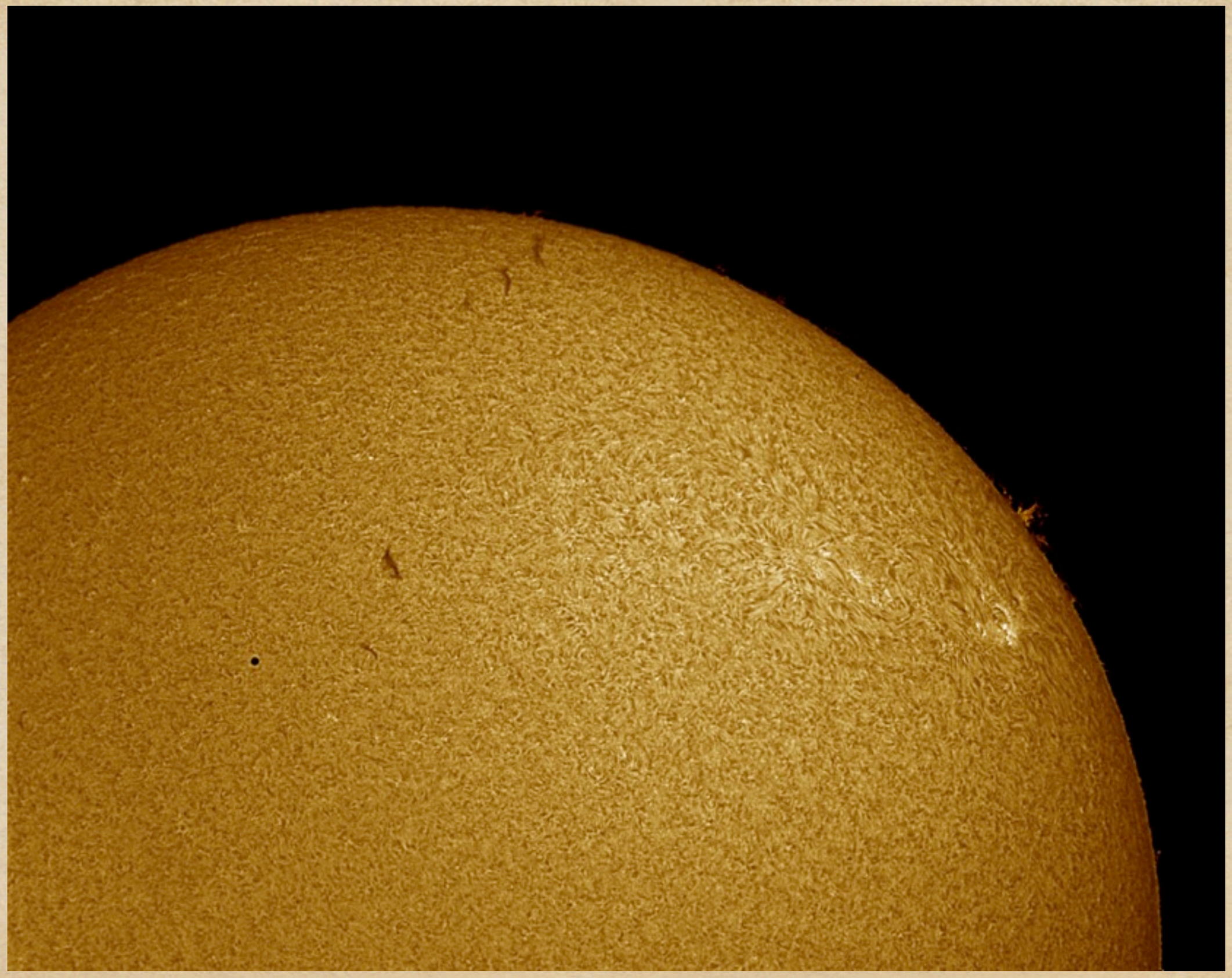
Fugitive Phenomena*

*Transits of Venus

What is a Transit

When one celestial body appears to move across the face of another celestial body.

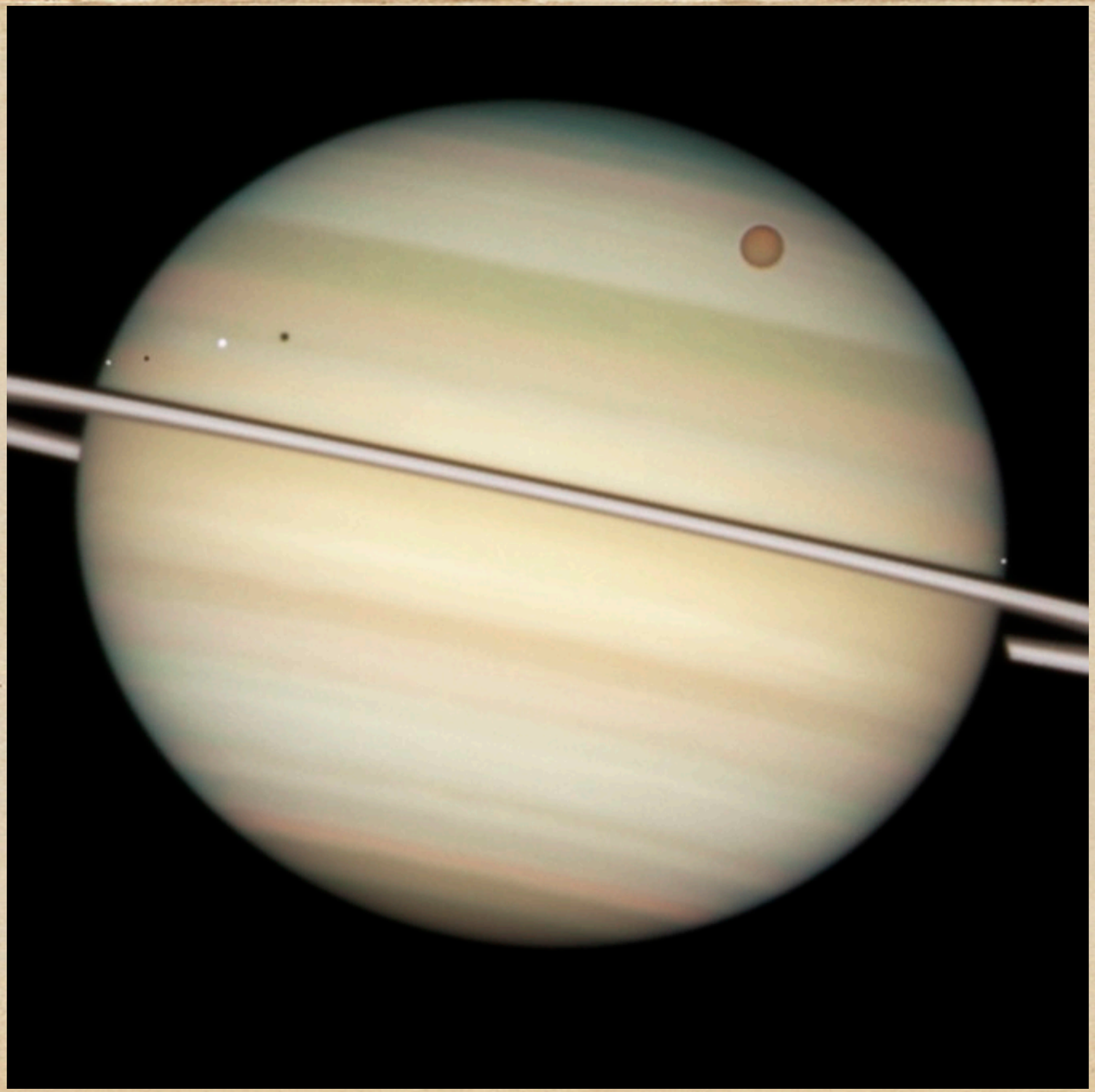
Credit & Copyright: David Cortner



Credits: Thierry Legault, NASA, ESA, Hubble Heritage Team, Phil Jones, Donald J. Lindler

Wednesday, May 30, 2012

Mercury across the Sun from Earth in H-alpha
Saturn's moons across Saturn from Hubble
Atlantis and Hubble across the Sun from Earth
Moon across the Earth from Deep Impact



Credits: Thierry Legault, NASA, ESA, Hubble Heritage Team, Phil Jones, Donald J. Lindler

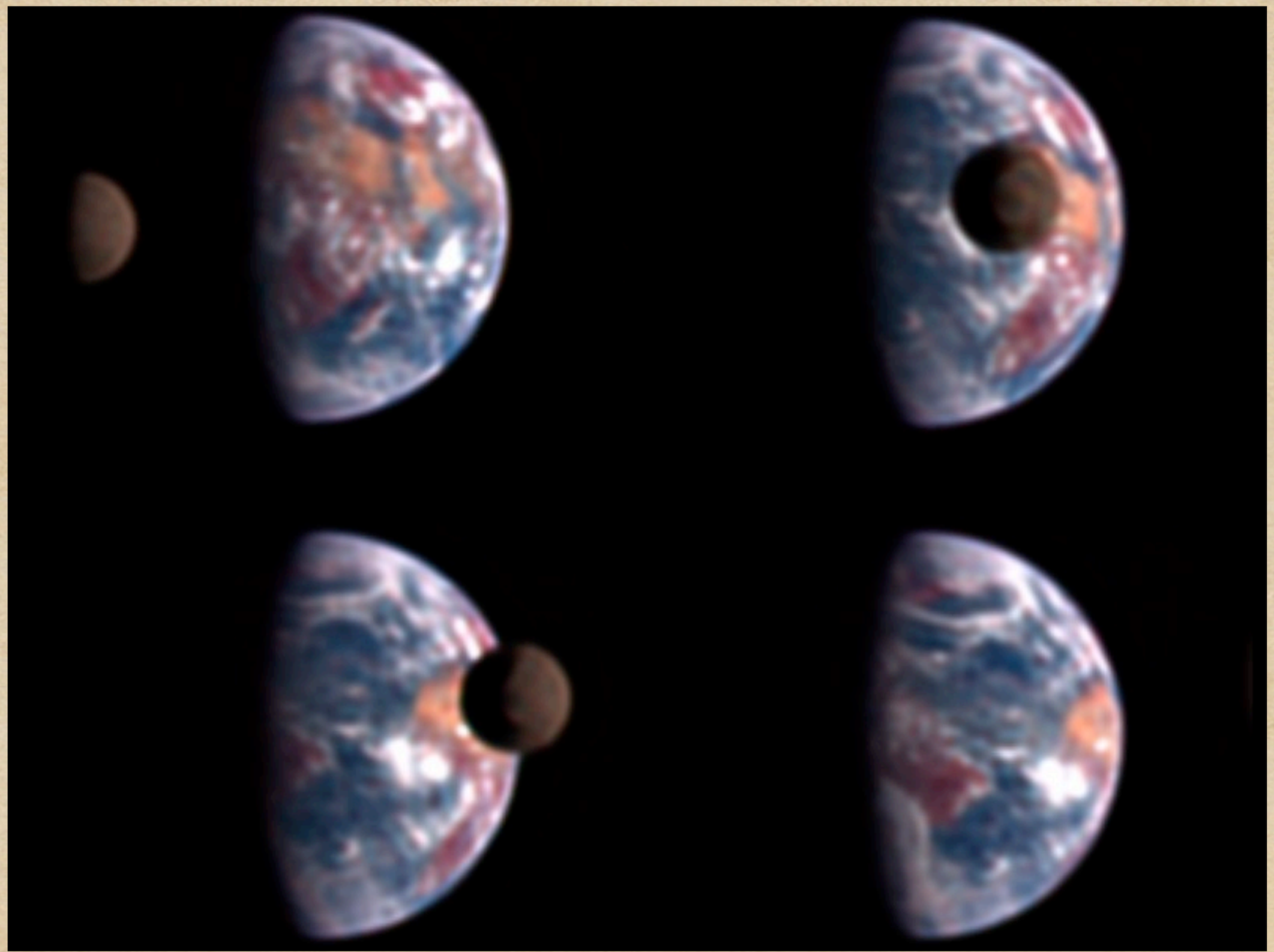
Wednesday, May 30, 2012

Mercury across the Sun from Earth in H-alpha
Saturn's moons across Saturn from Hubble
Atlantis and Hubble across the Sun from Earth
Moon across the Earth from Deep Impact

Credits: Thierry Legault, NASA, ESA, Hubble Heritage Team, Phil Jones, Donald J. Lindler

Wednesday, May 30, 2012

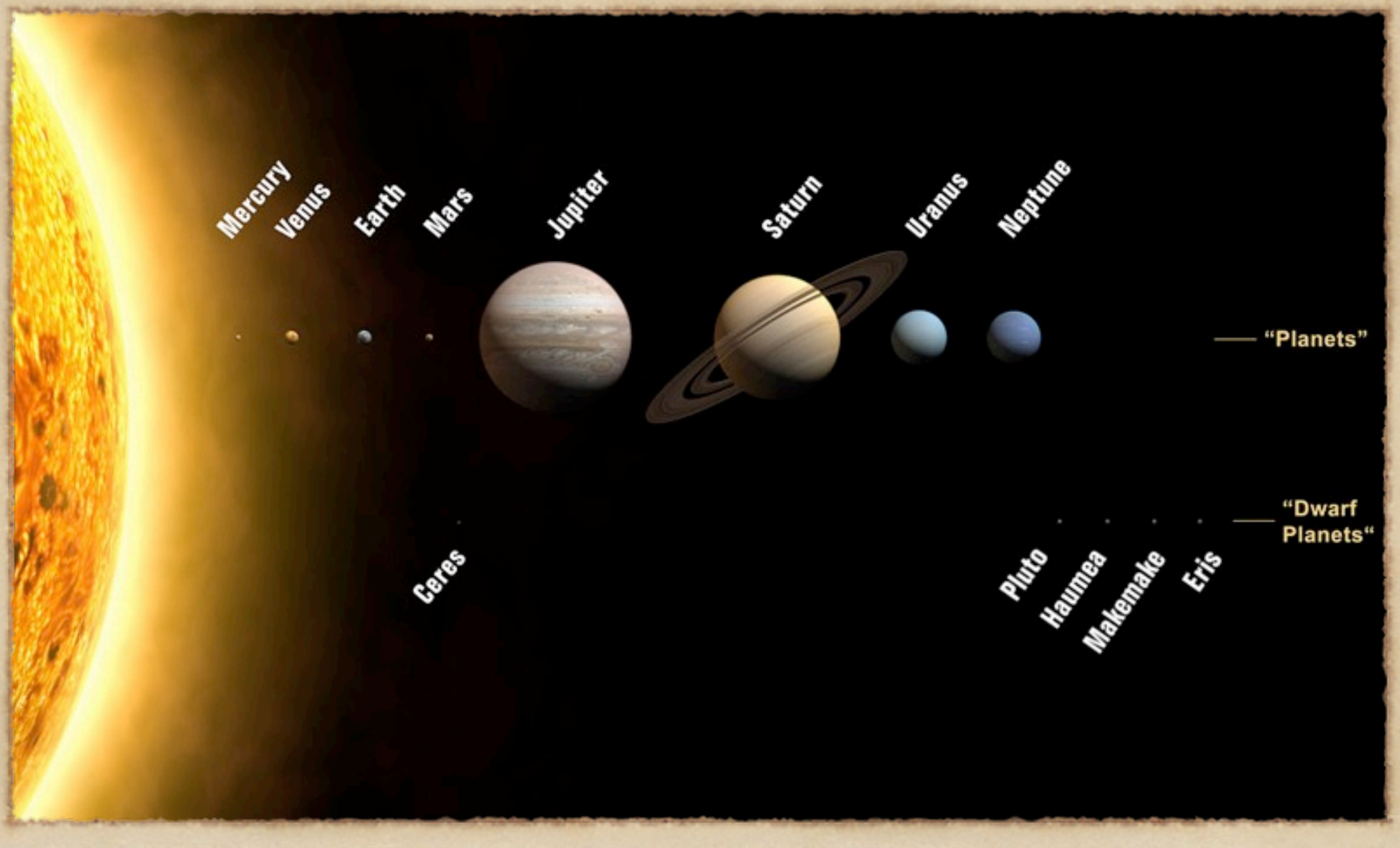
Mercury across the Sun from Earth in H-alpha
Saturn's moons across Saturn from Hubble
Atlantis and Hubble across the Sun from Earth
Moon across the Earth from Deep Impact



Credits: Thierry Legault, NASA, ESA, Hubble Heritage Team, Phil Jones, Donald J. Lindler

Wednesday, May 30, 2012

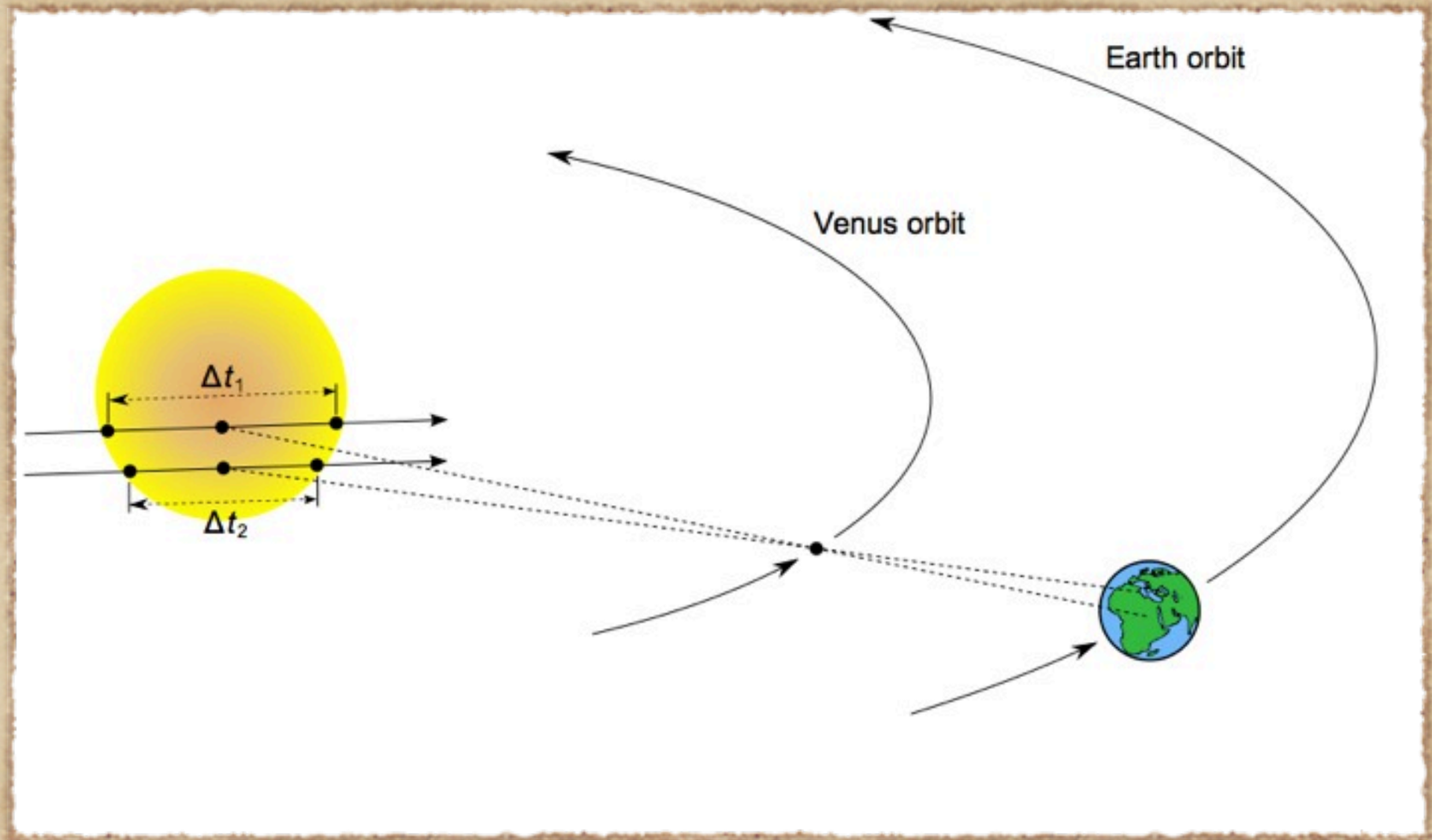
Mercury across the Sun from Earth in H-alpha
Saturn's moons across Saturn from Hubble
Atlantis and Hubble across the Sun from Earth
Moon across the Earth from Deep Impact



Our Solar System

Wednesday, May 30, 2012

Can only see transits of the sun from Mercury and Venus



Why Look at Transits?

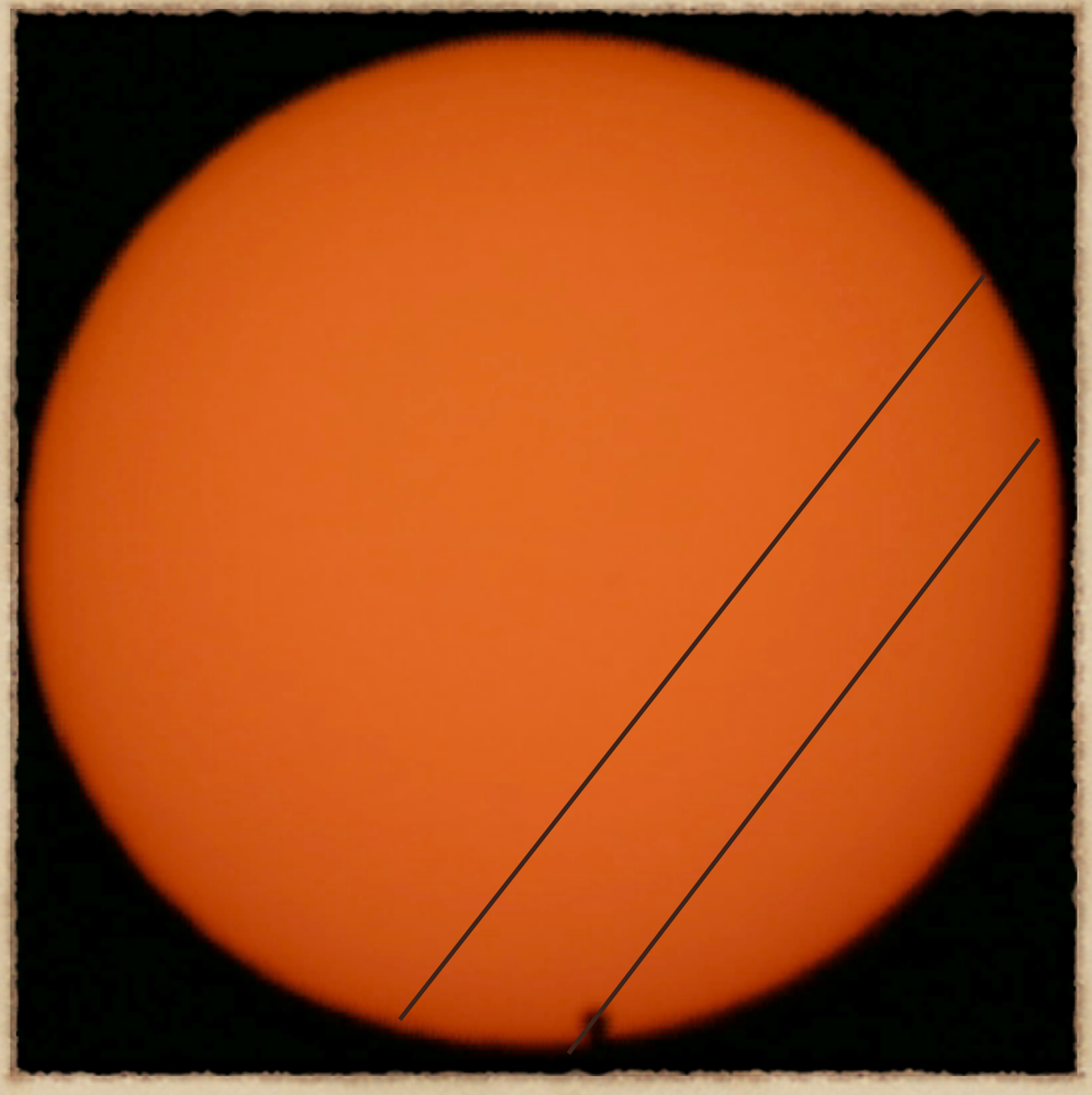
To Measure an A.U.

Transit Movie

The transit of Venus across the Sun as recorded by ESAC observers located in Portugal 8 June 2004.

Transit Movie

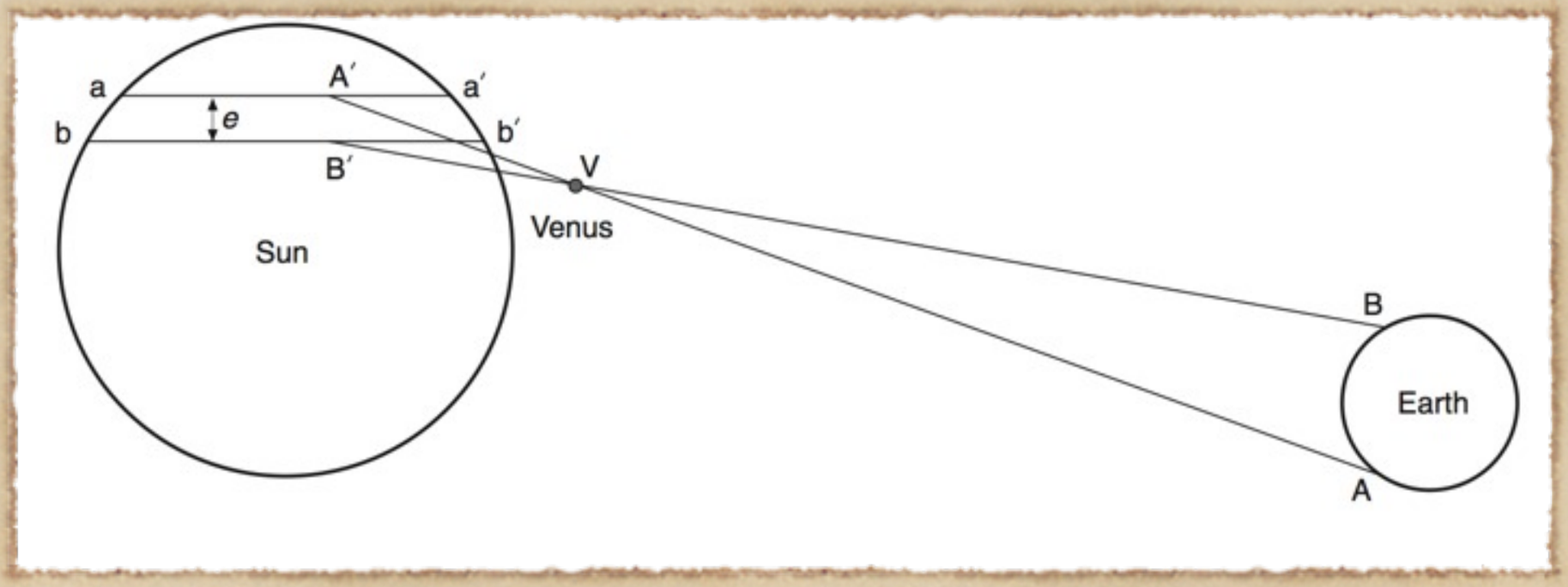
The transit of Venus across the Sun as recorded by ESAC observers located in Portugal 8 June 2004.



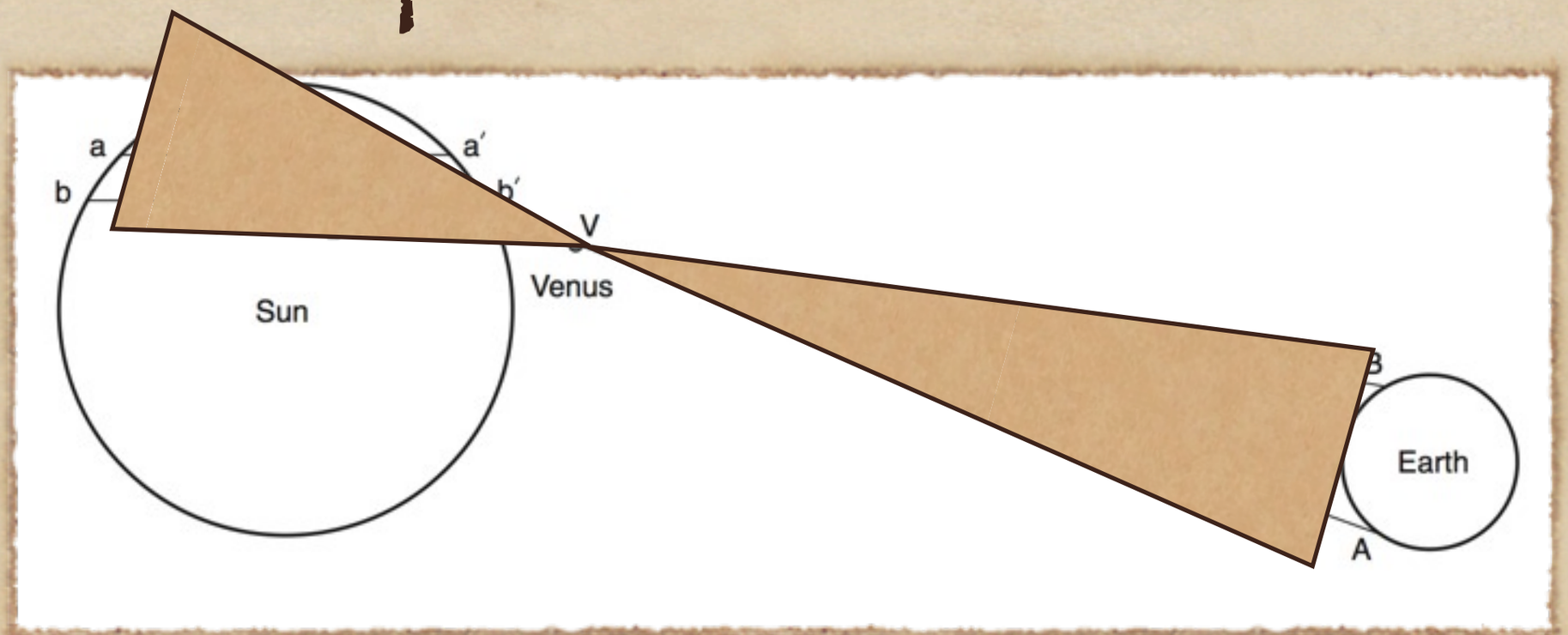
Transit Movie

The transit of Venus across the Sun as recorded by ESAC observers located in Portugal 8 June 2004.

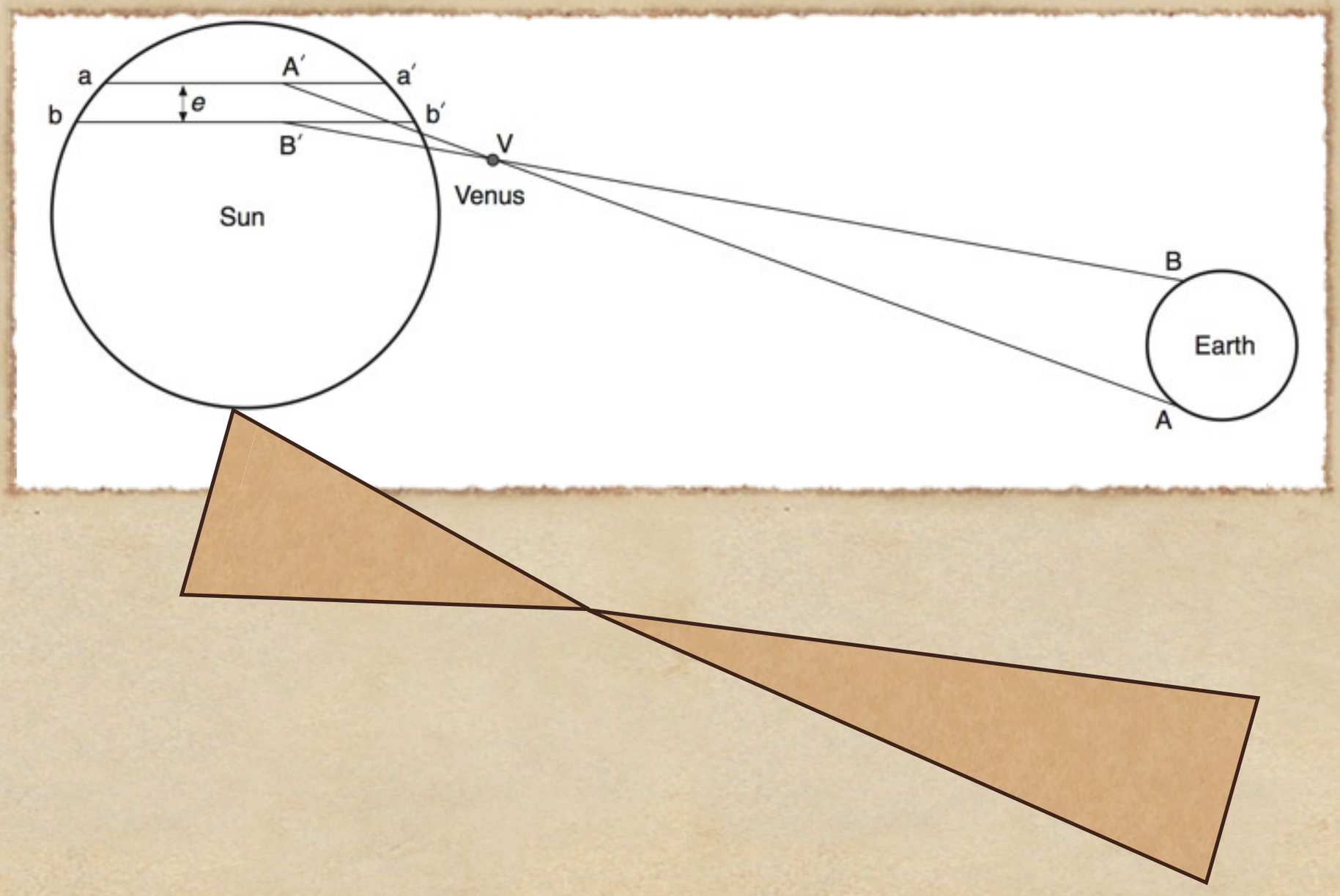
Simple Calculation



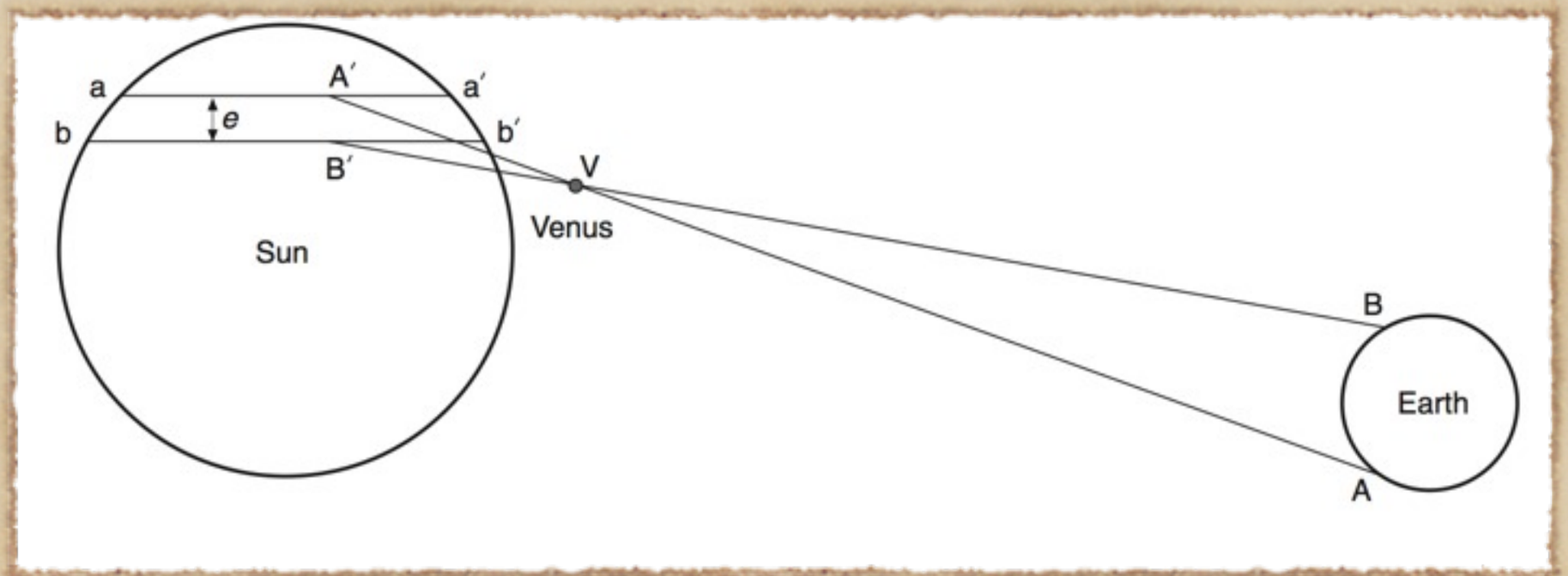
Simple Calculation



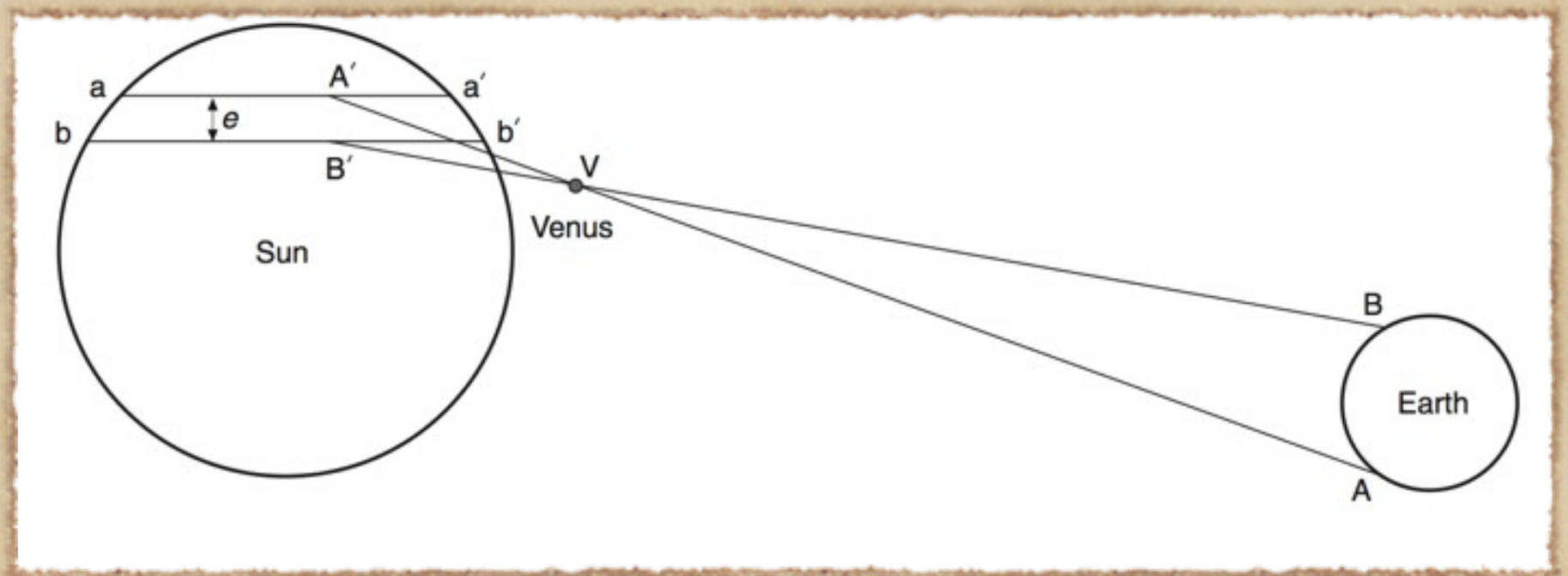
Simple Calculation

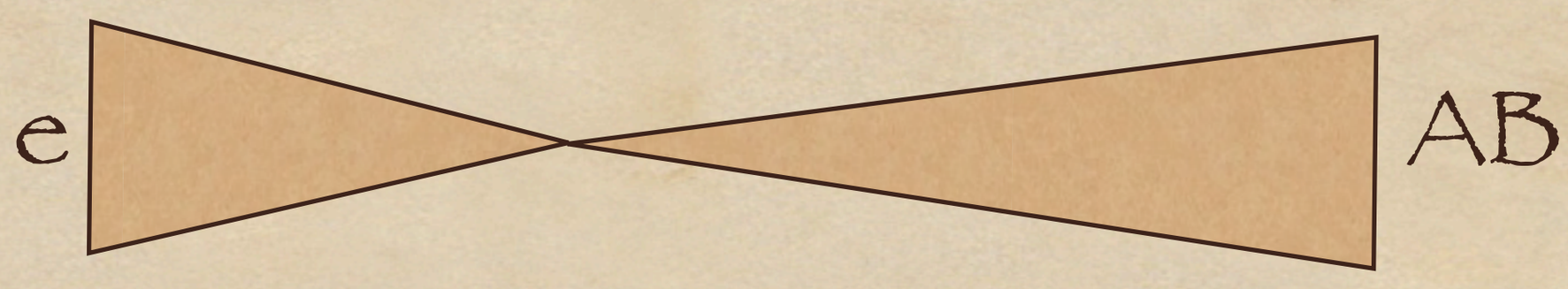


Simple Calculation

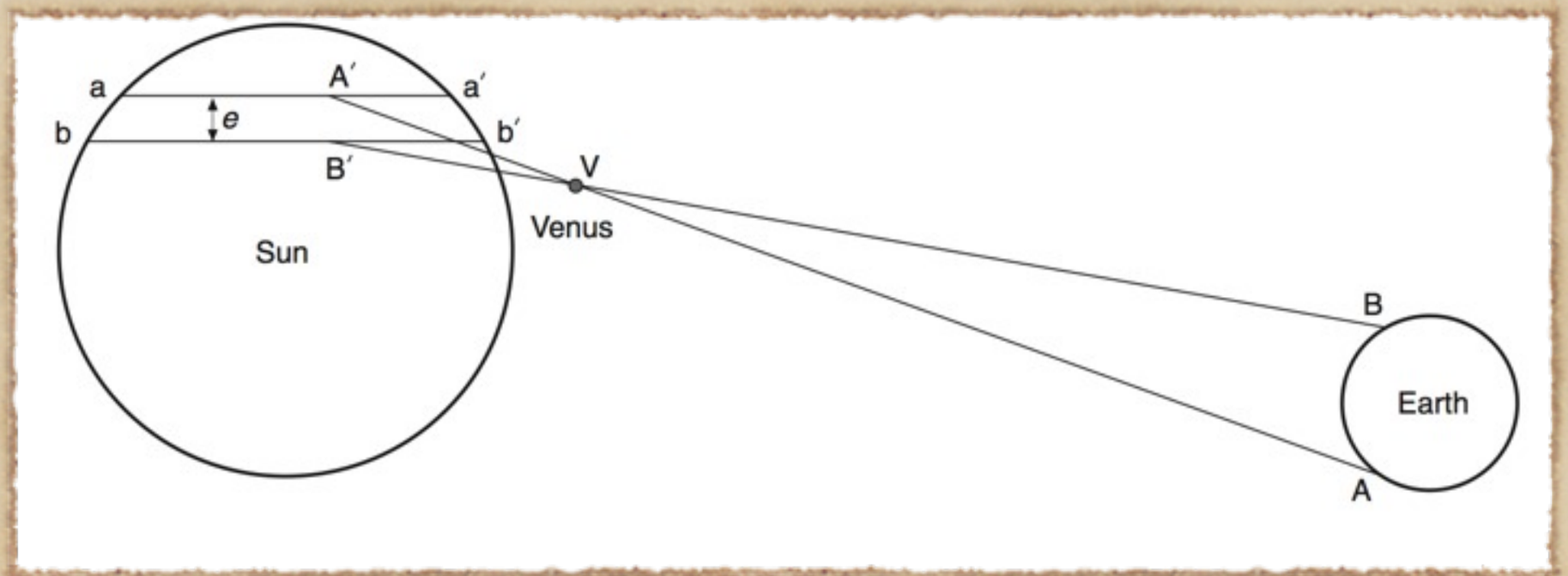


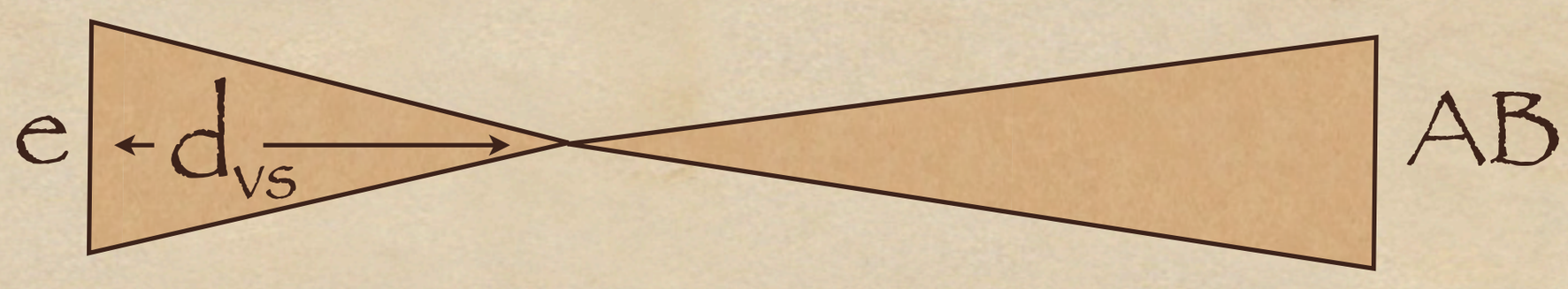
Simple Calculation



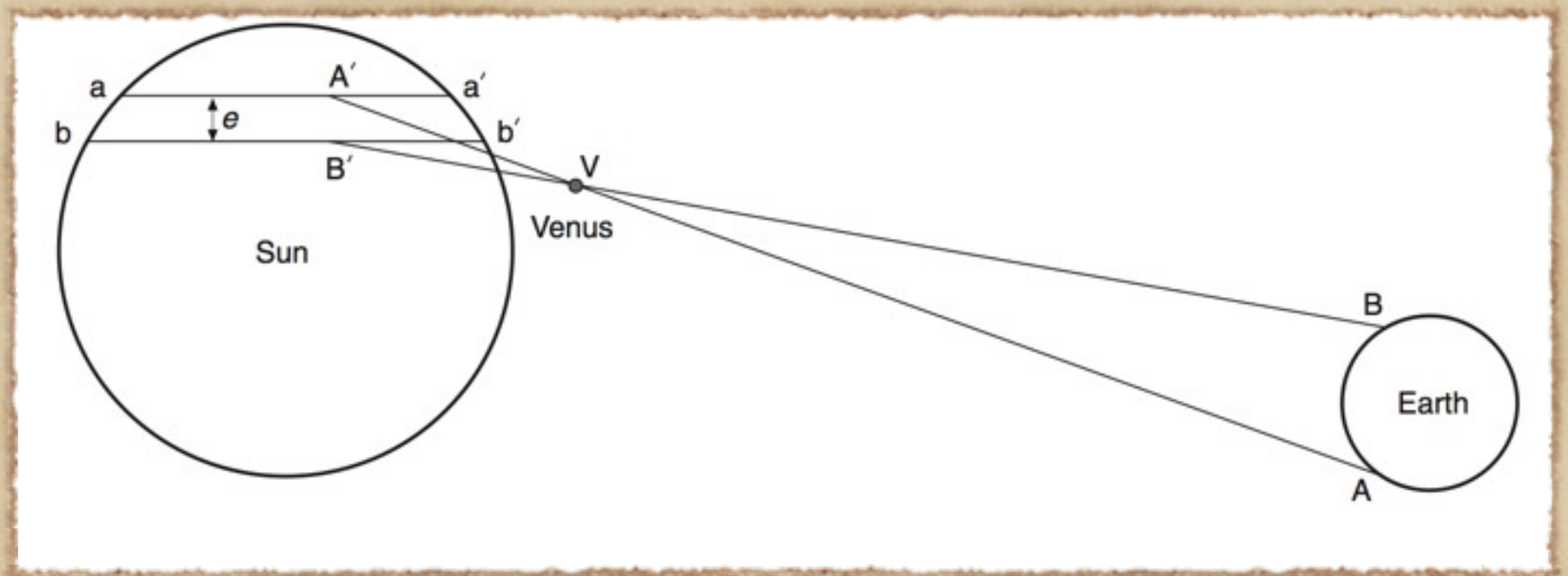


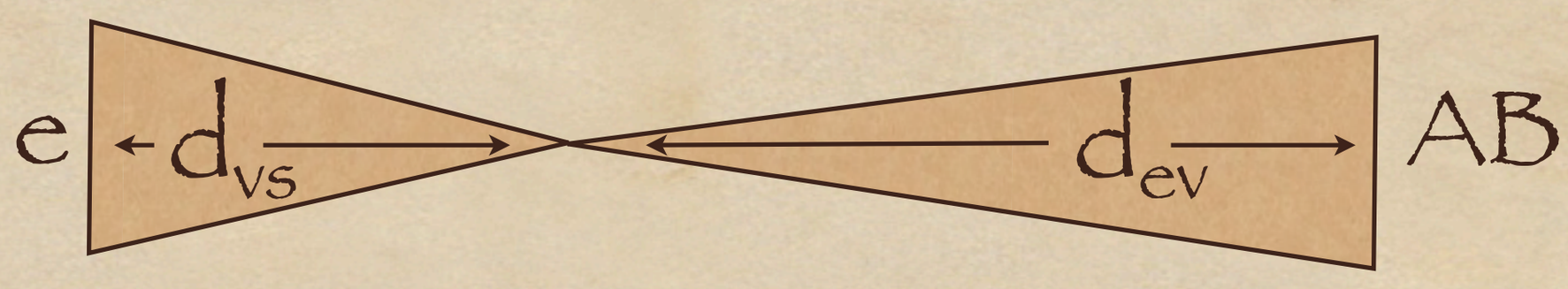
Simple Calculation



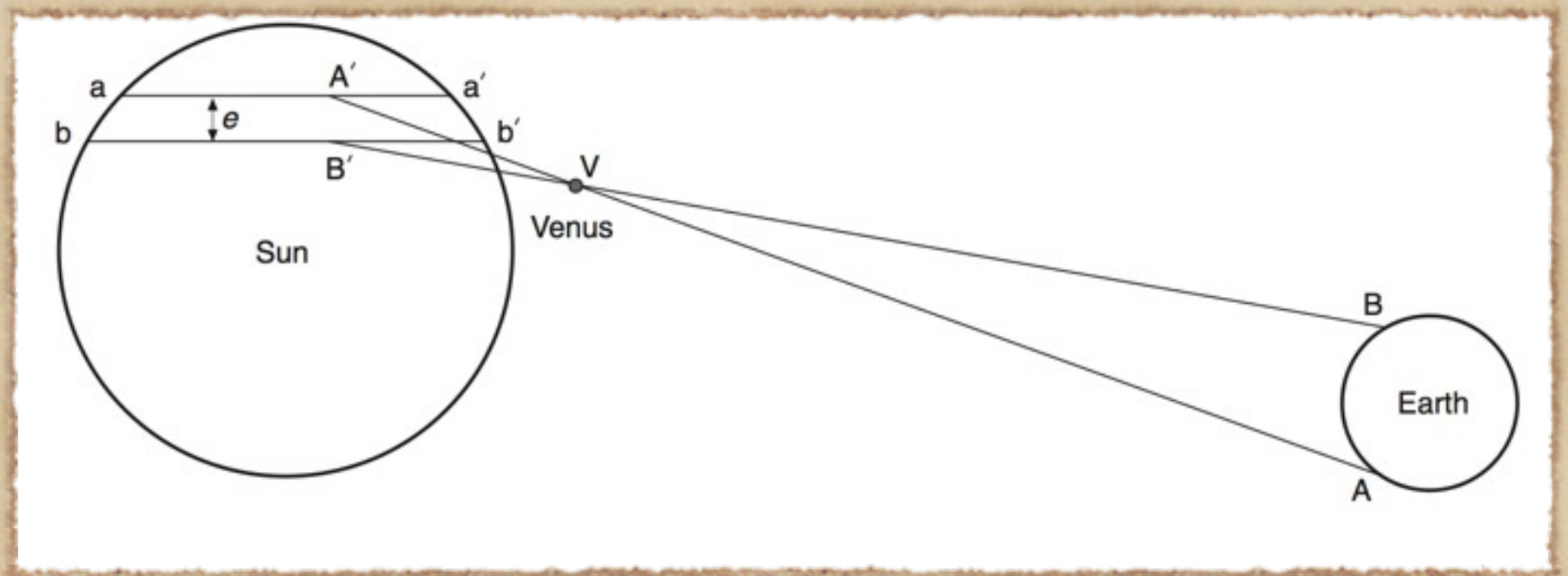


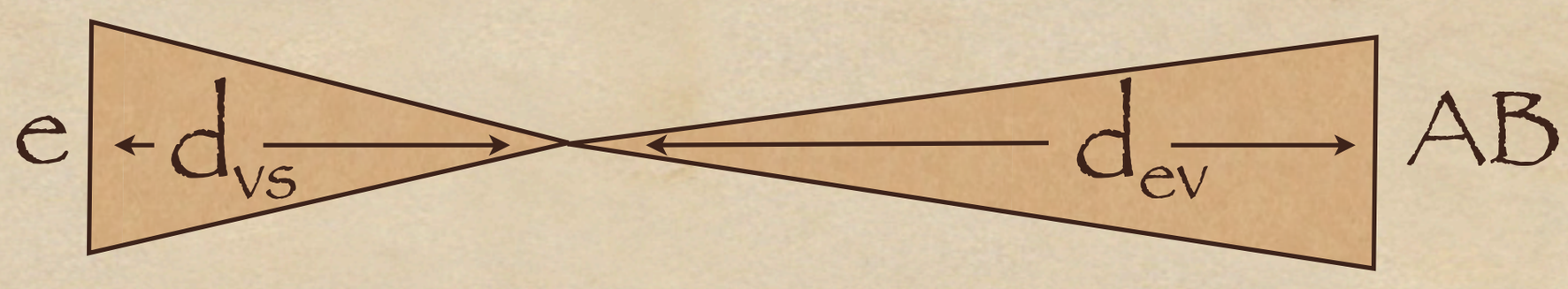
Simple Calculation





Simple Calculation

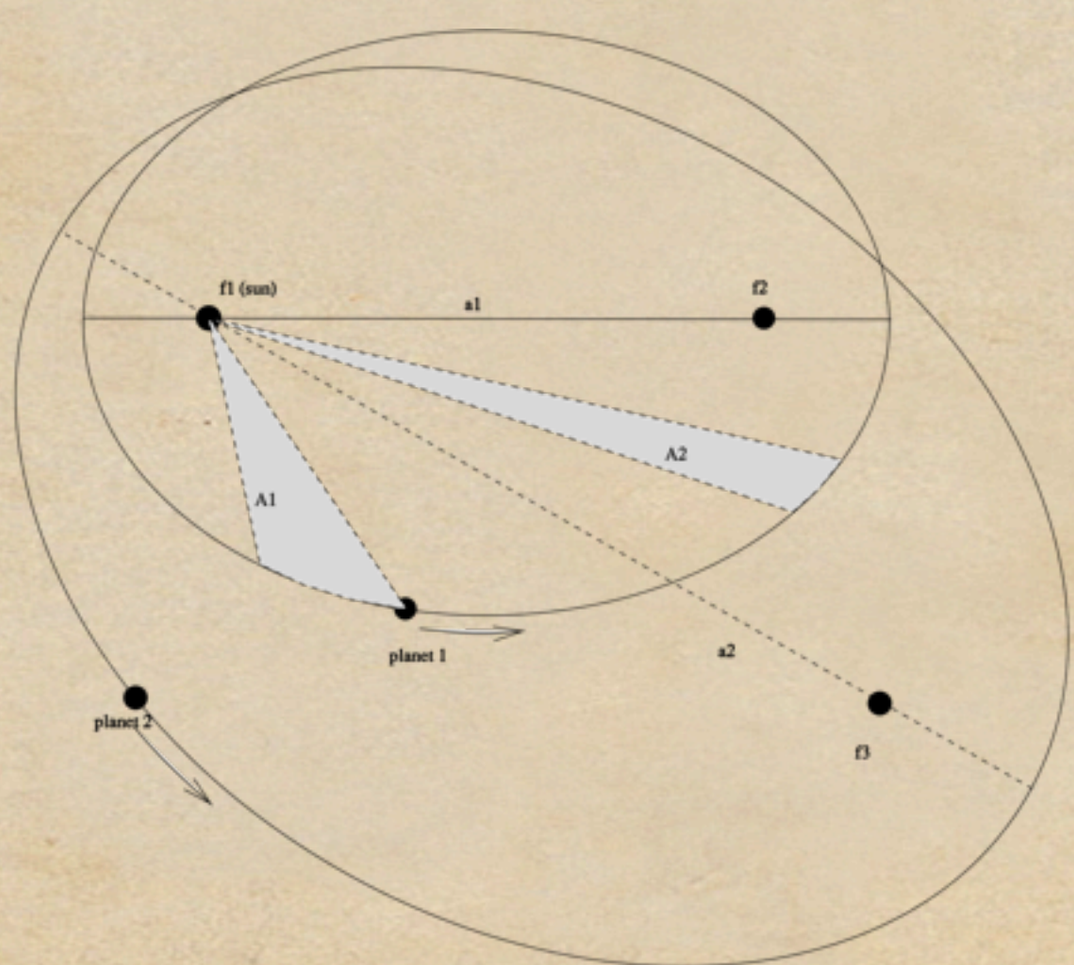




$$e = AB * d_{vs} / d_{ev}$$

Kepler's Third Law

$$T_V^2/a_V^3 = T_E^2/a_E^3$$

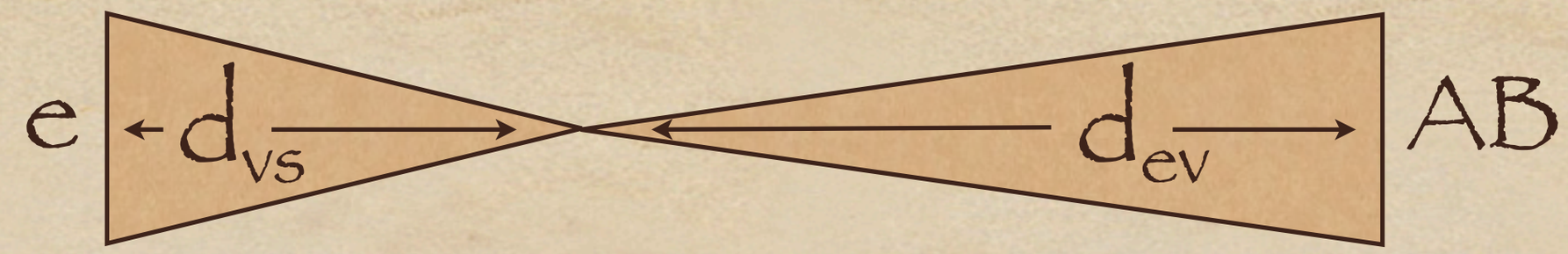


Johannes Kepler, 1571-1630

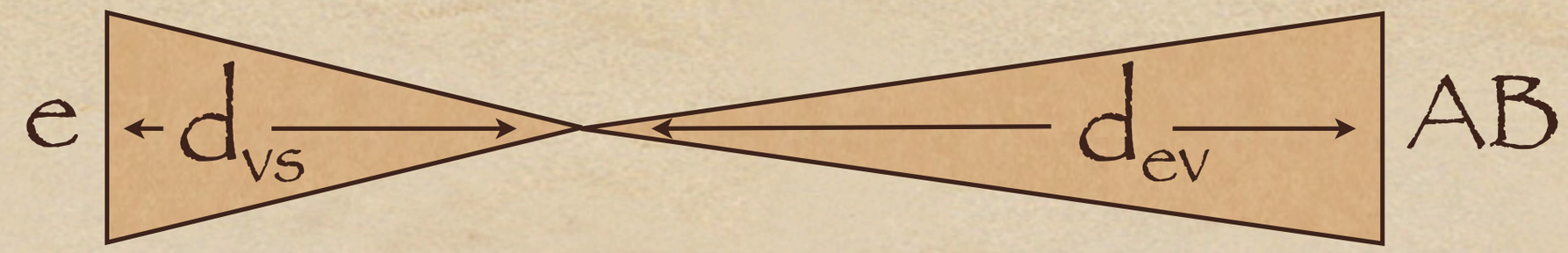
Wednesday, May 30, 2012

German Mathematician

1. ellipse with sun at focus
2. lines sweep equal areas
3. square of period directly proportional to cube of s-m axis

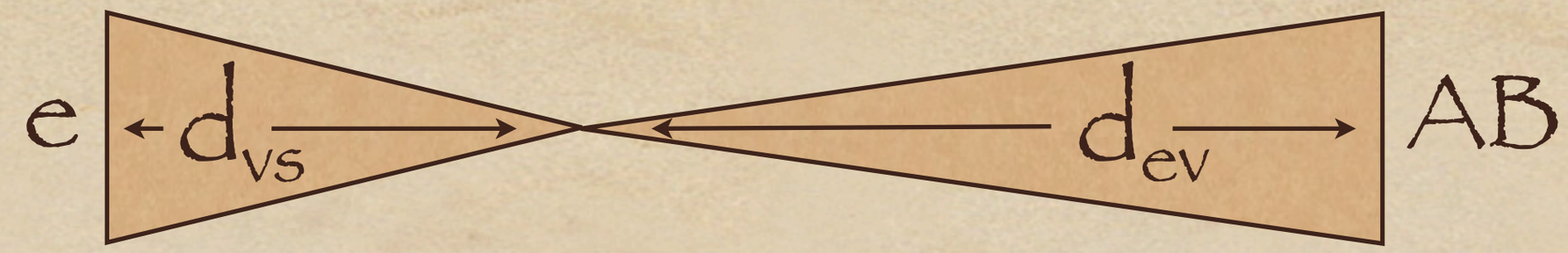


$$e = AB * d_{vs} / d_{ev}$$



$$T_v^2/a_v^3 = T_E^2/a_E^3$$

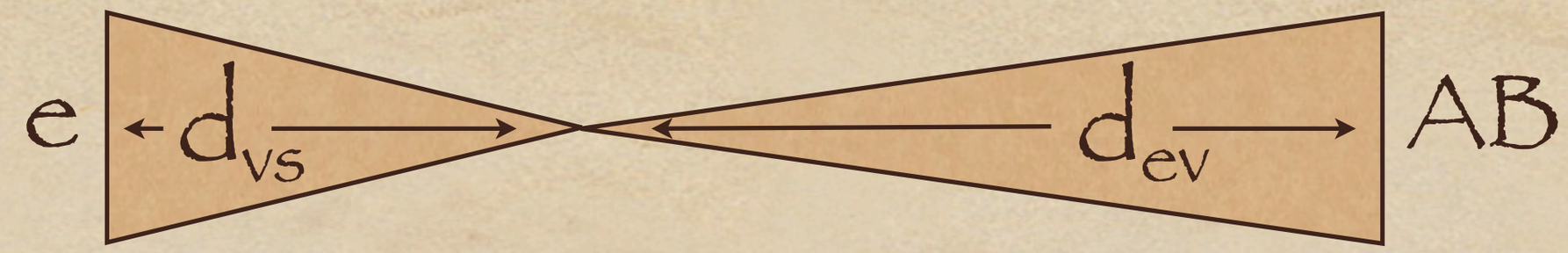
$$e = AB * d_{vs}/d_{ev}$$



$$T_v^2/a_v^3 = T_E^2/a_E^3$$

$$a_v/a_E = (T_v/T_E)^{2/3}$$

$$e = AB * d_{vs}/d_{ev}$$

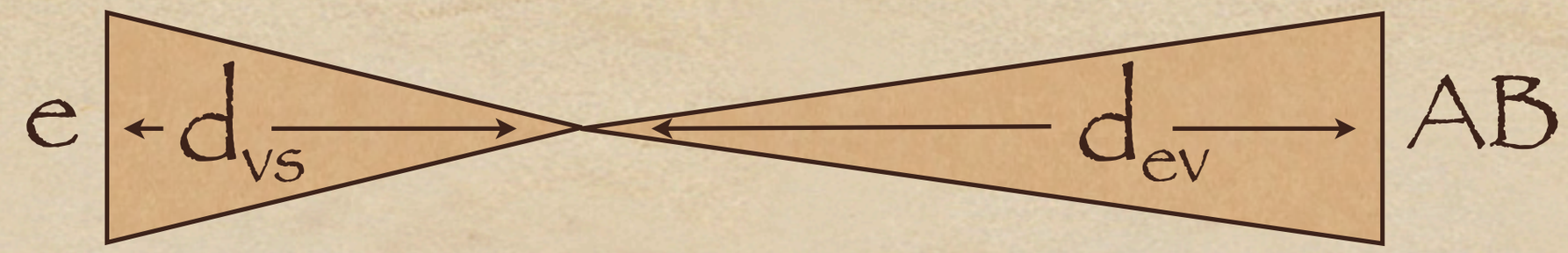


$$T_v^2/a_v^3 = T_E^2/a_E^3$$

$$e = AB * d_{vs}/d_{ev}$$

$$a_v/a_E = (T_v/T_E)^{2/3}$$

$$d_{vs}/(d_{vs}+d_{ev}) = (T_v/T_E)^{2/3}$$



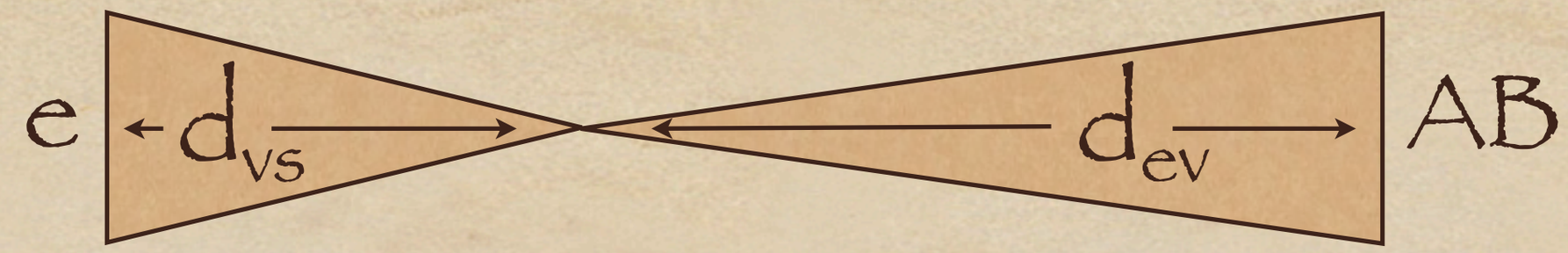
$$e = AB * d_{vs}/d_{ev}$$

$$T_v^2/a_v^3 = T_E^2/a_E^3$$

$$a_v/a_E = (T_v/T_E)^{2/3}$$

$$d_{vs}/(d_{vs}+d_{ev}) = (T_v/T_E)^{2/3}$$

$$1 + d_{ev}/d_{vs} = (T_E/T_V)^{2/3}$$



$$e = AB * d_{vs}/d_{ev}$$

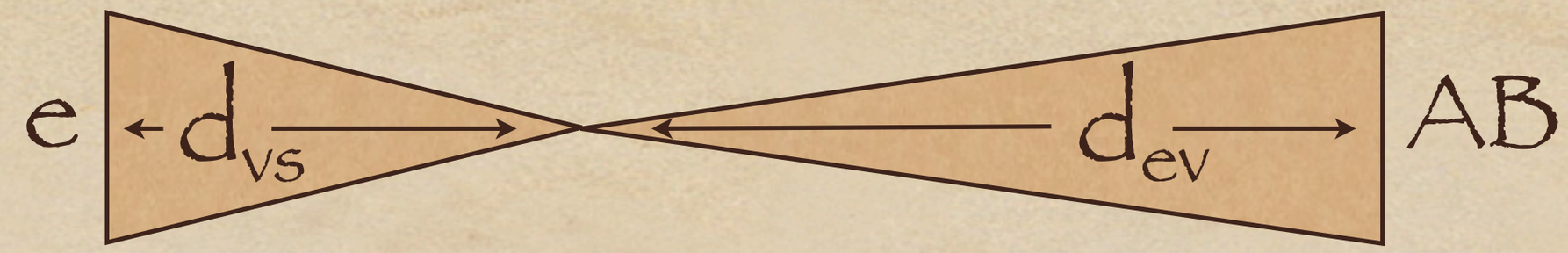
$$T_v^2/a_v^3 = T_E^2/a_E^3$$

$$a_v/a_E = (T_v/T_E)^{2/3}$$

$$d_{vs}/(d_{vs}+d_{ev}) = (T_v/T_E)^{2/3}$$

$$1 + d_{ev}/d_{vs} = (T_E/T_V)^{2/3}$$

$$d_{ev}/d_{vs} = (T_E/T_V)^{2/3} - 1$$



$$e = AB * \boxed{d_{vs}/d_{ev}}$$

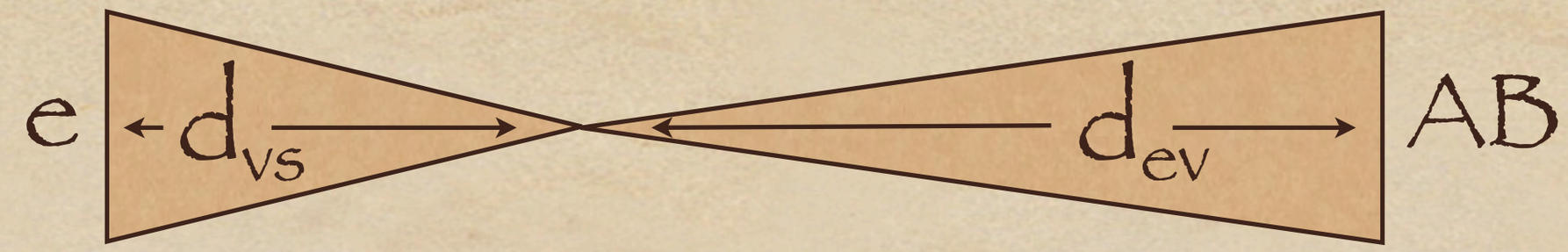
$$T_v^2/a_v^3 = T_E^2/a_E^3$$

$$a_v/a_E = (T_v/T_E)^{2/3}$$

$$d_{vs}/(d_{vs}+d_{ev}) = (T_v/T_E)^{2/3}$$

$$1 + d_{ev}/d_{vs} = (T_E/T_V)^{2/3}$$

$$\boxed{d_{ev}/d_{vs}} = (T_E/T_V)^{2/3} - 1$$



$$T_v^2/a_v^3 = T_E^2/a_E^3$$

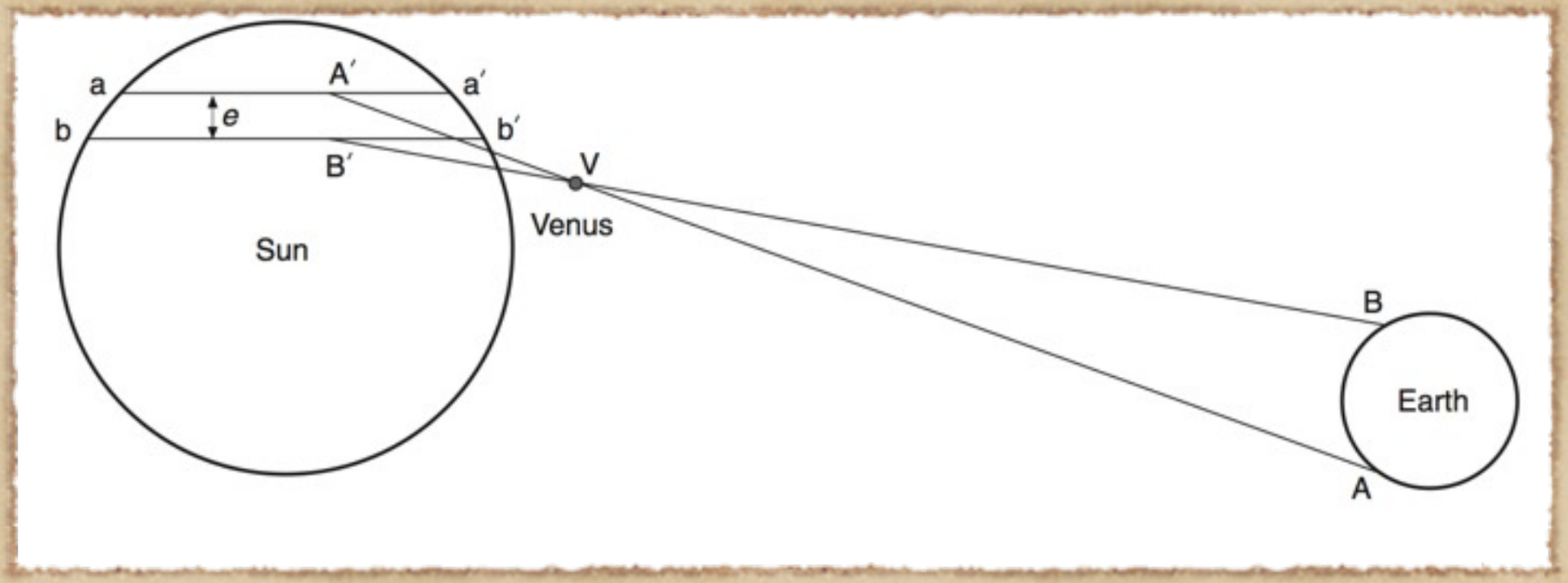
$$a_v/a_E = (T_v/T_E)^{2/3}$$

$$d_{vs}/(d_{vs}+d_{ev}) = (T_v/T_E)^{2/3}$$

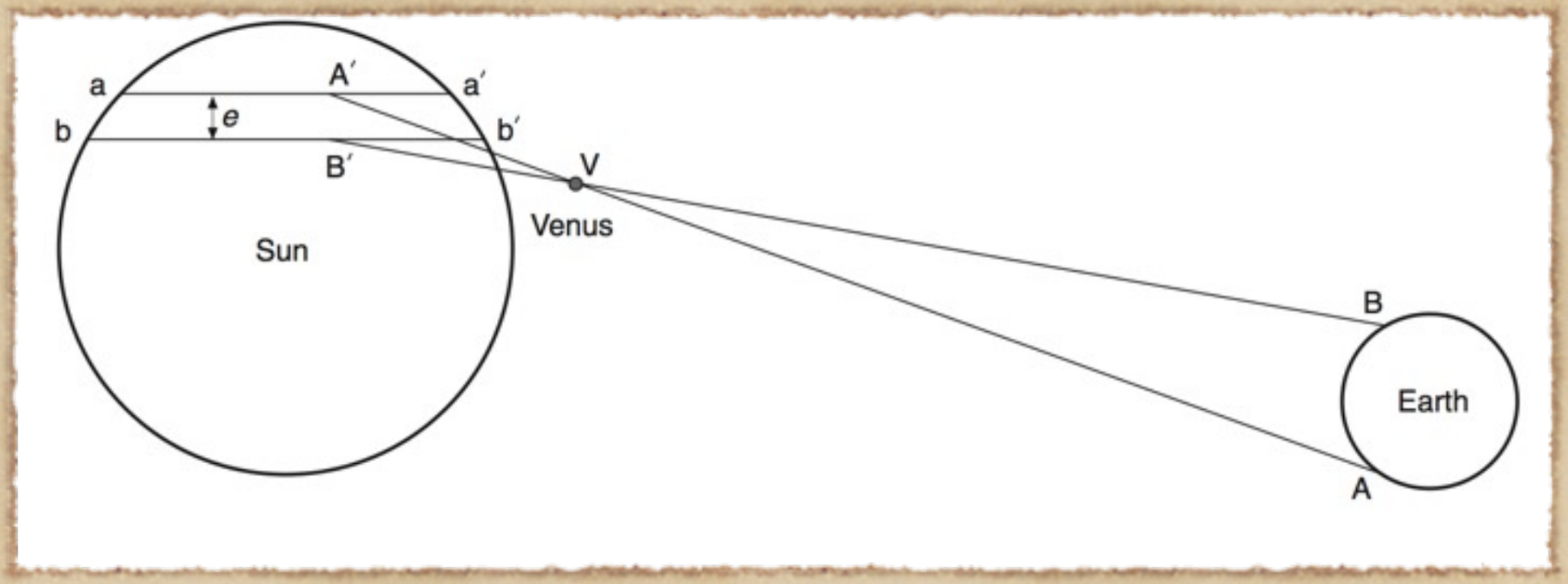
$$1 + d_{ev}/d_{vs} = (T_E/T_V)^{2/3}$$

$$\boxed{d_{ev}/d_{vs}} = (T_E/T_V)^{2/3} - 1$$

$$e = AB * \boxed{d_{vs}/d_{ev}}$$

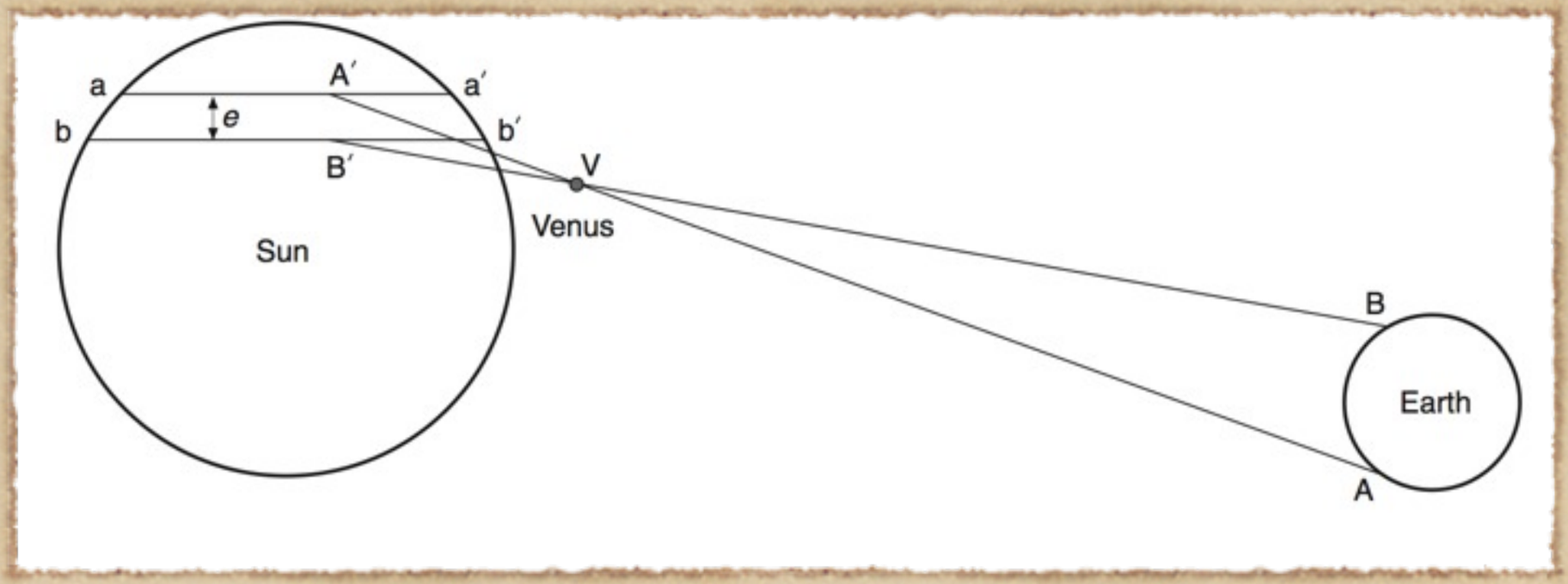


$$e = AB * d_{vs} / d_{ev}$$



$$e = AB * d_{vs} / d_{ev}$$

$$e = AB * [(T_E / T_V)^{2/3} - 1]^{-1}$$



$$e = AB * d_{vs} / d_{ev}$$

$$e = AB * [(T_E / T_V)^{2/3} - 1]^{-1}$$

- Can Measure all of this:
  - AB = Distance on Earth (km)
  - e = Distance on Sun (fraction)
  - T_E = Earth's orbital period (days)
  - T_V = Venus' orbital period (days)

Some Numbers

$$e = AB * [(T_E / T_V)^{2/3} - 1]^{-1}$$

Some Numbers

$$e = AB * [(T_E / T_V)^{2/3} - 1]^{-1}$$

$$AB = 4000 \text{ km}$$

$$T_E = 365 \text{ days}$$

$$T_V = 225 \text{ days}$$

Some Numbers

$$e = AB * [(T_E / T_V)^{2/3} - 1]^{-1}$$

$$AB = 4000 \text{ km}$$

$$T_E = 365 \text{ days}$$

$$T_V = 225 \text{ days}$$

$$e = 4000 * [(365/225)^{2/3} - 1]^{-1}$$

Some Numbers

$$e = AB * [(T_E / T_V)^{2/3} - 1]^{-1}$$

$$AB = 4000 \text{ km}$$

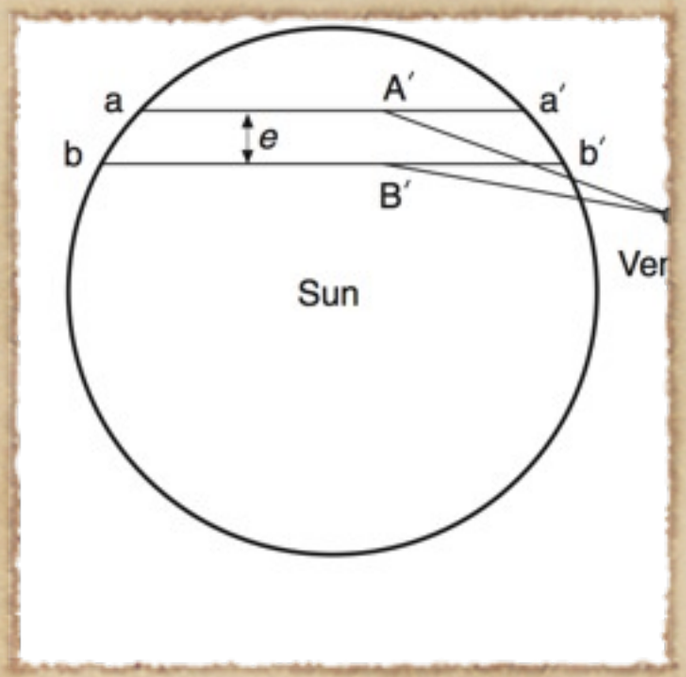
$$T_E = 365 \text{ days}$$

$$T_V = 225 \text{ days}$$

$$e = 4000 * [(365/225)^{2/3} - 1]^{-1}$$

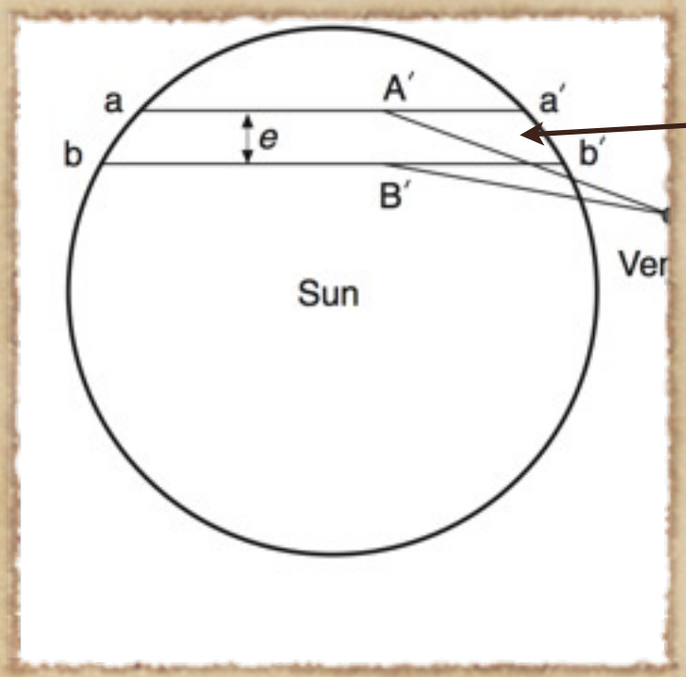
$$e = 10{,}500 \text{ km}$$

More Geometry



Modern Number = 149,597,871 km

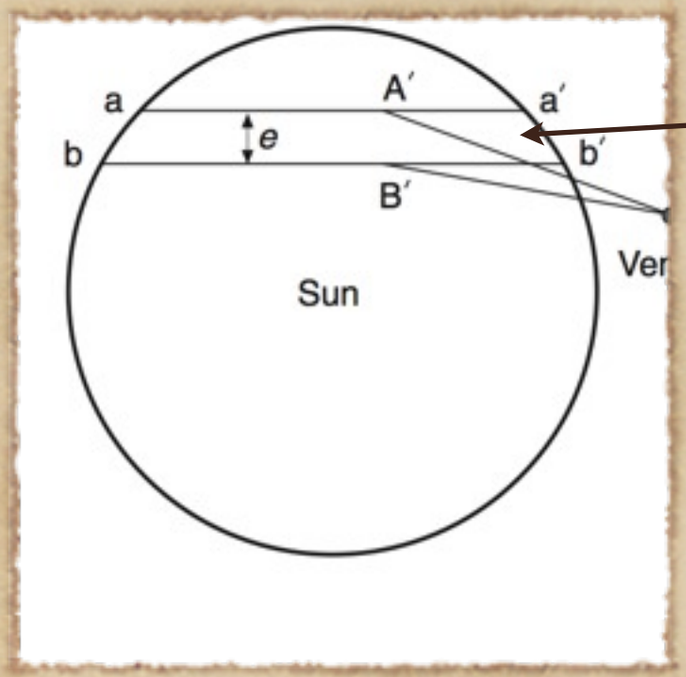
More Geometry



135 e's in the Sun

Modern Number = 149,597,871 km

More Geometry



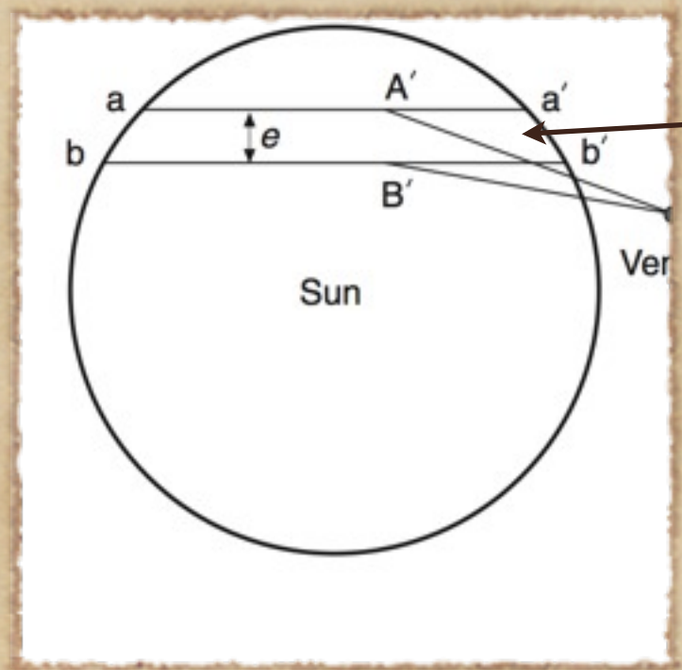
135 e's in the Sun

$D_{sun} = e*135 = 1{,}420{,}000$ km

Wednesday, May 30, 2012

Modern Number = 149,597,871 km

More Geometry



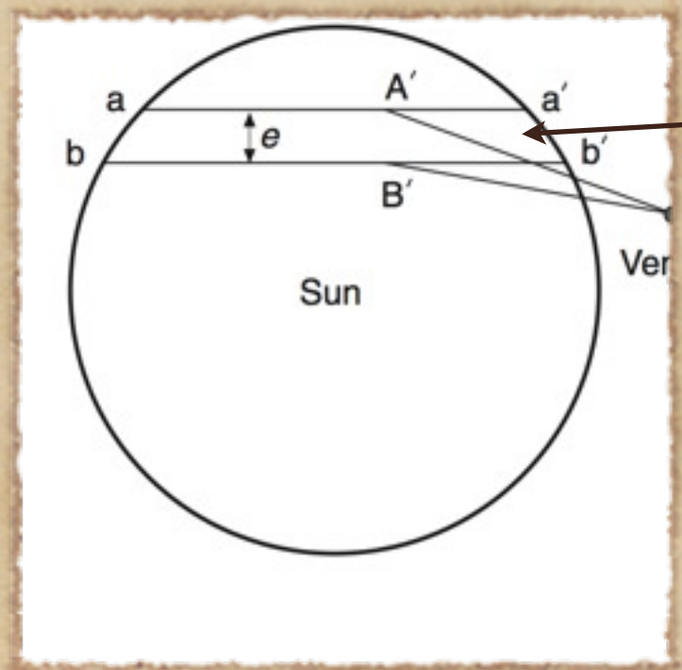
135 e's in the Sun

$D_{sun} = e*135 = 1{,}420{,}000$ km

We know: $D_{sun} = 0.53°$

Modern Number = 149,597,871 km

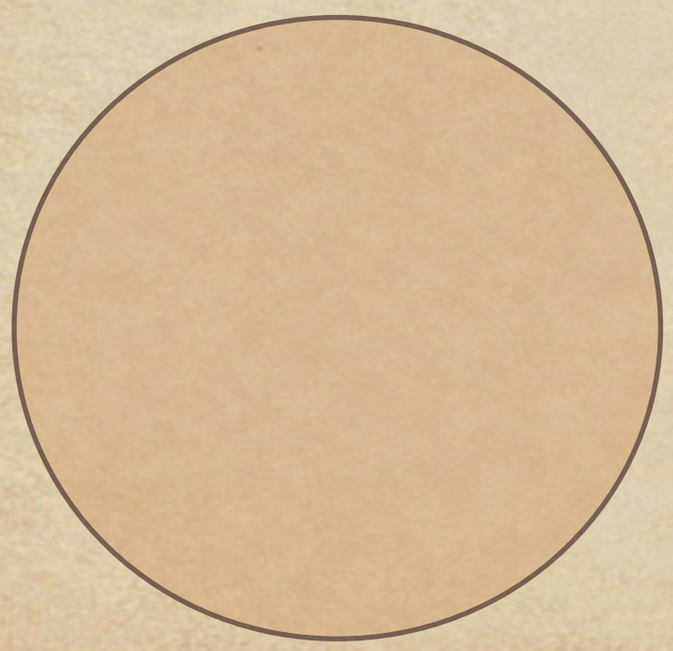
More Geometry



135 e's in the Sun

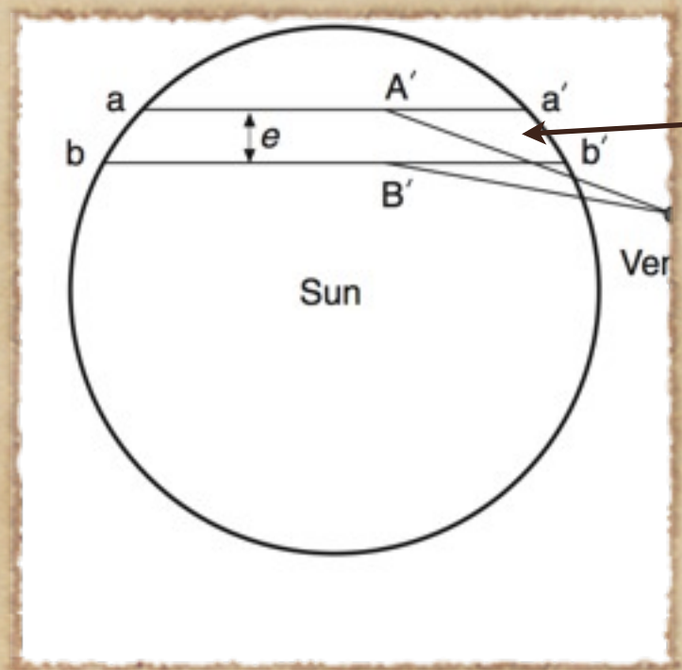
$D_{sun} = e*135 = 1{,}420{,}000$ km

We know: $D_{sun} = 0.53°$



Modern Number = 149,597,871 km

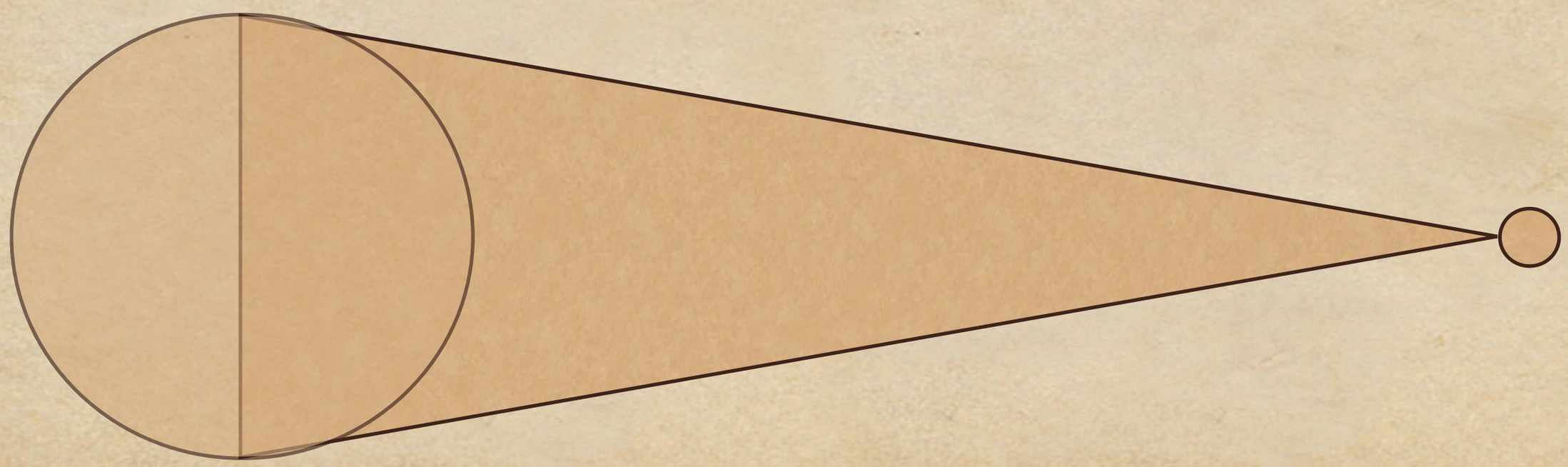
More Geometry



135 e's in the Sun

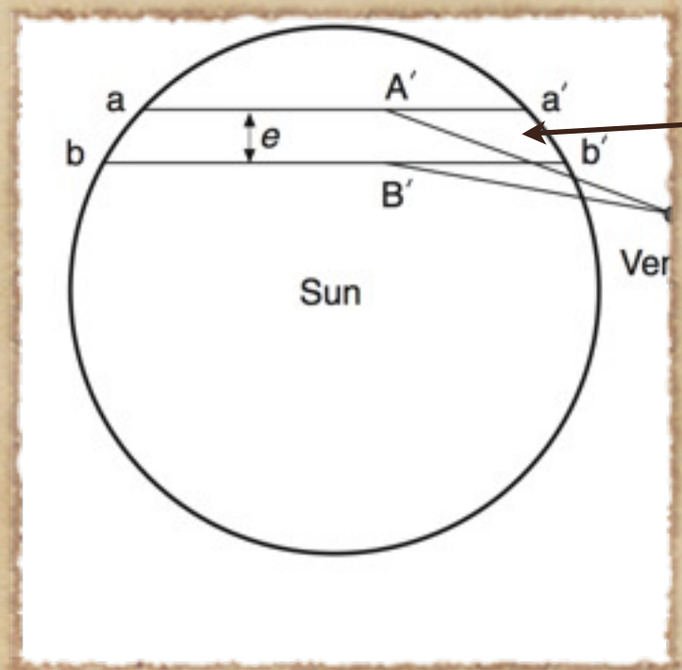
$D_{sun} = e*135 = 1{,}420{,}000$ km

We know: $D_{sun} = 0.53°$



Modern Number = 149,597,871 km

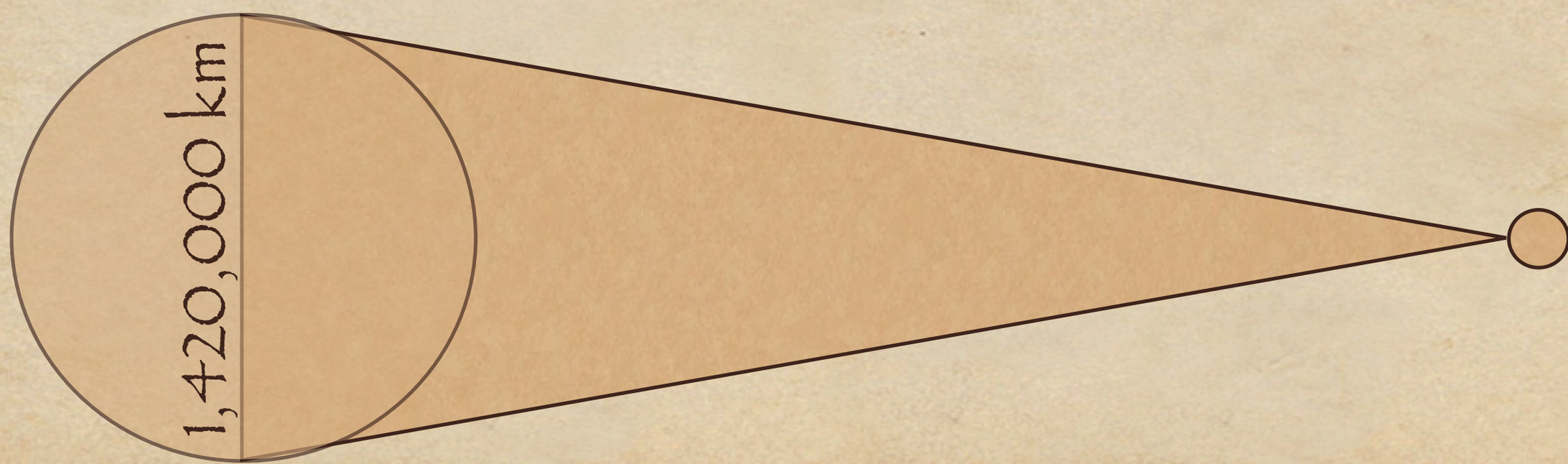
More Geometry



135 e's in the Sun

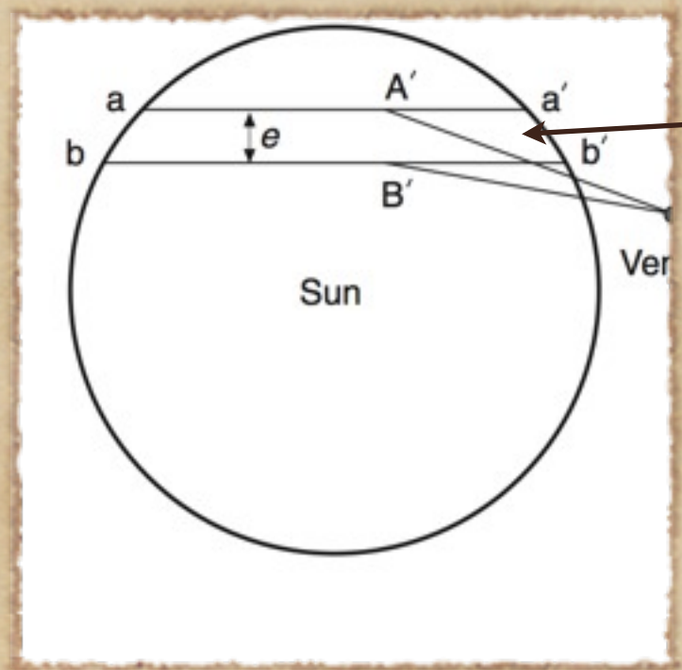
$D_{sun} = e*135 = 1{,}420{,}000$ km

We know: $D_{sun} = 0.53°$



Modern Number = 149,597,871 km

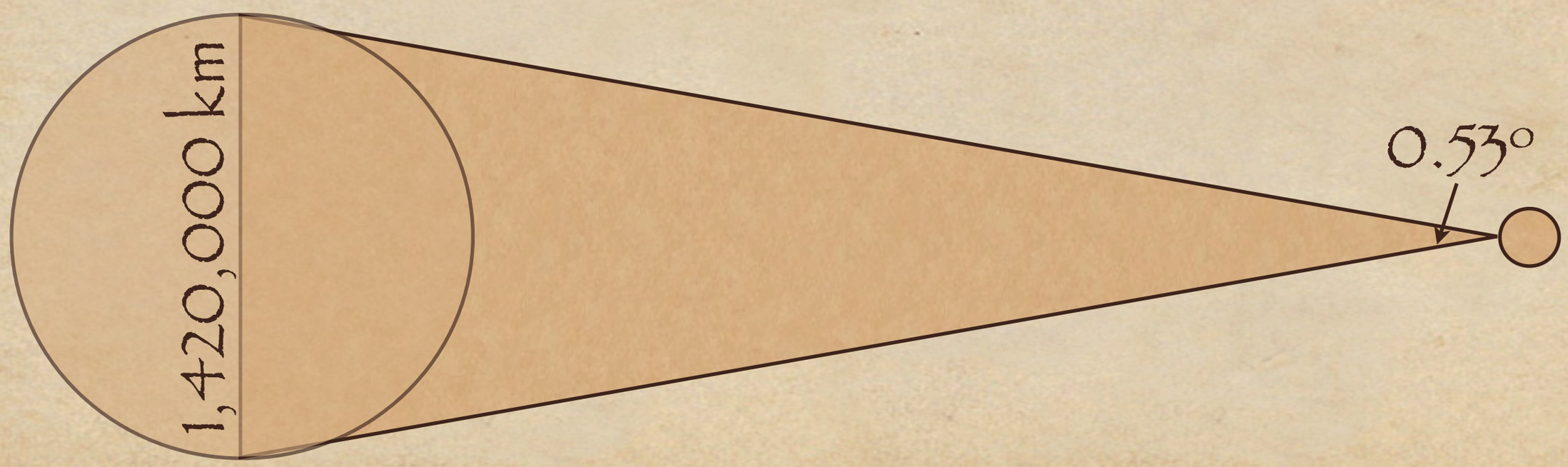
More Geometry



135 e's in the Sun

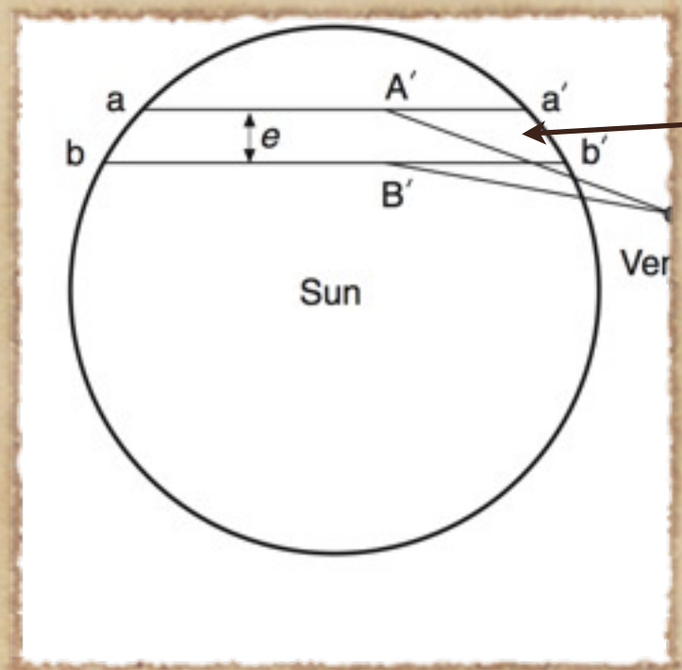
$D_{sun} = e*135 = 1{,}420{,}000$ km

We know: $D_{sun} = 0.53°$



Modern Number = 149,597,871 km

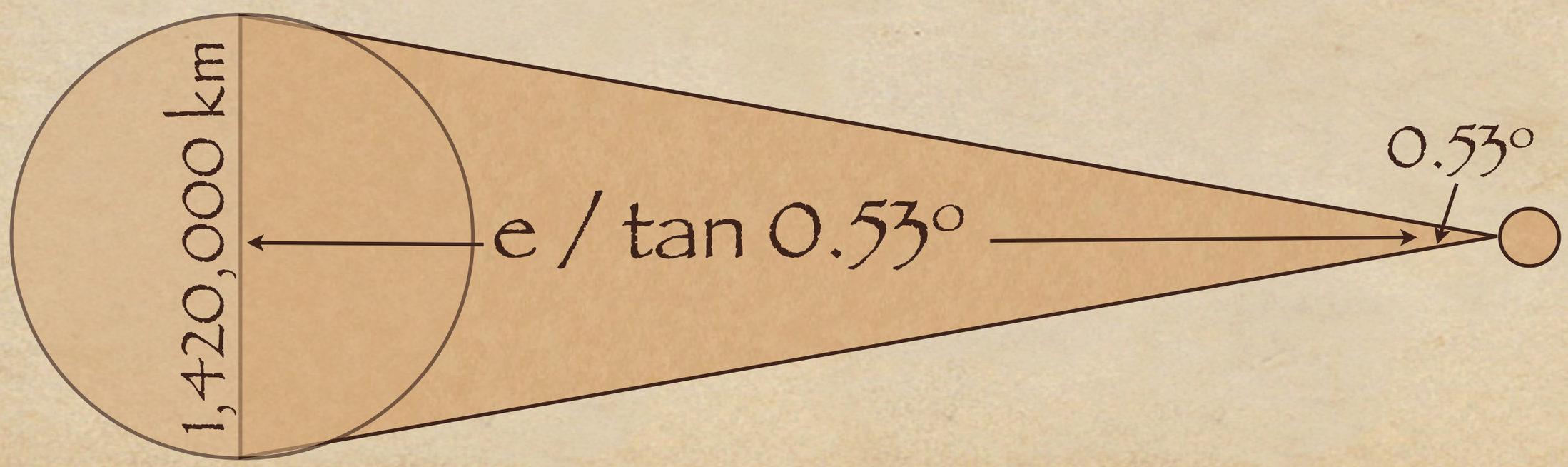
More Geometry



135 e's in the Sun

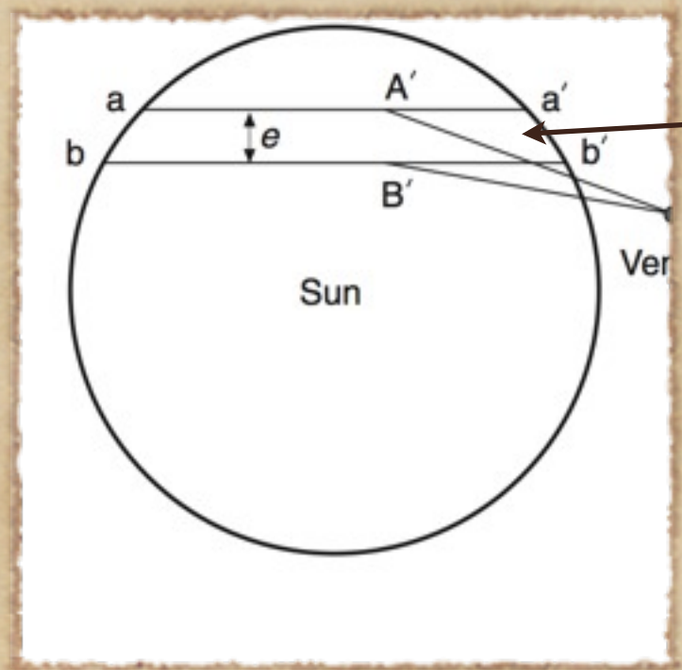
$D_{sun} = e*135 = 1{,}420{,}000$ km

We know: $D_{sun} = 0.53°$



Modern Number = 149,597,871 km

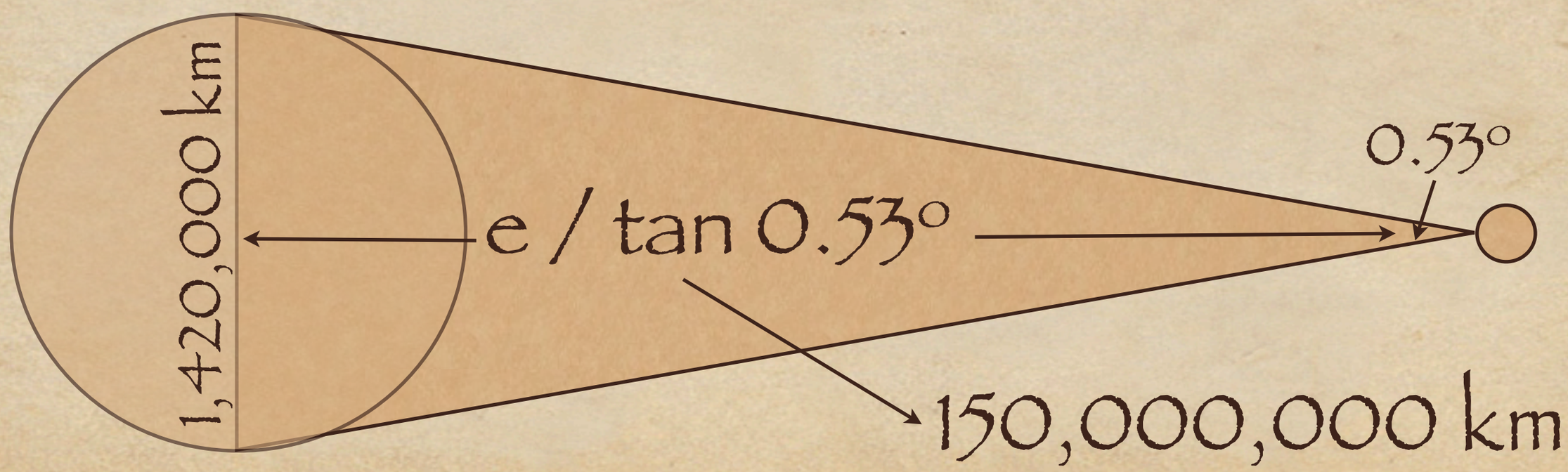
More Geometry



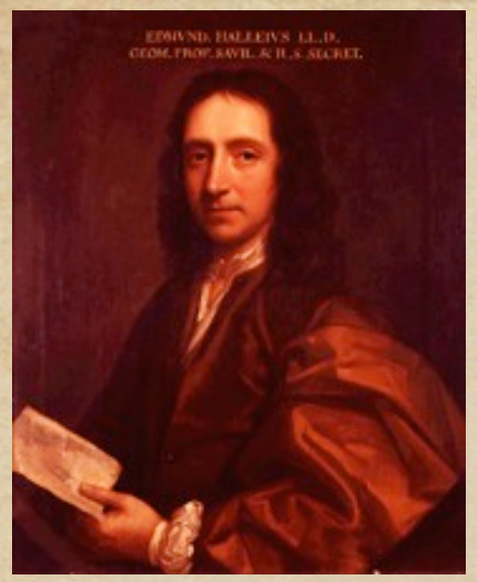
135 e's in the Sun

$D_{sun} = e*135 = 1{,}420{,}000$ km

We know: $D_{sun} = 0.53°$

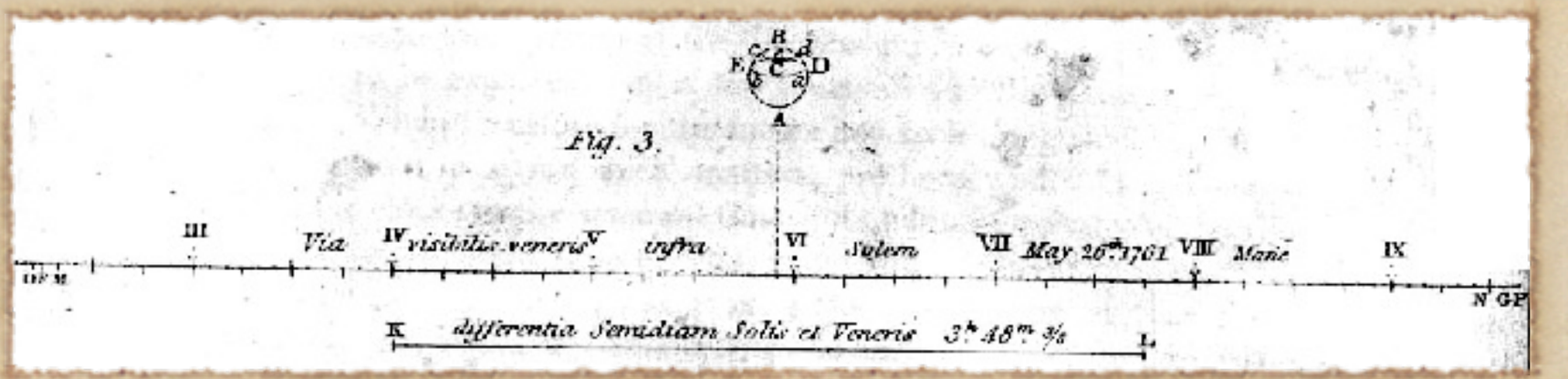


Modern Number = 149,597,871 km



Not quite how it was done...

Dr. Edmund Halley
Philosphical Transactions Vol. XXIX (1716), Sec. R. S., NO 348, p. 454
Translated from the Latin



But for the sake of such as are not thoroughly acquainted with the doctrine of parallaxes, I shall further explain the matter both by a figure and a somewhat more accurate calculation. Therefore, supposing that at London, May 25, 17h55m, 1761, the sun be in 15° 37' of Gemini, and consequently that at his centre the ecliptic tends towards the north in an angle of 6° 10'; and that the visible path of Venus within the sun's disk at that time descends towards the south, forming an angle with the ecliptic of 8° 28'; then the path of Venus will tend a little towards the south in respect of the equator, intersecting the parallels of declination in an angle of 2° 18'. Supposing likewise that Venus be near the sun's centre at the said time, and distant from it towards the south 4 minutes, describing, by a retrograde motion on the sun's disk, 4 minutes an hour. The sun's semi-diameter will be nearly 15' 51", and that of Venus 37½". And supposing, for trial sake, the difference of the horizontal parallaxes of Venus and the sun to be 31", such as it is on the supposition of the sun's parallax being 12½". Therefore let a small circle, as AEBD, fig. 3, pl. 5, be described from the centre C, whose semi-diameter let be 31", representing the earth's disk, and in it drawing DabE and cde the ellipses of the parallels of 22 and 56° N. lat. in the same manner as is now used by astronomers for constructing solar eclipses: and let BCA be the meridian in which the sun is, to which let be inclined the right line FHG, representing the path of Venus, in an angle of 2° 18', whose distance from the centre C let be 240 such parts as BC is 31; and from C let fall the right line CH perpendicular upon FG. Then supposing the planet in H at 17h55m, or 5h55m in the morning, let the right line FHG be divided into the horary spaces III; IV, IV; V, V; VI, &c. equal to CH, that is, 4 minutes. Let the right line KL be also equal to the difference of the apparent semi-diameters of the sun and Venus, or 15' 13½"....

When do these happen

Date	Transit Contact Times (TT) Begins h:m	Greatest h:m	Ends h:m	Sun RA h	Dec °	Min Sep "	PA °	Transit Series
AD 1396 Nov 23	15:49	19:32	23:15	16.59	-22.10	424.4	197	6
AD 1518 May 26	22:30-	02:00	05:29	4.79	22.45	505.3	164	5
AD 1526 May 23	16:14	19:15	22:15	4.64	22.18	666.8	344	7
AD 1631 Dec 07	03:40	05:21	07:01	16.91	-22.64	939.3	16	8
AD 1639 Dec 04	14:56	18:27	21:57	16.74	-22.34	523.6	197	6
AD 1761 Jun 06	02:00	05:19	08:39	4.96	22.69	570.4	165	5
AD 1769 Jun 03	19:13	22:26	01:38+	4.80	22.44	609.4	344	7
AD 1874 Dec 09	01:42	04:07	06:32	17.06	-22.82	829.9	15	8
AD 1882 Dec 06	13:54	17:06	20:18	16.88	-22.56	637.3	196	6
AD 2004 Jun 08	05:12	08:21	11:30	5.12	22.89	626.9	166	5
AD 2012 Jun 06	22:09-	01:31	04:53	4.97	22.68	554.4	345	7
AD 2117 Dec 11	23:58-	02:52	05:46	17.20	-22.97	723.7	14	8
AD 2125 Dec 08	13:15	16:06	18:57	17.03	-22.74	736.4	195	6
AD 2247 Jun 11	08:47	11:42	14:38	5.29	23.05	691.3	167	5
AD 2255 Jun 09	01:16	04:48	08:19	5.14	22.87	491.8	346	7
AD 2360 Dec 13	22:44-	01:59	05:13	17.35	-23.09	625.7	13	8
AD 2368 Dec 10	12:38	15:00	17:23	17.17	-22.90	836.4	194	6
AD 2490 Jun 12	11:57	14:40	17:22	5.45	23.17	741.1	168	5
AD 2498 Jun 10	04:11	07:49	11:27	5.30	23.02	442.7	347	7
AD 2603 Dec 16	21:13-	00:44	04:16	17.49	-23.18	517.1	12	8
AD 2611 Dec 13	12:24	14:06	15:48	17.32	-23.03	934.8	193	6
AD 2733 Jun 15	15:39	18:01	20:24	5.62	23.24	808.3	169	5
AD 2741 Jun 13	07:16	11:00	14:45	5.47	23.14	385.6	348	7
AD 2846 Dec 17	20:23-	00:05	03:47	17.64	-23.24	432.1	11	8

When do these happen

	Date	Transit Contact Times (TT) Begins h:m	Greatest h:m	Ends h:m	Sun RA h	Sun Dec °	Min Sep "	PA °	Transit Series
	AD 1396 Nov 23	15:49	19:32	23:15	16.59	-22.10	424.4	197	6
8 yrs	AD 1518 May 26	22:30-	02:00	05:29	4.79	22.45	505.3	164	5
	AD 1526 May 23	16:14	19:15	22:15	4.64	22.18	666.8	344	7
8 yrs	AD 1631 Dec 07	03:40	05:21	07:01	16.91	-22.64	939.3	16	8
	AD 1639 Dec 04	14:56	18:27	21:57	16.74	-22.34	523.6	197	6
8 yrs	AD 1761 Jun 06	02:00	05:19	08:39	4.96	22.69	570.4	165	5
	AD 1769 Jun 03	19:13	22:26	01:38+	4.80	22.44	609.4	344	7
8 yrs	AD 1874 Dec 09	01:42	04:07	06:32	17.06	-22.82	829.9	15	8
	AD 1882 Dec 06	13:54	17:06	20:18	16.88	-22.56	637.3	196	6
8 yrs	AD 2004 Jun 08	05:12	08:21	11:30	5.12	22.89	626.9	166	5
	AD 2012 Jun 06	22:09-	01:31	04:53	4.97	22.68	554.4	345	7
8 yrs	AD 2117 Dec 11	23:58-	02:52	05:46	17.20	-22.97	723.7	14	8
	AD 2125 Dec 08	13:15	16:06	18:57	17.03	-22.74	736.4	195	6
8 yrs	AD 2247 Jun 11	08:47	11:42	14:38	5.29	23.05	691.3	167	5
	AD 2255 Jun 09	01:16	04:48	08:19	5.14	22.87	491.8	346	7
8 yrs	AD 2360 Dec 13	22:44-	01:59	05:13	17.35	-23.09	625.7	13	8
	AD 2368 Dec 10	12:38	15:00	17:23	17.17	-22.90	836.4	194	6
8 yrs	AD 2490 Jun 12	11:57	14:40	17:22	5.45	23.17	741.1	168	5
	AD 2498 Jun 10	04:11	07:49	11:27	5.30	23.02	442.7	347	7
8 yrs	AD 2603 Dec 16	21:13-	00:44	04:16	17.49	-23.18	517.1	12	8
	AD 2611 Dec 13	12:24	14:06	15:48	17.32	-23.03	934.8	193	6
8 yrs	AD 2733 Jun 15	15:39	18:01	20:24	5.62	23.24	808.3	169	5
	AD 2741 Jun 13	07:16	11:00	14:45	5.47	23.14	385.6	348	7
	AD 2846 Dec 17	20:23-	00:05	03:47	17.64	-23.24	432.1	11	8

When do these happen

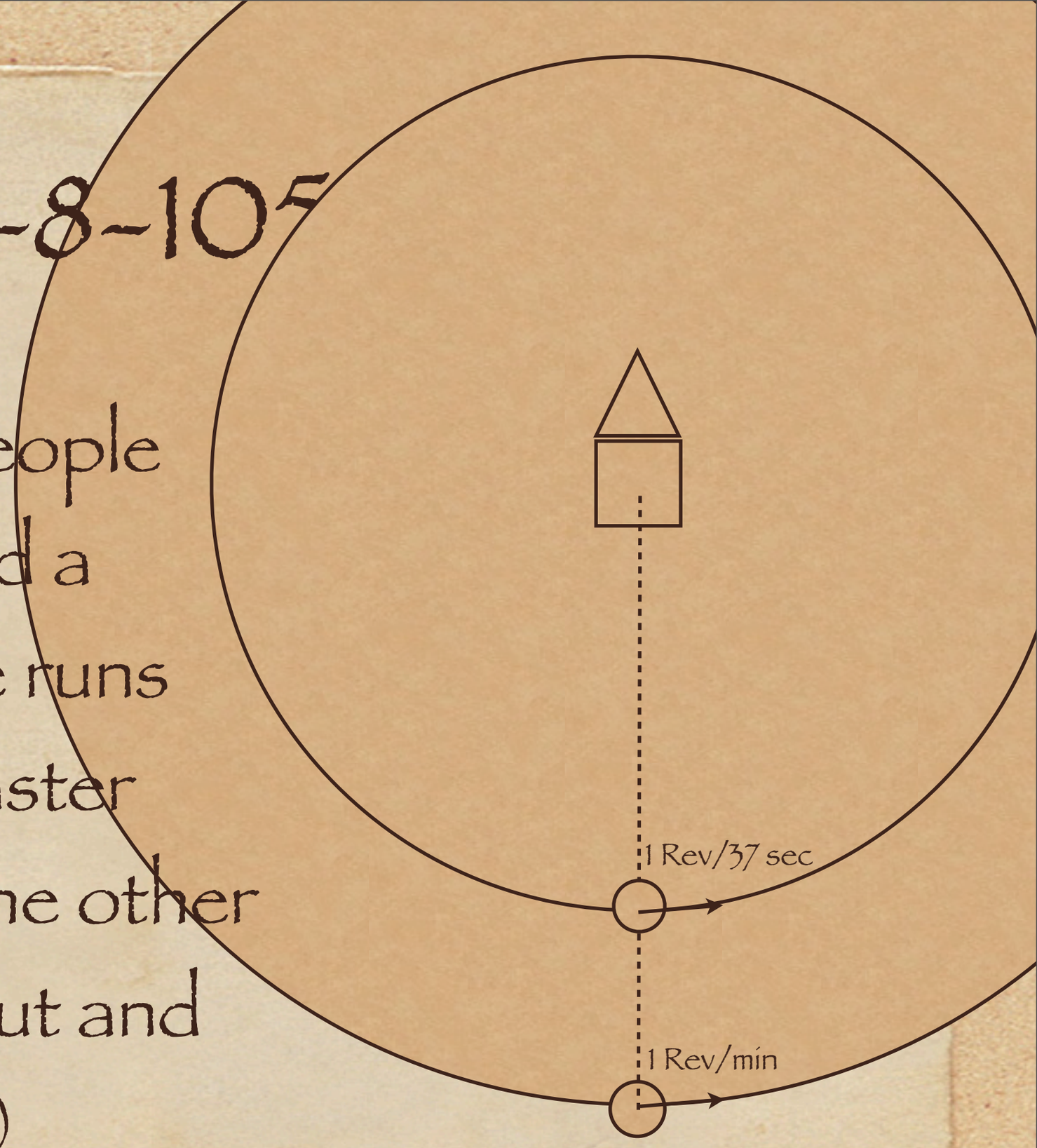
	Date	Transit Contact Times (TT) Begins h:m	Greatest h:m	Ends h:m	Sun RA h	Dec °	Min Sep "	PA °	Transit Series
	AD 1396 Nov 23	15:49	19:32	23:15	16.59	-22.10	424.4	197	6
8 yrs	AD 1518 May 26	22:30-	02:00	05:29	4.79	22.45	505.3	164	5
105.5 yrs	AD 1526 May 23	16:14	19:15	22:15	4.64	22.18	666.8	344	7
8 yrs	AD 1631 Dec 07	03:40	05:21	07:01	16.91	-22.64	939.3	16	8
	AD 1639 Dec 04	14:56	18:27	21:57	16.74	-22.34	523.6	197	6
8 yrs	AD 1761 Jun 06	02:00	05:19	08:39	4.96	22.69	570.4	165	5
105.5 yrs	AD 1769 Jun 03	19:13	22:26	01:38+	4.80	22.44	609.4	344	7
8 yrs	AD 1874 Dec 09	01:42	04:07	06:32	17.06	-22.82	829.9	15	8
	AD 1882 Dec 06	13:54	17:06	20:18	16.88	-22.56	637.3	196	6
8 yrs	AD 2004 Jun 08	05:12	08:21	11:30	5.12	22.89	626.9	166	5
105.5 yrs	AD 2012 Jun 06	22:09-	01:31	04:53	4.97	22.68	554.4	345	7
8 yrs	AD 2117 Dec 11	23:58-	02:52	05:46	17.20	-22.97	723.7	14	8
	AD 2125 Dec 08	13:15	16:06	18:57	17.03	-22.74	736.4	195	6
8 yrs	AD 2247 Jun 11	08:47	11:42	14:38	5.29	23.05	691.3	167	5
105.5 yrs	AD 2255 Jun 09	01:16	04:48	08:19	5.14	22.87	491.8	346	7
8 yrs	AD 2360 Dec 13	22:44-	01:59	05:13	17.35	-23.09	625.7	13	8
	AD 2368 Dec 10	12:38	15:00	17:23	17.17	-22.90	836.4	194	6
8 yrs	AD 2490 Jun 12	11:57	14:40	17:22	5.45	23.17	741.1	168	5
105.5 yrs	AD 2498 Jun 10	04:11	07:49	11:27	5.30	23.02	442.7	347	7
8 yrs	AD 2603 Dec 16	21:13-	00:44	04:16	17.49	-23.18	517.1	12	8
	AD 2611 Dec 13	12:24	14:06	15:48	17.32	-23.03	934.8	193	6
8 yrs	AD 2733 Jun 15	15:39	18:01	20:24	5.62	23.24	808.3	169	5
105.5 yrs	AD 2741 Jun 13	07:16	11:00	14:45	5.47	23.14	385.6	348	7
	AD 2846 Dec 17	20:23-	00:05	03:47	17.64	-23.24	432.1	11	8

When do these happen

	Date	Transit Contact Times (TT) Begins h:m	Greatest h:m	Ends h:m	Sun RA h	Dec °	Min Sep "	PA °	Transit Series
	AD 1396 Nov 23	15:49	19:32	23:15	16.59	-22.10	424.4	197	6
121.5 yrs									
8 yrs	AD 1518 May 26	22:30-	02:00	05:29	4.79	22.45	505.3	164	5
105.5 yrs									
8 yrs	AD 1526 May 23	16:14	19:15	22:15	4.64	22.18	666.8	344	7
121.5 yrs									
8 yrs	AD 1631 Dec 07	03:40	05:21	07:01	16.91	-22.64	939.3	16	8
105.5 yrs									
8 yrs	AD 1639 Dec 04	14:56	18:27	21:57	16.74	-22.34	523.6	197	6
121.5 yrs									
8 yrs	AD 1761 Jun 06	02:00	05:19	08:39	4.96	22.69	570.4	165	5
105.5 yrs									
8 yrs	AD 1769 Jun 03	19:13	22:26	01:38+	4.80	22.44	609.4	344	7
121.5 yrs									
8 yrs	AD 1874 Dec 09	01:42	04:07	06:32	17.06	-22.82	829.9	15	8
105.5 yrs									
8 yrs	AD 1882 Dec 06	13:54	17:06	20:18	16.88	-22.56	637.3	196	6
121.5 yrs									
8 yrs	AD 2004 Jun 08	05:12	08:21	11:30	5.12	22.89	626.9	166	5
105.5 yrs									
8 yrs	AD 2012 Jun 06	22:09-	01:31	04:53	4.97	22.68	554.4	345	7
121.5 yrs									
8 yrs	AD 2117 Dec 11	23:58-	02:52	05:46	17.20	-22.97	723.7	14	8
105.5 yrs									
8 yrs	AD 2125 Dec 08	13:15	16:06	18:57	17.03	-22.74	736.4	195	6
121.5 yrs									
8 yrs	AD 2247 Jun 11	08:47	11:42	14:38	5.29	23.05	691.3	167	5
105.5 yrs									
8 yrs	AD 2255 Jun 09	01:16	04:48	08:19	5.14	22.87	491.8	346	7
121.5 yrs									
8 yrs	AD 2360 Dec 13	22:44-	01:59	05:13	17.35	-23.09	625.7	13	8
105.5 yrs									
8 yrs	AD 2368 Dec 10	12:38	15:00	17:23	17.17	-22.90	836.4	194	6
121.5 yrs									
8 yrs	AD 2490 Jun 12	11:57	14:40	17:22	5.45	23.17	741.1	168	5
105.5 yrs									
8 yrs	AD 2498 Jun 10	04:11	07:49	11:27	5.30	23.02	442.7	347	7
121.5 yrs									
8 yrs	AD 2603 Dec 16	21:13-	00:44	04:16	17.49	-23.18	517.1	12	8
105.5 yrs									
8 yrs	AD 2611 Dec 13	12:24	14:06	15:48	17.32	-23.03	934.8	193	6
121.5 yrs									
8 yrs	AD 2733 Jun 15	15:39	18:01	20:24	5.62	23.24	808.3	169	5
105.5 yrs									
8 yrs	AD 2741 Jun 13	07:16	11:00	14:45	5.47	23.14	385.6	348	7
105.5 yrs									
	AD 2846 Dec 17	20:23-	00:05	03:47	17.64	-23.24	432.1	11	8

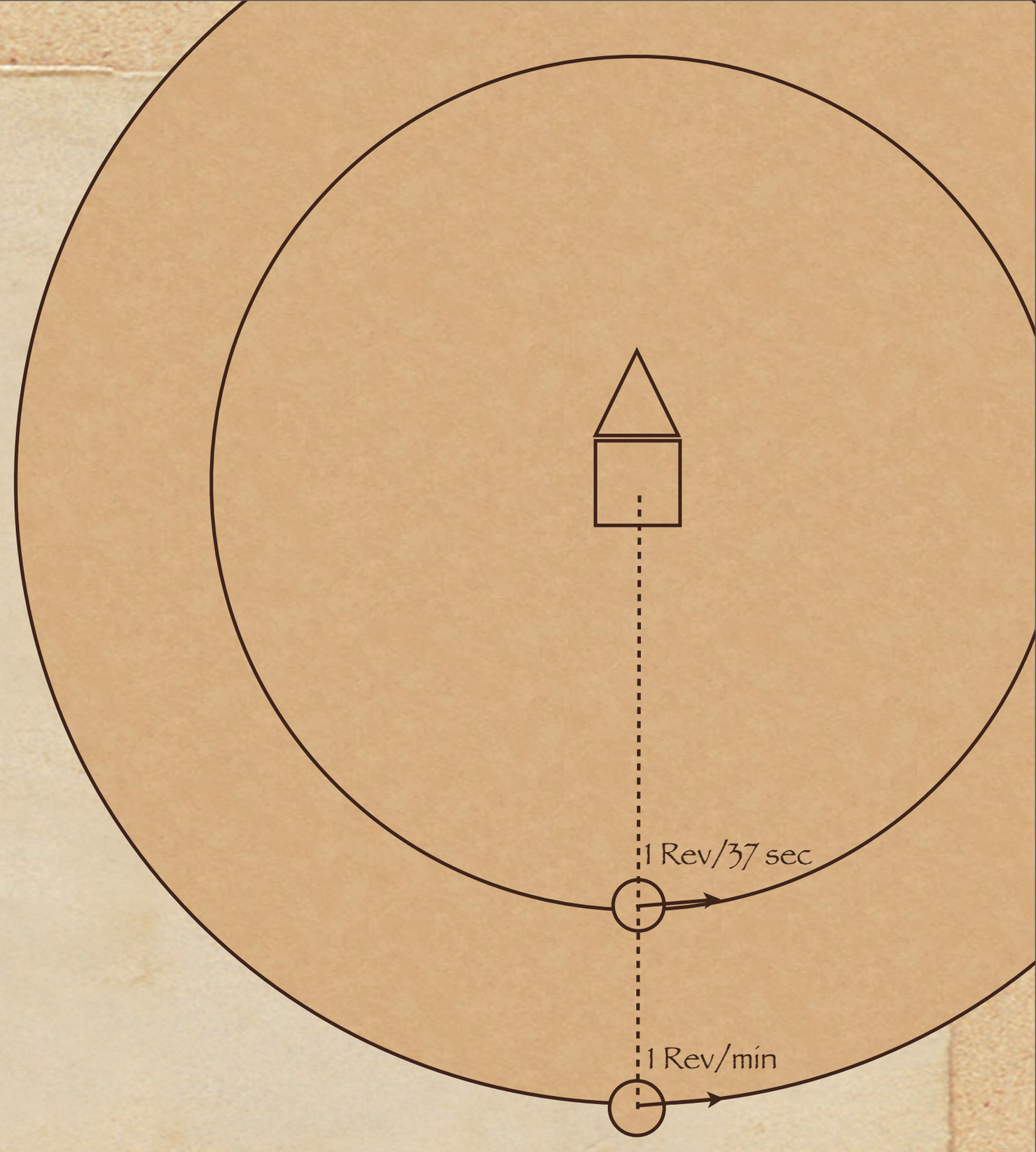
The 8-121-8-105

- Imagine two people running around a house but one runs close in and faster (Venus) and the other runs farther out and slower (Earth)



$T_E = 365$ days

$T_V = 225$ days

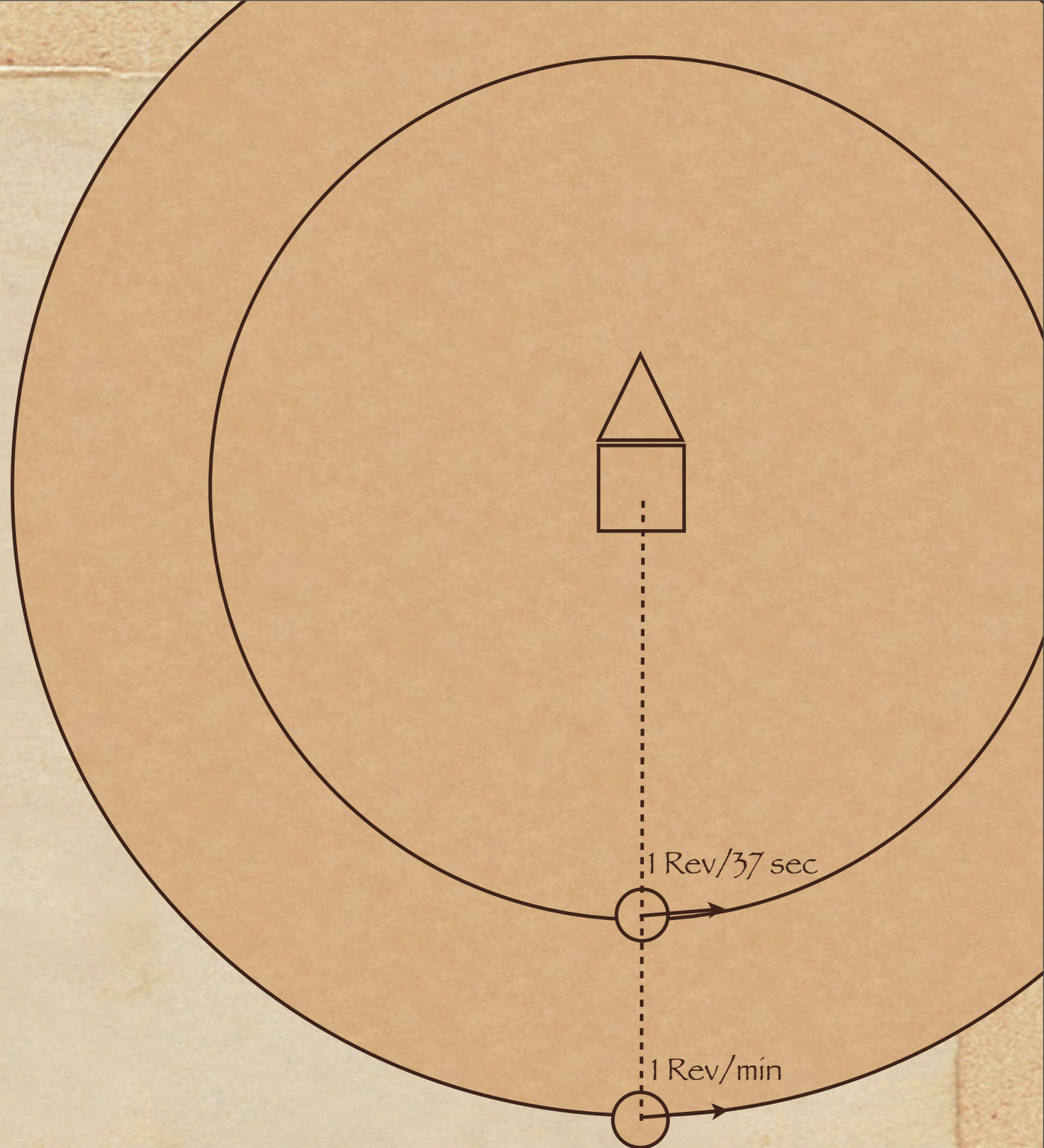


$T_E = 365$ days

$T_V = 225$ days

$T_V / T_E = 225/365$

$= 8/13 = 37/60$



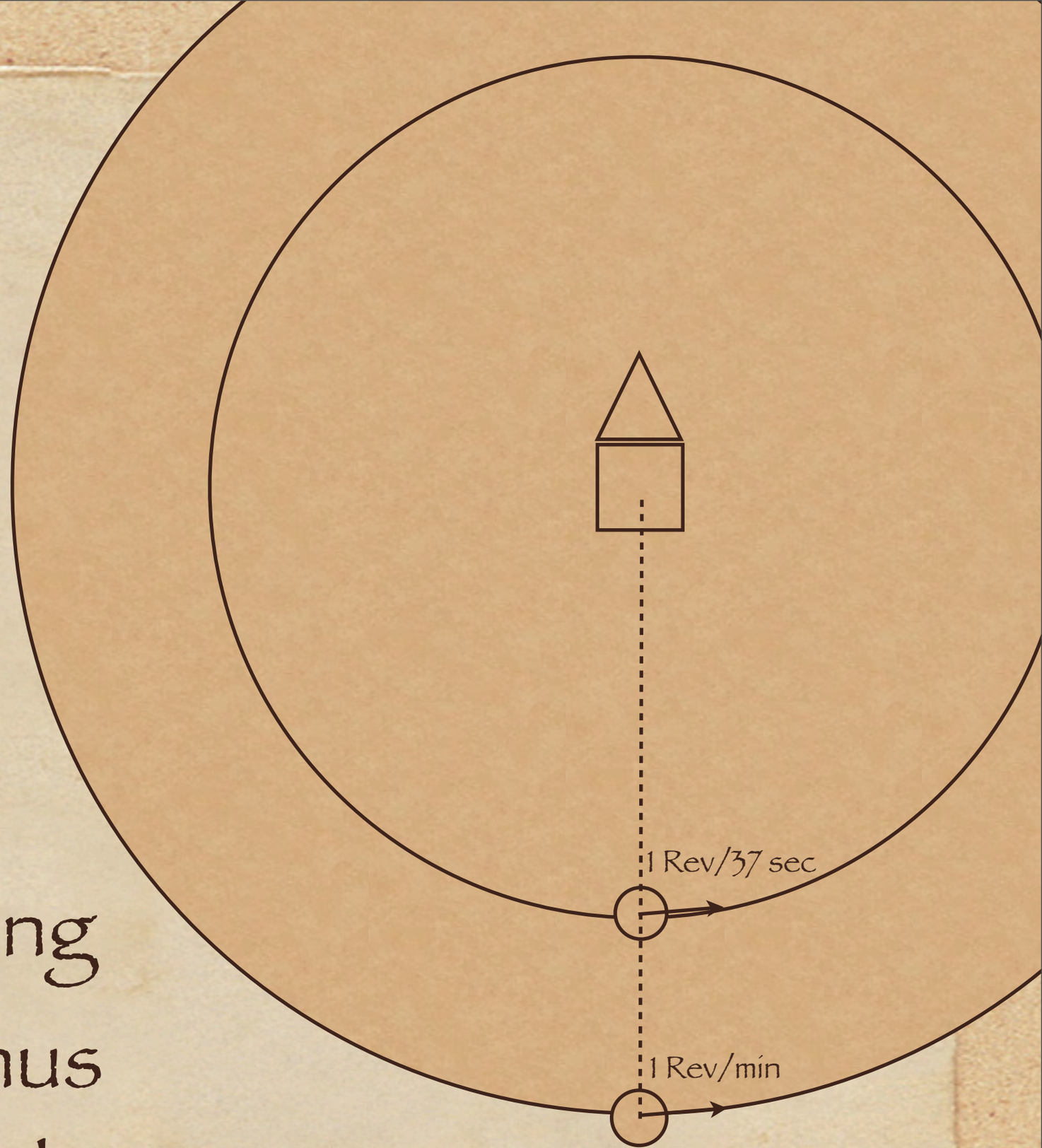
$T_E = 365$ days

$T_V = 225$ days

$T_V / T_E = 225/365$

$= 8/13 = 37/60$

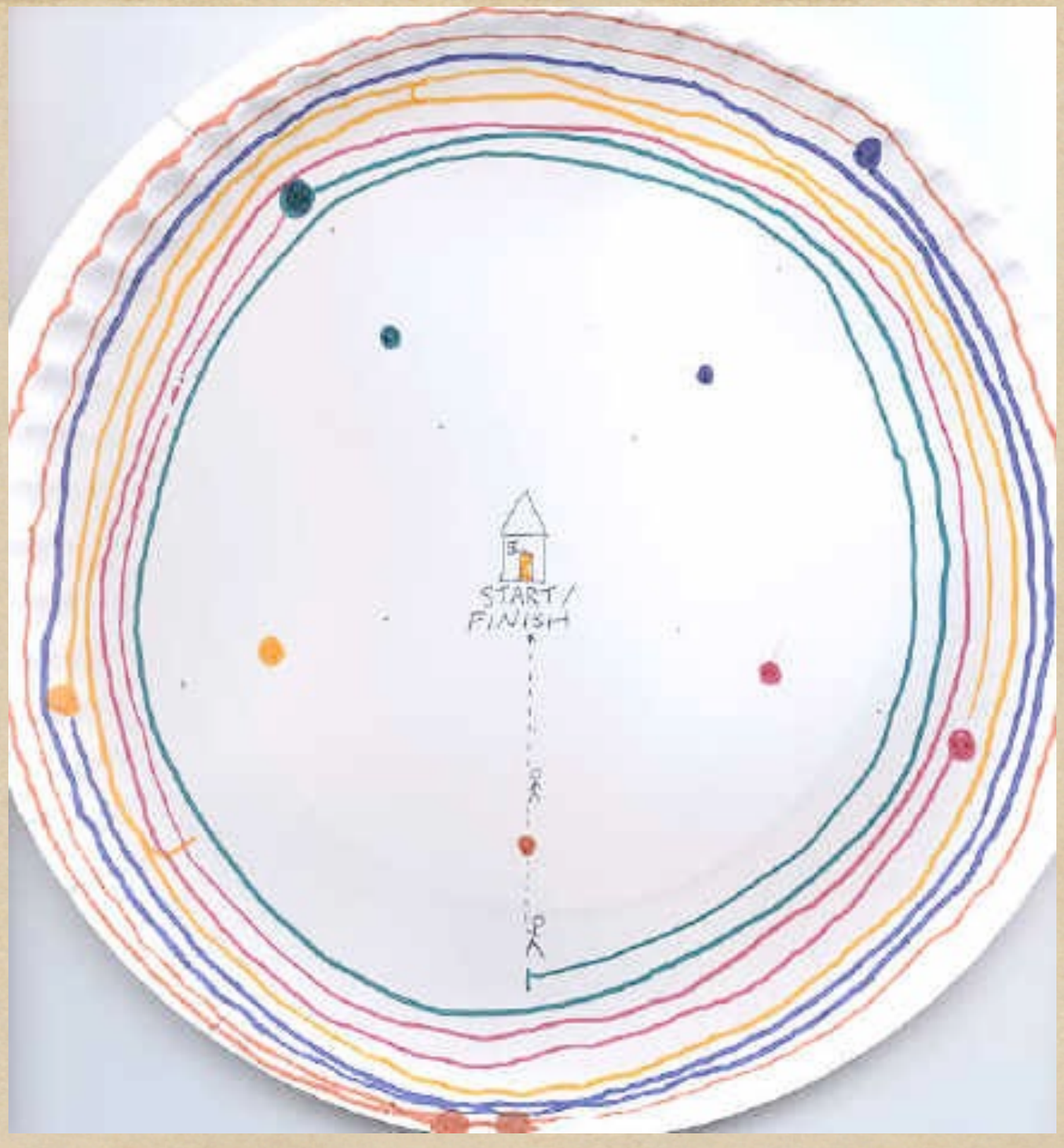
After running 1.6 laps, Venus will lap Earth



Venus laps earth every 1.6 laps...

Wednesday, May 30, 2012

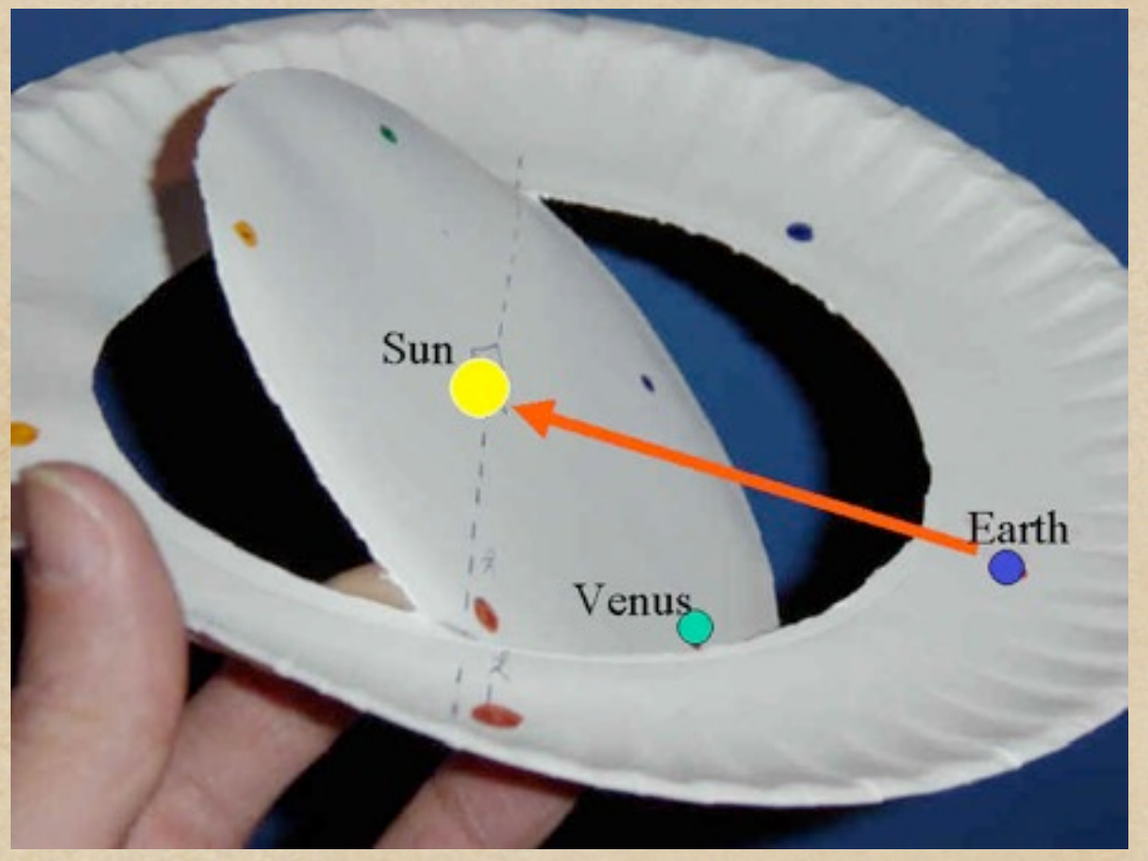
Venus will go around 13 times for the Earth's 8, but transits don't happen every 1.6 years...



Venus laps earth every 1.6 laps...

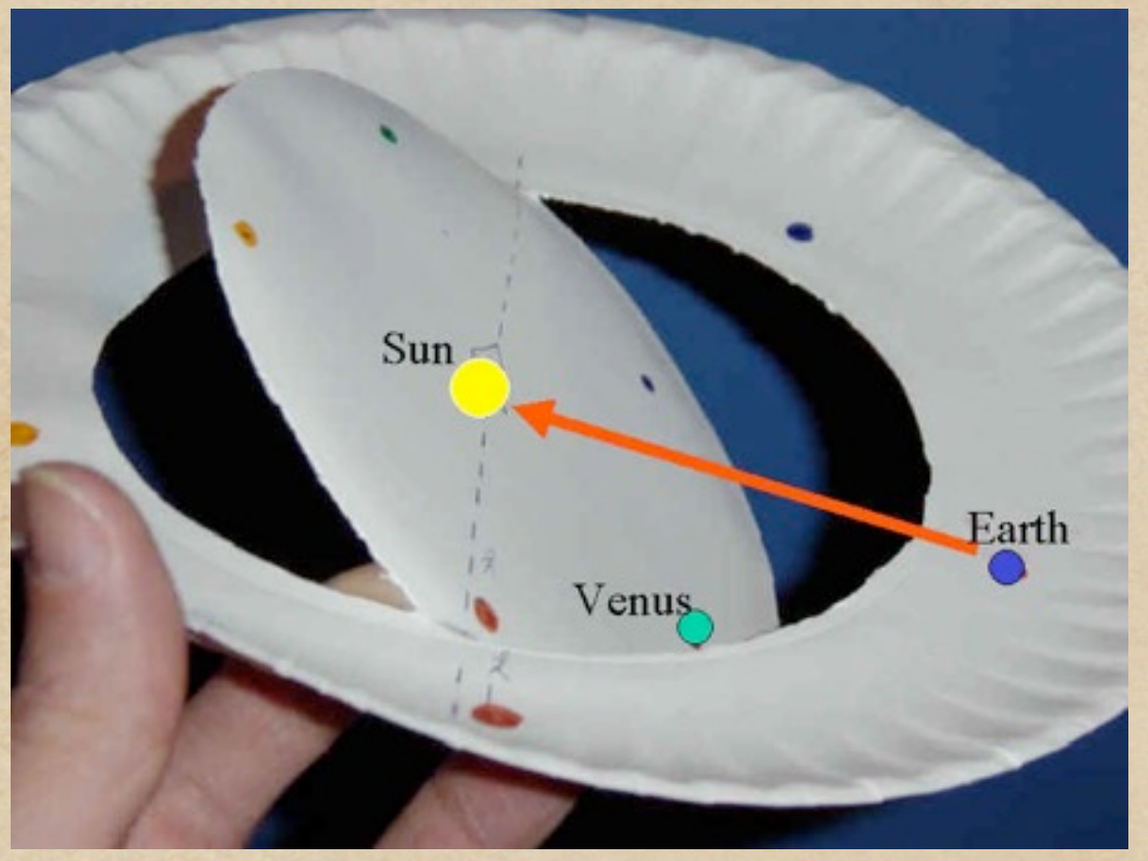
Venus will go around 13 times for the Earth's 8, but transits don't happen every 1.6 years...

Complications



Inclined Orbit

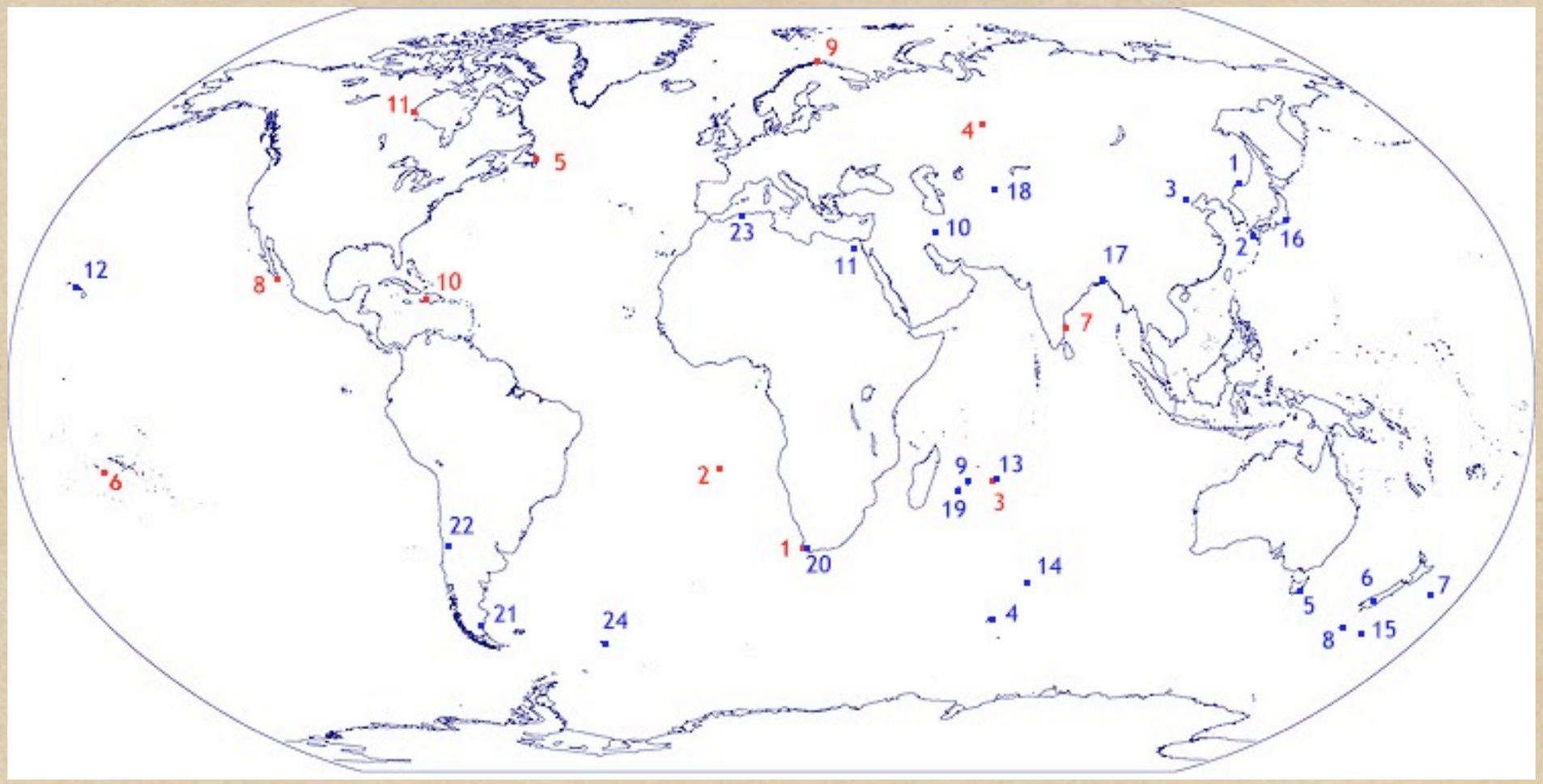
Complications



Inclined Orbit

Not Really 8/13 but 7.997/13

The Transit Expeditions



Red: Transit Expeditions of 1761 and 1769

Blue: Transit Expeditions of 1874 and 1882

Back to Haley...

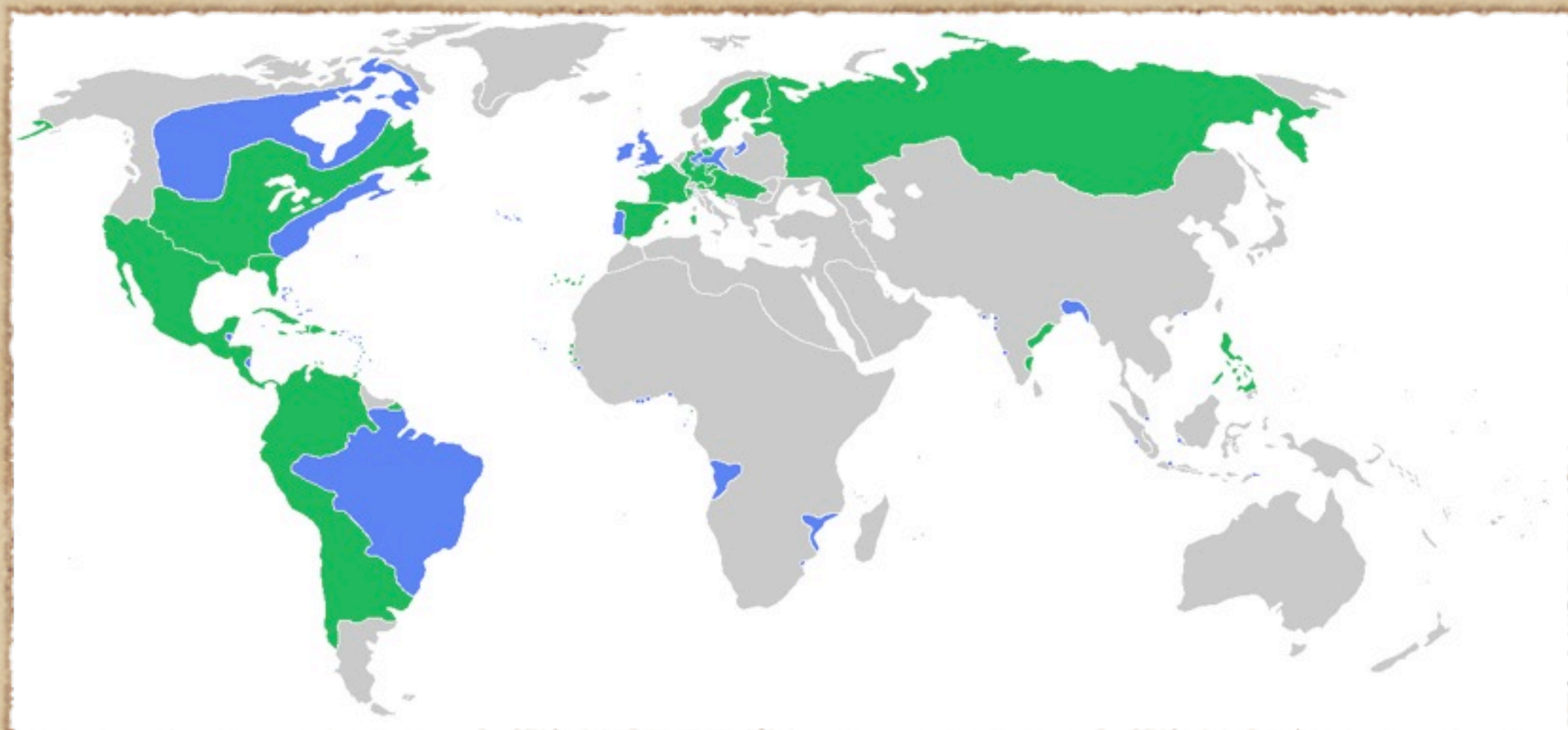
...indeed I would have several observations made of the same phenomenon in different parts, both for further confirmation, and lest a single observer should happen to be disappointed by the intervention of clouds from seeing what I know not if those either of the present or following age shall ever see again; and upon which, the certain and adequate solution of the noblest, and otherwise most difficult problem depends. Therefore again and again, I recommend it to the curious strenuously to apply themselves to this observation.

What was going on in the 1760's?

- Seven Year's War
- French and Indian War
- Britain Declared War on Spain and Naples
- St. Louis, Mo is established
- B.E.I. Co. is conquering India
- Stamp Act
- British Army occupies Boston
- Russo-Turkish War
- War of the Regulation

The Transits of 1761 and 1769

- Only visible from South Africa, Siberia, North America, Indian Ocean, South Pacific and Central America
- Only way to get there was via Ship
  - Scurvy, Disease and Shipwreck highly likely
  - Travel time measured in months and years



The Seven Year's War

Wednesday, May 30, 2012

Everyone had papers that gave them safe passage but, you know, hard to talk to a cannon.

Neville Maskelyne* (1761)

*Most of these stories from R. Pogge @ Ohio State

middle of nowhere, “food was bad and the weather was horrible”. Decided to observe from Greenwich the next time.

Neville Maskelyne* (1761)

*Most of these stories from R. Pogge @ Ohio State

middle of nowhere, “food was bad and the weather was horrible”. Decided to observe from Greenwich the next time.

Jeremiah Dixon & Charles Mason (1761)

Wednesday, May 30, 2012

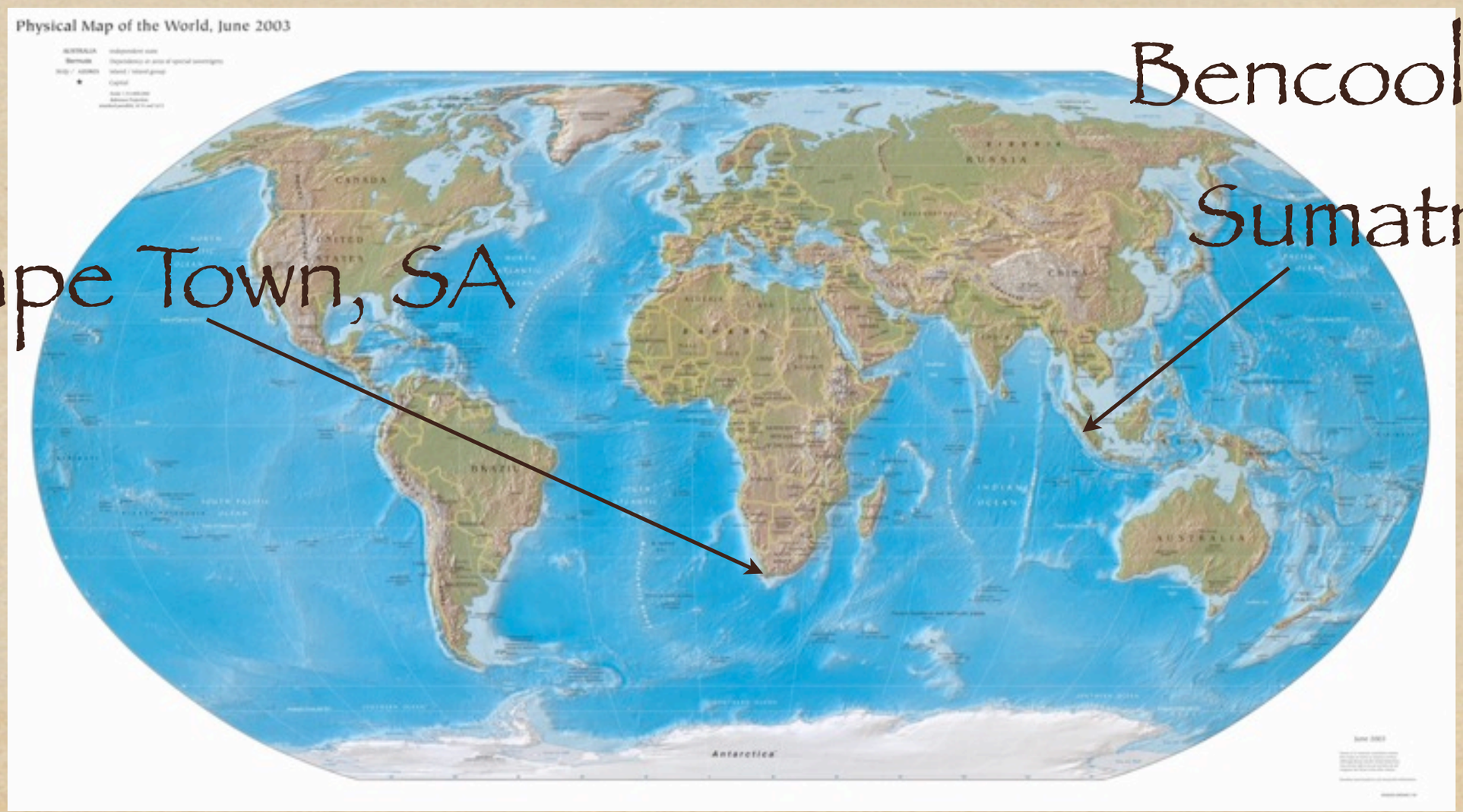
(*HMS Seahorse*) **attacked** by 34-gun French frigate *le Grande* only a few hours after sailing (Portsmouth) .... 11 dead and 37 wounded.....repairing and refitting ... **set sail again** (Society threatened).... **Cape Town** before the transit..... **setup** observing station ... got excellent data.

Jeremiah Dixon & Charles Mason (1761)

Wednesday, May 30, 2012

(*HMS Seahorse*) **attacked** by 34-gun French frigate *le Grande* only a few hours after sailing (Portsmouth) .... 11 dead and 37 wounded.....repairing and refitting ... **set sail again** (Society threatened).... **Cape Town** before the transit..... **setup** observing station ... got excellent data.

Jeremiah Dixon & Charles Mason (1761)



Wednesday, May 30, 2012

(*HMS Seahorse*) **attacked** by 34-gun French frigate *le Grande* only a few hours after sailing (Portsmouth) .... 11 dead and 37 wounded.....repairing and refitting ... **set sail again** (Society threatened).... **Cape Town** before the transit..... **setup** observing station ... got excellent data.

John Winthrop (1761)

Armillary Sphere. Original instruments are house at Harvard.

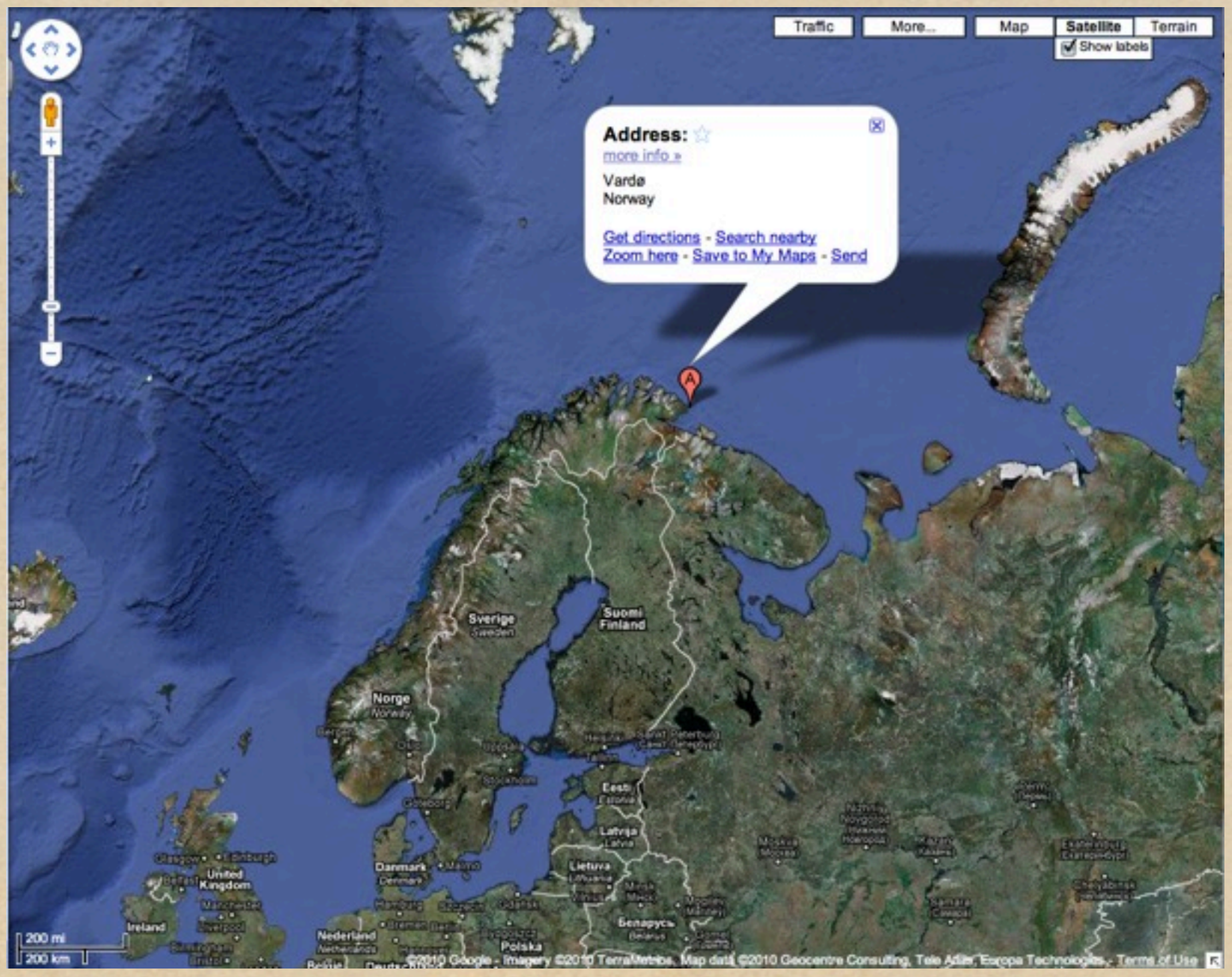
John Winthrop (1761)

Armillary Sphere. Original instruments are house at Harvard.

John Winthrop (1761)

Armillary Sphere. Original instruments are house at Harvard.

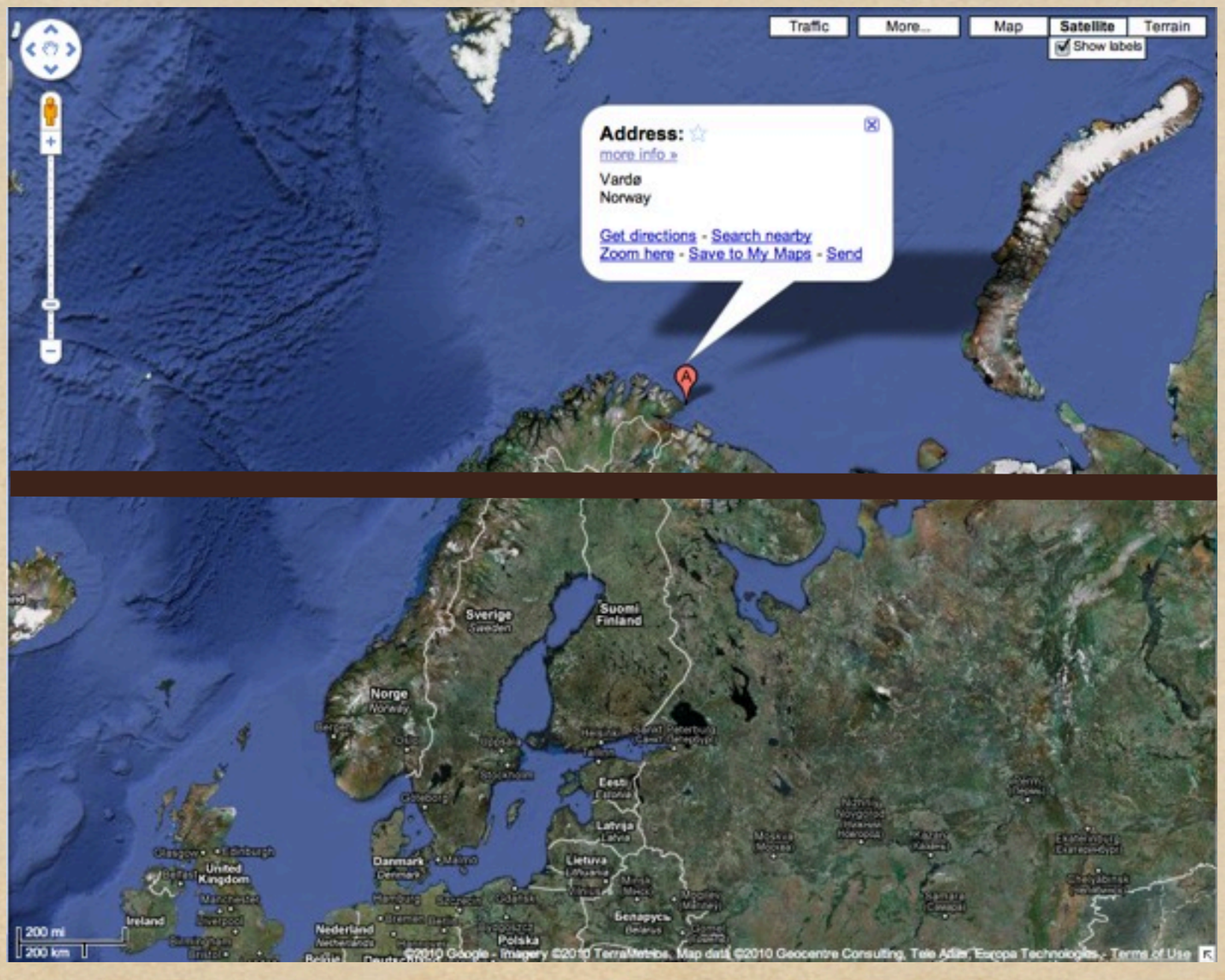
Fr. Maximillian Hell, S. J. (1761 & 1769)



Wednesday, May 30, 2012

October 1768, **constructed wooden observatory** in the centre of the village... completed in January, had several hatches in the roof and walls... Nowadays, there is a plaque to commemorate Hell's observation.

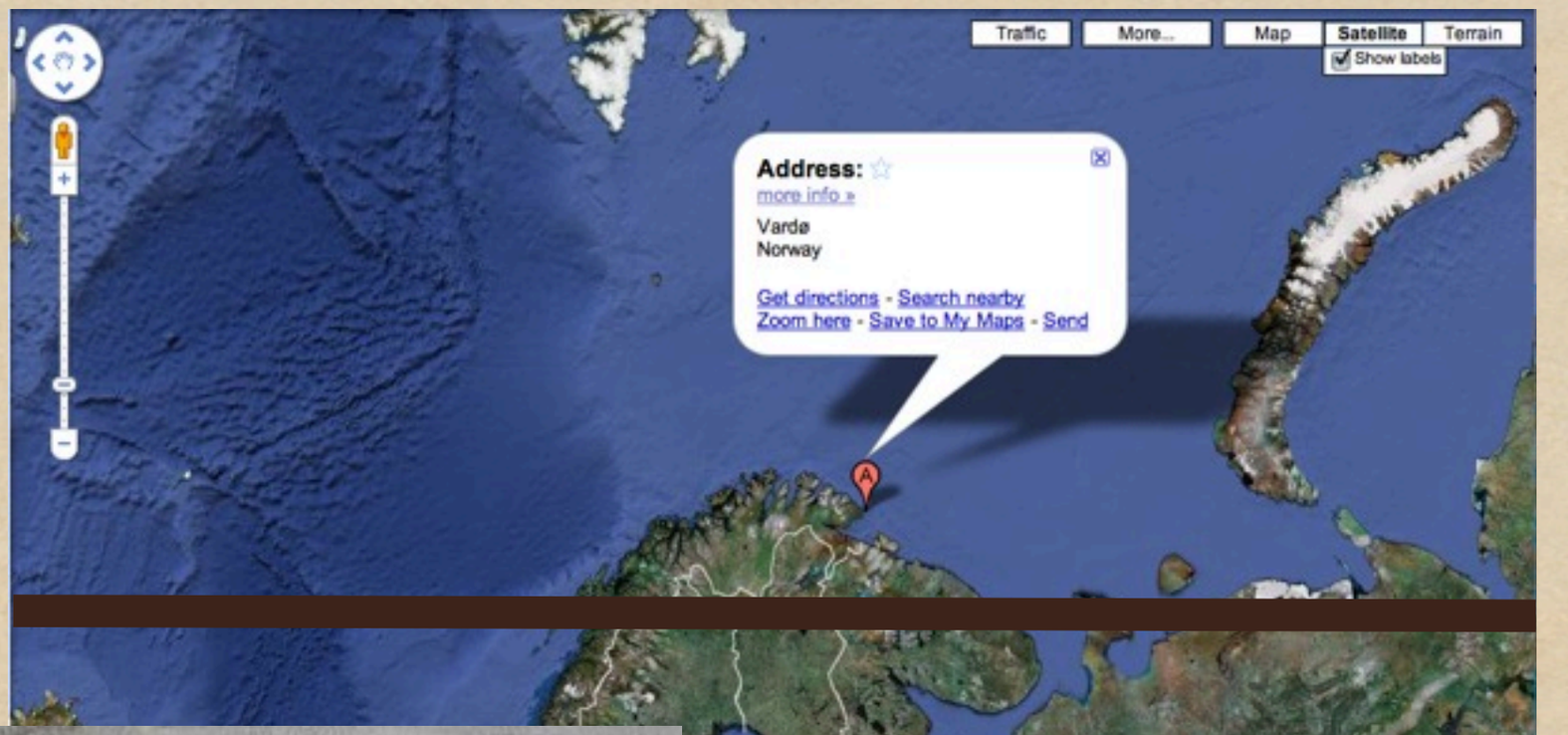
Fr. Maximillian Hell, S. J. (1761 & 1769)



Wednesday, May 30, 2012

October 1768, **constructed wooden observatory** in the centre of the village... completed in January, had several hatches in the roof and walls... Nowadays, there is a plaque to commemorate Hell's observation.

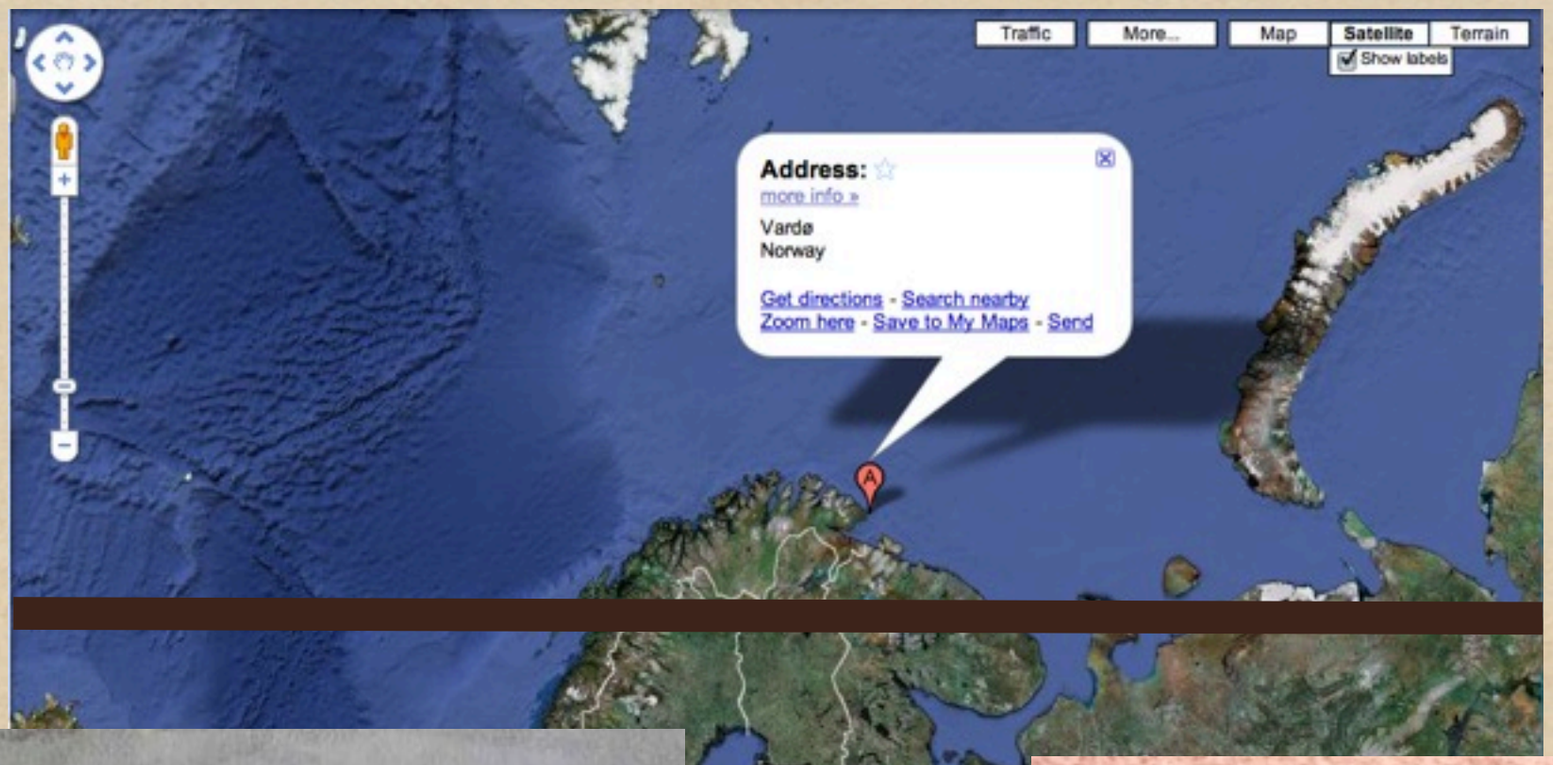
Fr. Maximillian Hell, S. J. (1761 & 1769)

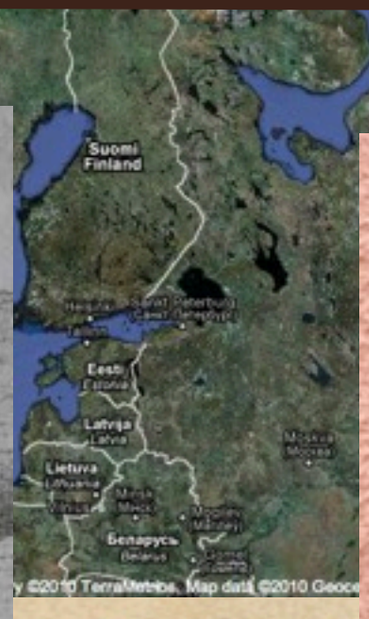


Wednesday, May 30, 2012

October 1768, **constructed wooden observatory** in the centre of the village... completed in January, had several hatches in the roof and walls... Nowadays, there is a plaque to commemorate Hell's observation.

Fr. Maximillian Hell, S. J. (1761 & 1769)





Wednesday, May 30, 2012

October 1768, **constructed wooden observatory** in the centre of the village... completed in January, had several hatches in the roof and walls... Nowadays, there is a plaque to commemorate Hell's observation.

Alexandre-Guí Píngré (1761)

Wednesday, May 30, 2012

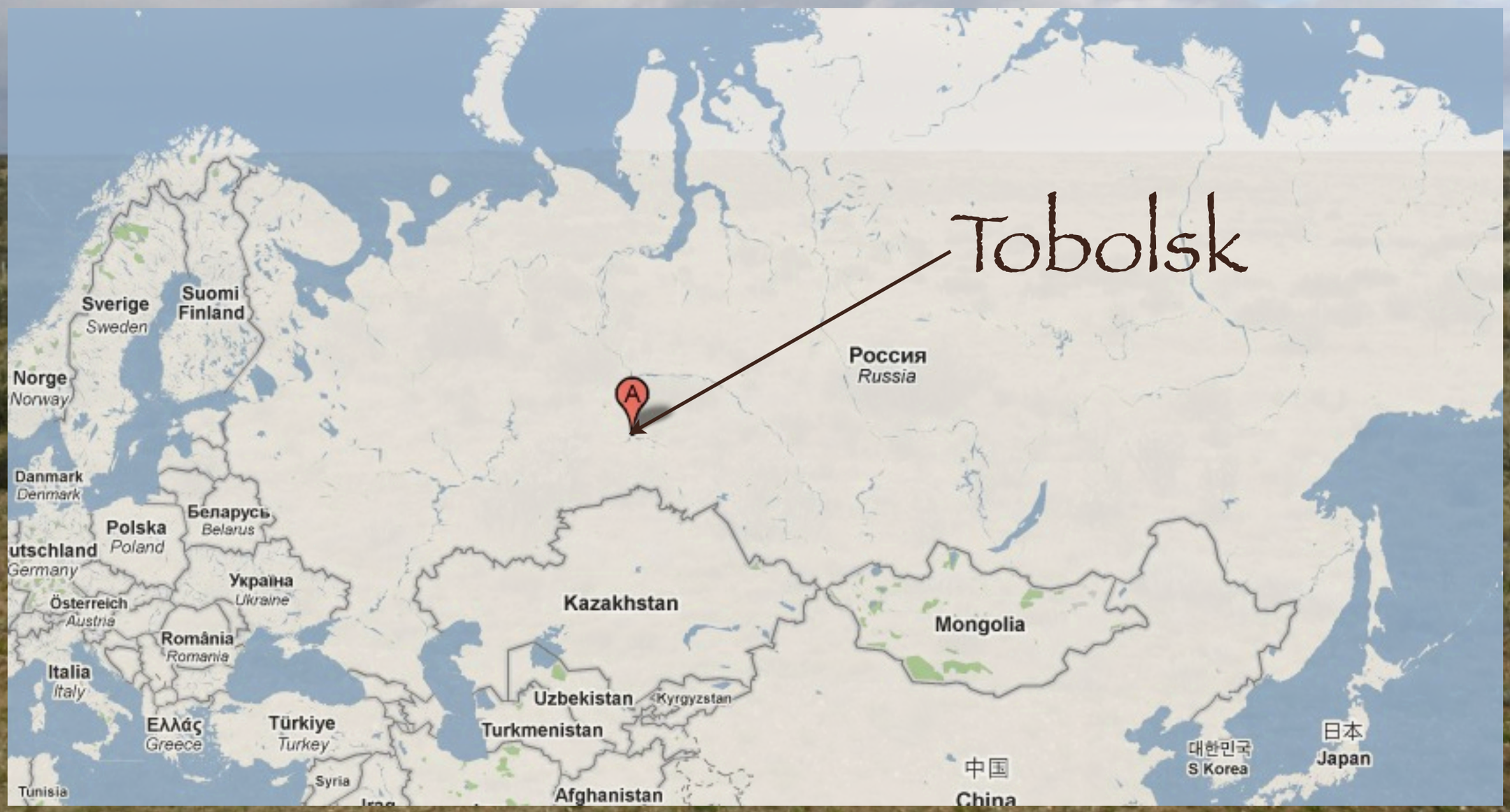
Roderigue,...**rained out** ... saw at least part of the transit.....post-transit work... British Man-O-War **shelled and sacked** Roderigue. ....**three** times... **catch a ship back** and almost there ... **beset by a British warship** ... **fierce battle**.... **captured** ... transported to Lisbon as PoW for exchange....**overland** to Paris

Jean-Baptise Chappe d'Auteroche (1761)

Wednesday, May 30, 2012

horse-drawn sled ... across the frozen Volga river before ice break ... five months ... Russian "rasputitsa" ... a sea of gooey mud ... Napoleon and Hitler .... arrived with 6 days .... physically protected by Cossacks ... local peasantry thought floods caused by him

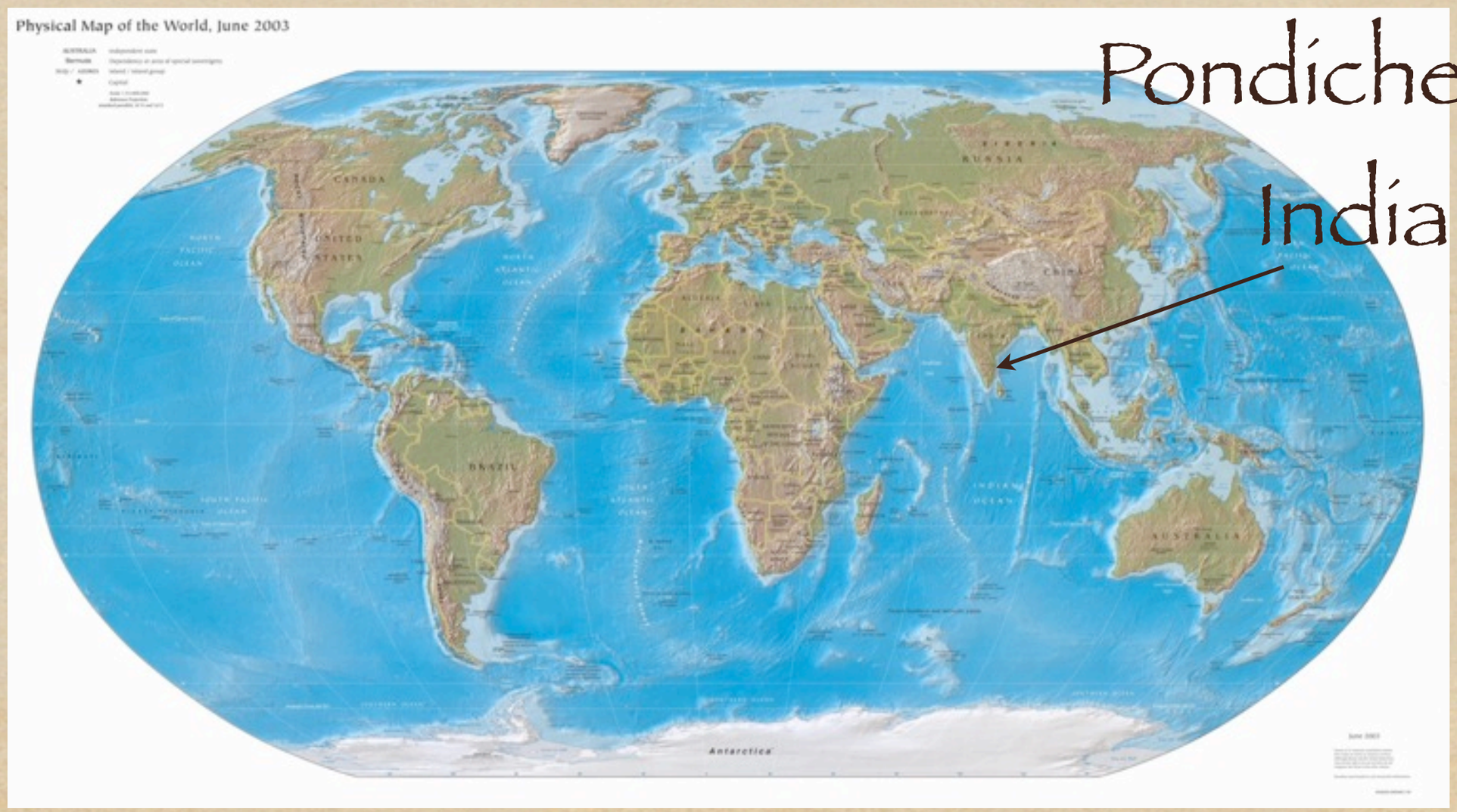
Jean-Baptise Chappe d'Auteroche (1761)



Wednesday, May 30, 2012

horse-drawn sled ... across the frozen Volga river before ice break ... five months ... Russian "rasputitsa" ... a sea of gooey mud ... Napoleon and Hitler .... arrived with 6 days .... physically protected by Cossacks ... local peasantry thought floods caused by him

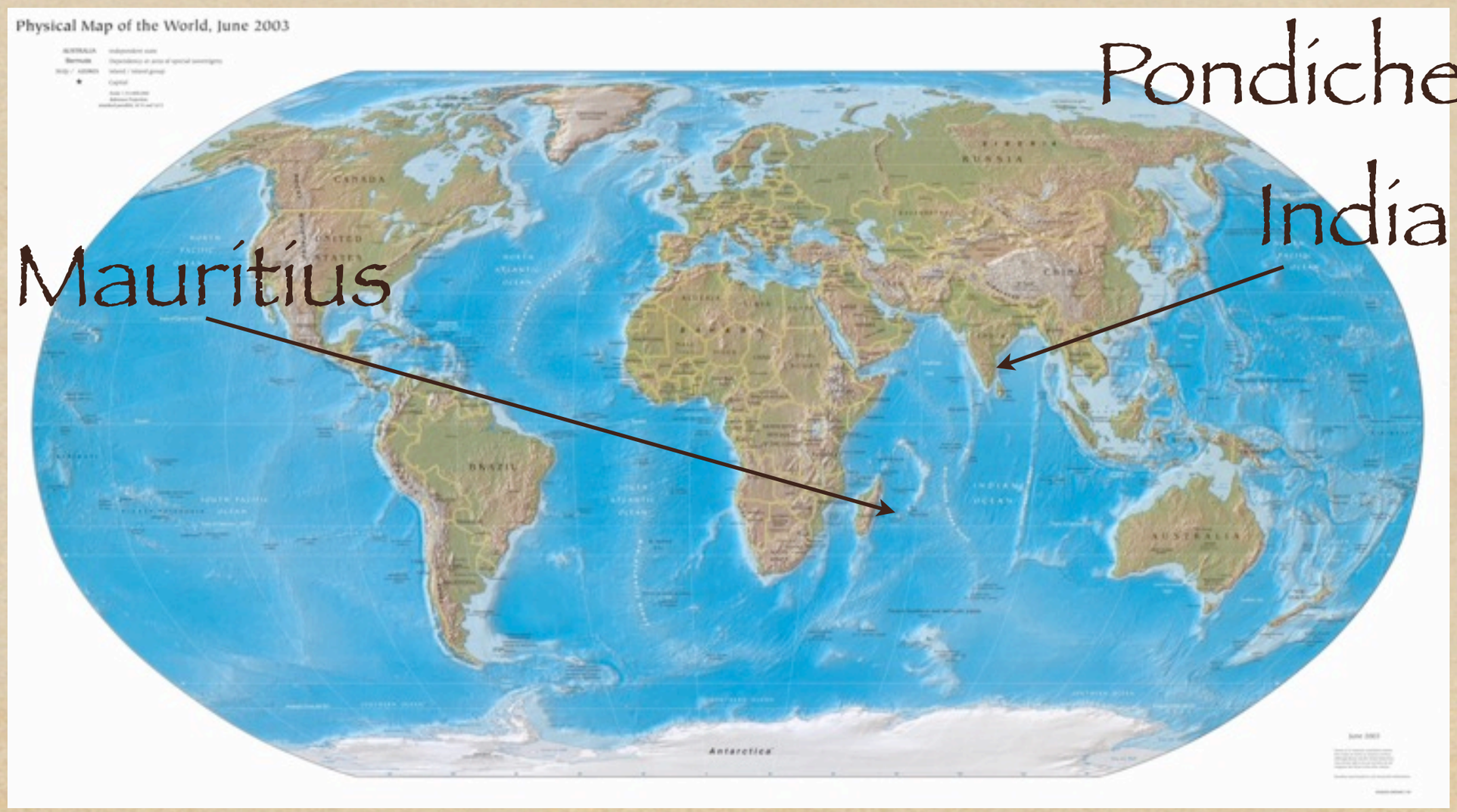
Guillaume Joseph Hyacynth Jean-Baptiste Le Gentil de la Galaisire (1761)



Wednesday, May 30, 2012

Educated French nobleman ... dispatched March 26, 1760 ... 3 months at sea... Mauritius ... Indian Ocean swarming with British warships ... Pondicherry under siege ... troop ship ... learned from passing ships ... had fallen 4 months before ... back to Mauritius.... transit occurred ... wait until the 1769 ... scientific studies of Mauritius/Madagascar ... best site for 1769 would be Manila in the Philippines

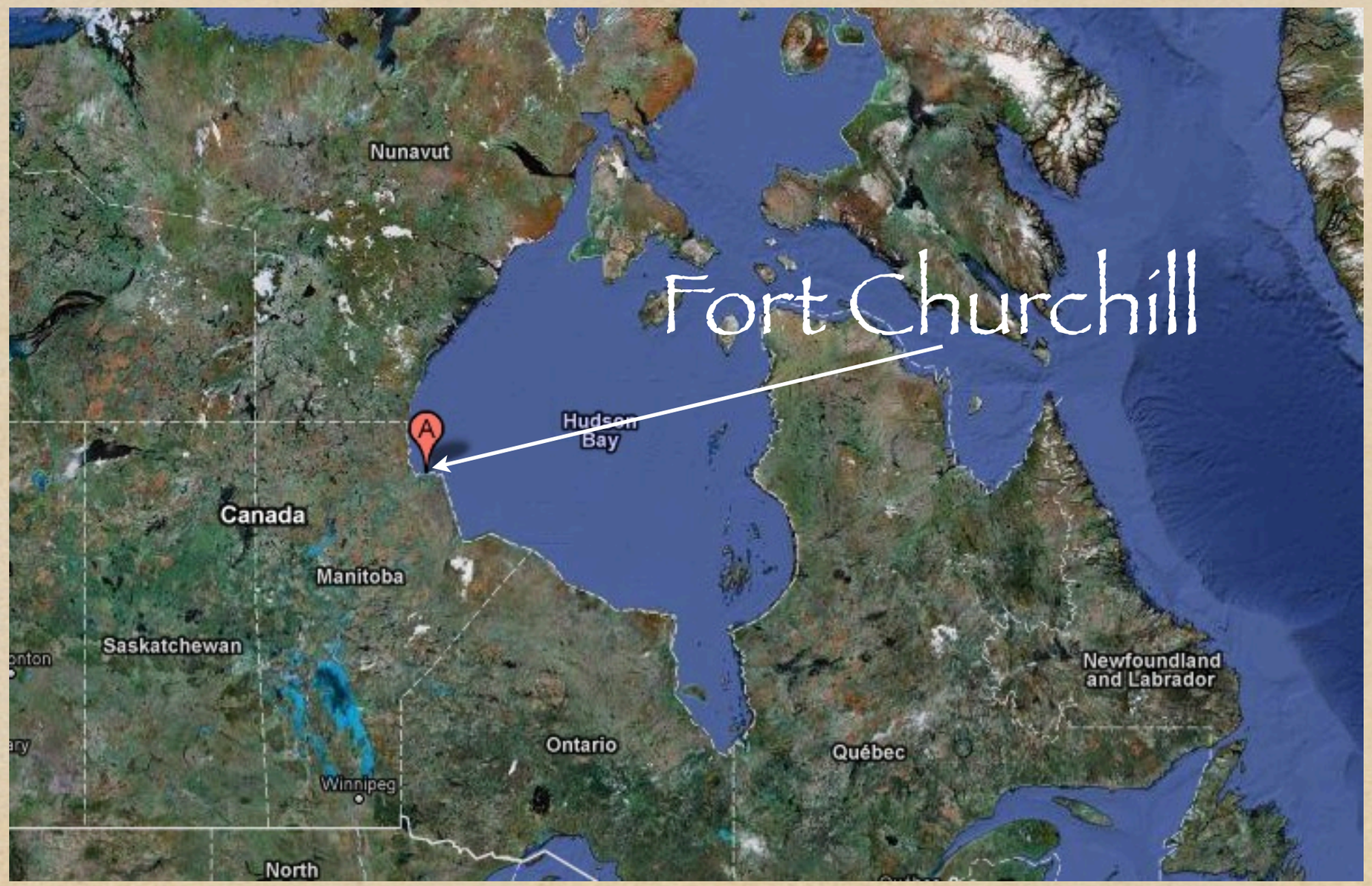
Guillaume Joseph Hyacynth Jean-Baptiste Le Gentil de la Galaisire (1761)



Wednesday, May 30, 2012

Educated French nobleman ... dispatched March 26, 1760 ... 3 months at sea... Mauritius ... Indian Ocean swarming with British warships ... Pondicherry under siege ... troop ship ... learned from passing ships ... had fallen 4 months before ... back to Mauritius.... transit occurred ... wait until the 1769 ... scientific studies of Mauritius/Madagascar ... best site for 1769 would be Manila in the Philippines

William Wales (1769)



Wednesday, May 30, 2012

Middle of nowhere ... Polar Bear capital ... left a year early and decided to winter over .... 5 minutes for a pint of brandy to go from liquid to mushy to frozen solid .... good transit timings despite the bugs ... disappears from astronomy

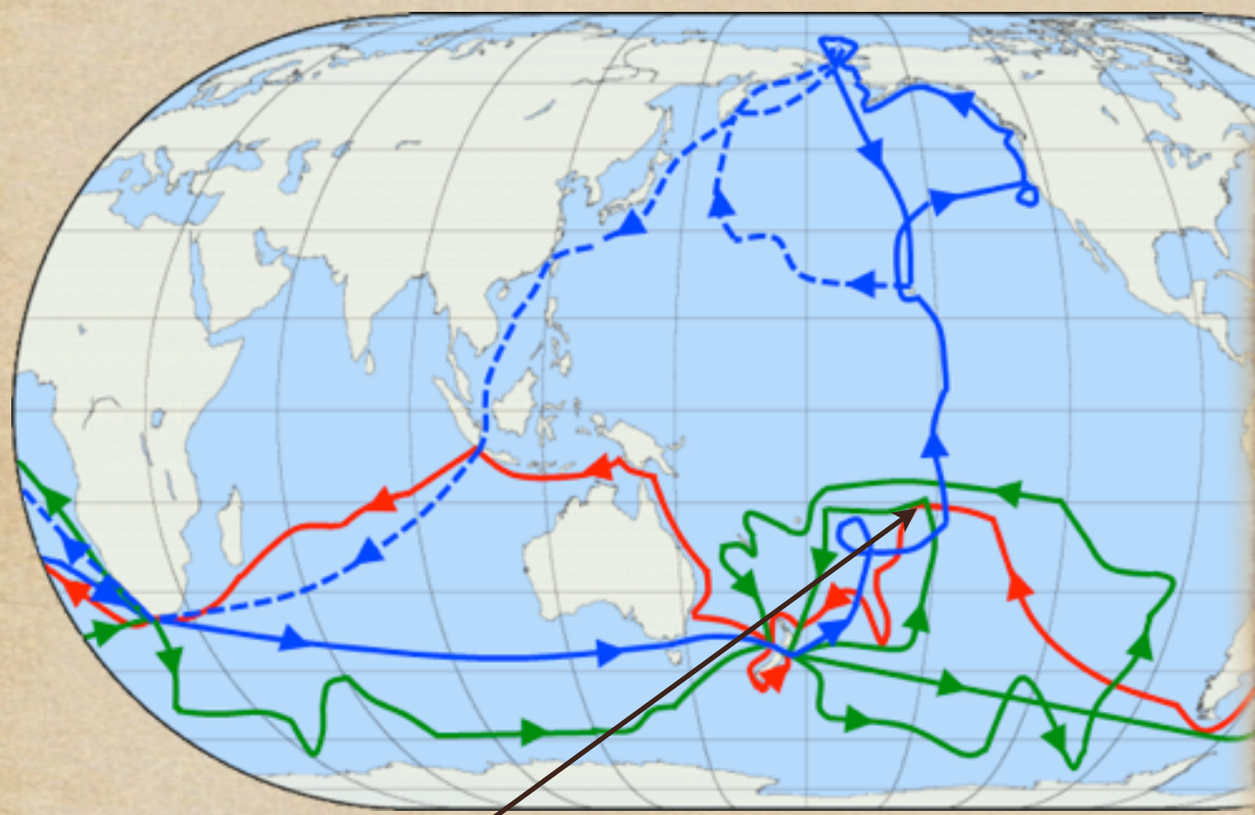
Jean-Baptise Chappe d'Auteroche (1769)

San Jose del Cabo

Wednesday, May 30, 2012

tip of Baja California ... trip down and setup was uneventful ... excellent timings ... epidemic of fever ... trained as an physician ... nursed the sick ... took ill himself ... died a few days later ... 3/4 of the inhabitants ... all of the French Academe but 3 .... set out ... two dying en route .... data were ... best made of either transit.

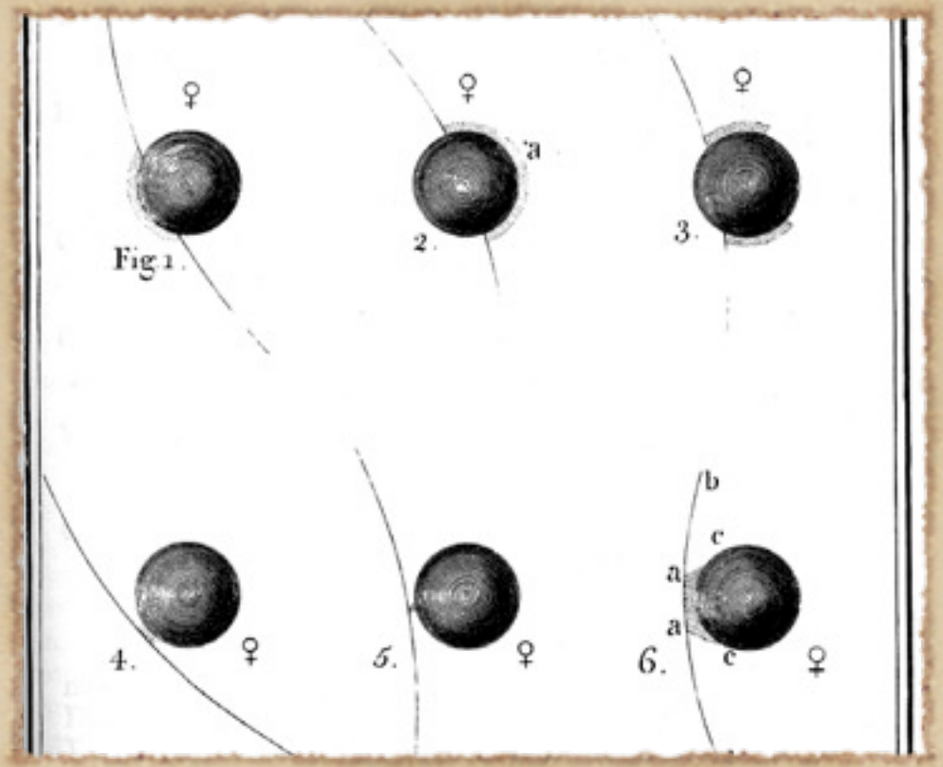
Captain James Cook (1769)



Tahiti

Wednesday, May 30, 2012

8 month journey ... constructed a fort (Point Venus) ... good data w/ Charles Green ... black drop effect ... timing error ~ 10 sec not 2 sec ... Green died in Batavia (modern Djakarta) ... Cook and his crew completed circumnavigation



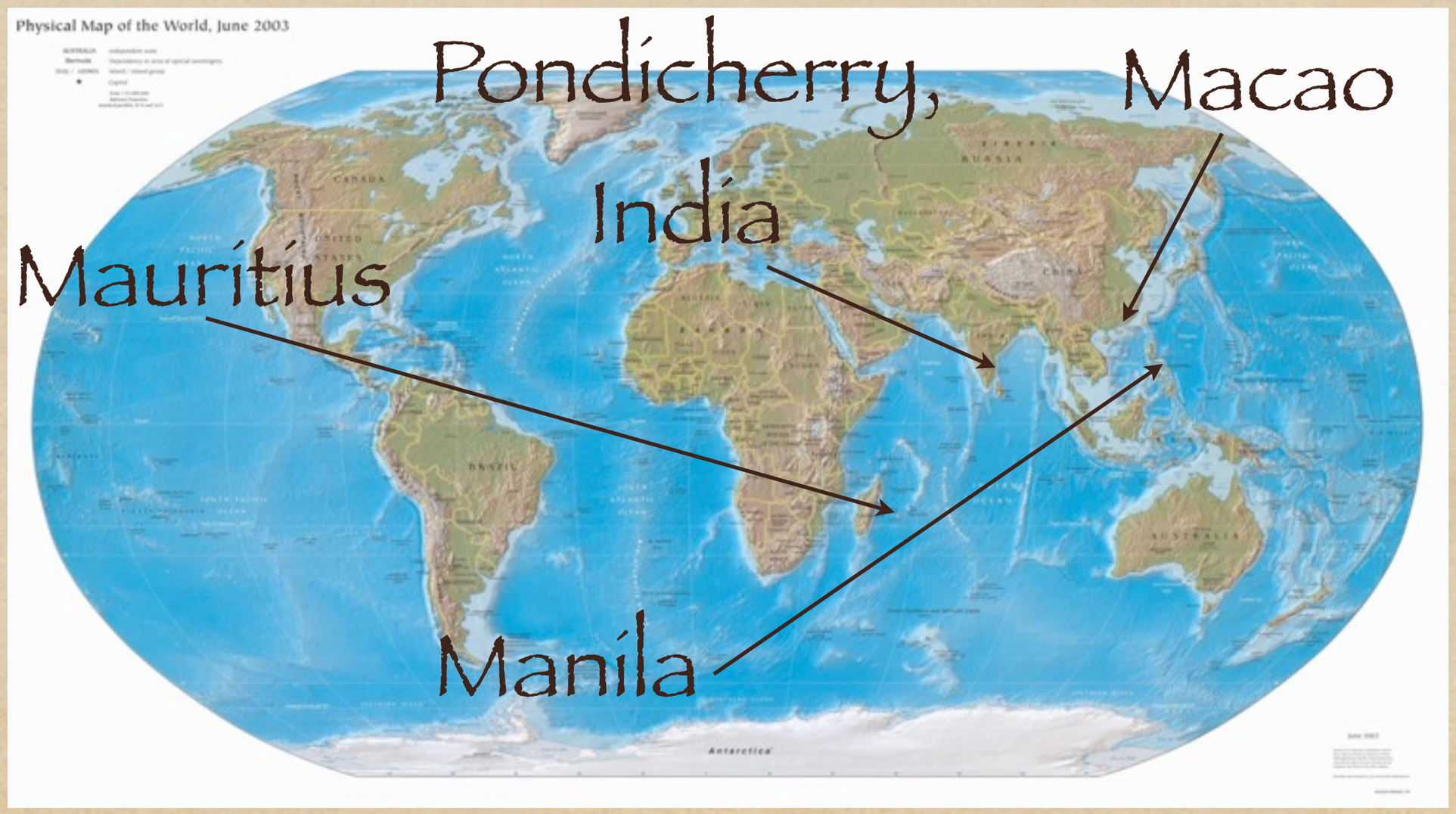
Black-Drop Effect

Wednesday, May 30, 2012

Depiction by Torben Bergman in 1761. Instead of getting the error to 1/500, made it more like 1/150. Clocks were accurate but the optics/atmosphere weren't.

Black Drop Effect

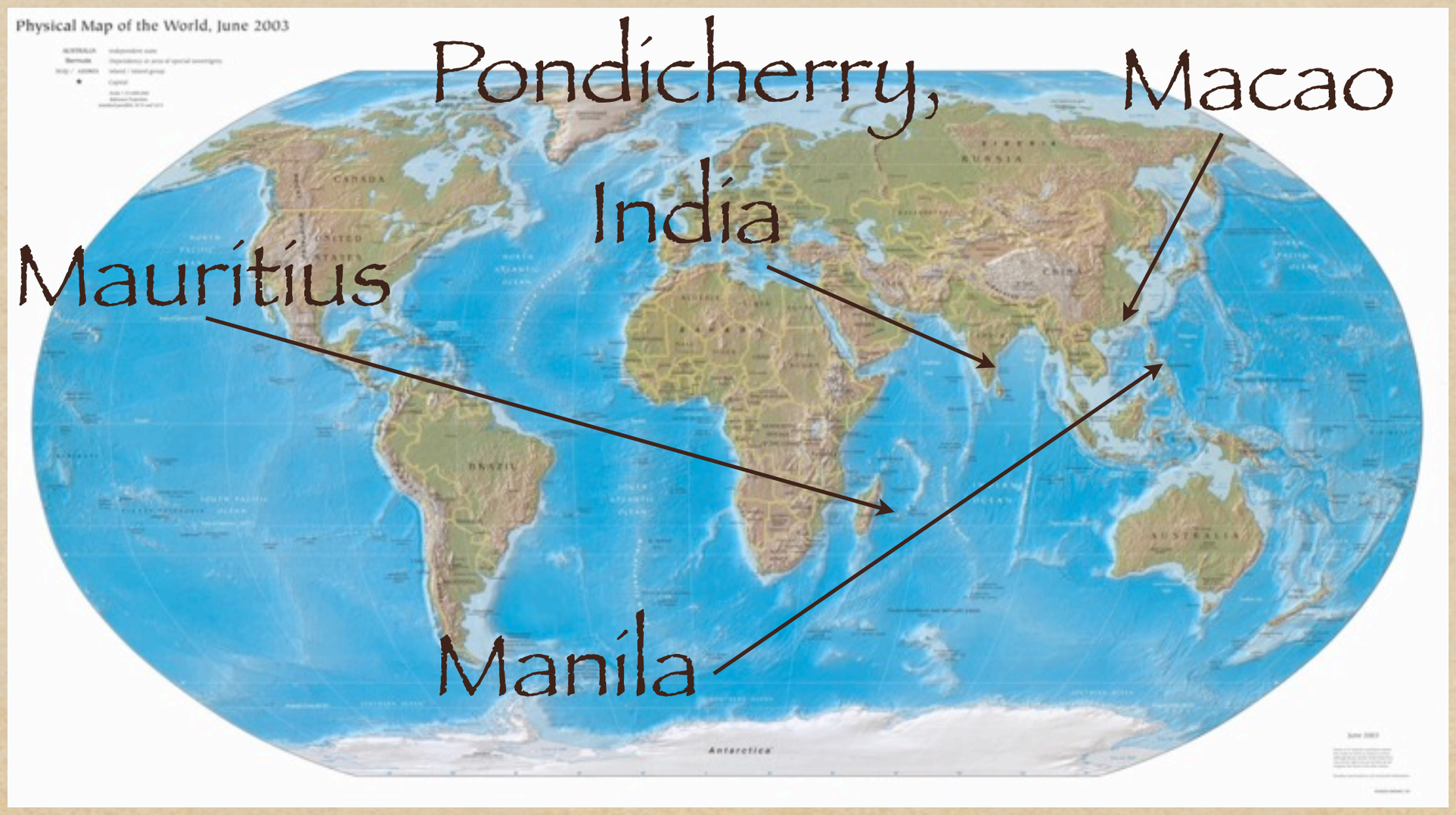
Guillaume Joseph Hyacynth Jean-Baptiste Le Gentil de la Galaisire (1769)



Wednesday, May 30, 2012

set sail aboard a Spanish ship bound for Manila in May of 1766 ... 3 month voyage, arrived Manila ... Spanish governor not fond of foreigners .... during setup suspected of being a spy ... tailed and harassed .... Before arrested sailed to Macao ... passage to Pondicherry ... 1768 passage on Indian ship ... nearly shipwrecked in Malacca Straits ... pilot decided to sulk in cabin ... 32-days ... setup observatory in a ruined pavilion (architect/skilled masons) ... spent a year ... good weather transit day ... weather changed 2am transit day ... sun rose behind clouds ... 9 years, 70,000 miles

Guillaume Joseph Hyacynth Jean-Baptiste Le Gentil de la Galaisire (1769)



Wednesday, May 30, 2012

wait ship home .... severe dysentery and fever ... secured passage bound for Mauritius in 1770 ... waited around for ship ... finally on ship (very late) ... hurricane that nearly de-masted the vessel ... limped back ... a Spanish warship bound for Cadiz .. 2 weeks around cape ... August 1771 ... docked Cadiz ... Paris. "11 years, 6 months, and 13 days" ... caretaker incompetent ... robbed repeatedly... relatives ... rumor that he had died ... loot his estate, stripping it bare. The French Academe ... given his chair to somebody else .... hired lawyers ... effectively bankrupted him....Better.... Academe created special chair ...

Results?

- Managed to calculate the distance to within 1% of the modern value

153 ± 1 million kilometers

(refined to 149.7 ± 0.9 million km)

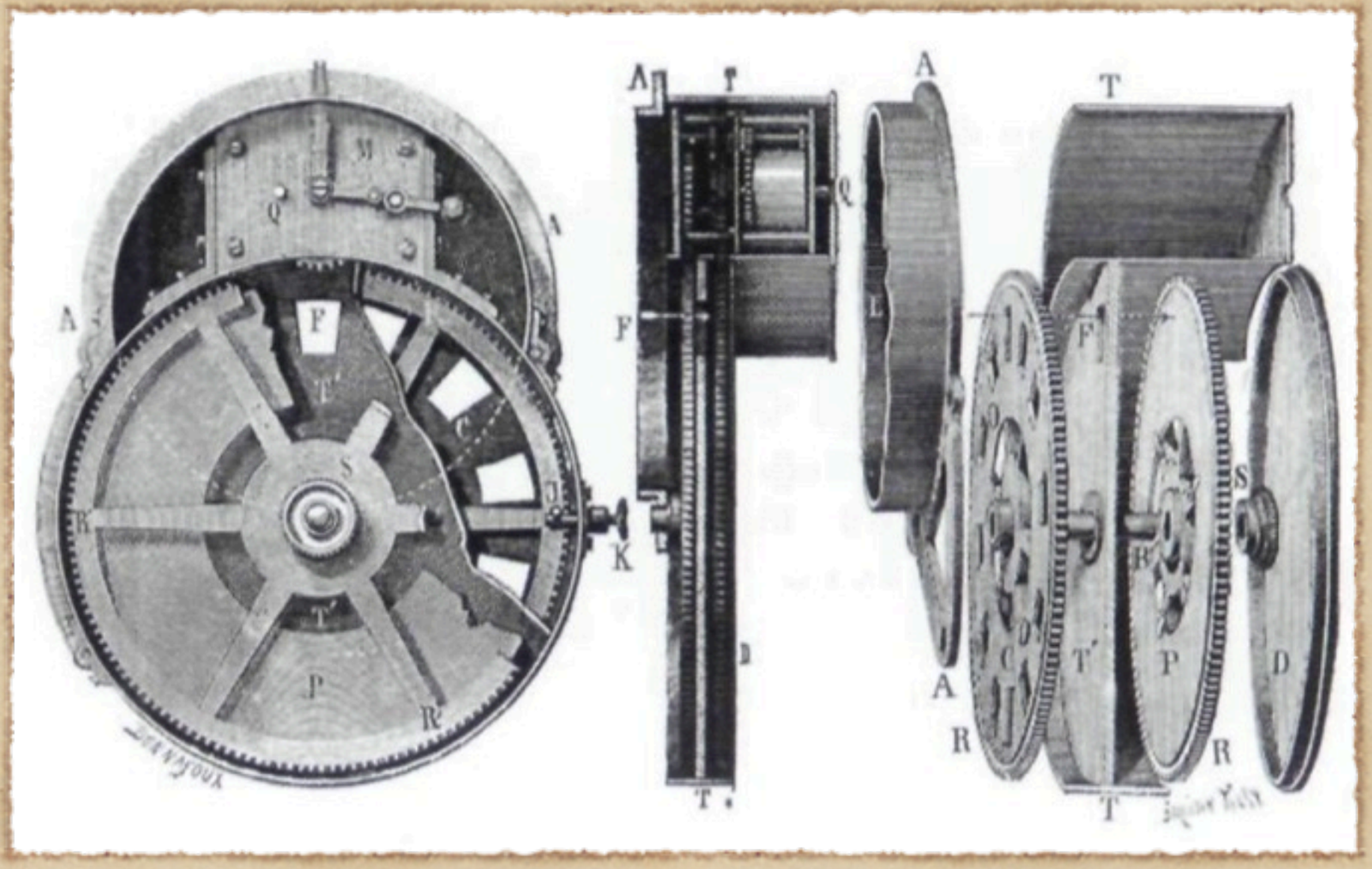
What was going on between 1874 and 1882?

- Aston Villa Formed
- Blue Jeans Patented
- Civil Rights Act Passes
- Telephone was Patented
- Battle of Little Big Horn
- Serbia and Montenegro declare war on Turkey
- (Another) Russo-Turkish War
- Aceh War
- Second Afghan War
- Anglo Zulu War
- Light Bulb Invented
- Boer War
- War of the Pacific
- Phoenix is incorporated
- Gunfight at the O.K. Corral

Boer War story.

The Transits of 1874 & 1882

- Must Easier Travel Arrangements
- Photography!
- Not much better data than before, better methods had been developed
- But some really cool pictures and devices.



Janssen's Revolver Camera

Forerunner of cinematography

The 1882 Transit of Venus Reanimated

Photographic Plates

Wednesday, May 30, 2012

David Todd in california used a new solar photographic telescope to take 147 glass negatives.

Results?

- Combined the 17th century and 19th century data

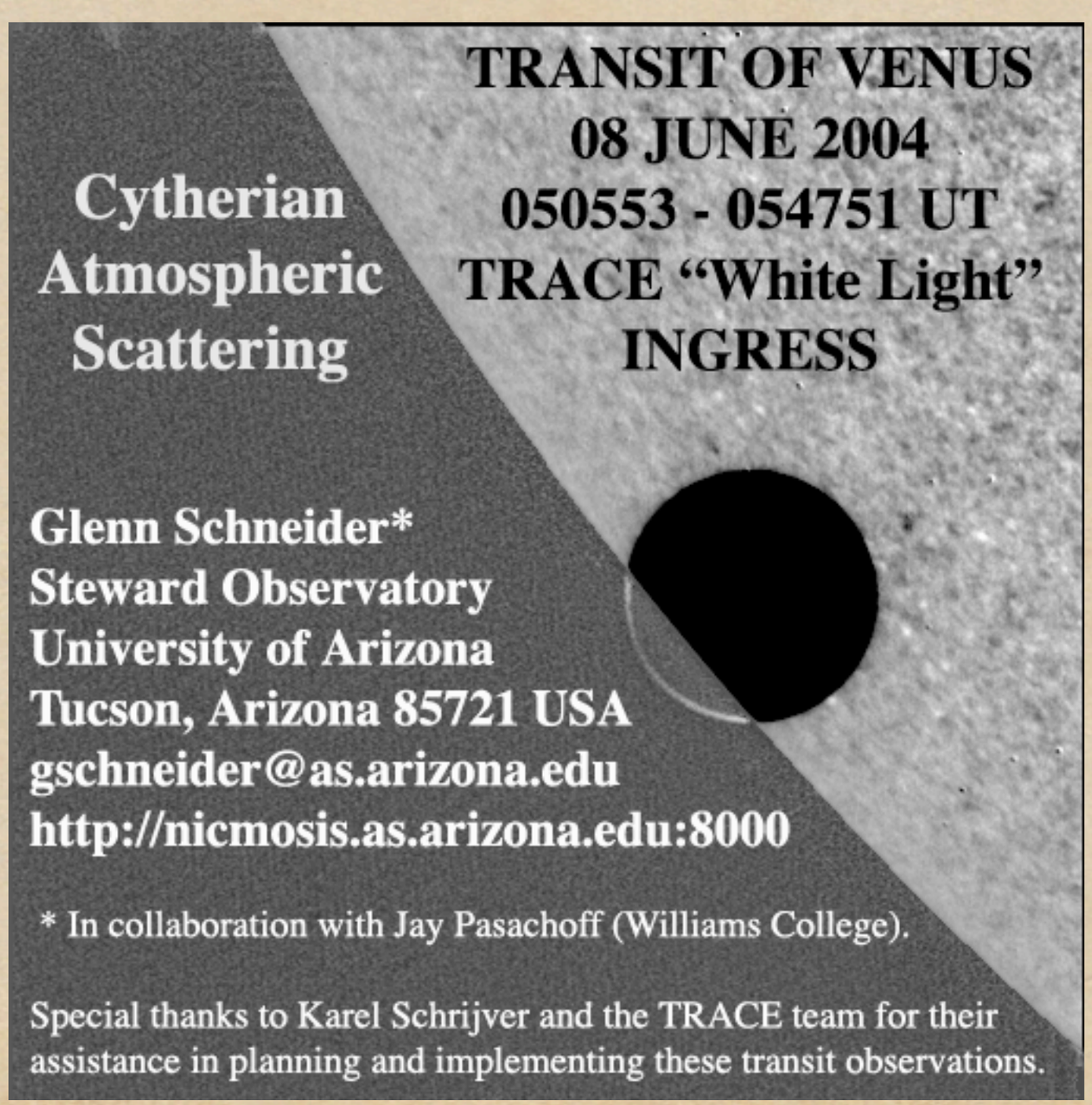
  149.59 ± 0.31 million kilometers

- Using modern techniques

  149,597,870.691 ± 0.030 kilometers

The Transit of 2004

The Transit of 2004



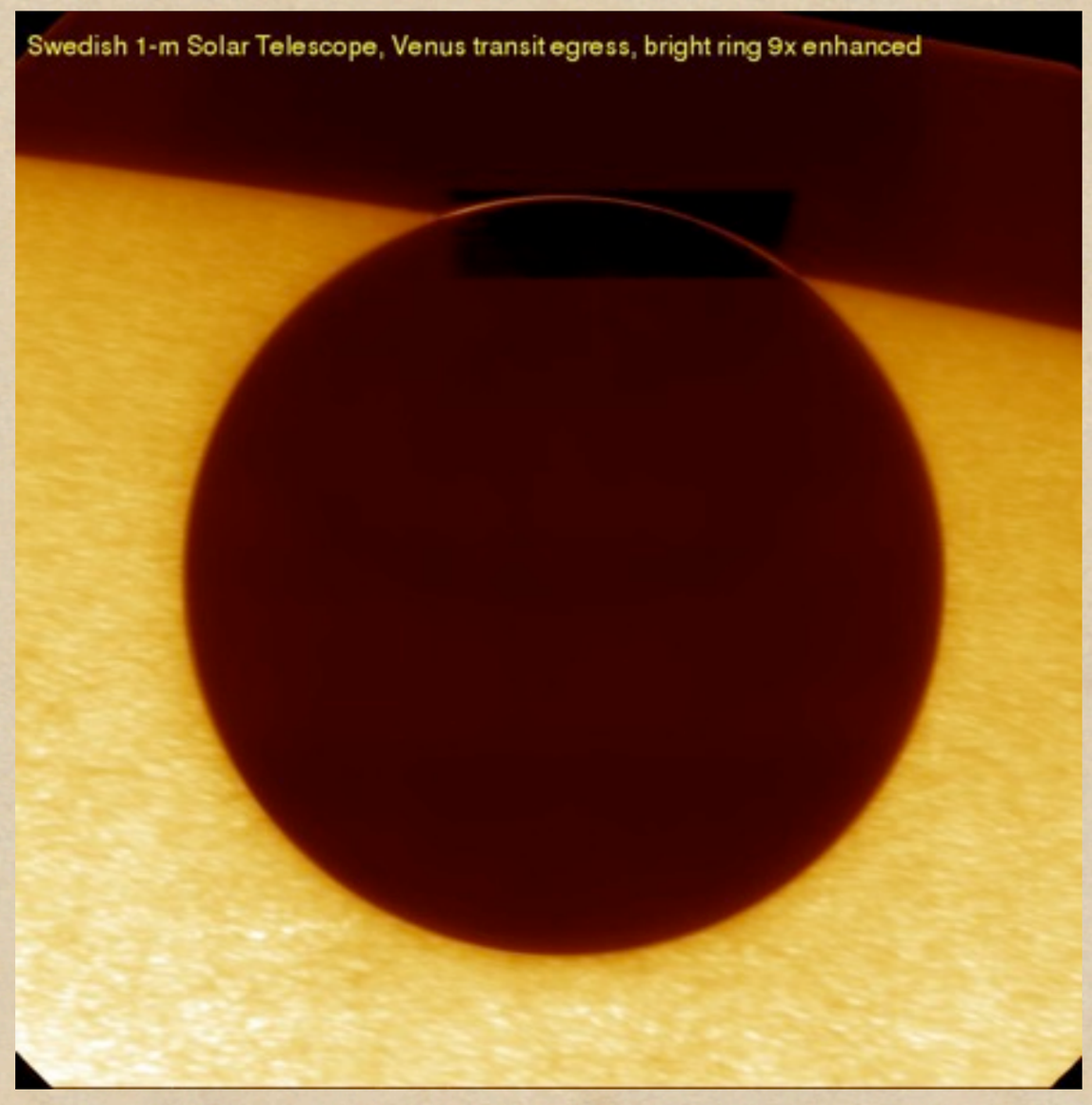
Cytherian Atmospheric Scattering

Glenn Schneider*
Steward Observatory
University of Arizona
Tucson, Arizona 85721 USA
gschneider@as.arizona.edu
http://nicmosis.as.arizona.edu:8000

* In collaboration with Jay Pasachoff (Williams College).

Special thanks to Karel Schrijver and the TRACE team for their assistance in planning and implementing these transit observations.

More Images from 2004



Credits: D. Kiselman, Steve Mitch, Jimmy Westlake

More Images from 2004

Credits: D. Kiselman, Steve Mitch, Jimmy Westlake

More Images from 2004

Credits: D. Kiselman, Steve Mitch, Jimmy Westlake

The Transit of 2012

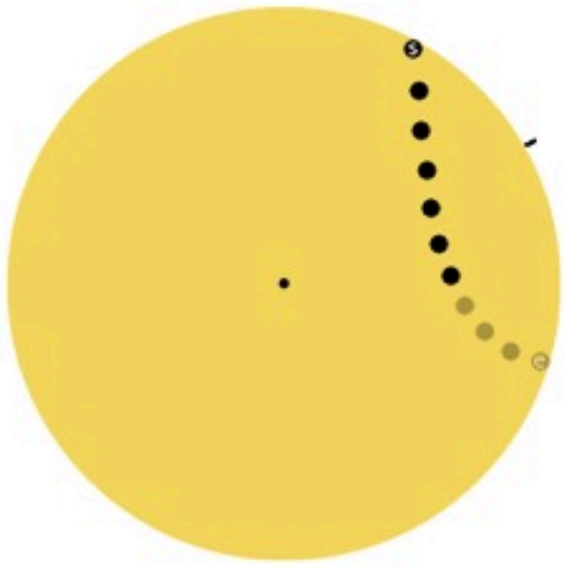
Longitude -110.9948 Latitude 31.858897 Height 888 Time zone -7 daylight saving time Compute Reset

contact	date	time	position angle	distance	sun's altitude	sun's azimuth
1. ingress, exterior	2012 June 5	15.06.02	+40.8 °	974".8	+52.7 °	+266.0 °
2. ingress, interior	2012 June 5	15.23.39	+38.3 °	916".6	+49.0 °	+268.6 °
minimum separation	2012 June 5	18.25.29	+344.9 °	548".7	+11.1 °	+289.8 °
3. egress, interior	2012 June 5	21.29.50*	+291.7 °	916".5	-21.5 °	+317.2 °
4. egress, exterior	2012 June 5	21.47.56*	+289.2 °	974".7	-24.0 °	+320.8 °
	2012 June 5	18.26.59	+344.3 °	548".8	+10.8 °	+290.0 °

sun's setting and rising on June 5 and 6 19.23 ▼ 05.23 ▲ horizon

mean cloud amount in June 30%

type your address Find coordinates



Left: The marker on the map indicates your location. Drag it to change your location. (Image courtesy of Google Maps) *Right*: Movement of Venus across the solar disk, relative to the zenith. Ingress is at 's' and egress at 'e'. The disks of Venus divide the duration of the transit in ten equal parts.