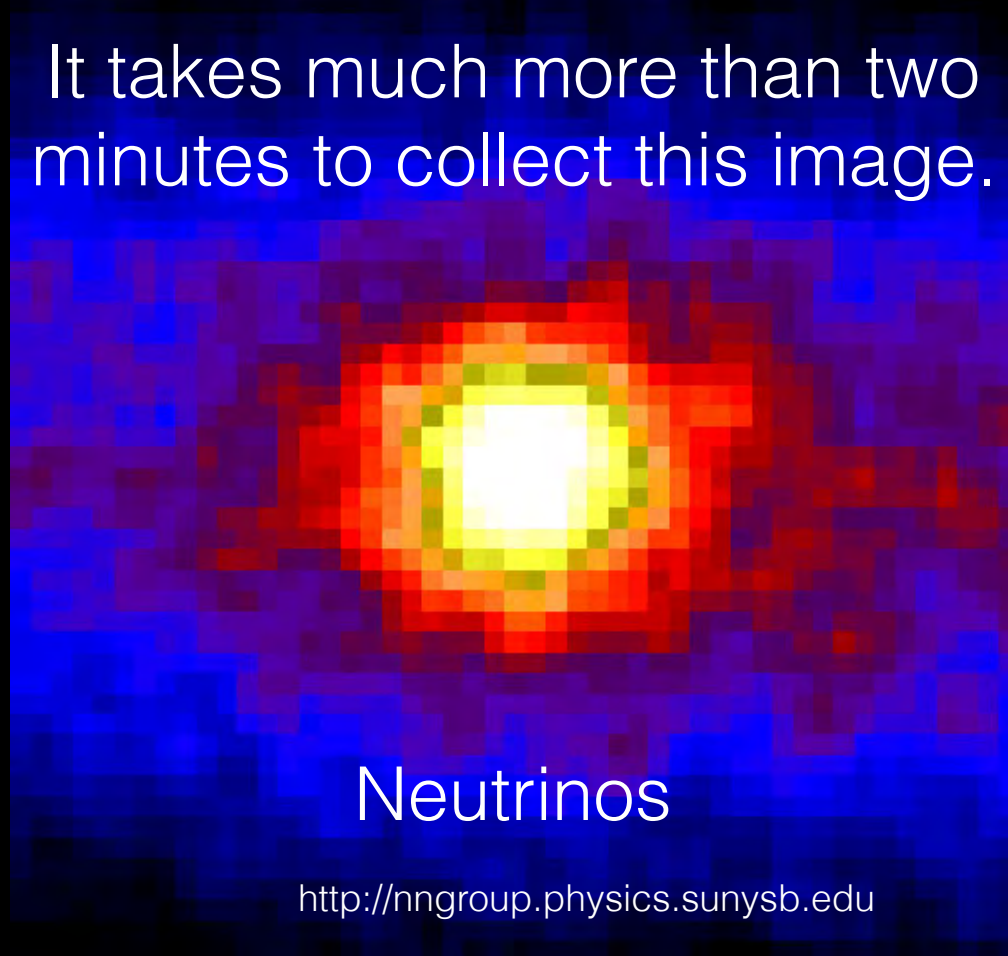
Image of Sun During Eclipse

It takes much more than two minutes to collect this image.



Visible Light

https://en.wikipedia.org/wiki/Solar_eclipse



Neutrinos

<http://nngroup.physics.sunysb.edu>

- Neutrinos pass right through the moon without loss!

Other Solar Eclipses

- September 4, 2011
 - Solar eclipse by Saturn observed by NASA's Cassini mission
- November 24, 1969
 - Apollo 12 astronauts photographed Solar eclipse by Earth.

September 4, 2011

Cassini spacecraft observed Sun eclipsed by Saturn



November 24, 1969



Apollo 12 photo of Earth eclipsing Sun
during journey home from the moon.

Conclusion

- August 21, 2017 will offer the residents and visitors in Oregon a rare opportunity to experience one of Nature's dramatic events.
- Care should be taken to safely observe the eclipse.
- DON'T MISS THIS ONE - Another total solar eclipse won't cross Oregon until 2169, although a sliver of the Oregon coast will experience a total eclipse in 2108!