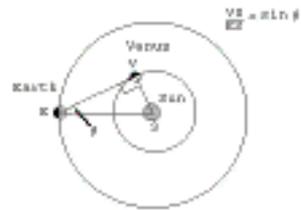


# The Science and Math of Transits



<http://www.astro.uni-bonn.de/~dfischer/skyreports/2004/venus.html>

*The Astronomical Unit from differential astrometry of the 2004 Transit of Venus?* by Daniel Fischer. "Based on a handful of medium-quality photographs of the full solar disk taken during the 2004 transit of Venus, a first attempt to derive the AU by relative astrometry to two sunspots in AR 627 is made."



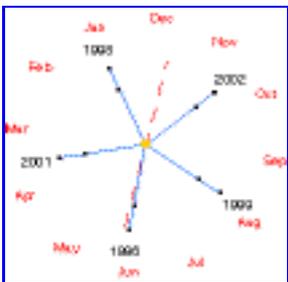
[http://www.dsellers.demon.co.uk/venus/ven\\_ch1.htm](http://www.dsellers.demon.co.uk/venus/ven_ch1.htm)

A tutorial on the transit of Venus as a technique for measuring solar parallax and quantifying the Astronomical Unit; excerpts with illustrations from [the book](#) "The Transit of Venus & the Quest for the Solar Parallax" by David Sellers.



[http://home.hetnet.nl/~smvanroode/venustransit/eng/eng\\_parallax.html](http://home.hetnet.nl/~smvanroode/venustransit/eng/eng_parallax.html)

Measure the distance to the sun by knowing only your location (lat/long) and the time(s) of internal contact. That is, "compute the mean equatorial solar parallax online from your own and others' observations of the 2004 transit of Venus, employing *either* Halley's or Delisle's method." This is the easiest method for casual observers to quantify the distance to the sun from their own data..



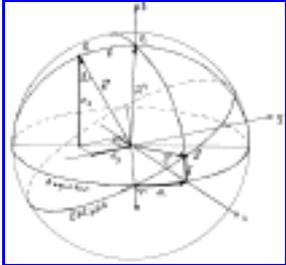
<http://dSPACE.dial.pipex.com/town/estate/vs76/trans.htm>

An explanation of the frequency of Venus transits by Peter M. Langford.



[http://sunearth.gsfc.nasa.gov/sunearthday/2004/index\\_vthome.htm](http://sunearth.gsfc.nasa.gov/sunearthday/2004/index_vthome.htm)

An extensive collection of Sun-Earth Day resources from the fun folks at the Sun-Earth Connection Education Forum.



<http://eclipse.astroinfo.org/transit/venus/project2004/pub/Blatter.etal.eng.200306.pdf>

*Venustransit 2004: Calculation of the Solar Parallax from Observations* by Heinz Blatter. Detailed math "gives an overview of the geometry and temporal patterns of transits, a rough estimate of the solar parallax and the corresponding error estimate. The possible and necessary corrections due to the rotation of the Earth, the eccentricities of the orbits of Venus and Earth and the inclination of the orbit of Venus are given as well." June 2003.



[blackdrop.htm](#)

The "[Black Drop](#)" Effect page addresses in detail the phenomenon at internal contact which has confounded astronomers for years.

<http://www.vt-2004.org/Background/Info12/EIS-B4.html>

Approximated method for the calculation of the parallax (with examples); from Venus Transit 2004 consortium. .



Compute the mean equatorial solar parallax online from your own and others' observations of the 2004 transit of Venus, employing Halley's method; courtesy of Steven M. van Roode.

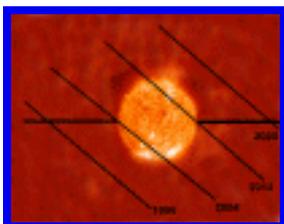
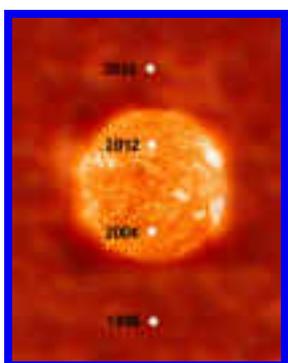


<http://www.phy6.org/stargaze/Svenus2.htm>

"Approximate calculation of the AU based on the June 8 transit of Venus, meant for the level of high school or beginning college and uses only algebra and simple trigonometry. It only relies on simulated data-- specifically, predicted times of 2nd and 3rd contact for Cairo and Durban;" from David P. Stern.

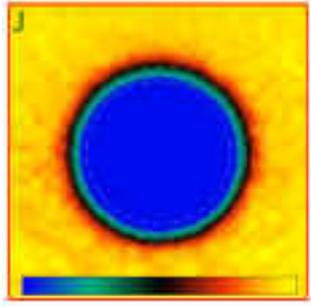
<http://merlin.alleg.edu/employee/d/doneal/articles/transit.html>

Introduction to the transit of Venus; from Douglas O'Neil.



Illustrations suggest Venus transits the sun in 2004 and 2012 but misses the sun in other years when it is near the nodes. Not to scale; orbital inclination is exaggerated. See the

[Transit Frequency](#) activity for details.



<http://nicmosis.as.arizona.edu:8000/POSTERS/TOM1999.jpg>

Poster on the 1999 transit of Mercury "definitively solves the problem of the black-drop effect that plagued past transits of Venus;" by Jay Pasachoff, Glenn Schneider and Leon Golub; from the American Astronomical Society's Division of Planetary Science meeting in 2001.

<http://www.williams.edu/astronomy/eclipse/transitVenus.htm>

Jay Pasachoff's site links to transit of Venus interests.

<http://www.aas.org/publications/baas/v32n4/aas197/785.htm>

Abstract describes physical cause of "black drop" effect; B. E. Schaefer (Univ. Texas Austin) at 2001 AAS meeting.

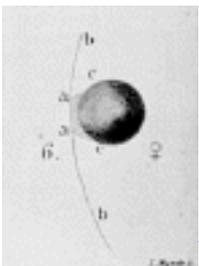


<http://www.transitsearch.org>

An observing program whose purpose is "to coordinate and direct a cooperative observational effort which will allow experienced amateur astronomers and small college observatories to discover transiting extrasolar planets."

[http://www.dsellers.demon.co.uk/venus/ven\\_ch8.htm](http://www.dsellers.demon.co.uk/venus/ven_ch8.htm)

Edmond Halley's admonition of 1716, in which he proposes a method to determine solar parallax and measure the distance to the sun by timing a transit of Venus from multiple sites across the globe.



<http://carnap.umd.edu/phil250/transits/transits.html>

Images related to determining the distance of the earth to the sun; "black drop" effect illustrations.



<http://home.att.net/~o.caimi/Venus.html>

"The Transit of Venus" by David Murray; from December 8, 1874, *Scribner's*.

"Astronomy, The Transit of Venus" by Gillet and Rolfe, 1882.

<http://home.hetnet.nl/~smvanroode/venustransit/ball.pdf>

Detailed math excerpted from Robert Stawell Ball's *Treatise on Spherical Astronomy*, 1908, addresses the conditions under which a transit takes place; variations of the sun's path as seen from different points on the

earth; and both Halley's and De Lisle's methods for applying a transit of Venus to determine the Astronomical Unit (A.U.)

<http://sunearth.gsfc.nasa.gov/eclipse/transit/catalog/Visible.html>

Formulas and data to show how to calculate whether the transit is visible from any given location; from Fred Espenak.

[http://libnova.sourceforge.net/group\\_\\_venus.html](http://libnova.sourceforge.net/group__venus.html)

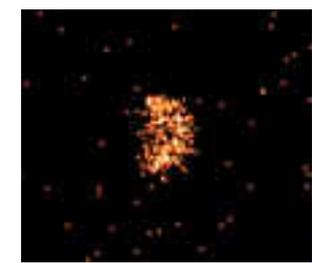
Calculation engines for C / C++ programmers, astronomers and anyone else interested in calculating positions of astronomical objects; from free software *libnova*, a general purpose, double precision, astronomical calculation library.

<http://www.ssec.wisc.edu/~sanjayl/planets/venus.htm>

Site suggests "early measurements of the speed of light were derived from observations of the transit of Venus..."

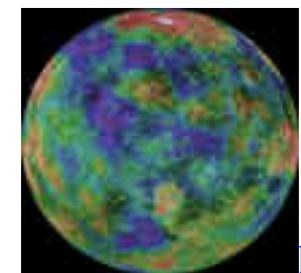
<http://www.lpl.arizona.edu/~rhill/alpo/transit.html>

Notes from the Mercury/Venus Transit Section of the Association of Lunar and Planetary Observers.



<http://chandra.harvard.edu/photo/cycle1/venus/index.html>

Venus in X-ray; images by Chandra observatory.

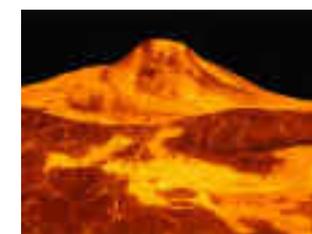


<http://www.seds.org/nineplanets/nineplanets/venus.html>

General background on Venus; from SEDS (Students for the Exploration and Development of Space).

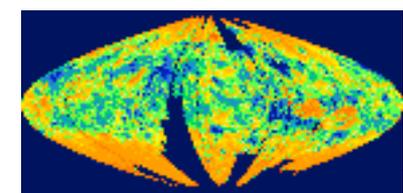
<http://nssdc.gsfc.nasa.gov/planetary/planets/venuspage.html>

Venus page from NSSDC (National Space Science Data Center); includes missions, data on CD ROM, and links.



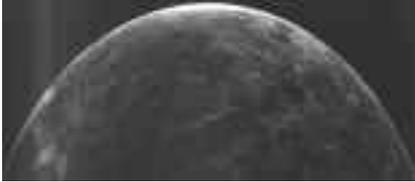
[http://nssdc.gsfc.nasa.gov/photo\\_gallery/photogallery-venus.html](http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-venus.html)

Photo gallery of Venus; from NSSDC.



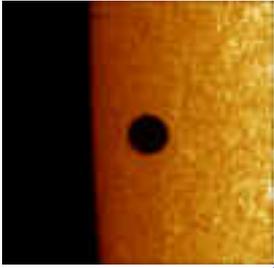
<http://nssdc.gsfc.nasa.gov/planetary/magellan.html>

Magellan mission to Venus.



<http://www.aoc.nrao.edu/pr/gbtfirstsci.html>

New radio telescope in West Virginia images Venus first; from National Radio Astronomy Observatory (NRAO).



<http://www.solarphysics.kva.se/>

Institute for Solar Physics captures the 2003 May 7 transit of Mercury.



<http://www.heavens-above.com>

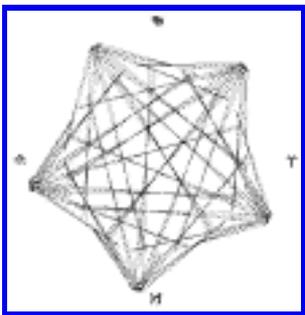
Distinguishes between "[transit of one body in front of another](#)" and "[meridian transit](#)," plus a lot of other great stuff at this website.

<http://www.seds.org/pub/info/newsletters/ejasa/1993/jasa9302.txt>

<http://www.seds.org/pub/info/newsletters/ejasa/1993/jasa9303.txt>

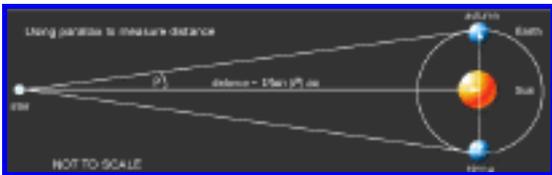
<http://www.seds.org/pub/info/newsletters/ejasa/1993/jasa9304.txt>

Three-part series on the Soviet and American exploration of Venus, appearing in the electronic Journal of the Astronomical Society of the Atlantic; by Larry Klaes.



<http://www.glenn.freehomepage.com/writings/Pentacle/>

"Pi, Phi, and the Pentacle" features the five-point pattern derived from the aligning orbits of Venus and earth; from Glenn R. Smith.

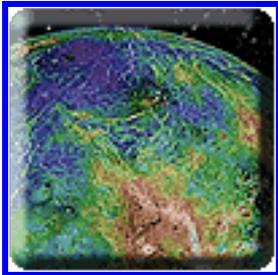


<http://www.transit-of-venus.org.uk/science.htm>

Using parallax to measure distance; from University of Central Lancashire.

[http://solareclipsewebpages.users.btopenworld.com/SENL\\_files/SENL.html](http://solareclipsewebpages.users.btopenworld.com/SENL_files/SENL.html)

Solar Eclipse Newsletter features listserv discussions about solar events. As June 2004 nears, several discussions address the transit of Venus, ranging from technical to travel.



<http://planetarynames.wr.usgs.gov/venus/venuTOC.html>

The origins of the names of Venus features are listed by the U.S. Geological Survey.

## Transit Geometry Calculations

(Courtesy of Sten Odenwald and Lou Mayo, Goddard Space Flight Center)

### 1. ANGULAR SIZE OF VENUS:

Distance to Venus =  $d \sim 0.277 \text{ AU} \sim 4.155e7 \text{ km}$

Diameter of Venus =  $D = 12,100\text{km}$

Angular Diameter =  $a = D/d$  (radians) =  $2.9215e-4$  radians  $\sim 60'' .3$

(which is very close to the published value of  $58'' .6$ )

### 2. ORBITAL VELOCITY

Venus average orbital velocity =  $v = 35.02 \text{ km/s}$  (max = 35.26, min = 34.79). Venus transits the sun at a solar latitude of about 60 degrees and takes about 6 hours to transit. Assume at 60 degrees solar latitude, Venus follows a path that is about  $2/3$  solar diameter = 0.33 degrees. Then, Venus transits 0.33 degrees of space in 6 hours, or about 0.055 degrees / hour. This is close to the calculation of 0.07 degrees / hour and dependent on the length of the chord (Venus' path) across the sun.

3. From Earth, Venus is at inferior conjunction. From Venus, Earth is at opposition.



<http://video.google.com/videoplay?docid=-760141133217062403&q=transit+venus>

NASA Connect offers lessons and exercises on scaling the solar system.

[www.transitofvenus.org](http://www.transitofvenus.org)

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