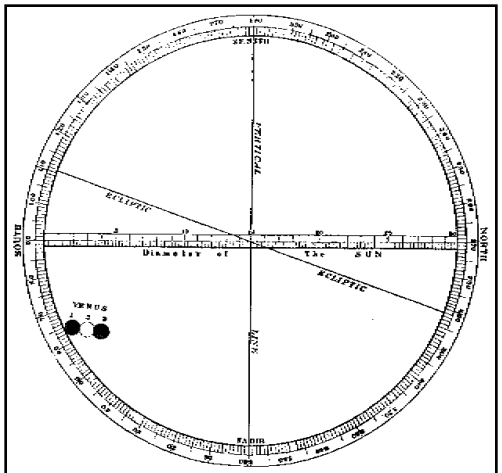
VENUS Transit 2004

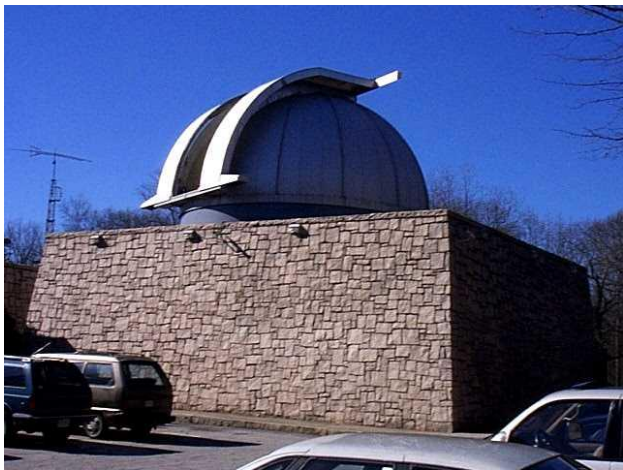
Twice in a Lifetime!

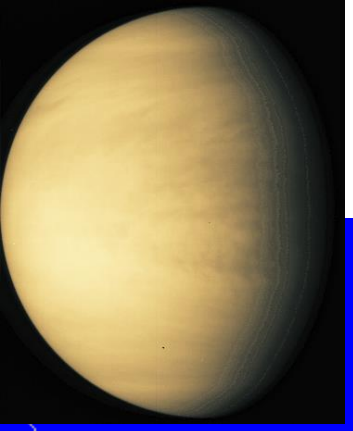
Sligo Creek Elementary School

Family Science Night

Lou Mayo (Raytheon / NASA GSFC)







Venus Tonight: 7pm, May 6, 2004

It’s All in the Geometry

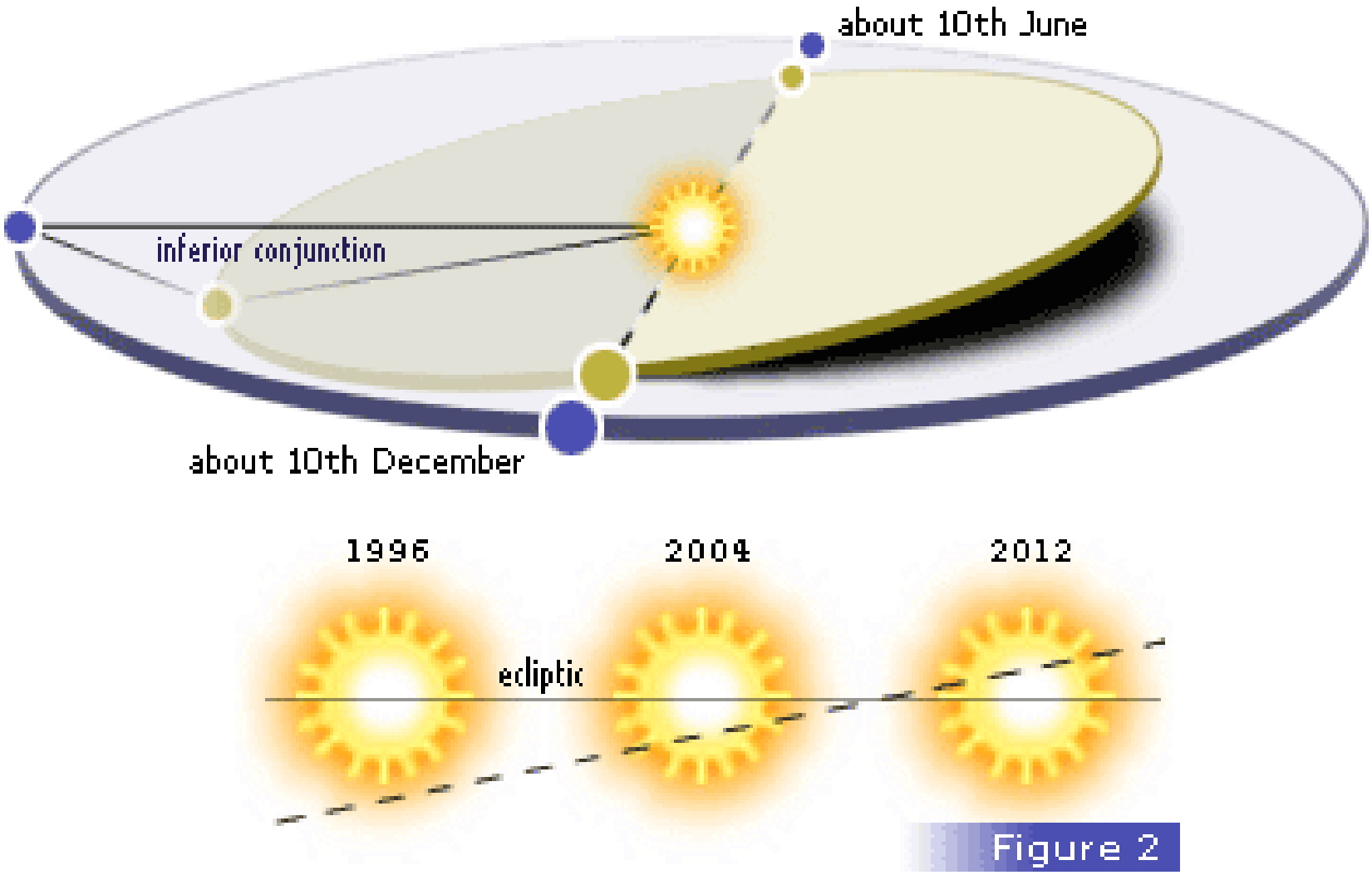
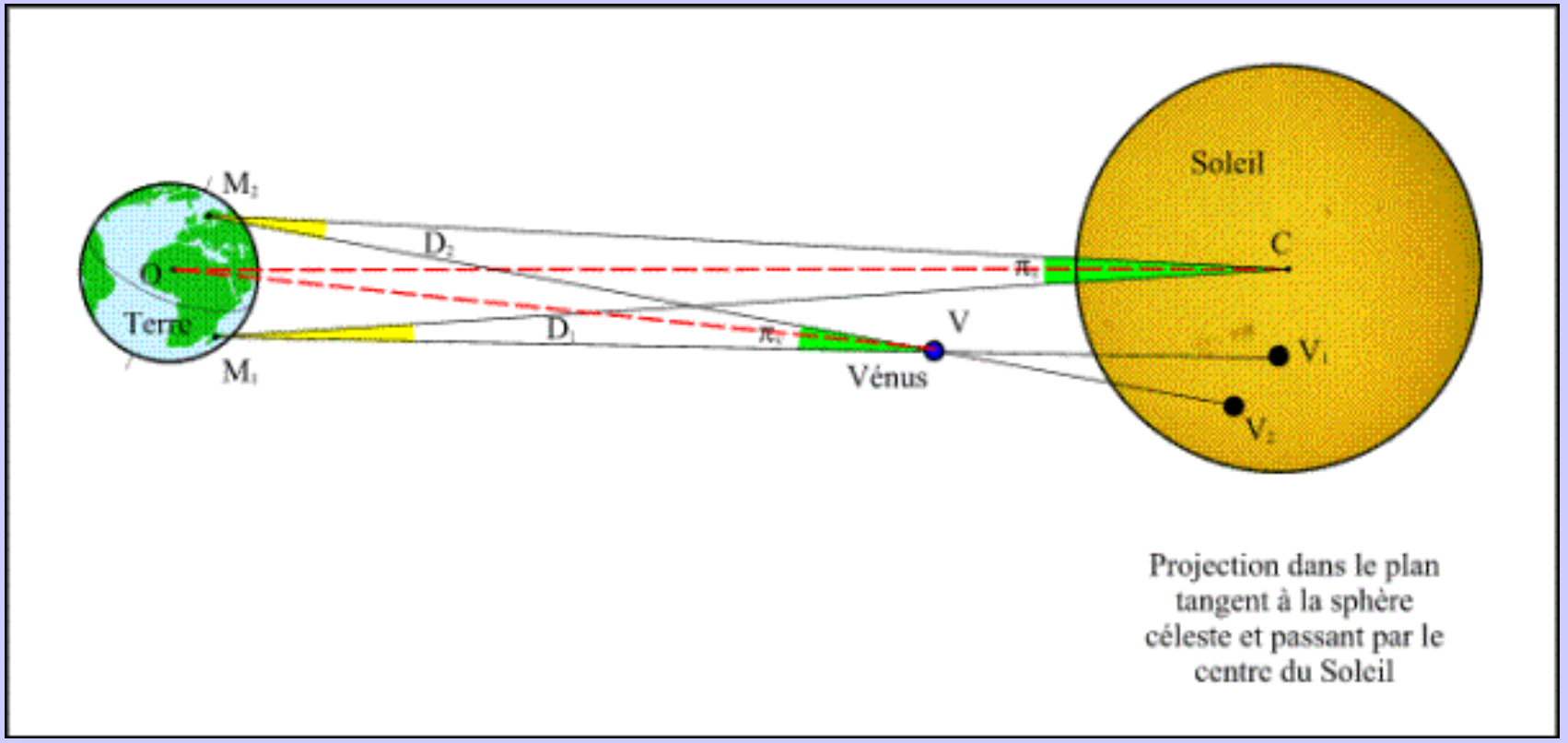


Figure 2

Venus Transit in French



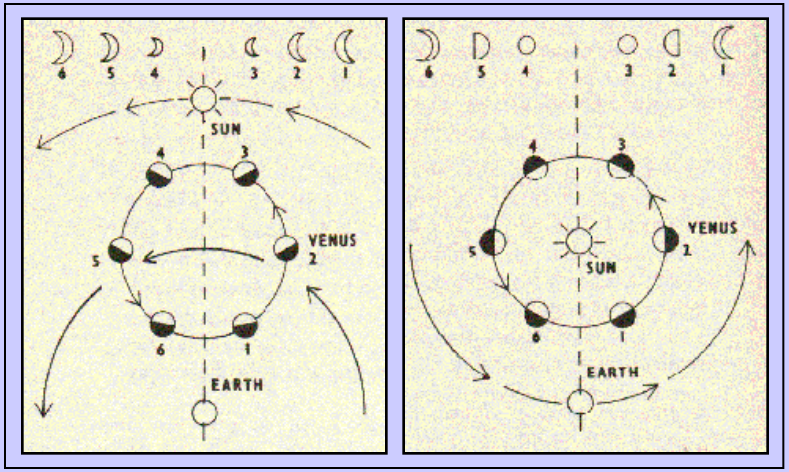
TRANSIT DATES

- December 1631
- December 1639
- June 1761
- June 1769
- December 1874
- December 1882
- June 2004
- June 2012
- December 2117
- December 2125

Venus' Role in History

Copernican System: 1, Ptolemaic System: 0

- Earliest records of observation date back to Babalonians ~3000 B.C.
- First telescopic observations - Galileo, 1610.
  - Venus had a cycle which could not be explained by its rotation around the earth
  - Venus exhibited phases
  - Venus changed apparent size



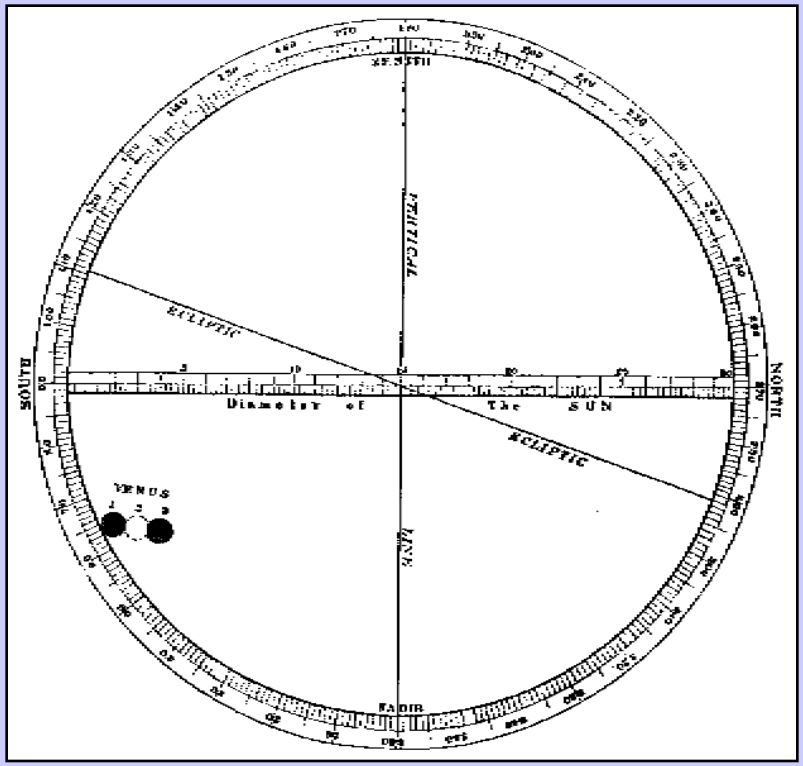
Cynthiae figuras aemulatur mater amorum. Translated: "the mother of love [Venus] emulates the figures of Cynthia [the Moon]."

- 1761 Transit was used to measure longitude before there were accurate clocks

Venus' Role in History

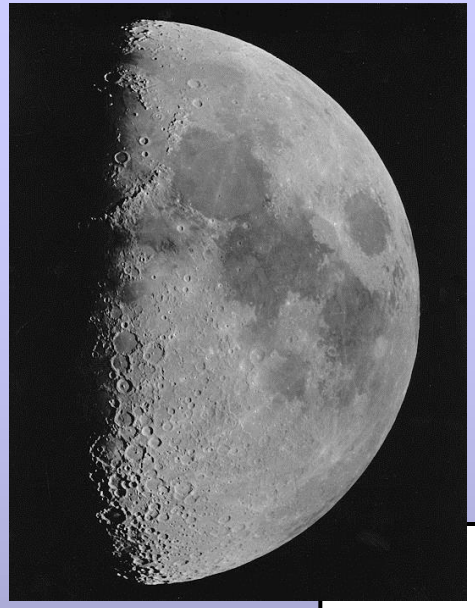
Size of the Solar System - Revealed!

- Kepler predicted the transit of December 1631 (though not observed!) and 120 year cycle.
- Jeremiah Horrocks (born c.1619) predict that a further transit of Venus would occur on 4th December 1639
- 1761 transit observations partly successful in determining value of A.U. Russian astronomer Mikhail V. Lomonosov, suggests Venus has an atmosphere.
- Captain James Cook et al., observed the 1769 transit from Tahiti.



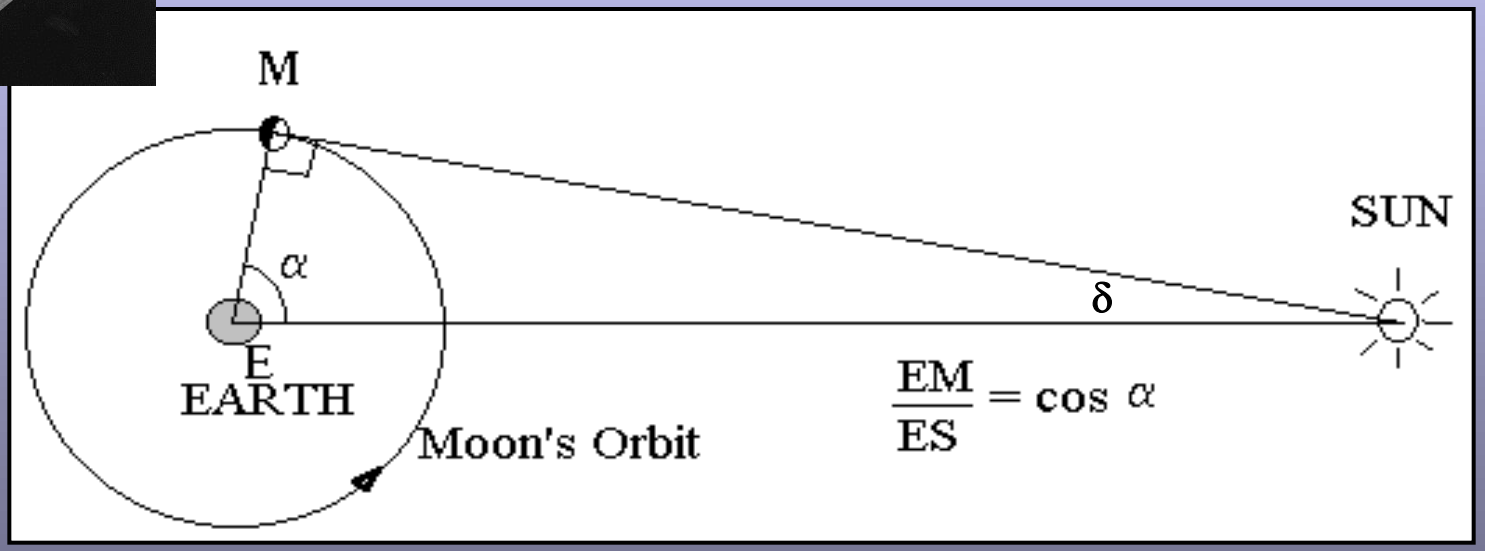
Local Time	D (% of Sun's Diameter)
3.15 pm	48.06
3.35 pm	45.00
3.45 pm	43.33

Figure from Johann Doppelmayer's Atlas Coelestis (1742)



Aristarchus of Samos (c.310 - 230 BC)

Early Estimate of the Astronomical Unit



Measured α = 87deg. Therefore:

ES/EM = 1 / cos (87 deg) ~ 20 and…δ ~ 3’

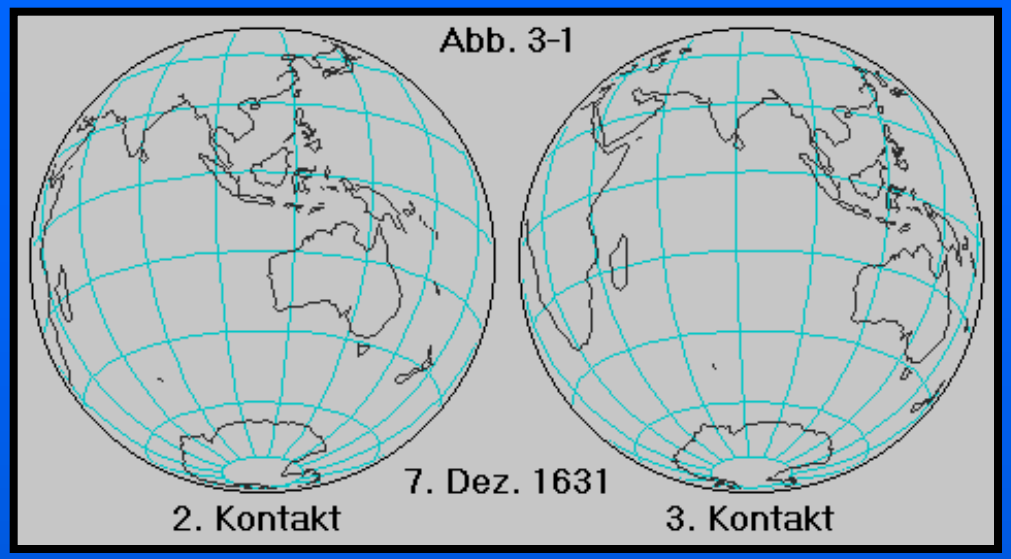
A new Method of determining the Parallax of the Sun

Edmond Halley

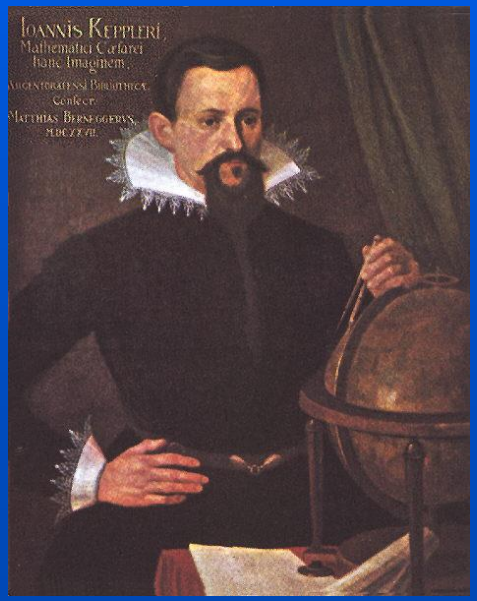
PHILOSOPHICAL TRANSACTIONS VOL. XXIX (1716) A new Method of determining the Parallax of the Sun, or his Distance from the Earth; by Dr. Halley, Sec. R. S. N0 348, p.454. Translated from the Latin.

It is well known that this distance of the sun from the earth, is supposed different by different astronomers. Ptolemy and his followers, as also Copernicus and Tycho Brahe, have computed it at 1200 semi-diameters of the earth, and Kepler at almost 3500; Riccioli doubles this last distance, and Hevelius makes it only half as much. But at length it was found, on observing by the telescope, Venus and Mercury on the sun's disk, divested of their borrowed light, that the apparent diameters of the planets were much less than hitherto they had been supposed to be; and in particular, that Venus's semi-diameter, seen from the sun, only subtends the fourth part of a minute, or 15 seconds; and that Mercury's sem-diameter, at his mean distance from the sun, is seen under an angle of 10 seconds only, and Saturn's semi-diameter under the same angle; and that the semi-diameter of Jupiter, the largest of all the planets, subtends no more than the third part of a minute at the sun. Whence, by analogy, some modern astronomers conclude that the earth's semi-diameter, seen from the sun, subtends a mean angle, between the greater of Jupiter and the less of Saturn and Mercury, and equal to that of Venus, viz. one of 15 seconds; and consequently, that the distance of the sun from the earth is almost 14,000 semi-diameters of the latter.

December 6, 1631



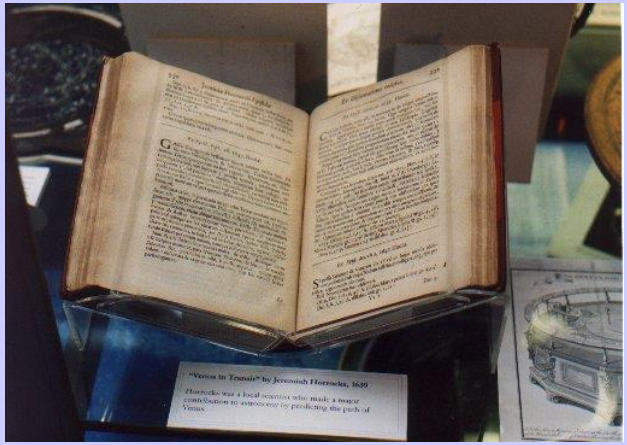
Pierre Gassendi
(1592-1655)



Joannis Kepler
(1571-1630)

- There are no records to suggest that anyone ever observed this event.
- Kepler predicted it would not be visible in Europe, so he requested that mariners keep a lookout for it.
- Pierre Gassendi (1592-1655) tries and fails to observe it

December 4, 1639



Horrocks' record of the 1639 transit

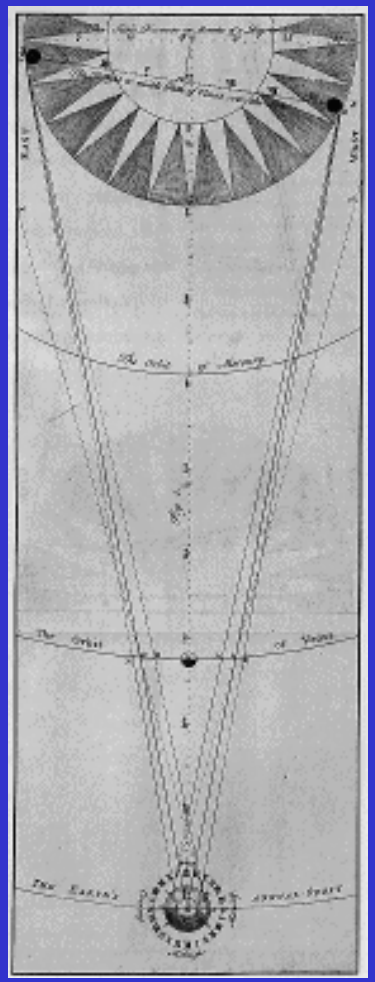
St Michael's Church
Hoole, England

Jeremiah Horrocks (1618-1641)

Discovered this transit because Kepler had not allowed for observer parallax. Horrocks completed his calculation in October 1639.

Horrocks was called away from his observations and missed the start of the transit, but observed it until sunset.

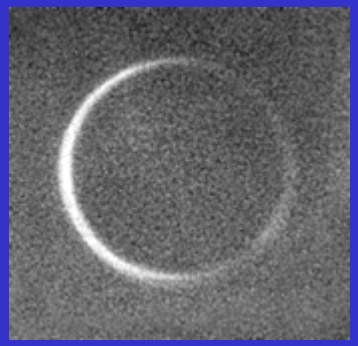
His friend William Crabtree observed it for only 30minutes because it happened late in the day from England. There are no other known observers



June 6, 1761

Edmond Halley came up with the idea of using the Mercury transit of 1677 to establish the sun-earth distance. He called for the first international multi-station study.

- **Observed from 70 stations.**
- **The first large-scale international scientific endeavor ever attempted.**
- **First measurement of Venus disk size**
- **Lomonosov detects atmosphere as a luminous ring at first contact**
- **AU = 96.1 to 77.8 million miles**

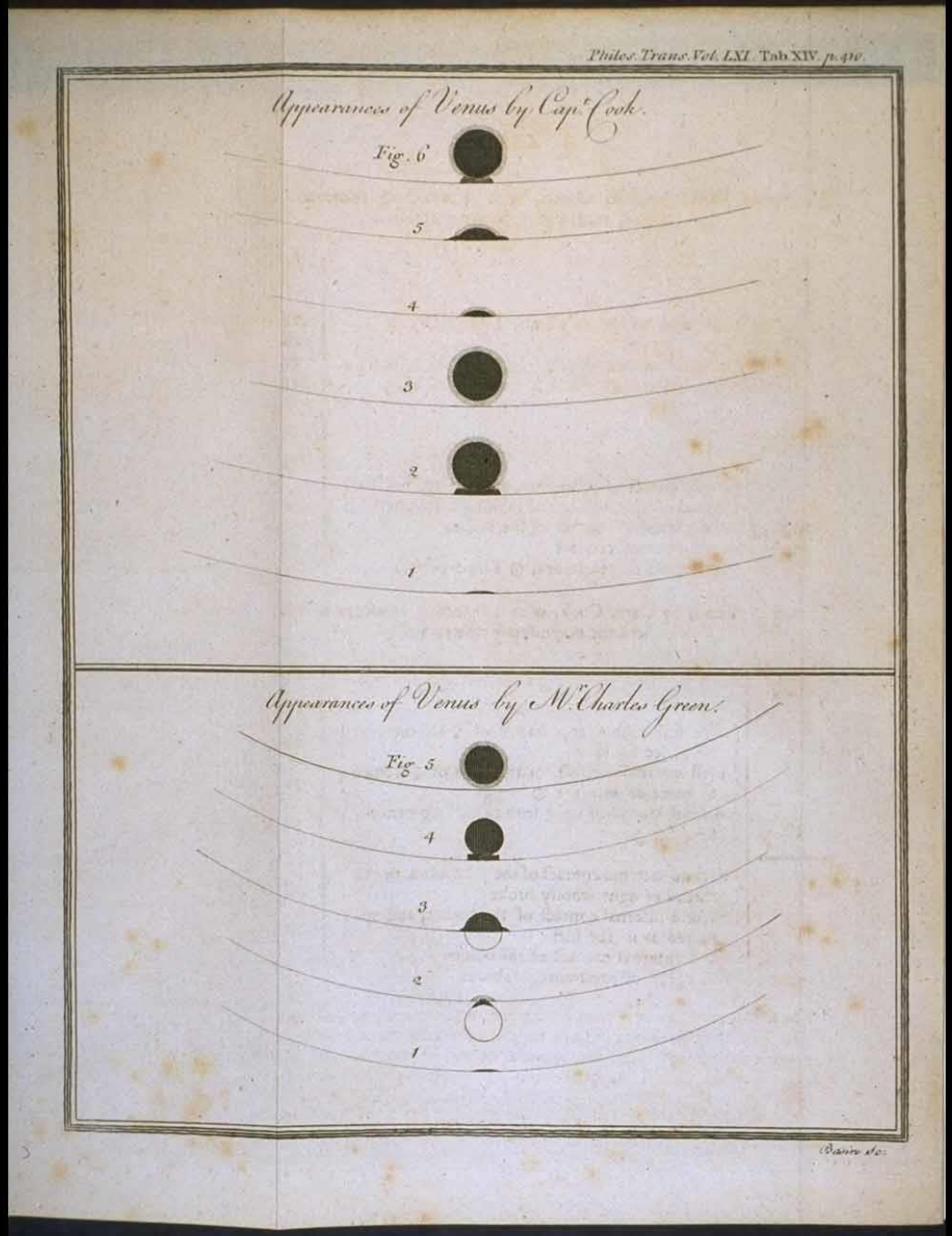


Edmond Halley (1656-1742)

June 3, 1769
Cap'n Cook

Only observable over Pacific Ocean and western half of North America.
Used as pretext for some governments to explore the South Seas and create better maps.

- **151 official observers, 77 stations, many amateur astronomers,**
- **Captain James Cook headed an expedition to the island of Tahiti**
- **Entire transit was observed under clear skies.**
- **solar parallax = 8.5-8.8" for a distance of 92.0 - 96.1 million miles.**
- **Adopted = 95.37 million.**



Transit of Venus (detail) from James Cook and Charles Green's "Observations Made ... at King George's Island in the South Sea" in *Philosophical Transactions of the Royal Society. Vol. 61, 1771.*

December 9, 1874

Venus described as identical to earth with animal and plant life.

No natural satellites ever seen during previous transits.

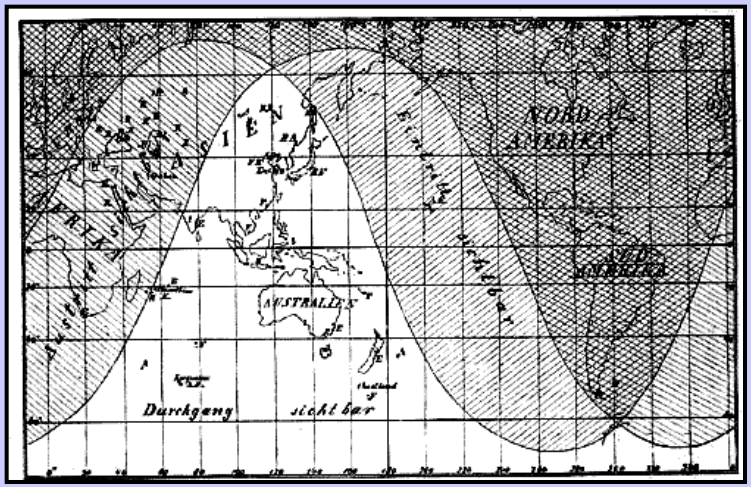
Parallax distances to 20 stars were known

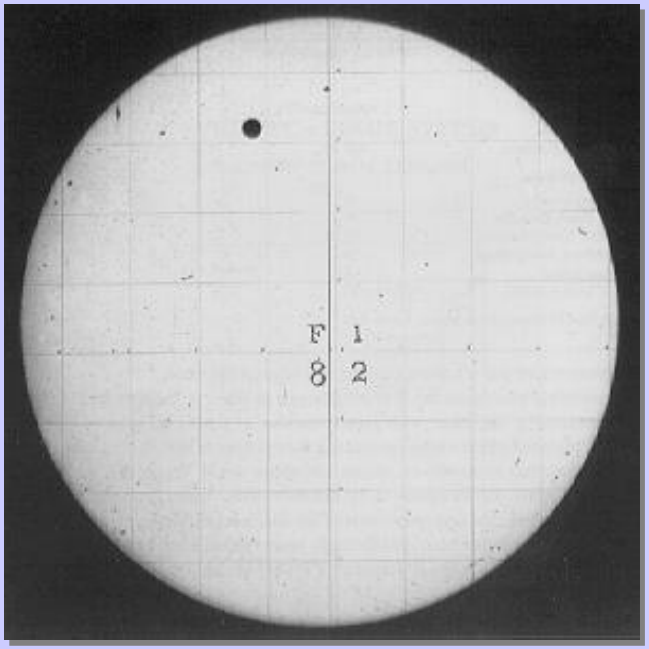
Extensive media coverage generated enormous public interest.

Congress appropriates $175,000 for expeditions.

AU=92.57 - 93.00 M miles

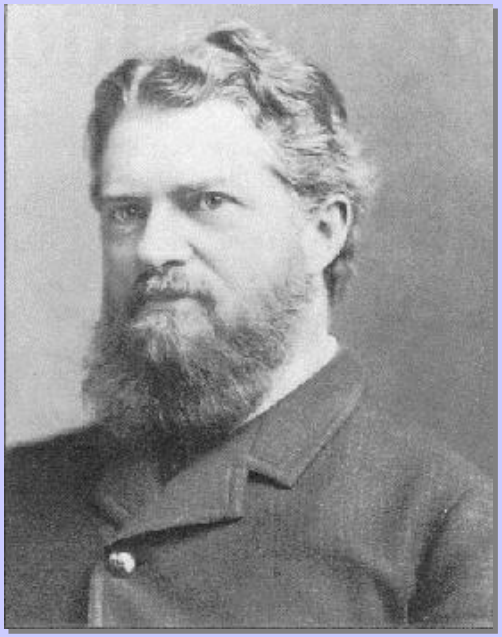
"The determination of this distance is one of the capital problems in astronomy" Simon Newcomb



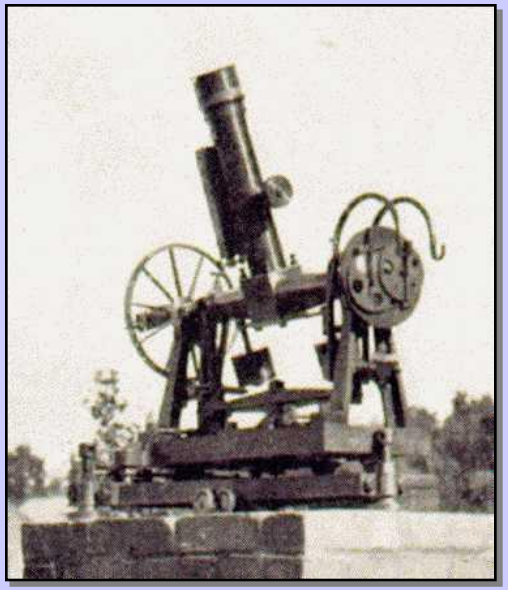


December 6, 1882

- **Significant decline in scientific interest.**
- **Congress appropriates $85,000 over strong objections by scientists including Simon Newcomb, (Prof of Mathematics, US Navy.)**
- **Newcomb heads expedition to Cape of Good Hope, South Africa. Near town of Wellington (40mi NE of Cape town)**
- **Funding for data reduction was hard to get, and all property had to be turned over to the Secretary of Navy in 1886**



Professor Simon Newcomb



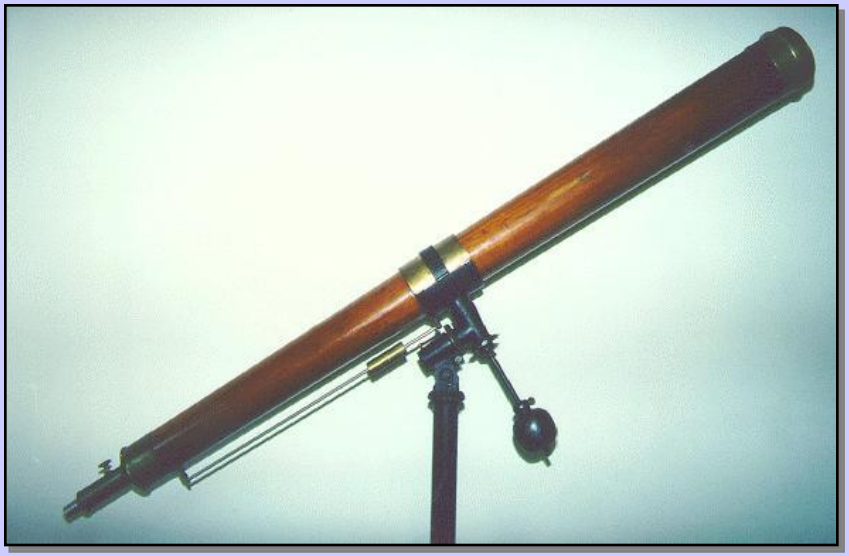
Solar Telescope used in 1882 expedition

"What the present conditions of the work may be, and how much of it is ready for press, I cannot say…All the men who took part in it or understood its details are either dead or on the retired list" **Simon Newcomb 1903**

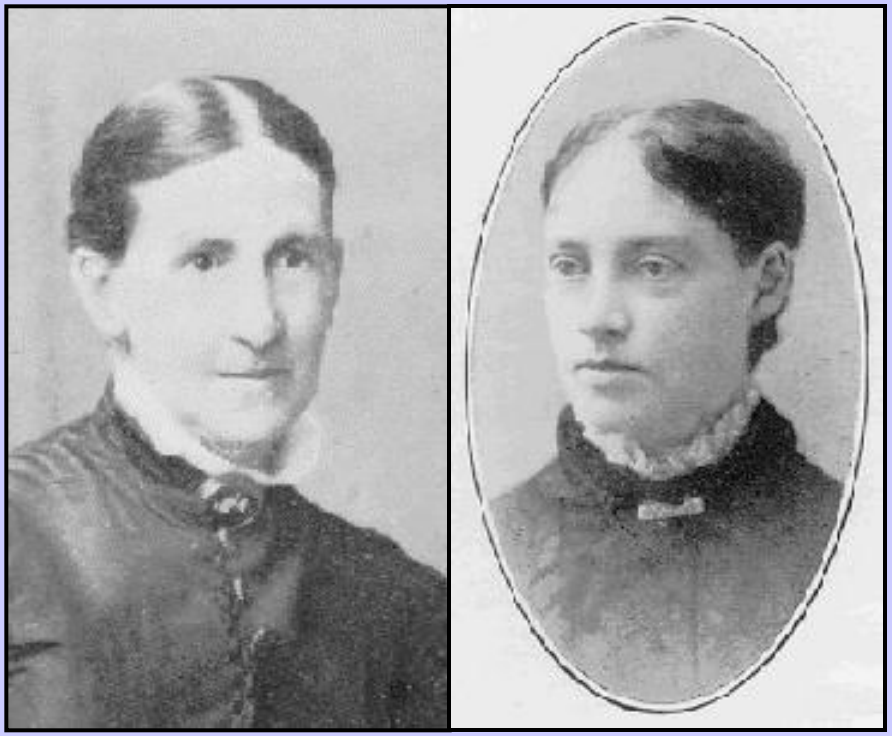
The biggest problem for attaining high-precision parallax measurements was the blurring effects of the Venus atmosphere, so the Venus Transit method was discarded after the 1882 transit and other methods sought out.

The Huguenot Seminary for Girls, Wellington, South Africa.

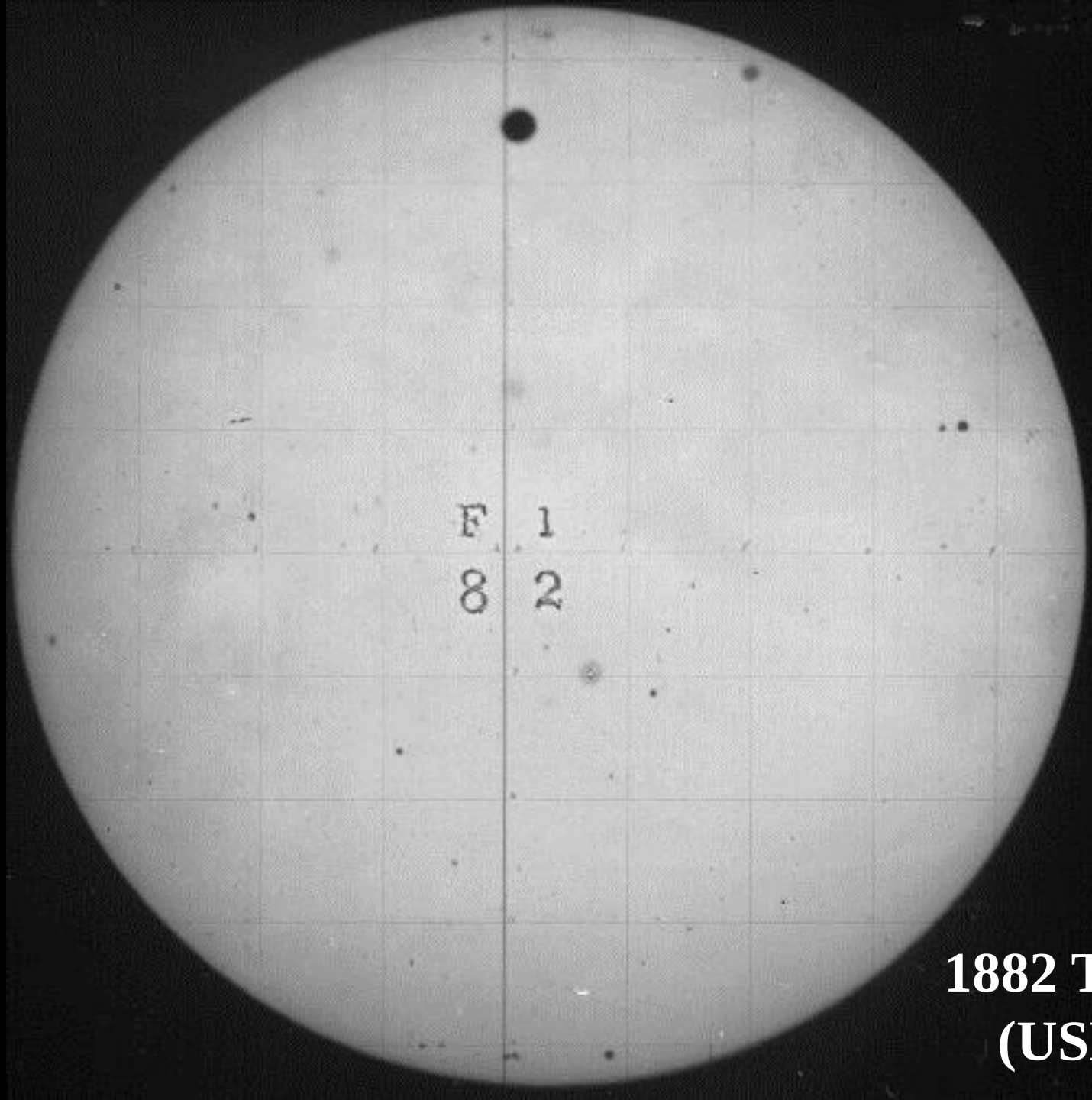
Miss Ferguson was always interested in astronomy with "a knowledge of a keen amateur, quite sufficient to infect others with her enthusiasm, and to give them the knowledge they needed to read books intelligently".



6” Fitz Refractor, installed in 1853



Abbie Ferguson Mary Cummings



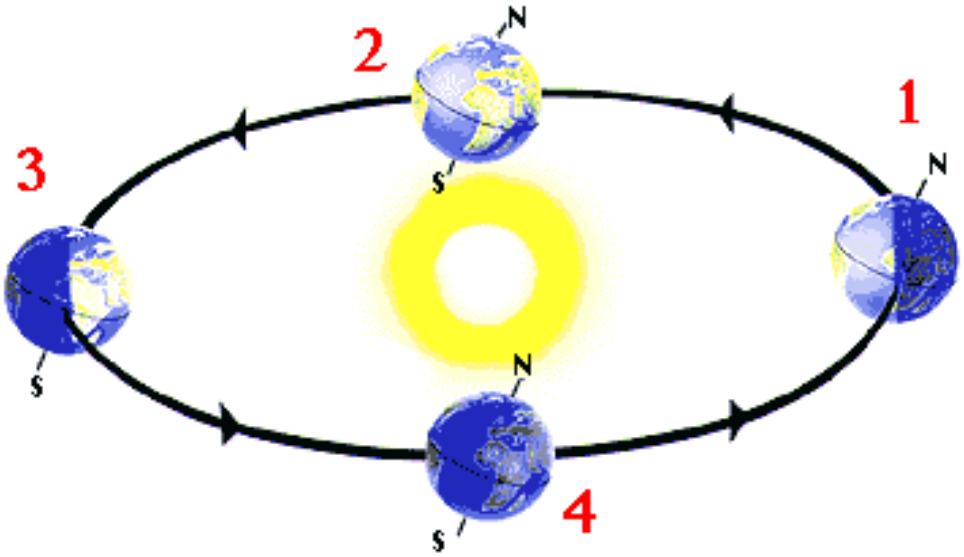
1882 Transit (USNO)

On April 28, 1883

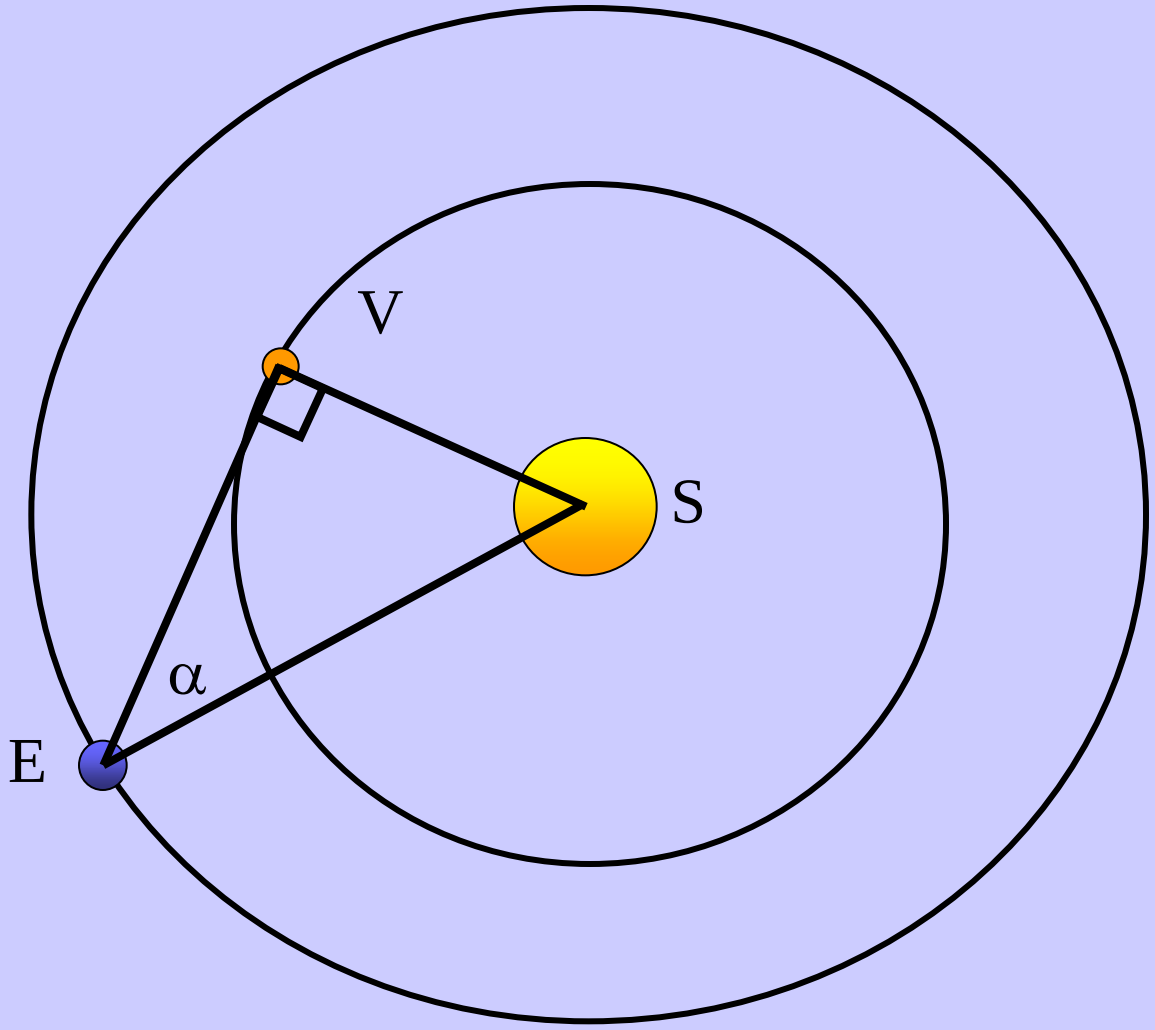
Harper's Weekly ran a cover that was unusual. It shows a group of children standing outside a cabin in Appalachia. One is holding a piece of smoked glass and watching the transit!

History of Sun-Earth distances

YEAR	DISTANCE	DISCOVERED BY…
-200	**4.2 million**	**Aristarchus of Samos**
1543	**52 million**	**Copernicus**
1672	**87,000,000**	**Mars parallax**
1769	**92,049,650 - 96,162,840**	**Venus Transit**
1843	**95,000,000**	**Textbook**
1874	**92,570,000 - 93,000,000**	**Venus Transit**
1877	**92,830,000**	**Photographic parallax of Mars**
195x	**95,697,000**	**20 years of Eros radar echo**
1960	**95,709,000**	**Pioneer-5**
2000	**95,741,000**	**40 years of Venus radar echoes**



How to calculate the AU
Step 1: Venus at Greatest Elongation



$VS / ES = \sin(\alpha)$

$\alpha \sim 46.054$ deg

$VS/1\ AU = \sin(\alpha)$

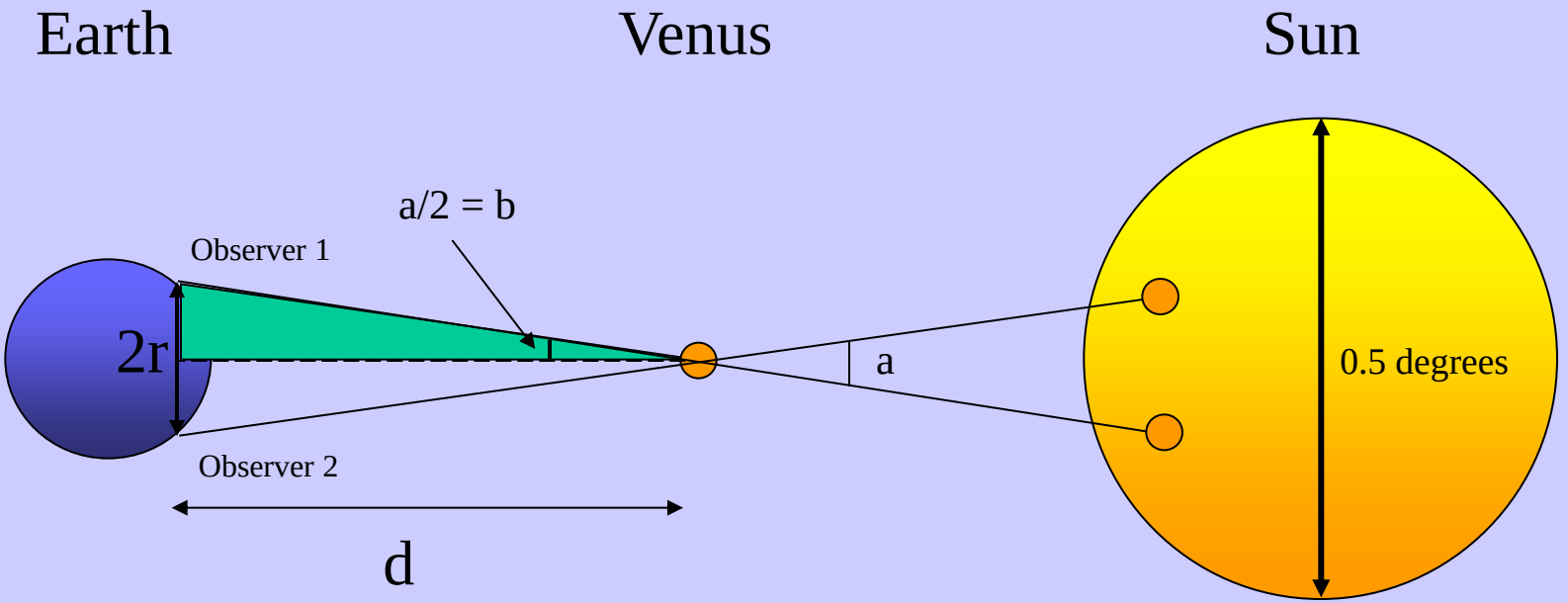
$VS = 0.72$ AU

so…

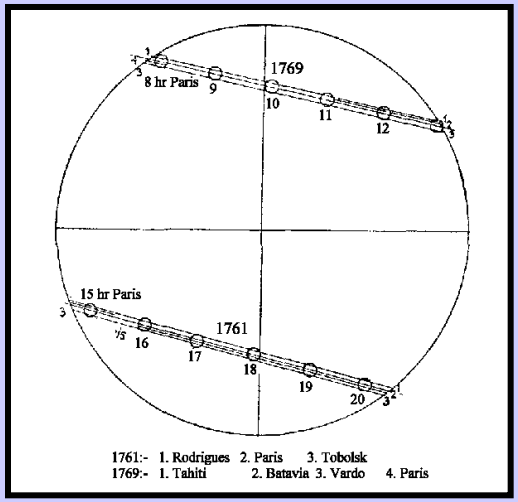
$EV = 1 - 0.72$ AU

$= 0.28$ AU

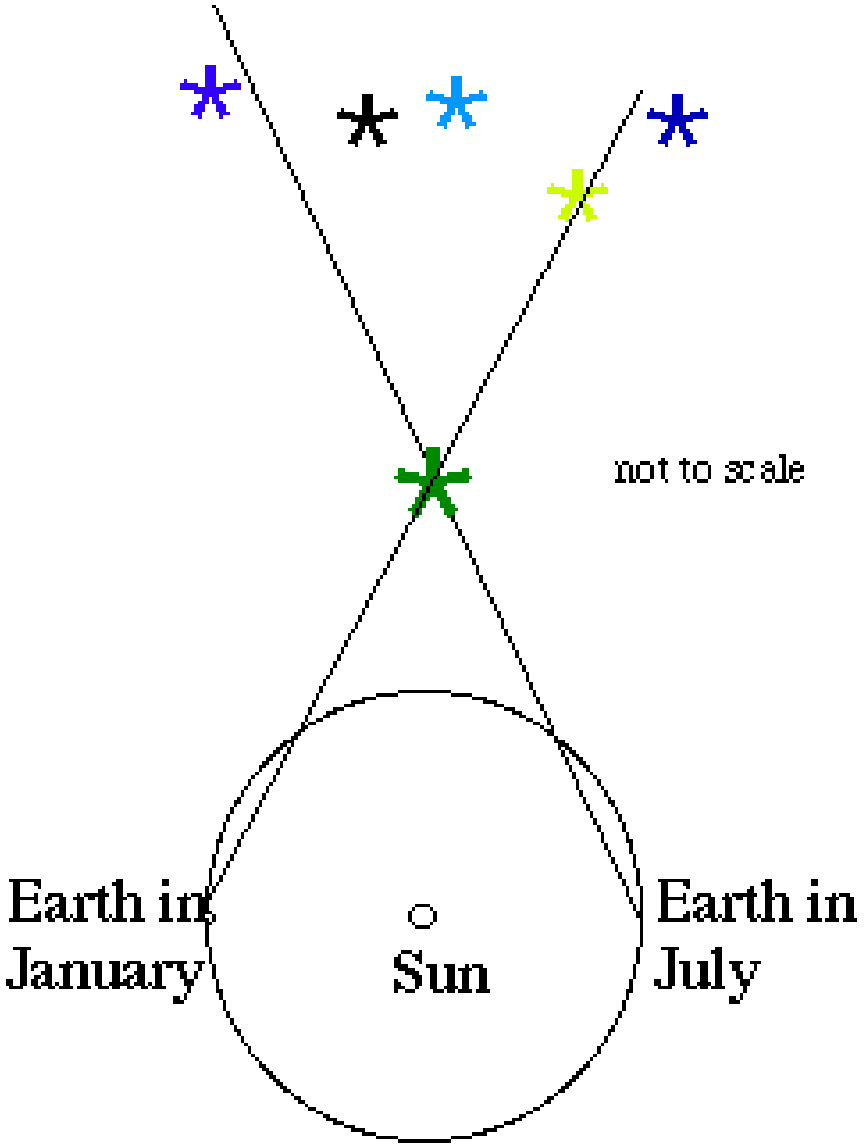
How to calculate the AU
Step 2: Parallax



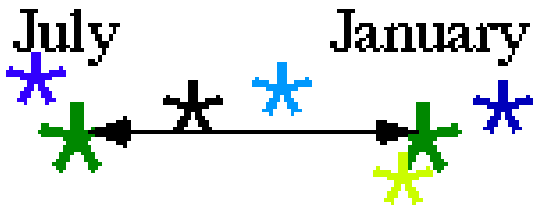
$$d = r / \tan(b)$$



Stellar Parallax



As seen on the sky in



Star distances are measured in units of the distance from the Sun to the Earth, the Astronomical Unit. The nearer the star, the larger is the angle (called the parallax) between the January and the July observations.

Finding the distance to the stars

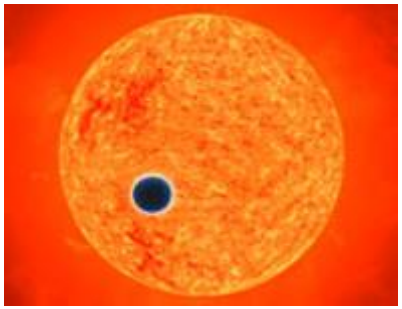
•The first parallax shift of a star was detected in 1838 by an astronomer named F. W. Bessel at the Konigsberg Observatory in Prussia.

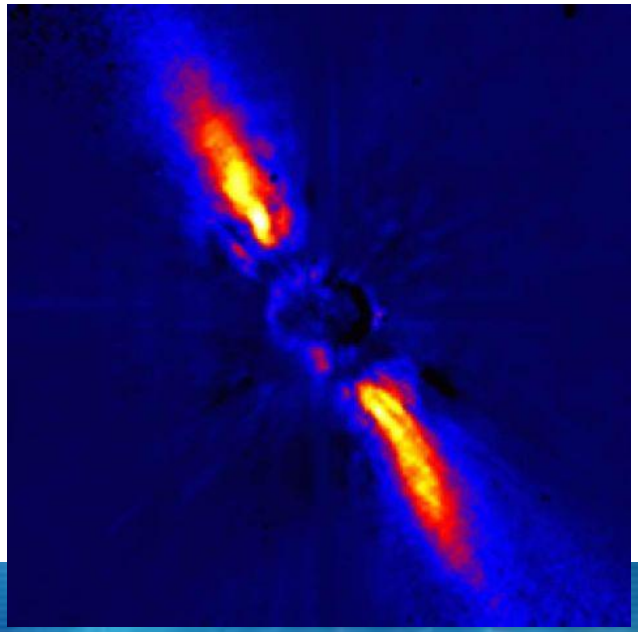
•The star was actually a binary called 61 Cygni, a gravitationally bound pair of red dwarf stars.

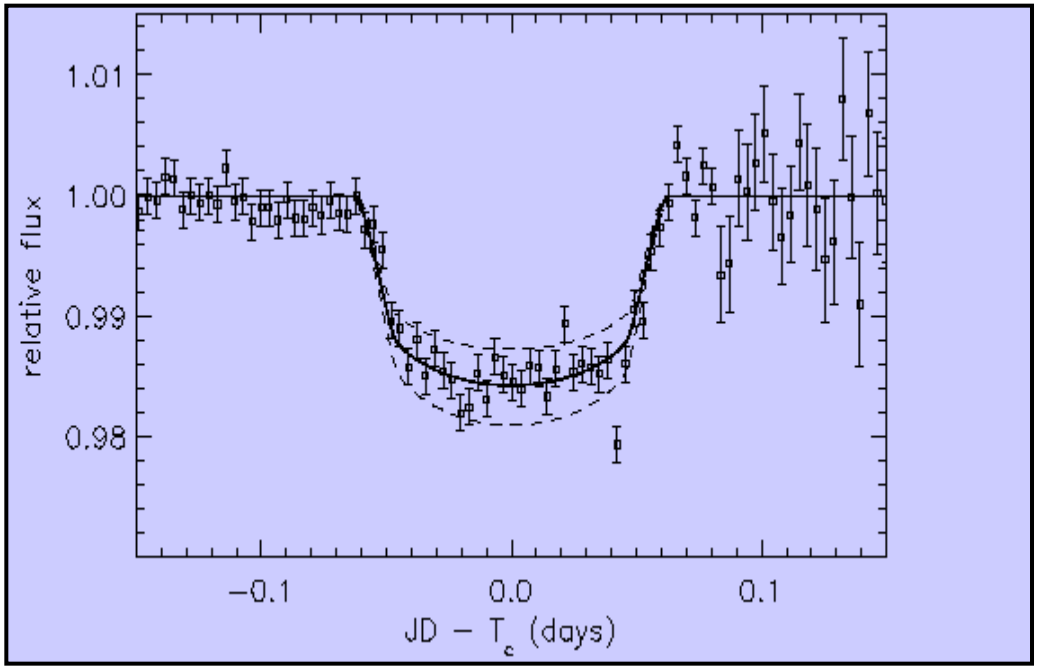
•Bessel found that these stars were making annual loops with a radius of .29 arcseconds, corresponding to a distance of 10.3 light years

Frederick W. Bessel

Searching for Extra-Solar Planets

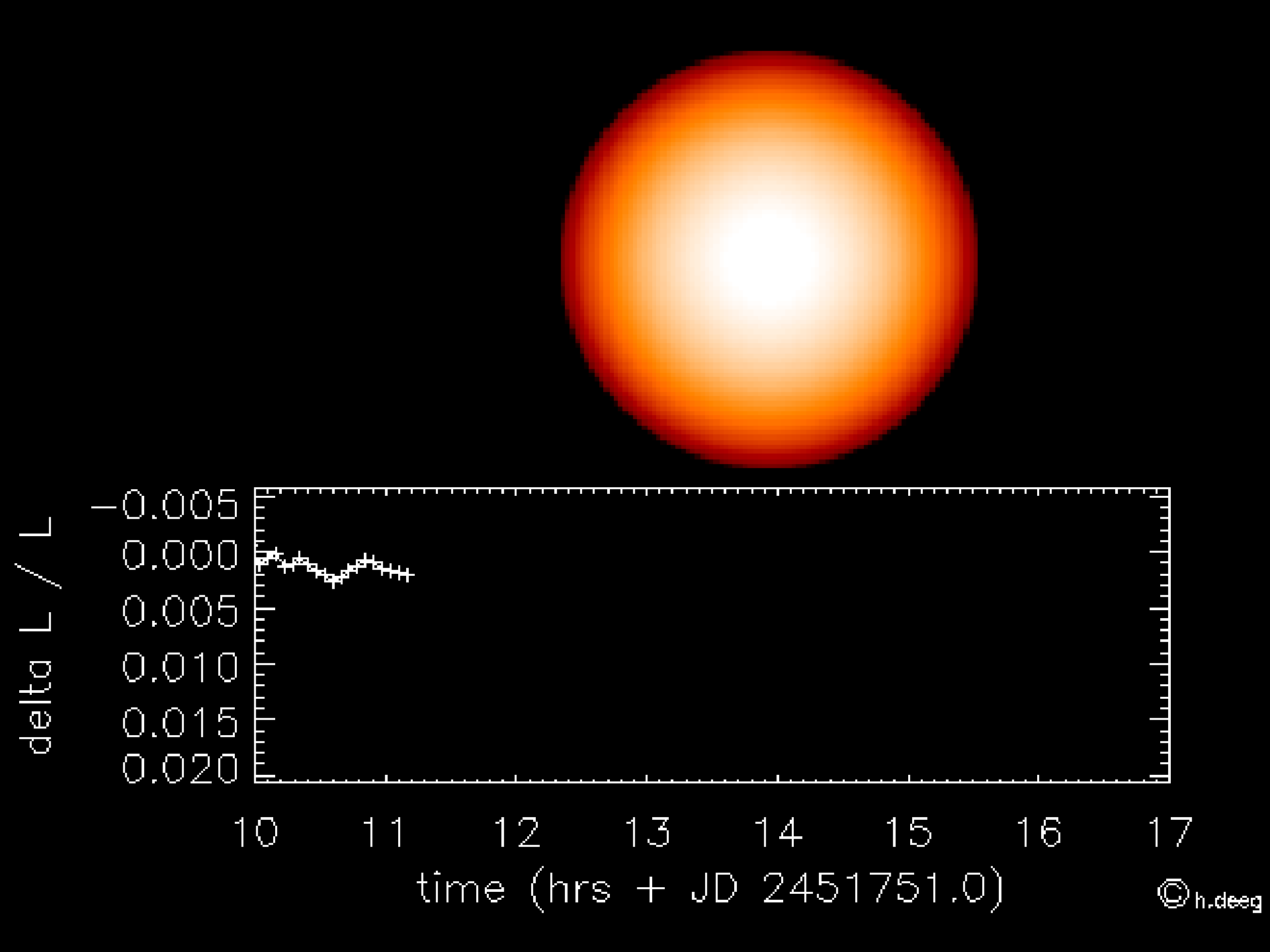






HD 209458 (mv = +7.7) in Pegasus

PLANET QUEST the search for another Earth


−0.005
0.000
0.005
0.010
0.015
0.020
delta L / L
10
11
12
13
14
15
16
17
time (hrs + JD 2451751.0)
©h.deeg

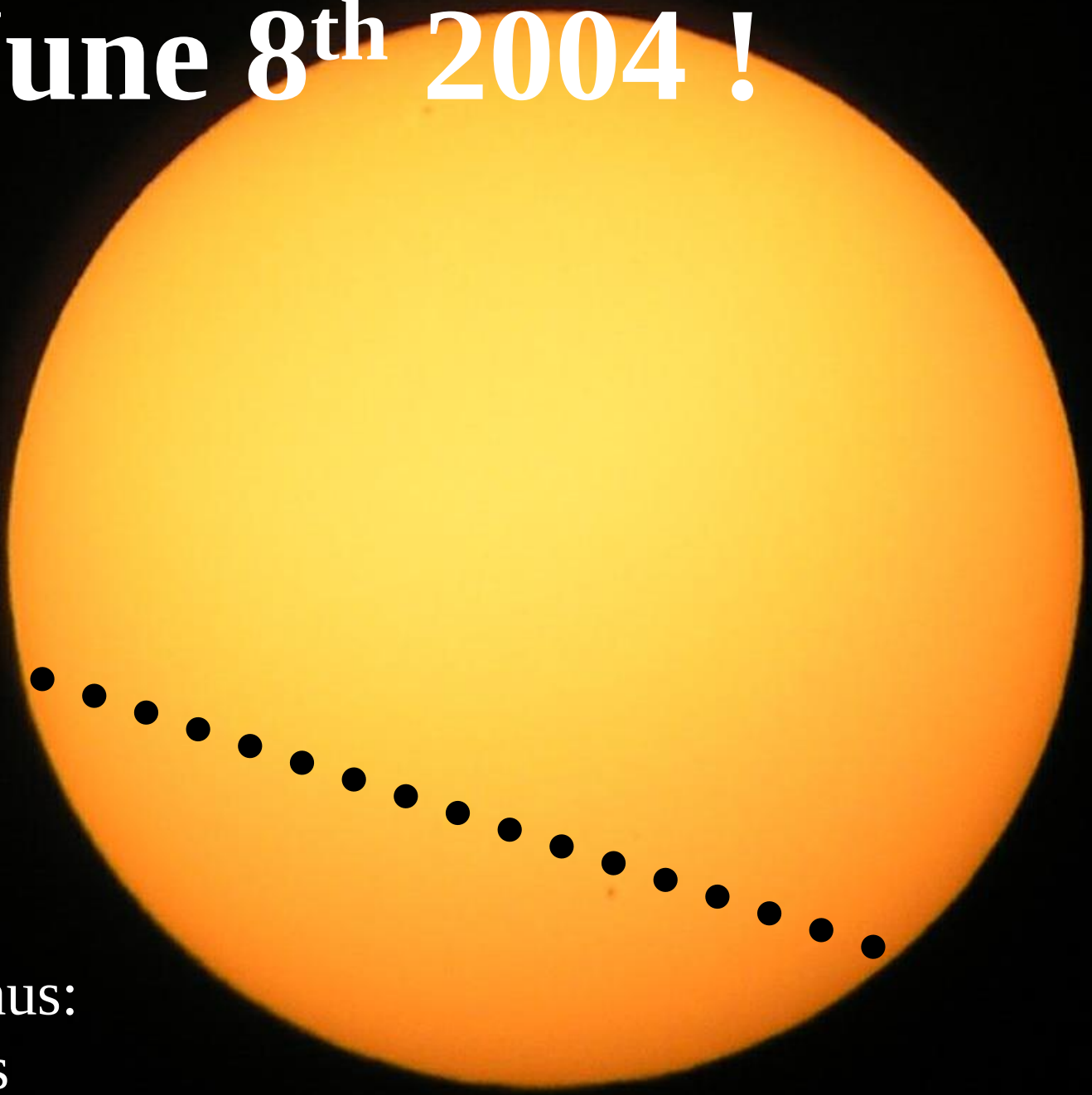
June 8th 2004 !

Transit begins:
05:13:25 UT
(1:13am EDT)

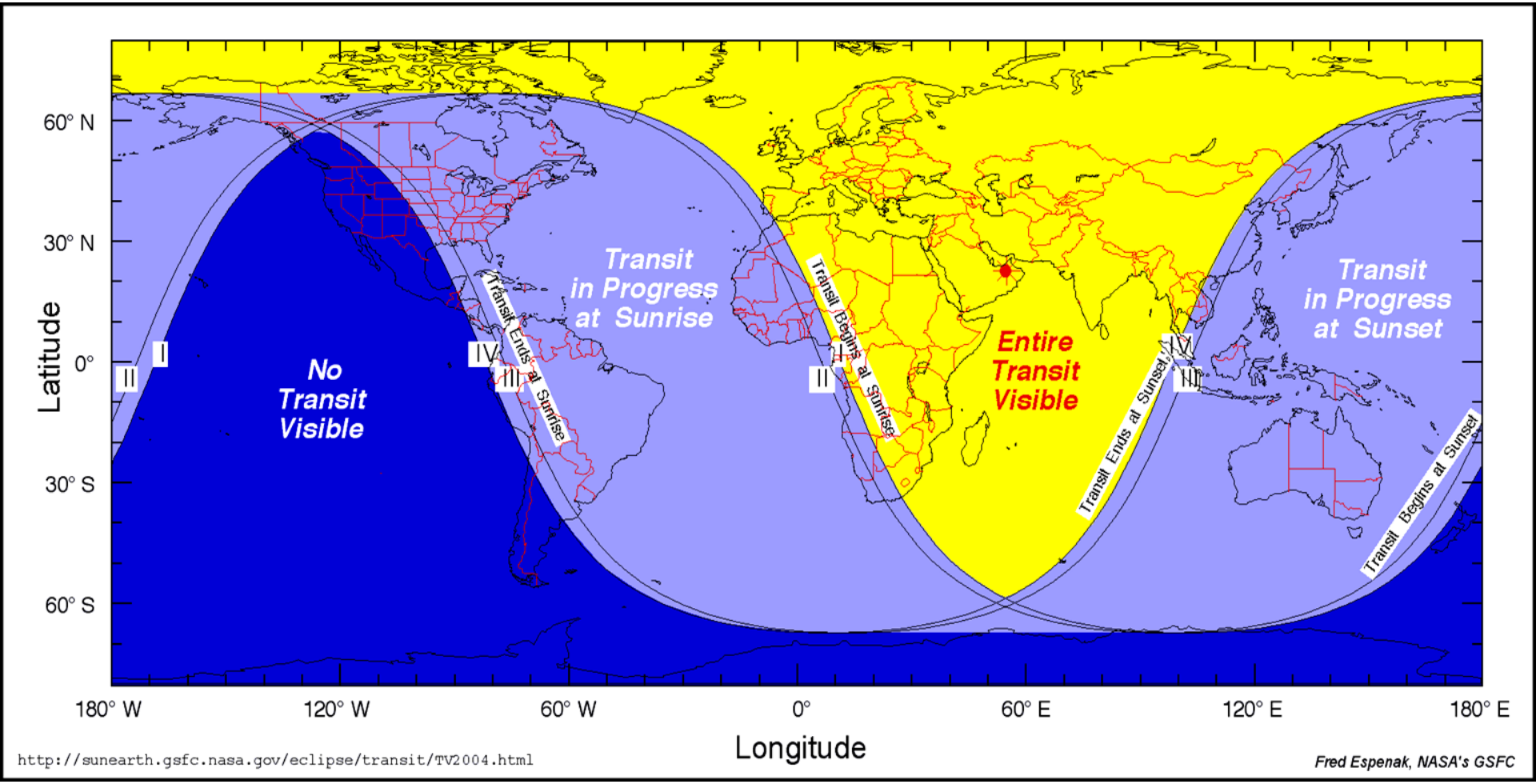
Transit ends:
11:25:56 UT
(7:25am EDT)

Sunrise:
6:05am (EDT)

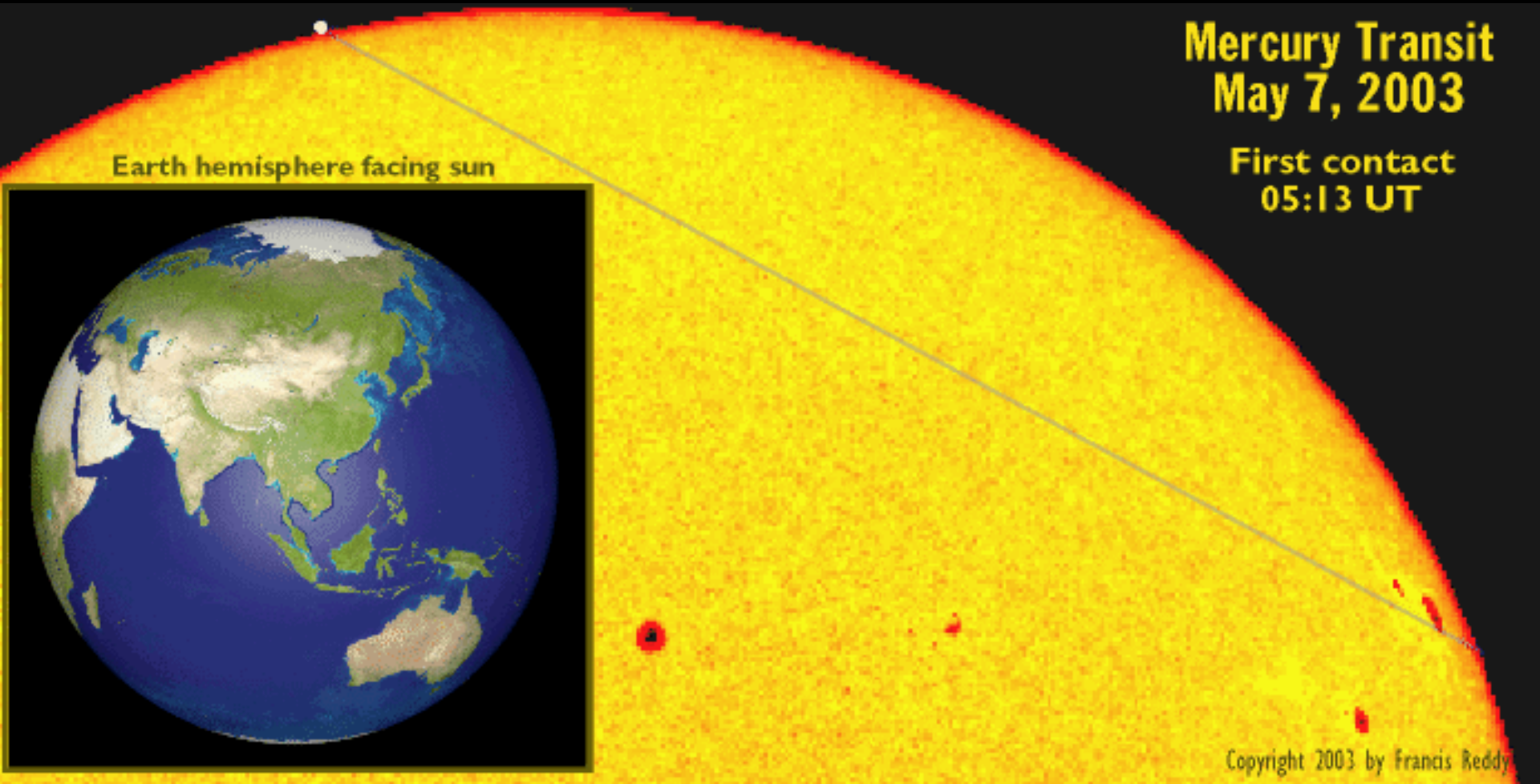
Diameter of Venus:
58.6 arc seconds



Where will the transit be visible?



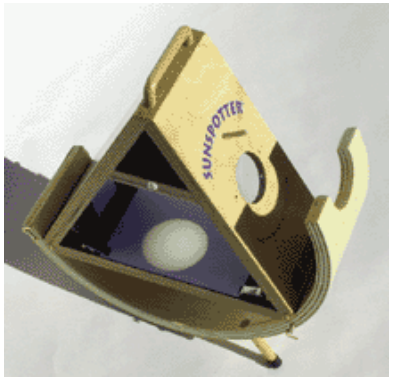
Mercury Transit
(Venus Transit Dress Rehearsal)



Mercury Transit – May 2003

Viewing the Transit

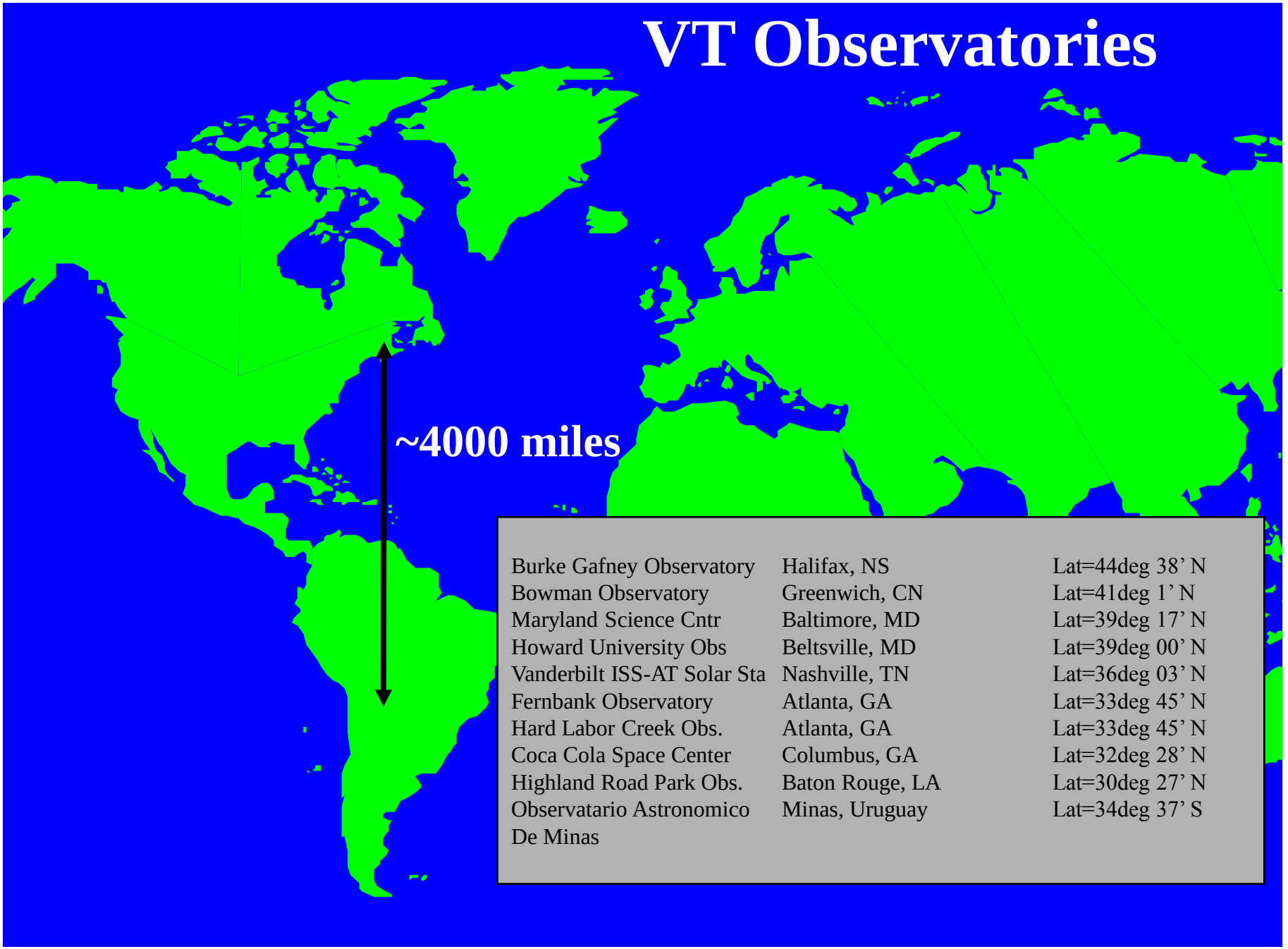
- ✓ Observe a live webcast from Athens Greece for the full 6+ hour transit
- ✓ See images taken from observatories spaced over 4000 miles apart
- ✓ Go to local events such as Maryland Science Center and Montgomery College
- ✓ Contact your local astronomy club
- ✓ Make a pin hole camera
- ✓ Project an image with binoculars or a properly filtered telescope



The Astronomical League

The World's Largest Federation of Amateur Astronomers

VT Observatories



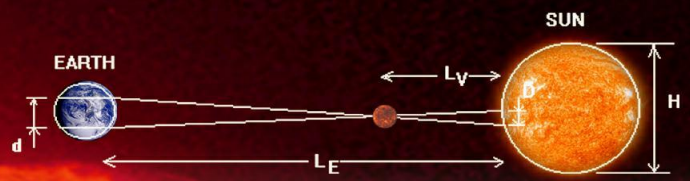
Burke Gafney Observatory	Halifax, NS	Lat=44deg 38' N
Bowman Observatory	Greenwich, CN	Lat=41deg 1' N
Maryland Science Cntr	Baltimore, MD	Lat=39deg 17' N
Howard University Obs	Beltsville, MD	Lat=39deg 00' N
Vanderbilt ISS-AT Solar Sta	Nashville, TN	Lat=36deg 03' N
Fernbank Observatory	Atlanta, GA	Lat=33deg 45' N
Hard Labor Creek Obs.	Atlanta, GA	Lat=33deg 45' N
Coca Cola Space Center	Columbus, GA	Lat=32deg 28' N
Highland Road Park Obs.	Baton Rouge, LA	Lat=30deg 27' N
Observatario Astronomico De Minas	Minas, Uruguay	Lat=34deg 37' S

1882, the date of the last Venus transit, quote by William Harkness of the U.S. Naval Observatory (from Sky and Telescope, Feb. 1995):

We are now on the eve of the second transit of a pair, after which there will be no other till the twenty-first century of our era has dawned upon the earth, and the June flowers are blooming in 2004.

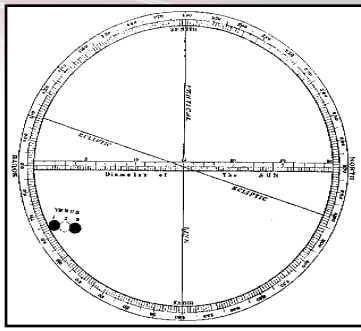
When the last transit season occurred the intellectual world was awakening from the slumber of ages, and that wondrous scientific activity which has led to our present advanced knowledge was just beginning. What will be the state of science when the next transit season arrives God only knows. Not even our children's children will live to take part in the astronomy of that day. As for ourselves, we have to do with the present

Transit of Earth: November 10, 2084



VENUS Transit 2004

Twice in a Lifetime

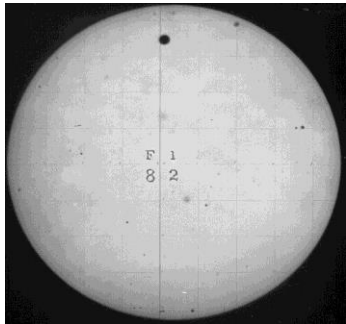


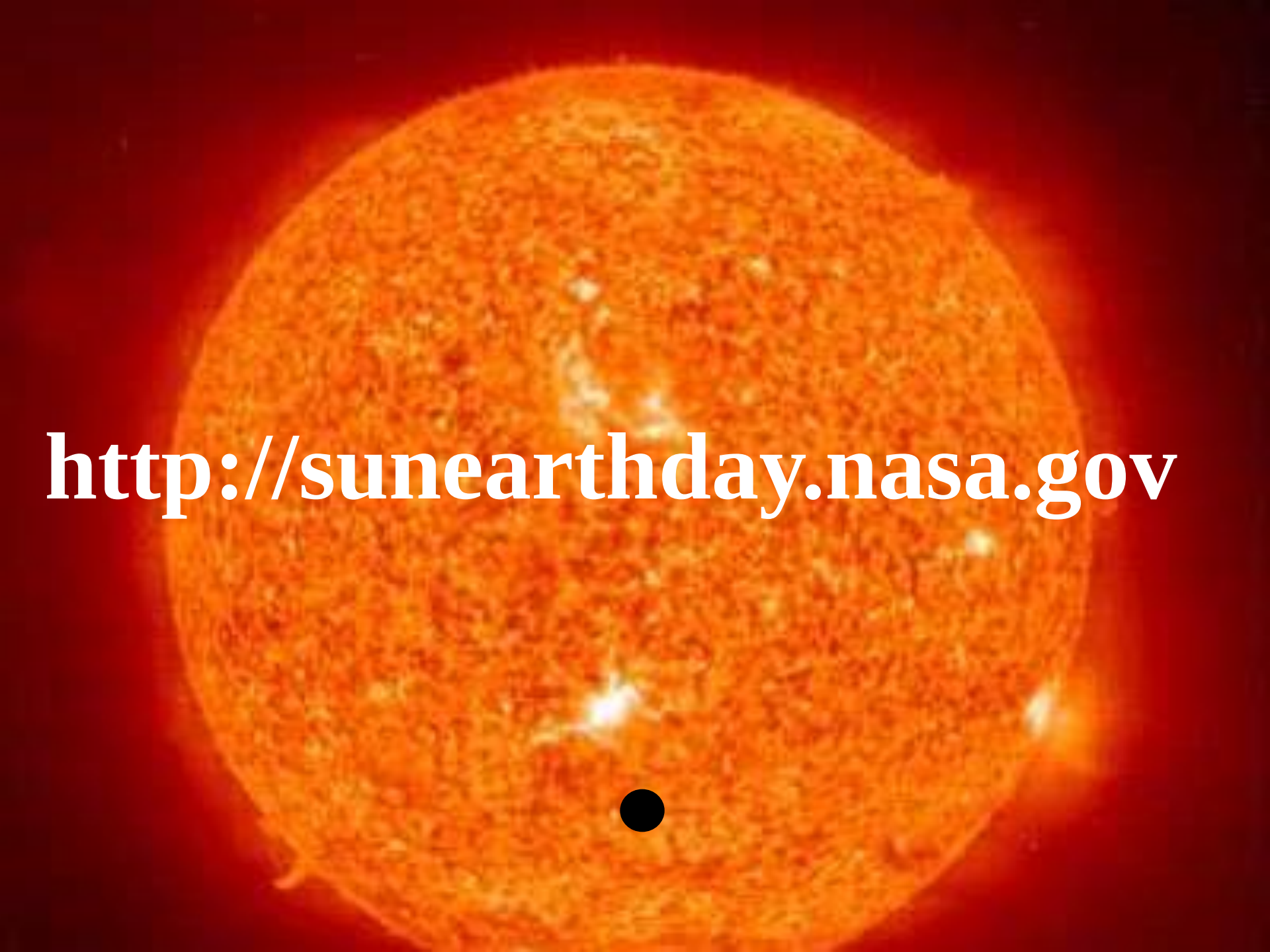
Experience the wonder of one of the rarest events in astronomy!!

Montgomery College, Takoma Park Campus
Roof of the Parking Garage at Fenton and King Street
Tuesday June 8th , 5:30 – 7:15am

http://www.montgomerycollege.edu/Departments/planet
http://sunearthday.nasa.gov

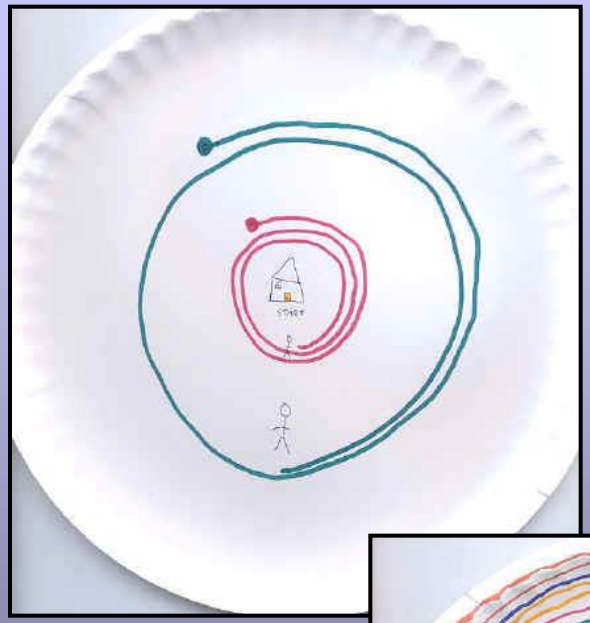
Lou Mayo
astronomertogo@verizon.net

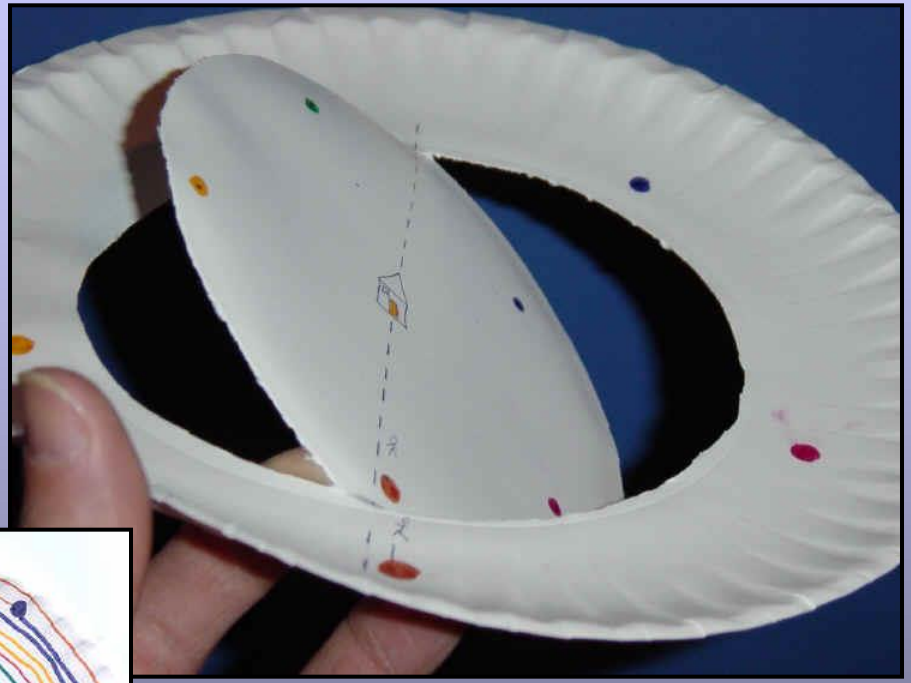


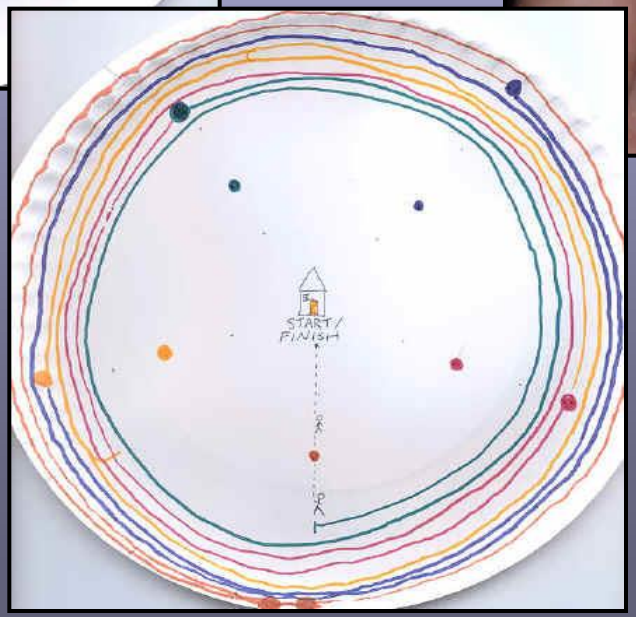

http://sunearthday.nasa.gov

Paper Plate Astronomy

http://analyzer.depaul.edu/paperplate/







Venus: 13 Earth: 8

Each time Earth completes 1.6 orbits, Venus catches up to it after 2.6 of its orbits

Earth Year: 365.256 d
Venus Year: 224.701 d