

# 2017 Solar Eclipse



Oregon 2017 Quarknet  
based on presentation to  
Oregon State Legislature

Jim Brau  
University of Oregon  
June 27, 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



Total  
Eclipse  
August 11, 1999



Annular  
Eclipse  
May 20, 2012

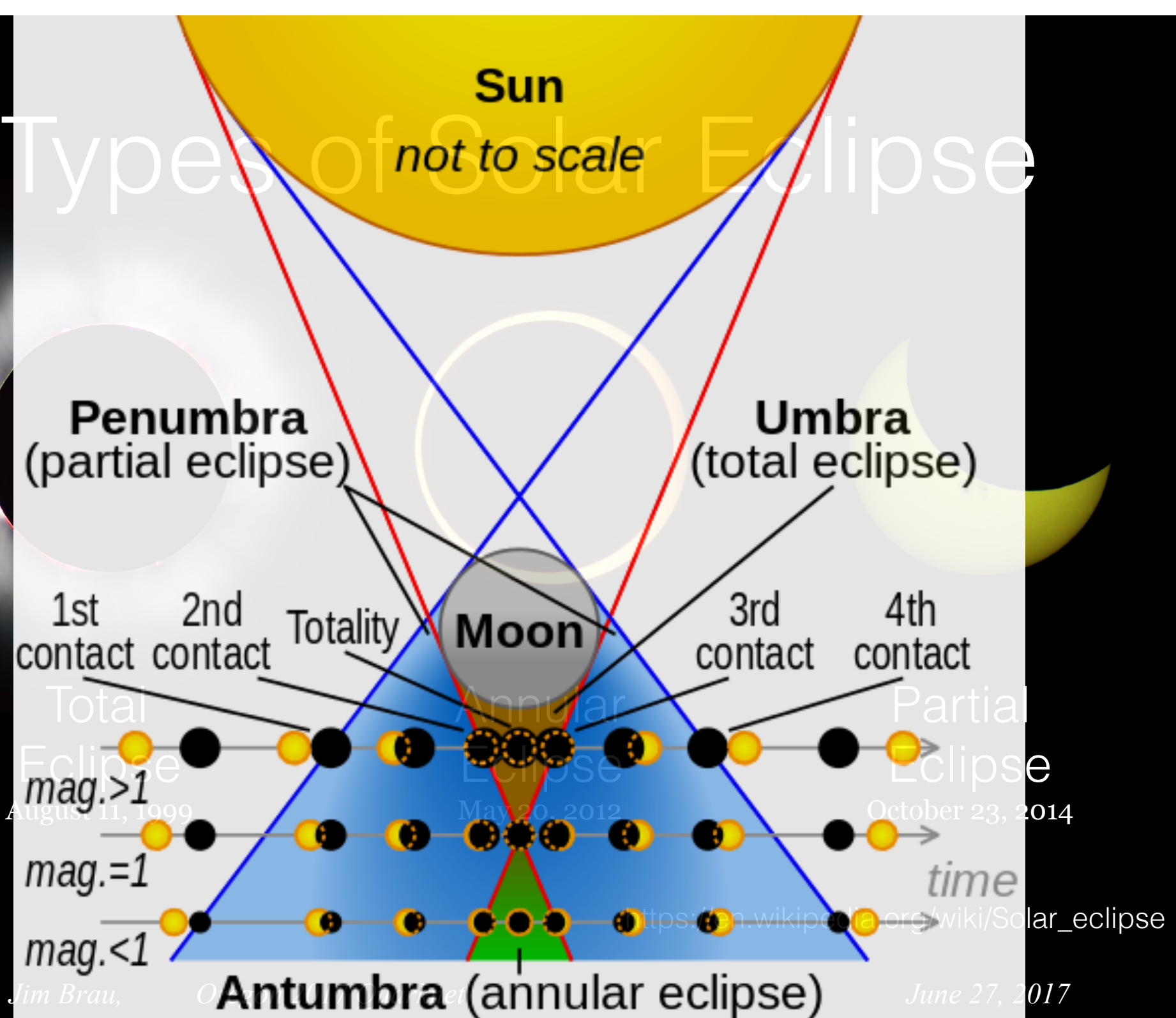


Partial  
Eclipse  
October 23, 2014

[https://en.wikipedia.org/wiki/Solar\\_eclipse](https://en.wikipedia.org/wiki/Solar_eclipse)



# Types of Solar Eclipse



# Types of Solar Eclipse



August 21  
will be  
a Total Eclipse



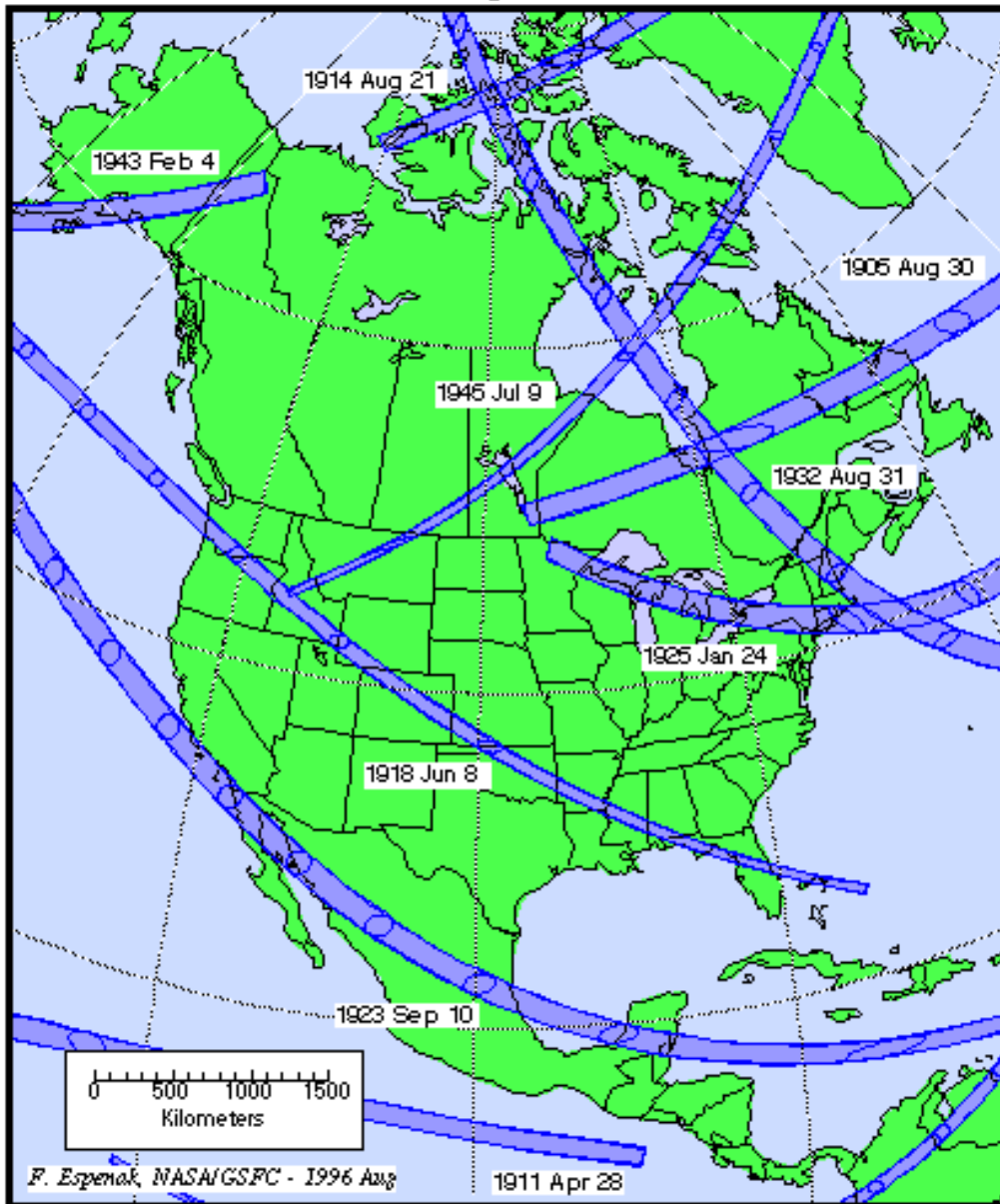
Annular  
Eclipse  
May 20, 2012



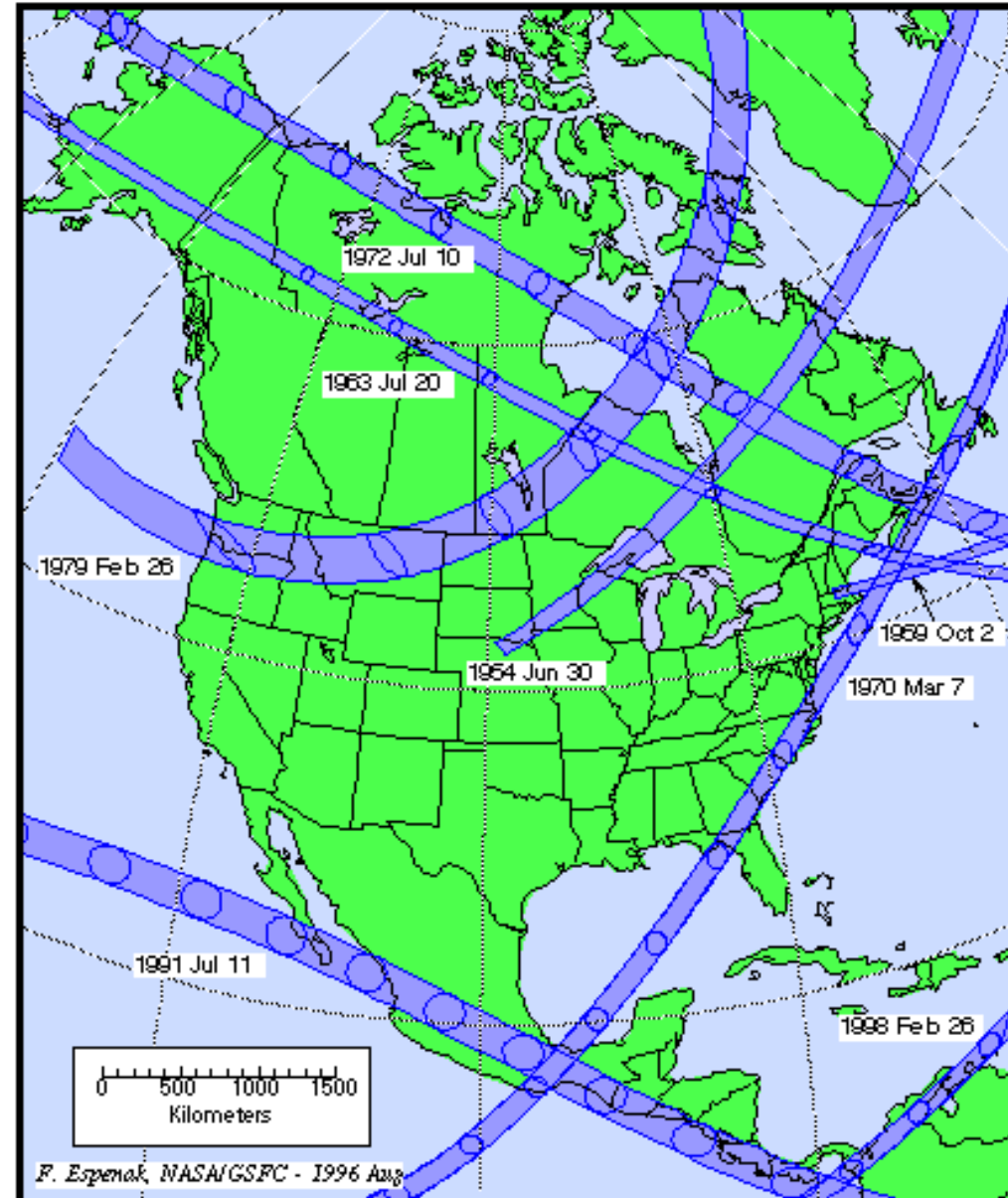
Partial  
Eclipse  
October 23, 2014

[https://en.wikipedia.org/wiki/Solar\\_eclipse](https://en.wikipedia.org/wiki/Solar_eclipse)

Total Solar Eclipses: 1901 - 1950



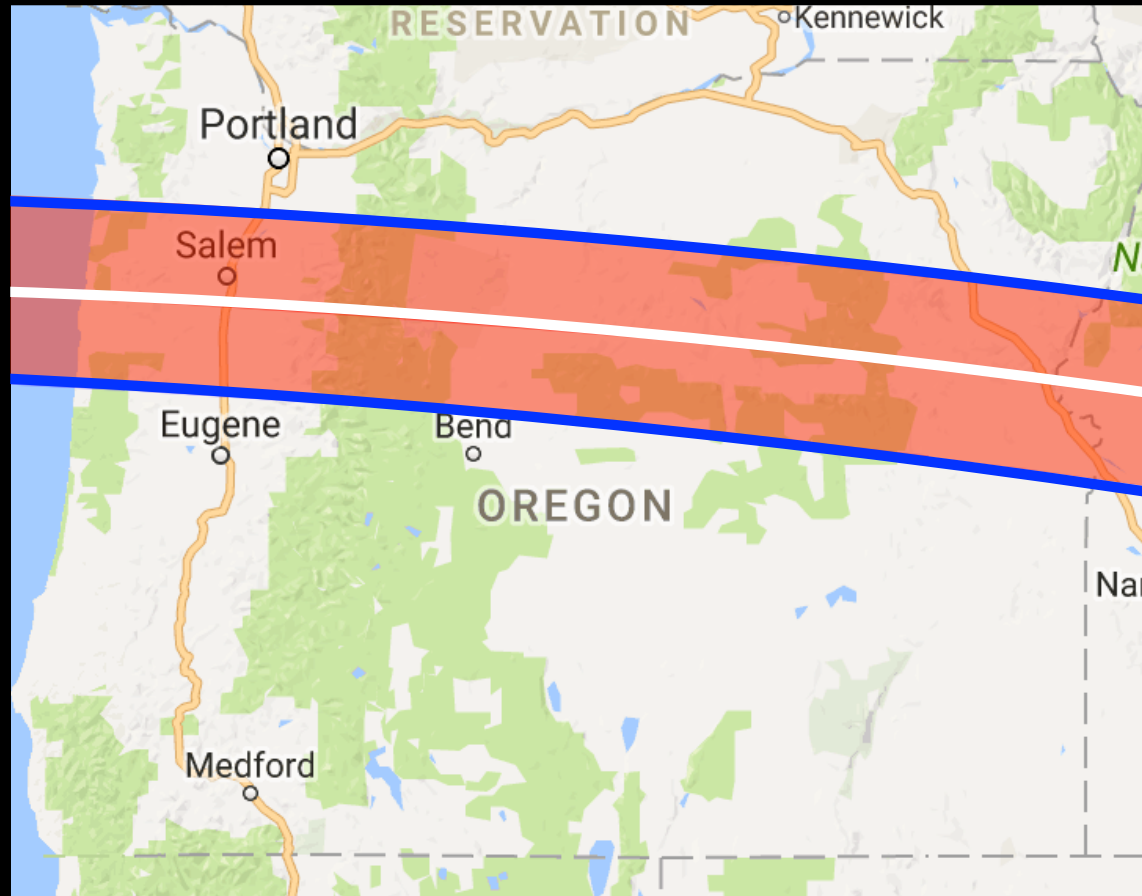
Total Solar Eclipses: 1951 - 2000



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



# August 21, 2017



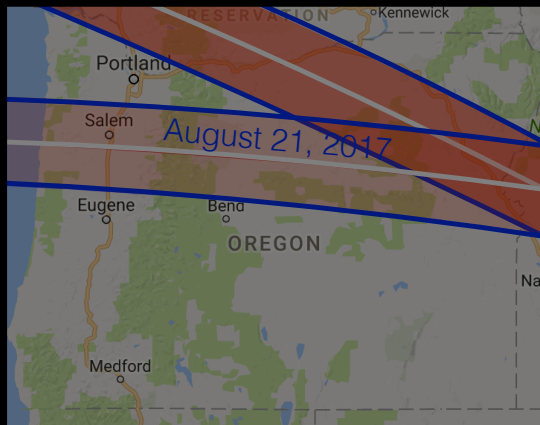
# Total Solar Eclipses Over Oregon Since Statehood



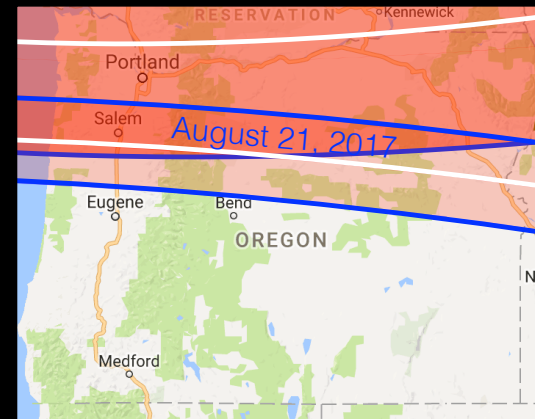
Jul 18, 1860



Jan 1, 1889



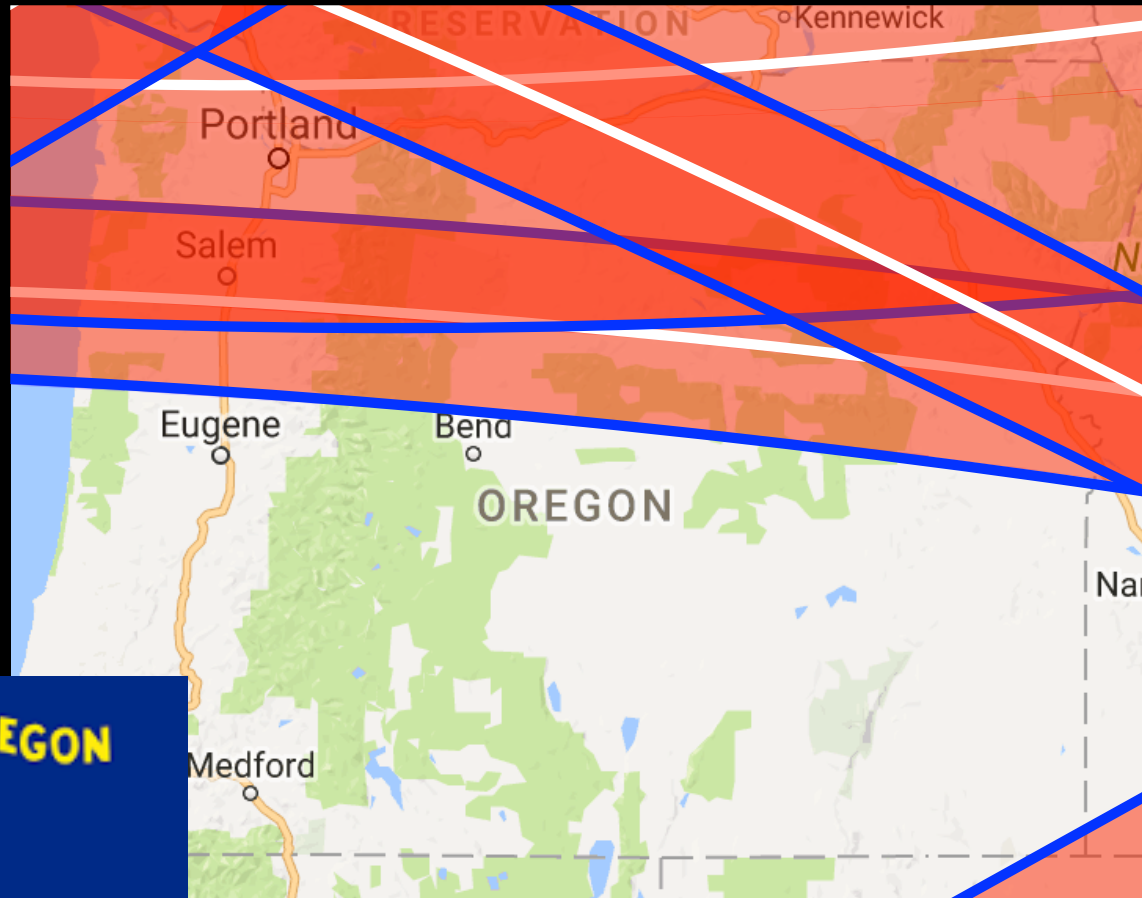
Jun 8, 1918



Feb 26, 1979

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

# Since Statehood in 1859





# 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.

TOTALITY BEGINS 2:35 P.M. PACIFIC STANDARD TIME

ABERDEEN

BAKER CITY 4:03 P.M. PACIFIC TIME

POCATELLO 5:12 P.M. MOUNTAIN TIME

GREEN RIVER 5:16 P.M. MOUNTAIN TIME

DENVER 5:23 P.M. MOUNTAIN TIME

GARDEN CITY 5:27 P.M. MOUNTAIN TIME

ORLANDO 6:41 P.M. CENTRAL STANDARD TIME

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.

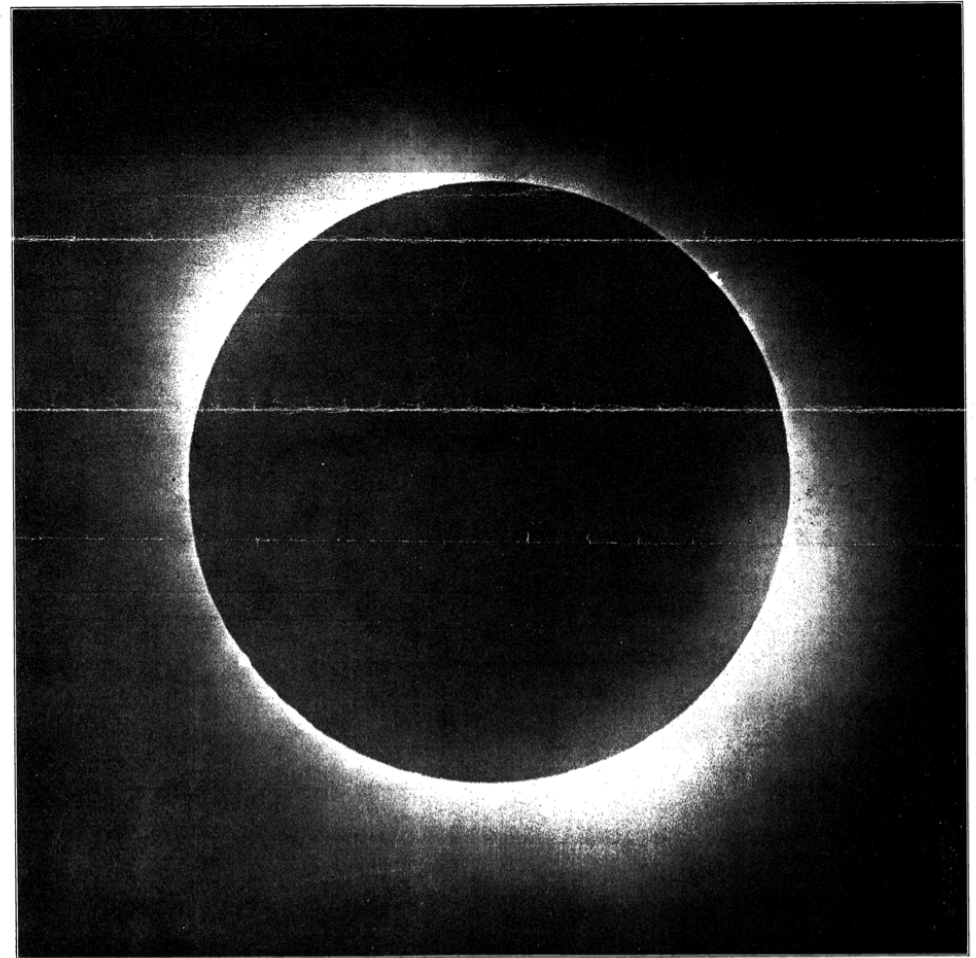
(Communicated by Rear Admiral T. B. Howard, USN., Ret., Superintendent.)

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

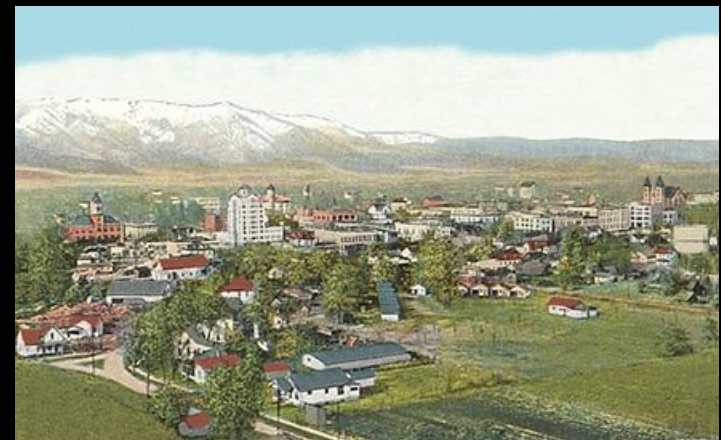
# Report of US Naval Observatory Team Total Solar Eclipse of June 8, 1918



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.



Credit: Princeton Univ. Art Museum

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

On the morning of June 8 the sky was entirely overcast.  
with the equatorial.  
somewhat. At the time of first contact there was  
a thin cloud over the sun but the contact was  
easily observed.



Credit: Princeton Univ. Art Museum

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



On the day of the eclipse, the sky was entirely overcast with the sun obscured by a thin cloud. The sun was easily observed.

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.



Credit: Princeton Univ. Art Museum

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

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Faeroe Islands on March 20, 2015. (Eric Adams, The Associated Press)



Credit: Princeton Univ. Art Museum

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.



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

On the morning of June 8, 1918, the sky was overcast. With the exception of a few clouds, which were somewhat thin and easily observed, the clouds were clear. The sun would be visible.



Credit: Princeton Univ. Art Museum

however, the seeing was very steady and the photographs, while they do not show the fainter and outer extensions of the corona, give fine representations of the inner corona and prominences. The seeing was very steady and the photographs, while they do not show the fainter and outer extensions of the corona, give fine representations of the inner corona and prominences.

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

On the morning of June 8, 1918, the sky was overcast.

With the evening, the clouds were somewhat thinner, and a thin cloud layer was easily observed.

At 7:30 p.m., the sun was visible through a clear space.

The seeing was very steady and the photographs, while they do not show the fainter and outer extensions of the corona, give fine representations of the inner corona and prominences.

Afterward, the sun was again visible through a clear space.

The seeing was very steady and the photographs, while they do not show the fainter and outer extensions of the corona, give fine representations of the inner corona and prominences.

Afterward, the sun was again visible through a clear space.

We hope for better weather this time!



Univ. Art Museum

USC\_0128.JPG.html

ing totality.



# 1918 and 2017



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

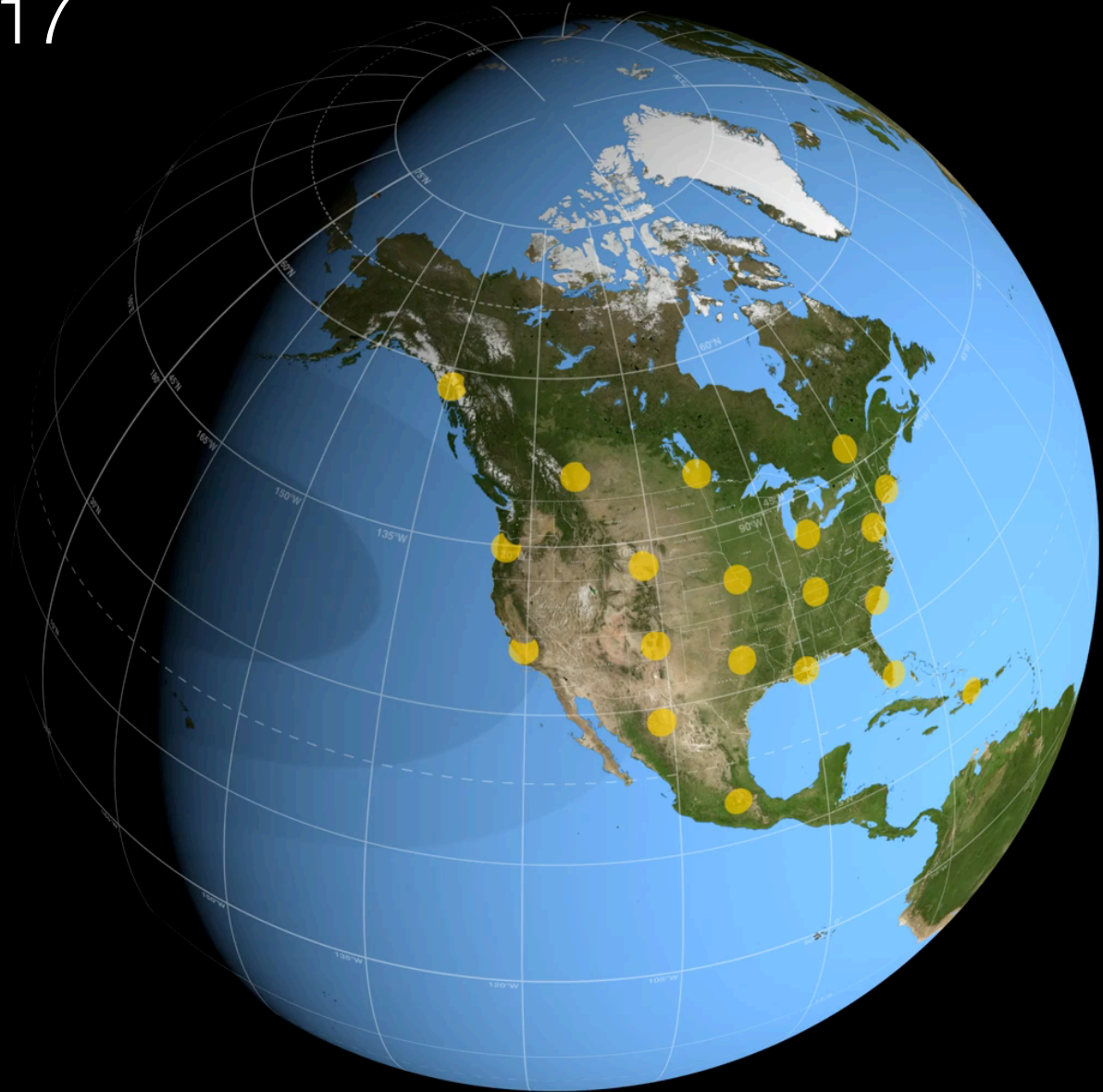
Map adapted by NationalEclipse.com from original at [eclipse.gsfc.nasa.gov](http://eclipse.gsfc.nasa.gov). Map copyright Google, INEGI. Eclipse predictions courtesy of Fred Espenak, NASA/Goddard Space Flight Center.

*Jim Brau,*

*Oregon 2017 Quarknet*

*June 27, 2017*

# August 21, 2017



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

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

*Jim Brau,*

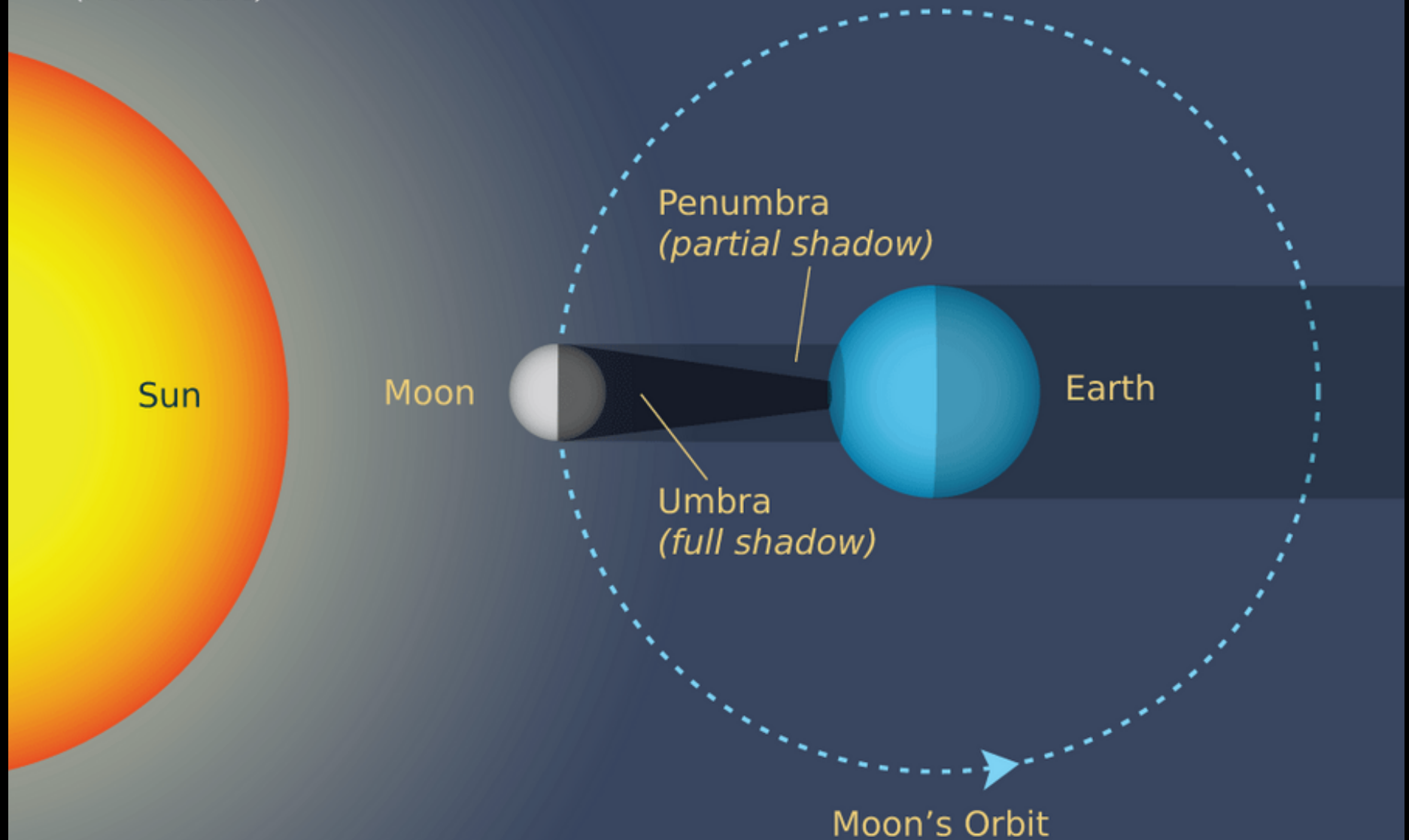
*Oregon 2017 Quarknet*

*June 27, 2017*



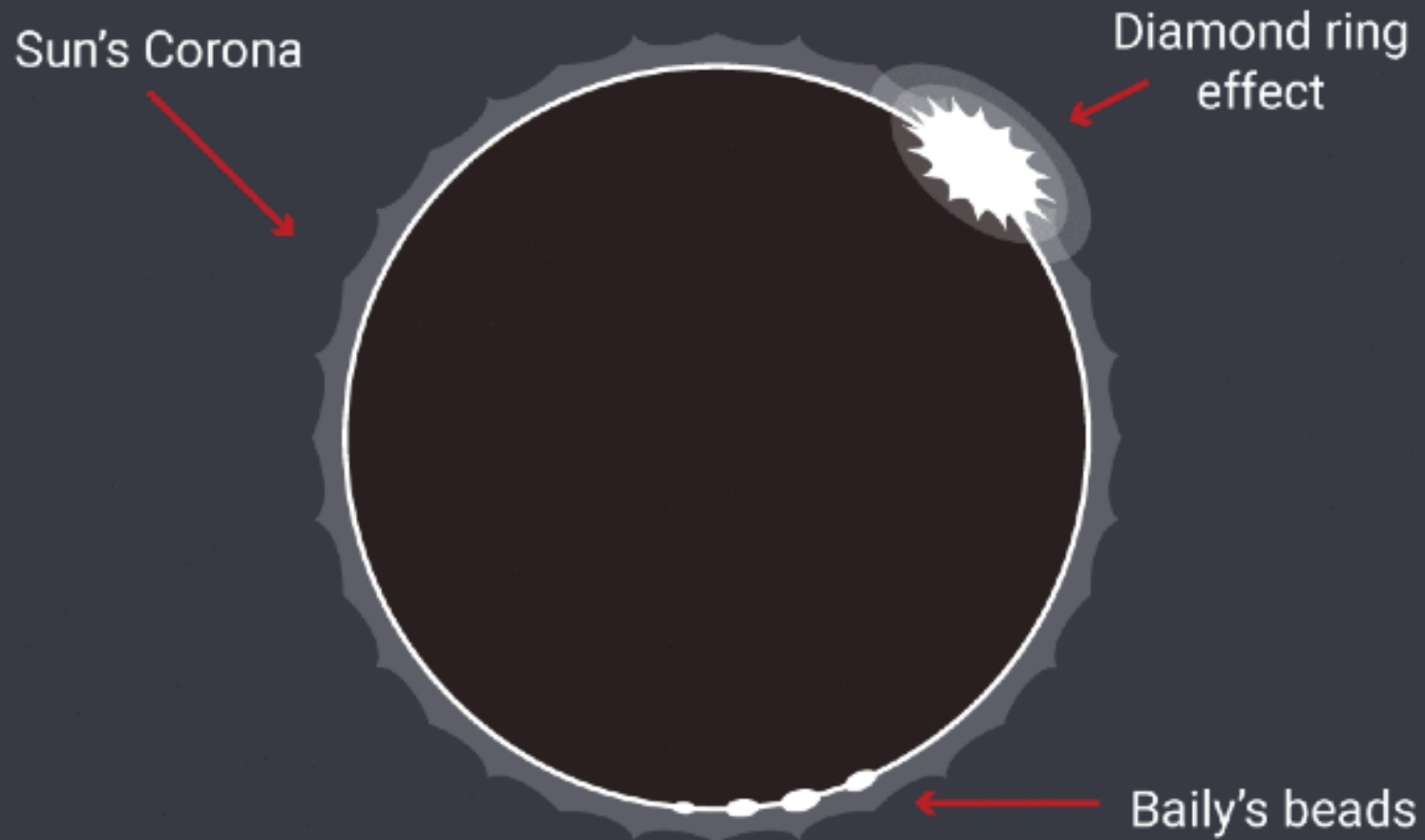
## Anatomy of a Solar Eclipse

(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>

# Baily's Beads

- Beads of bright sunlight
  - Appear on edge of Moon during solar eclipse
  - Sunlight shines through valleys between mountains on edge of Moon
  - Recorded by British astronomer Francis Baily during eclipse on May 13, 1836
  - Noted earlier (1715) by Sir Edmond Halley of Halley's comet fame:
    - "About two Minutes before the Total Immersion, the remaining part of the Sun was reduced to a very fine Horn, whose Extremities seemed to lose their Acuteness, and to become round like Stars ... which Appearance could proceed from no other Cause but the Inequalities of the Moon's Surface, there being some elevated parts thereof near the Moon's Southern Pole, by whose Interposition part of that exceedingly fine Filament of Light was intercepted."



<http://www.naasbeginners.co.uk/News/SolarEclipseMarch2015.htm>

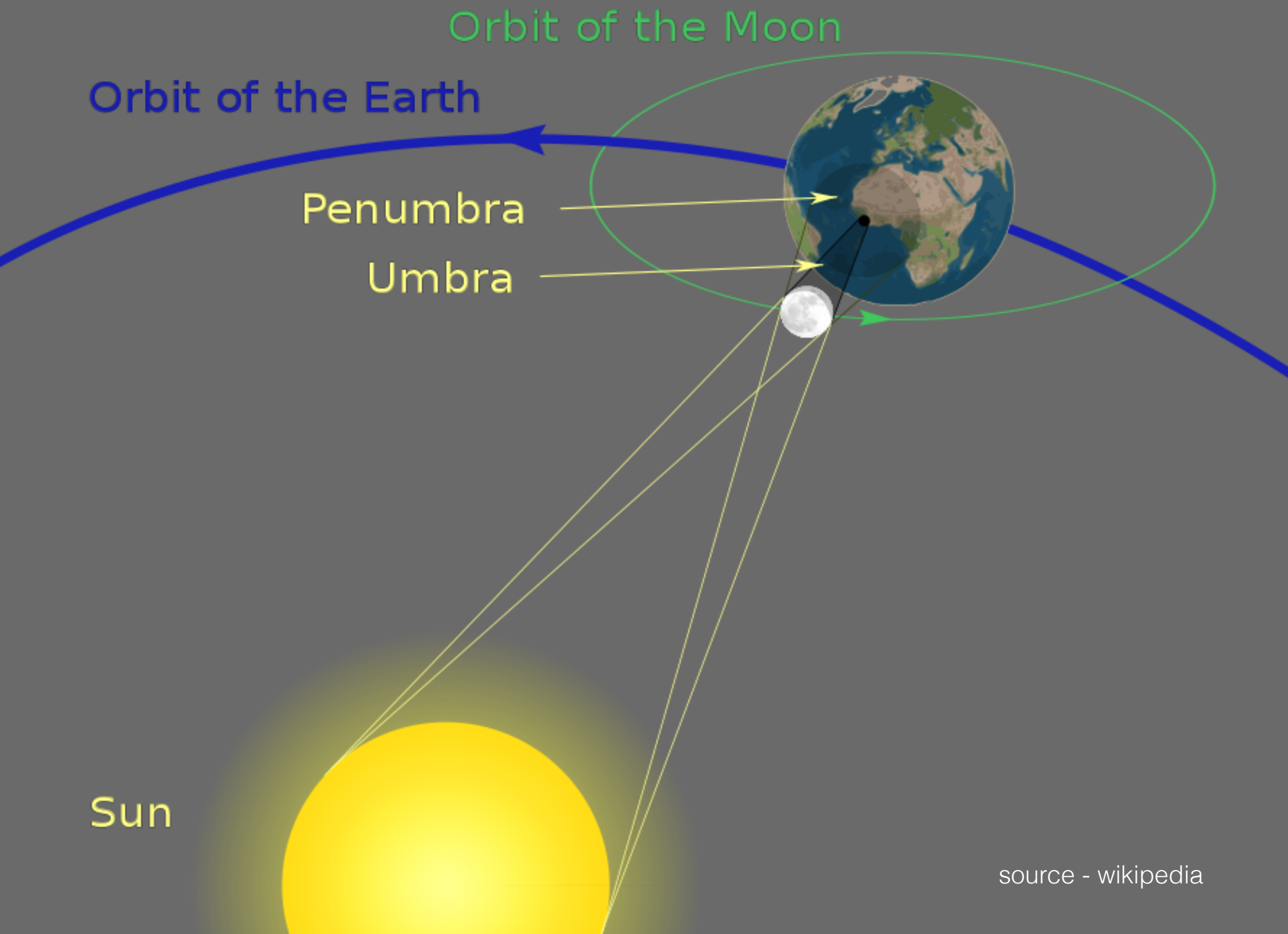


# Diamond Ring

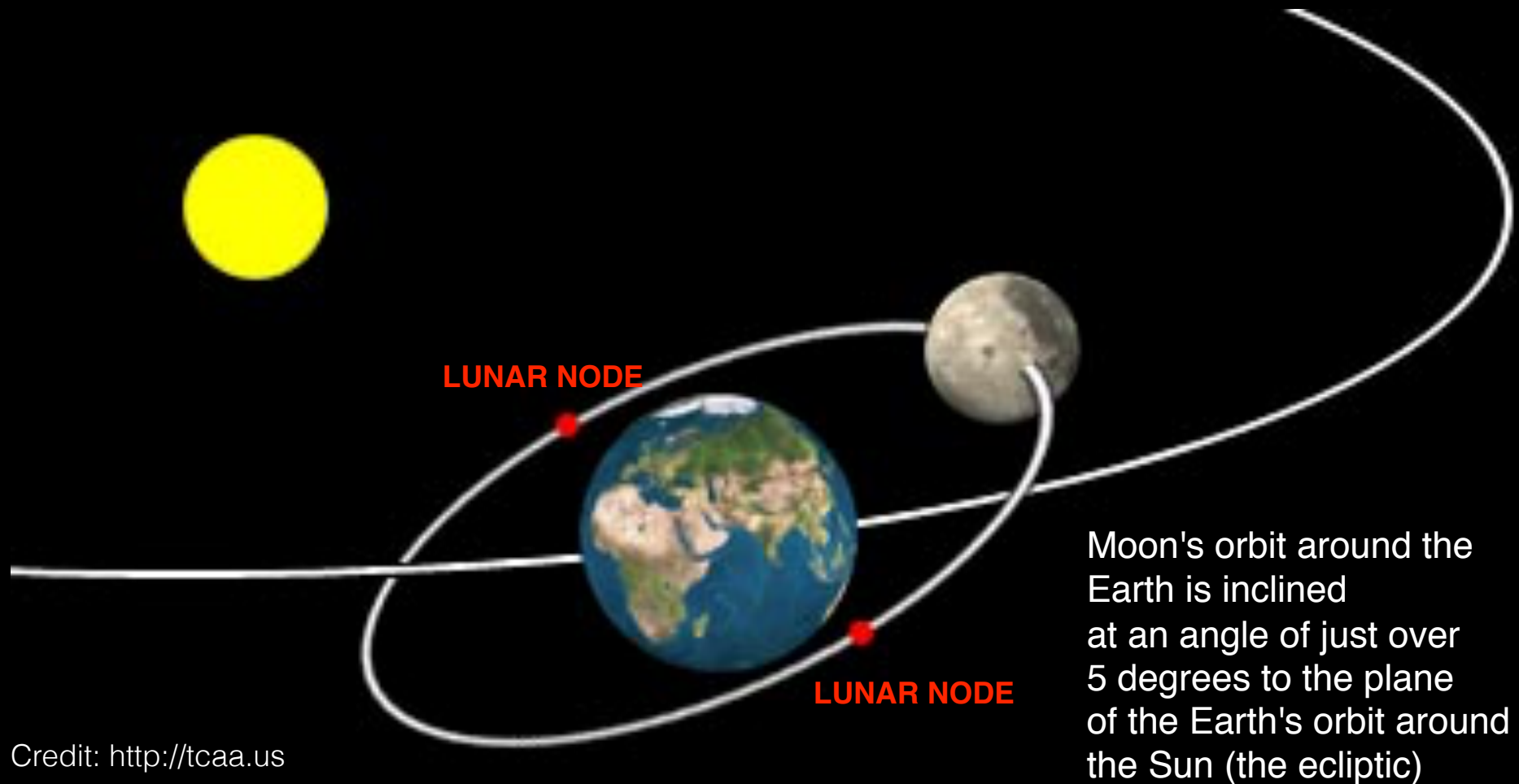
- Related to Bailey's beads:
  - At the moment of solar disappearance or reappearance.
  - The relief in the Moon's topography (a rugged terrain of mountains, craters, valleys, etc.) creates a large bead of light passing through a valley, appearing like a diamond ring.



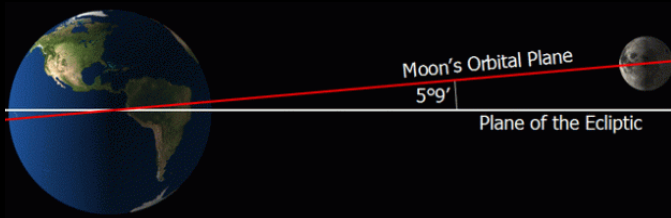
<http://www.mirror.co.uk/news/uk-news/solar-eclipse-2015-how-watch-5229108>  
Photo: Getty Images



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



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



<http://rasyonalist.org>

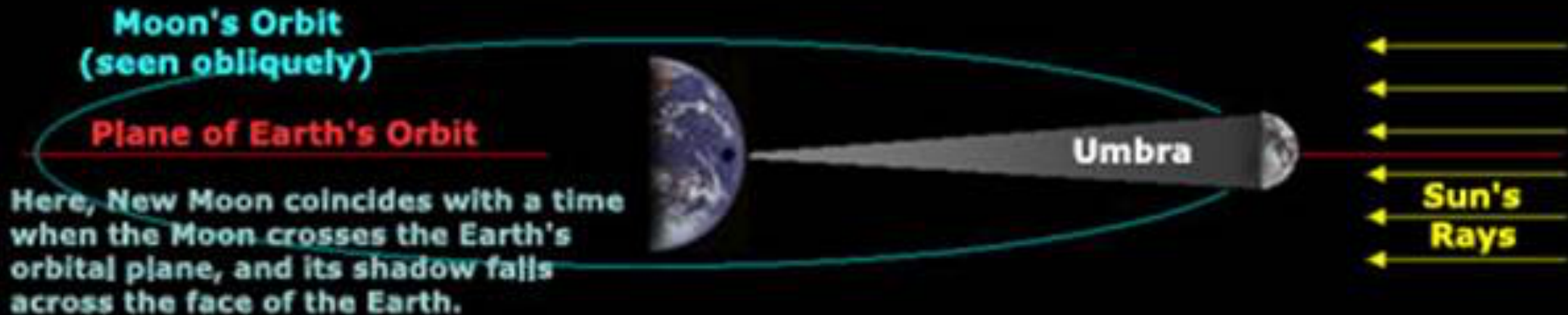


[http://phys23p.sl.psu.edu/phys\\_anim/astro/indexer\\_astroC.html](http://phys23p.sl.psu.edu/phys_anim/astro/indexer_astroC.html)





In most months of the year the Moon's orbit is not aligned such that new moon occurs in the ecliptic and will not create an eclipse.

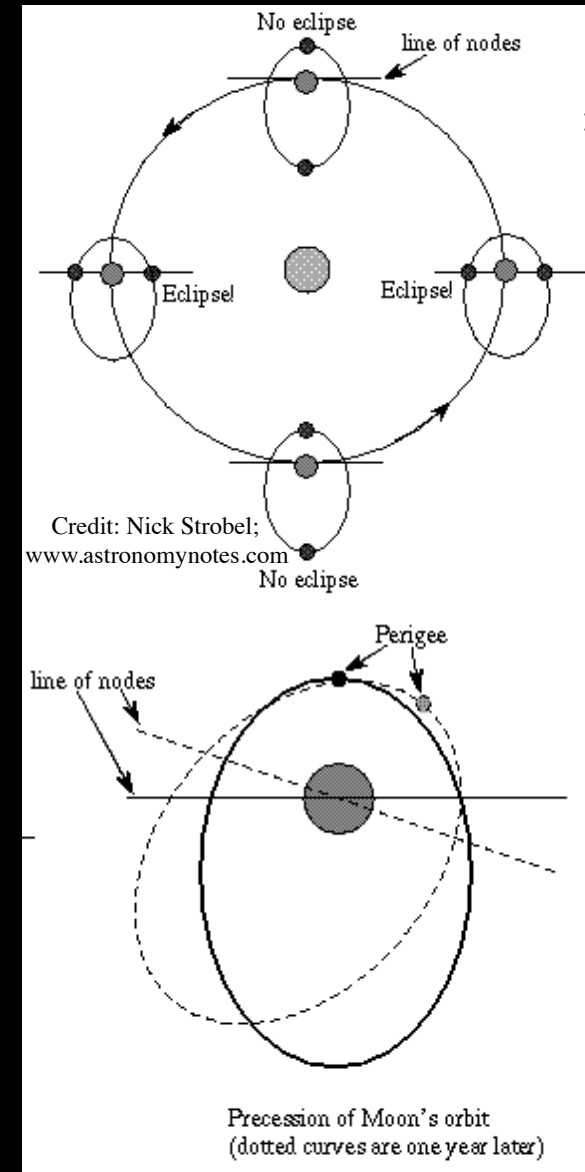


When Moon's orbit is aligned the Moon can make an eclipse.

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

# Ellipticity of orbits

- Ellipticity of orbits of Earth and Moon means the relative sizes of Sun and Moon in Earth's sky varies -
  - Distance of Earth from Sun varies:
    - 147 - 152 million miles
  - Distance of Moon to Earth varies:
    - 221,500 - 252,700 miles
- This changes the relative sizes and results in total or annular eclipses.



# How frequently does Moon align for solar eclipse

| Location              | Most recent totality | Next scheduled<br>Totality | Number of years<br>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.



# Viewing the Eclipse

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

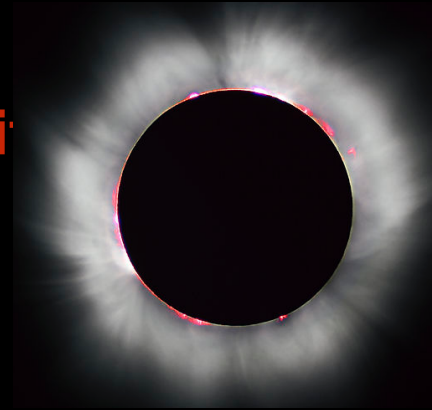
During partiality special glasses rated for solar viewing should be used.

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.

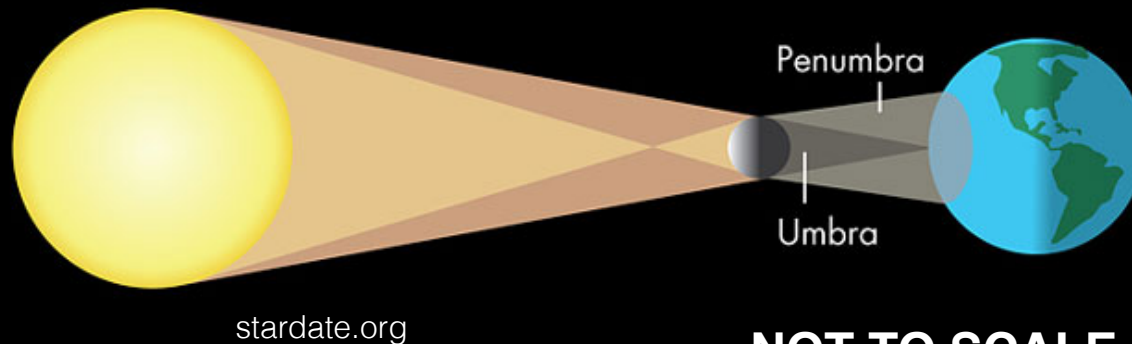


# Coincidence of Angular Sizes Resulting in Total Solar Eclipse



# 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.



**NOT TO SCALE**

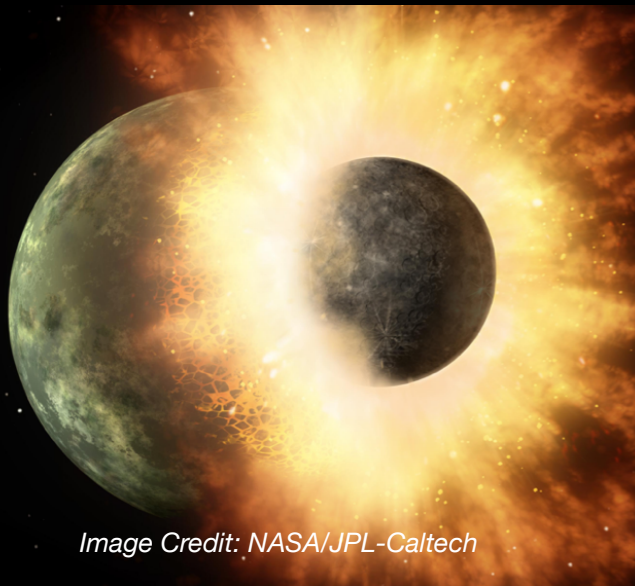


# Why Do We Have This Coincidence?

## - 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?



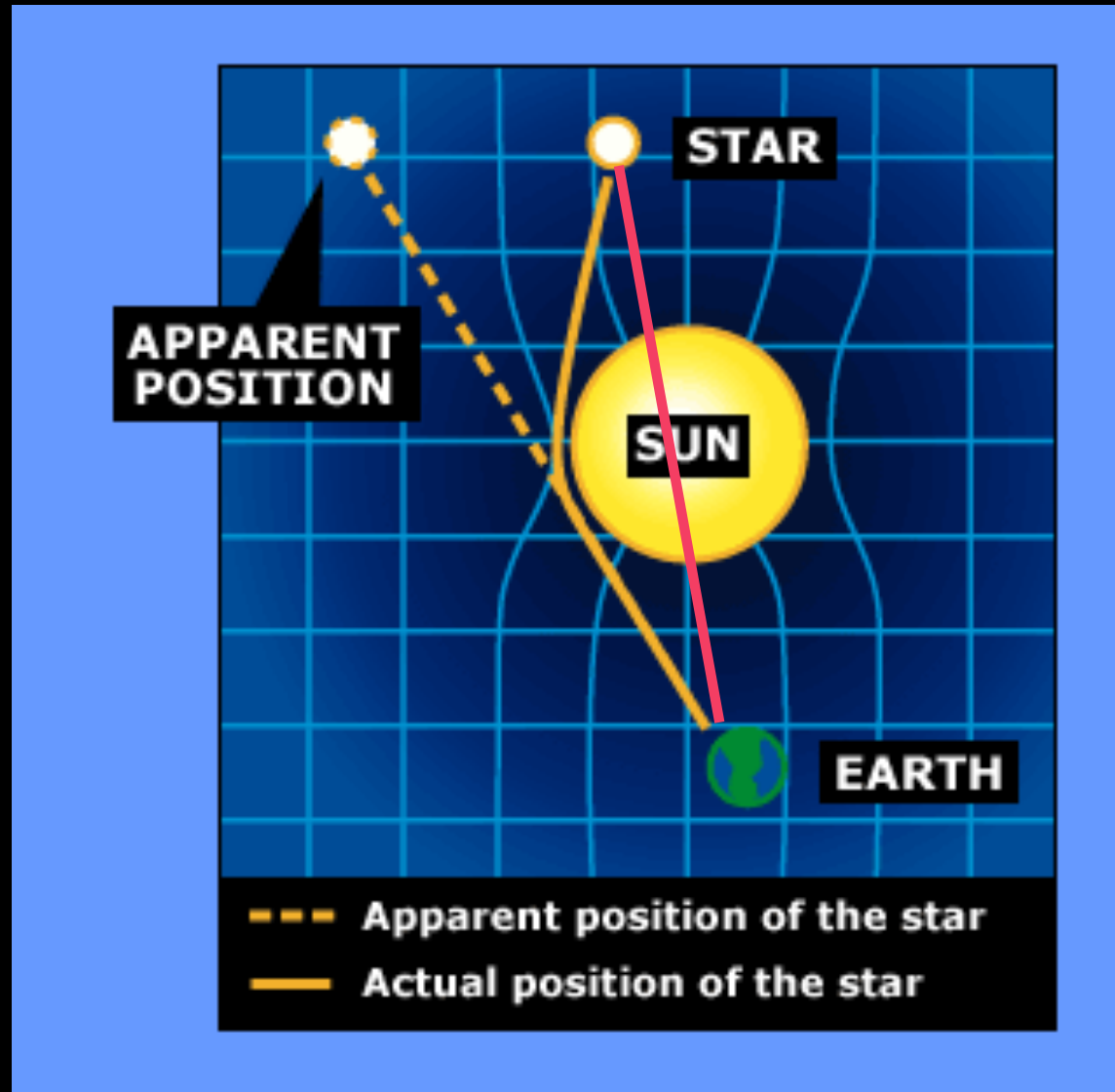
# Measure Solar Atmosphere or Corona

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

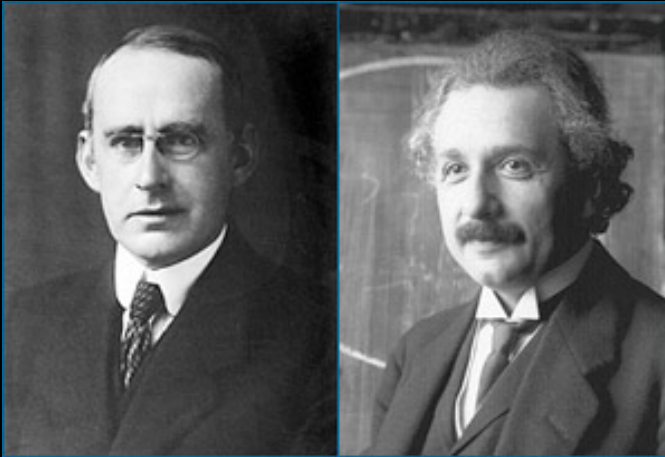


Credits: M. Druckmüller

# Test General Relativity

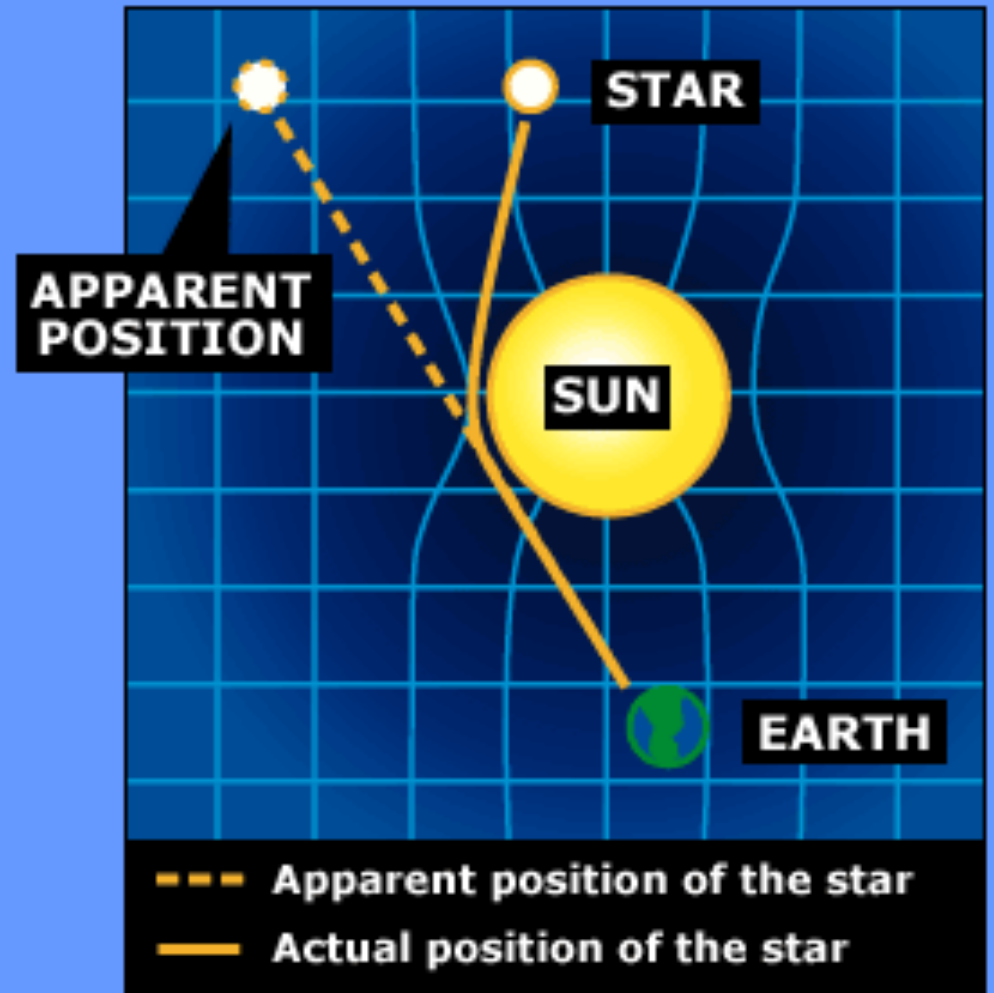


# Test General Relativity

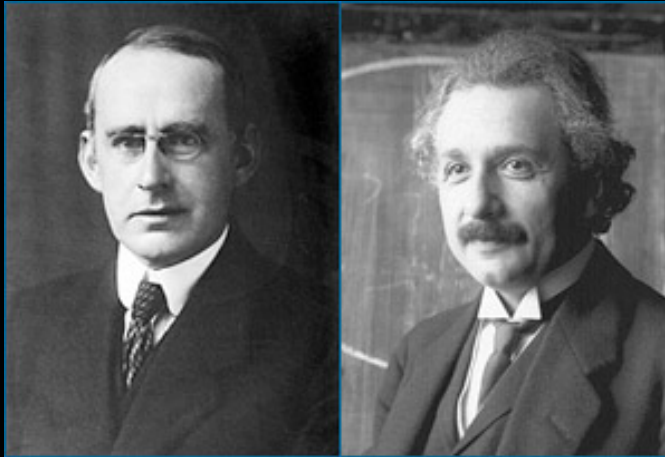


1915 - Einstein's General Relativity - new theory of gravity - predicts bending of light by gravity

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

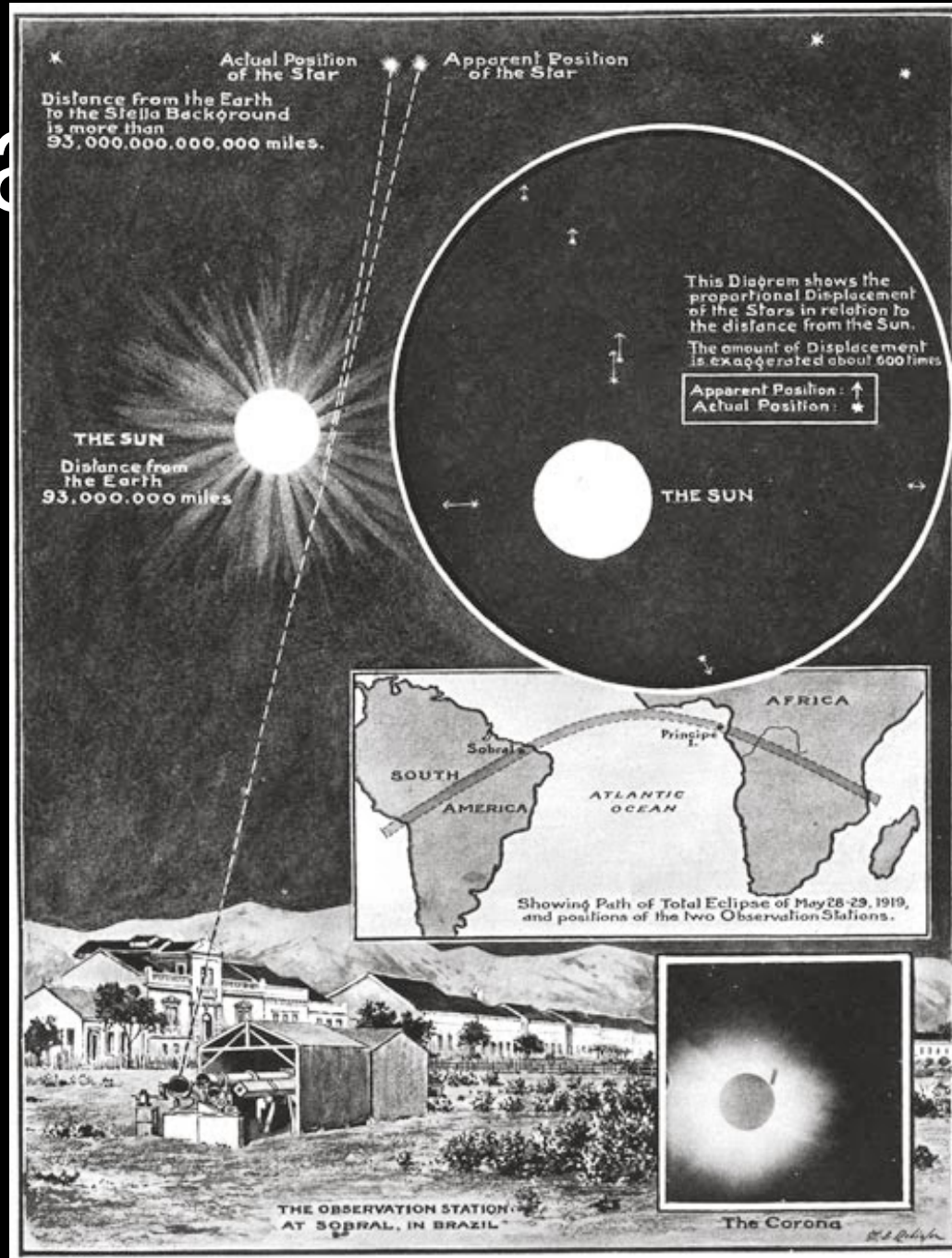


# Test General



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

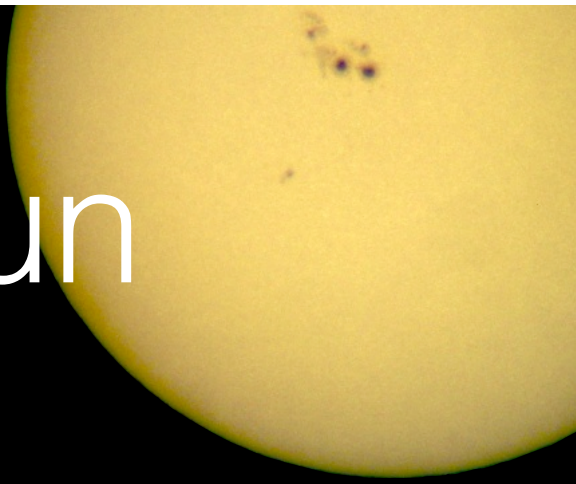
May 29, 1919 - Eddington leads expedition to test bending of starlight during TOTAL SOLAR ECLIPSE



Credit: Illustrated London News, 22 November 1919



# Power of the Sun

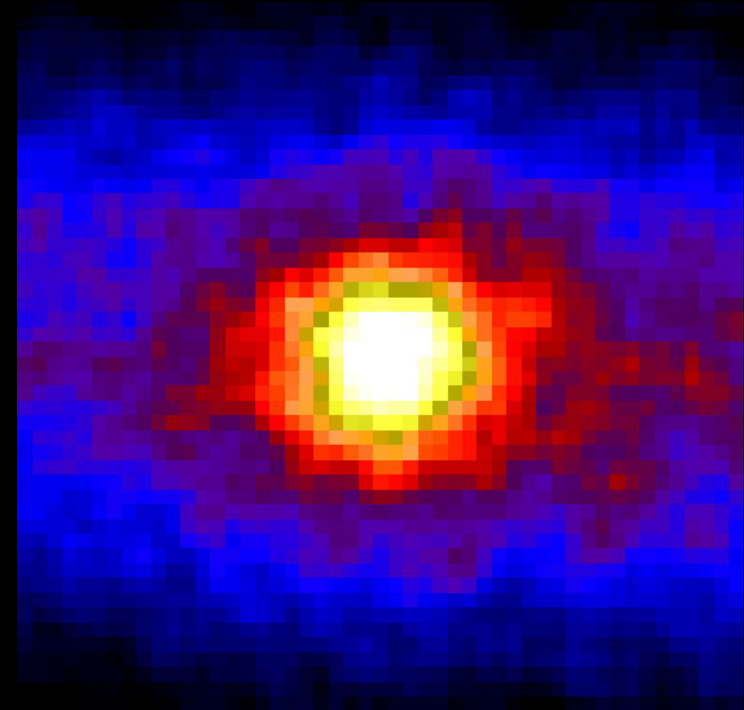


- The release of energy in the Sun results from thermonuclear reactions in which light elements (such as hydrogen) are fused into heavier elements (such as helium).
- The temperature at the center of the Sun, where these reactions are primarily at work, is 15,000,000 Kelvin (or 27,000,000 Fahrenheit).
- The power released in the sun is  $4 \times 10^{26}$  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.
- 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.



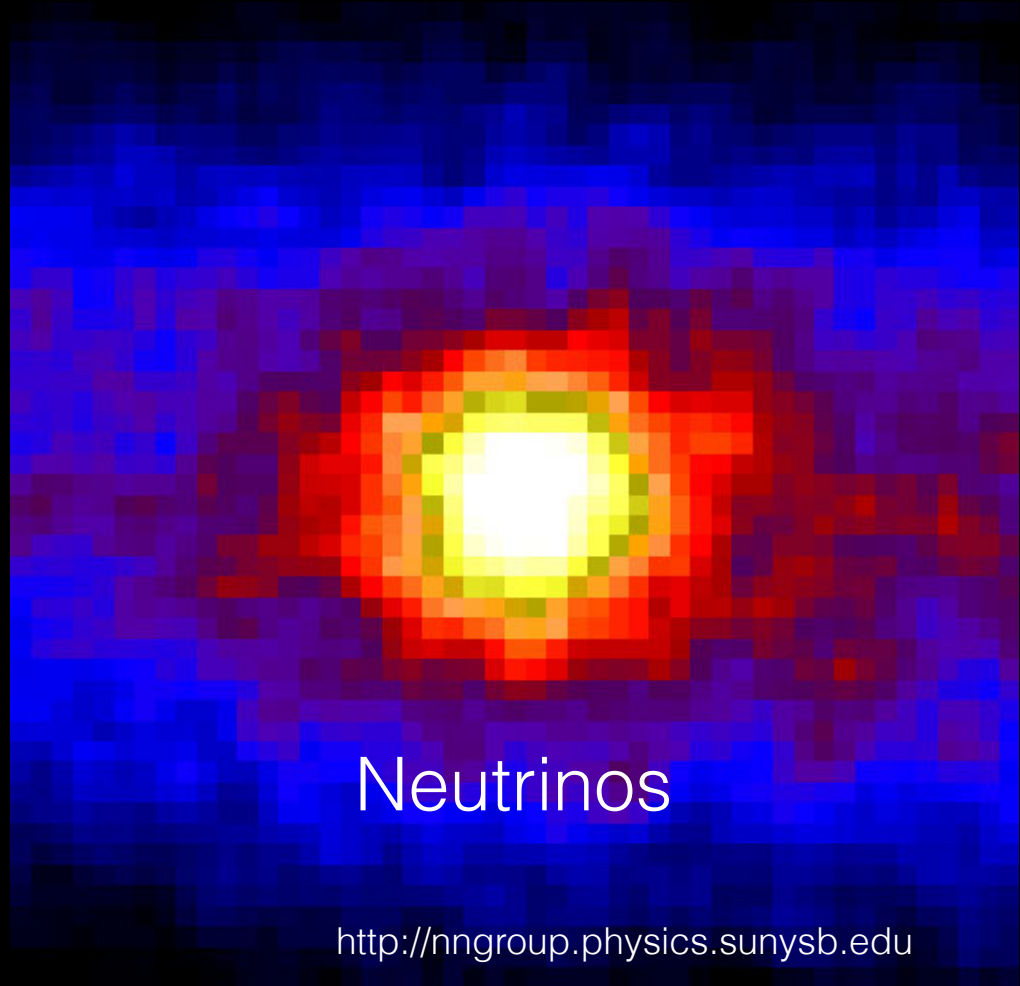
<http://nngroup.physics.sunysb.edu>

# Image of Sun Before Eclipse



Visible Light

<http://www.solarham.net>

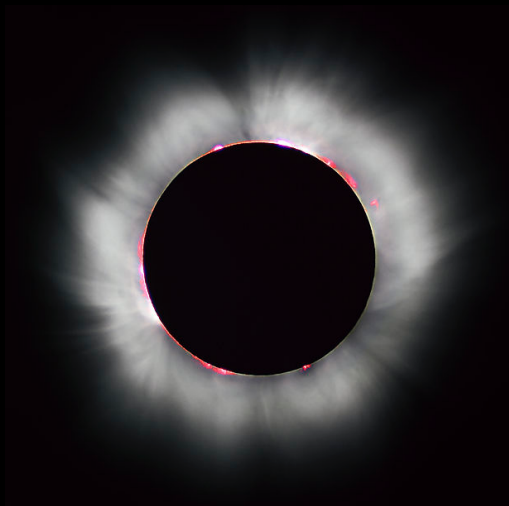


Neutrinos

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

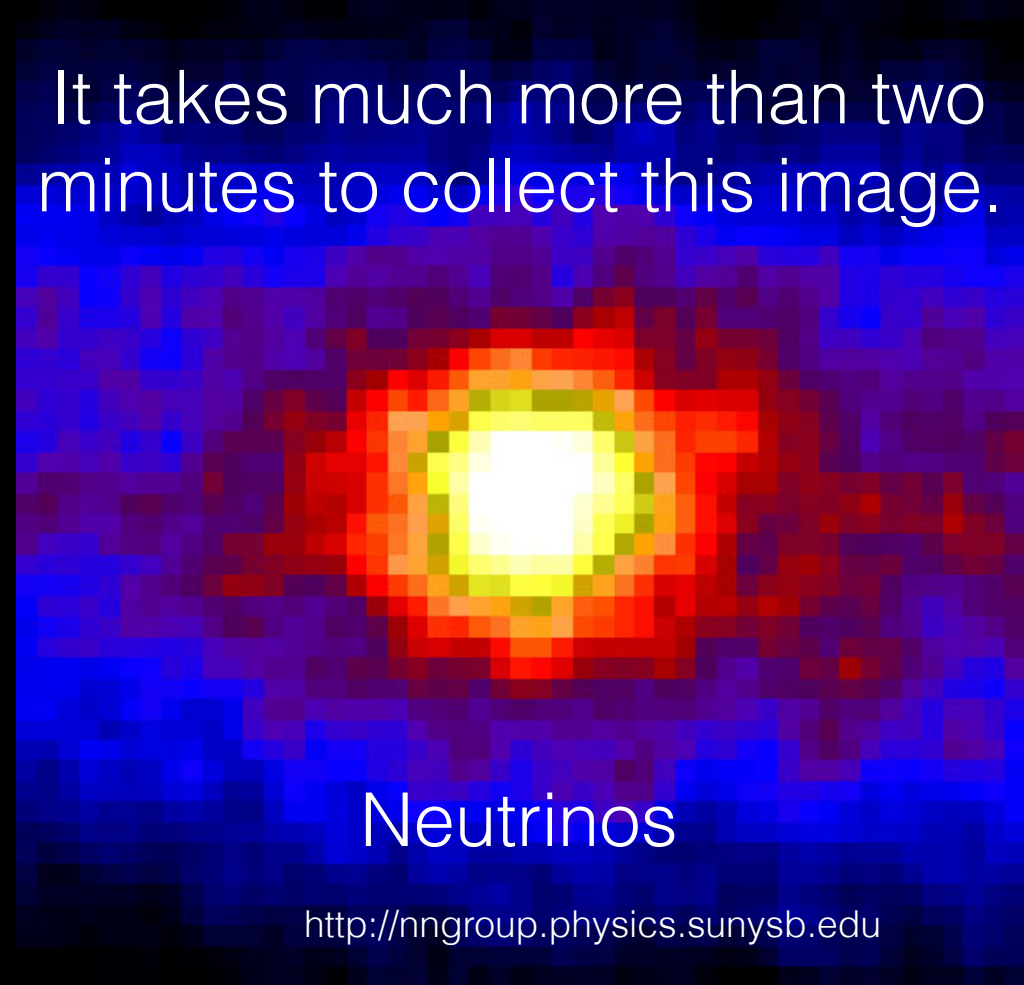
# Image of Sun During Eclipse

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



Visible Light

[https://en.wikipedia.org/wiki/Solar\\_eclipse](https://en.wikipedia.org/wiki/Solar_eclipse)



Neutrinos

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

- Neutrinos pass right through the moon without loss!

# Other Types of 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.
- June 5, 2012
  - Venus transit of Sun
- Search for exoplanets
  - Kepler space telescope

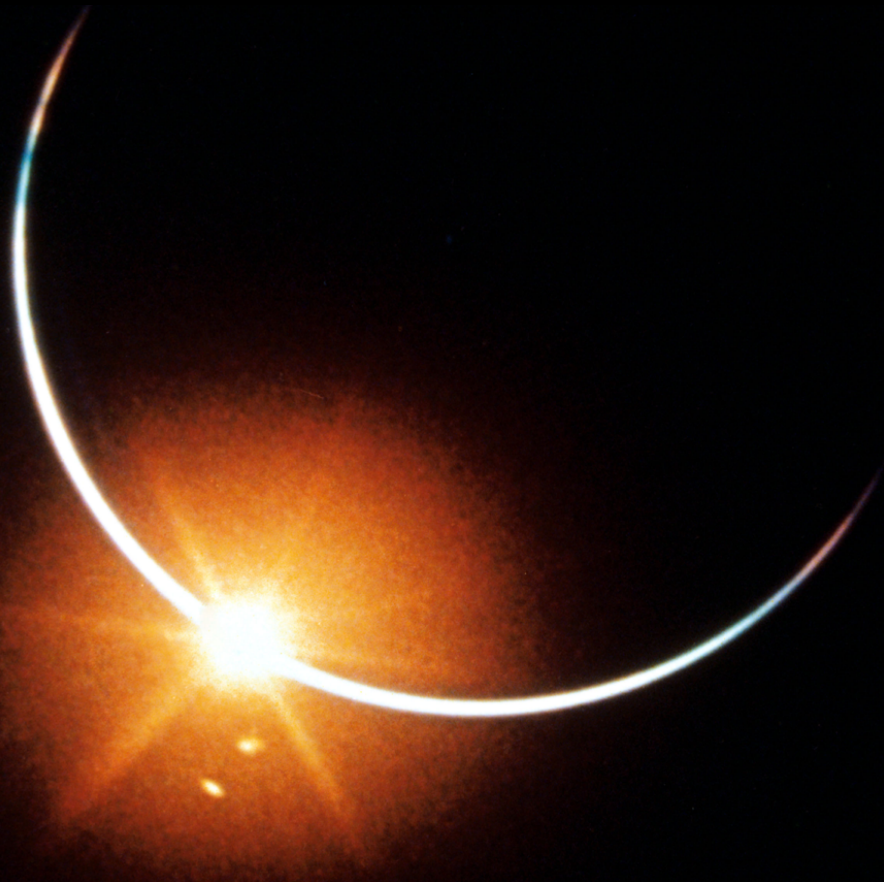
September 4, 2011

Cassini spacecraft observed Sun eclipsed by Saturn





November 24, 1969



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

# Solar Transit of Venus

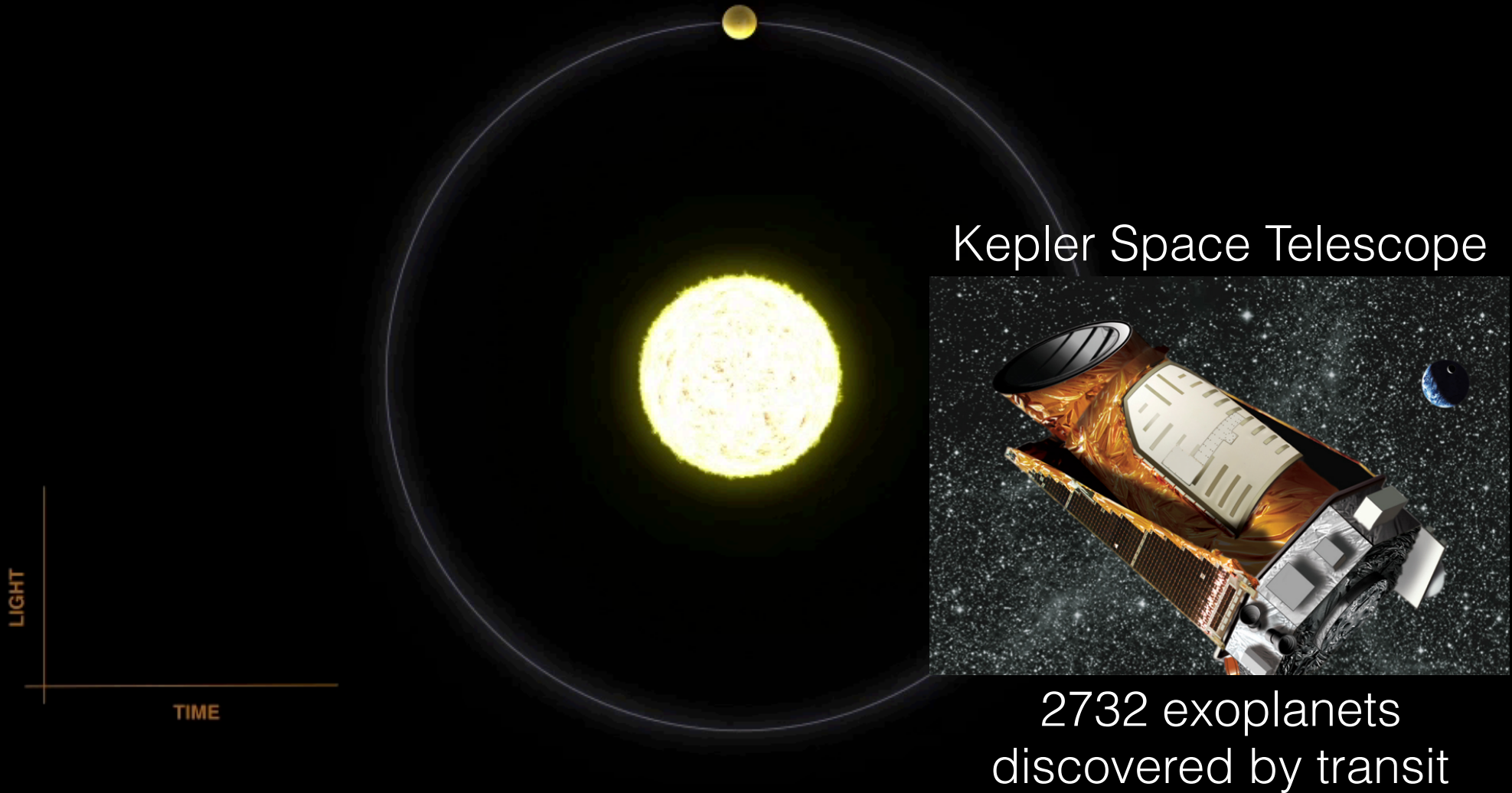
Transit of Venus Time Lapse - June 5, 2012  
Once in a Lifetime  
Next Venus Transit in 2117

- Transits of Venus are rare
  - Two in 21st century
  - Mercury transits are more common
    - 13 or 14 per century
    - next Mercury transit Nov 11, 2019
- Venus transit on June 5, 2012



Credit: YouTube - bobbfwed

# Search for Exoplanets

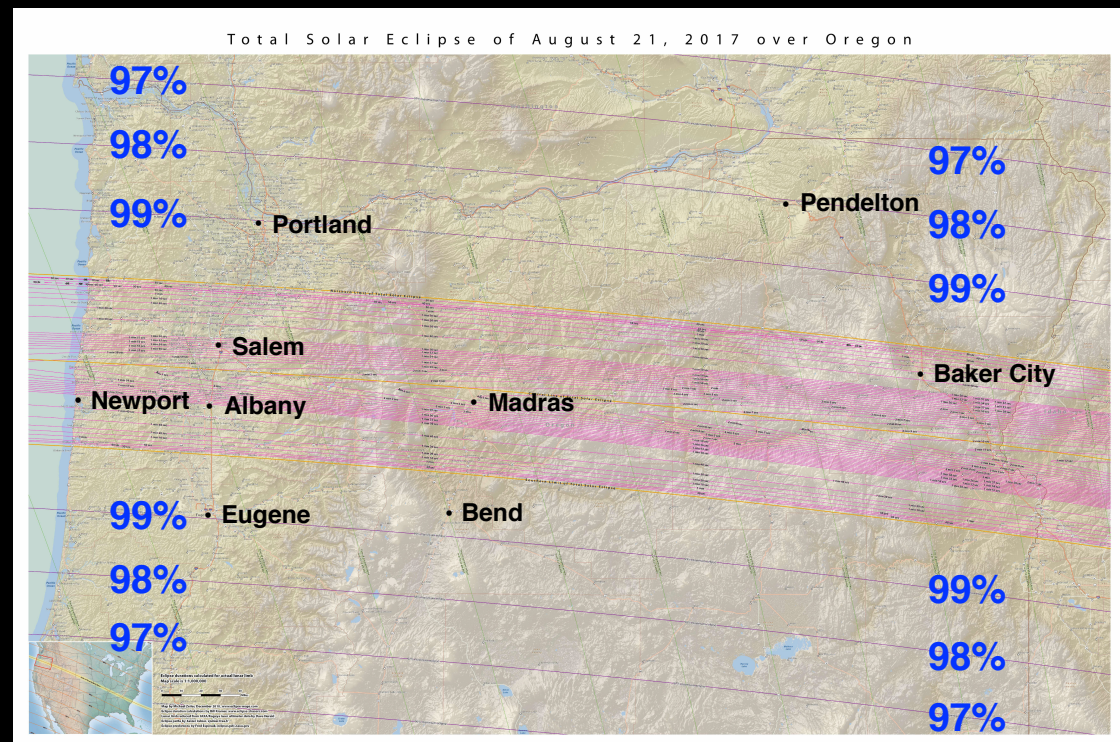




# August 21 Eclipse In Oregon

- TOTAL - Newport, Salem, Albany, Madras, Baker City
- 99.5% - Bend
- 99% - Eugene, Portland, Florence
- 98.5% - Burns, The Dalles
- 98% - Pendleton
- 97.5% - Astoria
- 97% - Roseburg
- 96% - Crater Lake
- 94% - Klamath Falls

<http://eclipsewise.com>



# 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.





# 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!