A Convenient Transit of Mercury: November 8-9, 2006

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Abstract

The 2006 transit will be Mercury's last until 2016, but fortunately its first portion will be visible throughout the Americas and the entire event can be seen from western North America and the eastern and central Pacific. Also, the last part of the transit will be visible from East Asia and the western Pacific.

The ALPO Transit Section invites visual, film, and electronic observations of transit optical phenomena, such as the "black drop," as well as timings of the transit contacts.

Introduction

This Fall we will experience the last transit of a planet across the Sun until that of Venus in 2012, and the last transit of Mercury until 2016. Thus we are fortunate that the 2006 transit is timed so that observers anywhere in the Americas will be able to see at least part of the event, and those on the Pacific coast will be able to watch all of it.

Transit Parameters

Figure 1 diagrams the appearance of the upcoming transit, while Table 1 gives some descriptive statistics for the event, where all times are in UT (Universal Time). Its total duration is slightly under five hours from *ingress*, the entrance of Mercury onto the Sun's disk, to *egress*, its exit from the Sun.

Some important points from the table are:

• Wherever you are in the visibility zone, the times of the transit events and the path of Mercury will be almost the same as for the hypothetical geocentric view. Nonetheless your location is still critical, as the times of local sunrise and sunset will determine whether you can see the transit at all, and if so which part of the transit you can see; ideally some observers may be able to watch the entire transit from beginning to end.

• Mercury's disk will be very small, both absolutely and in relation to the Sun – you will need to look carefully simply to identify the planet.

• Compared with its tiny disk, the planet will move very rapidly across the Sun's limb, limiting to a few seconds the length of video sequences that can be stacked without blurring the planet, the solar limb, or both.

Table 1. Transit of Mercury, 2006 Nov 08-09 Summary Data.

Quantity	***Value*** (all times UT)	***Comments***
Contact Times		Anywhere on Earth, contact times will occur within 0.8 minute of the geo-centric times, the transit duration will be within 1.2 minutes of the geocentric dur-ation, while the durations of ingress and egress will be within 0.5 seconds of the geocentric dura-tions. Also, the position angles of contacts will be within 1/4 degree of the geocentric position angles.
Contact 1 (begin ingress)	Nov 08 19h 12m 01.7s Position Angle 140°.9	
Contact 2 (end ingress)	Nov 08 19h 13m 54.6s Position Angle 141°.2	
Least Distance between centers	Nov 08 21h 41m 01.7s Distance 422″.9	
Contact 3 (begin egress)	Nov 09 00h 08m 13.6s Position Angle 269°.0	
Contact 4 (end egress)	Nov 09 00h 10m 06.5s Position Angle 269°.3	
Event Durations		
Transit	4h 58m 04.8s	
Ingress & Egress	1m 52.9s	
Apparent Diameters		Mercury's disk will appear only 1/195th as wide as that of the Sun.
Sun	1937″.48 (0°.54)	
Mercury	9″.96	
Apparent Velocity of Mercury relative to the Sun	5″.92/minute (0″.099/second)	This motion limits the total duration of a group of stacked images to a few seconds.
Differential Parallax (Mercury's minus the Sun's)	4″.14	This is the maxi-mum shift of the observed path of Mercury from its geocentric path.

Where Can the Transit be Seen?

Figure 2 shows the zones worldwide where the 2006 Transit of Mercury will be visible. As the transit takes place in late northern-hemisphere Fall, the southern hemisphere is favored for this transit. (The Earth's northern hemisphere had the best views of the May 2003 transit of Mercury and the June 2004 transit of Venus.) As with any transit, there are four visibility zones, depending largely on one's longitude:
(1) Localities that miss the transit completely because it starts after local sunset and ends before local sunrise. In 2006 these include central, southern and western Asia and all of Africa and Europe.

(2) Areas where the Sun rises before Mercury's ingress starts, but where the Sun sets with the transit still going on. Most of the Americas falls in this category.

(3) A region centered on the Pacific basin, but including New Zealand, easternmost Australia and the Pacific coast of North America where ingress occurs after sunrise and egress before sunset; thus the entire transit will be visible.

(4) Finally, eastern Asia and most of Australia will see the Sun rise with the transit already in progress, but will see the transit end before the Sun sets.

Although observers in western Canada and the United States are fortunate in being able to watch the whole transit, it will end with the Sun close to their southwestern horizon. Figure 3 is an enlarged view of western and northwestern North America, highlighting how close the Sun will be to the horizon when the transit ends.

At the end of this paper is an Appendix that gives the time period of visibility of the upcoming transit for the major metropolitan areas that can see some or all of the event. The Appendix table takes into account the times of sunrise (SR) and sunset (SS) for each area, assuming you have no horizon obstructions.

Observing the Transit

You can't observe a transit without observing the Sun, so you must take all the precautions you would when observing the partial or annular phases of a solar eclipse. There are only three safe ways to observe the Sun:

(1) Use a small aperture with a specially-designed narrow-band solar filter, most often one that passes light within only a few tenths of an Ångstrom unit centered on the hydrogen-alpha wavelength of 6562.8 Å.

(2) Use a full-aperture solar filter on the front end of your telescope. The filter should pass no more than 1/100,000th of the light in the visible, ultraviolet and infrared bands and should not have scratches or pinholes. Remember to similarly filter your finder, or cover its lens entirely. If using binoculars, safely filter both lenses.

(3) Project the Sun's image through the eyepiece onto a white screen. This allows several people to watch simultaneously. There are several disadvantages, however. First, contrast is low unless the screen is thoroughly shaded. Second, someone may foolishly try to look directly through the eyepiece. Third, the unfiltered sunlight inside your telescope will heat up its optics. This may actually shatter in the eyepiece, or the secondary or diagonal mirror. The same may happen with any filter placed behind the eyepiece; these so-called solar filters should be avoided entirely.

Mercury can be spotted on the Sun with low-power safely filtered binoculars, but you will probably need a telescope magnifying at least 50 times, and 60 mm in aperture or larger, to see the details of ingress and egress and time the four transit contacts, as diagrammed in Figure 4.

Contact 1 is the most difficult to time because the planets starts to "notch" the Sun's disk without any warning. You will need to orient the telescopic field prior to this event in order to catch it. With an undriven telescope, the Sun's motion defines celestial west. With an equatorial mounting, you can move the telescope to determine celestial directions; the position angle of first contact on the solar limb will be 4/7 of the way from east to south. Also, viewing with a narrow-band hydrogen alpha filter enables you to see Mercury silhouetted on the Sun's chromosphere just before it first touches the photosphere (which defines First Contact).

The remaining contacts would seem much easier to time accurately. However, the telescopic image is always somewhat blurred by atmospheric seeing and the finite resolution of one's optical system. This creates the famous "black drop" effect – a temporary fuzzy appendage connecting the limbs of Mercury and the Sun that makes exact contact timing impossible. Figure 5, a high-resolution composite image of the May 2003 transit of Mercury, illustrates the black-drop phenomenon.

The ALPO Mercury/Venus Transit Section (P.O. Box 2447, Antioch, CA 94531-2447 or johnwestfall at comcast.net) would like to receive your contact times in order to study the effects of the atmosphere and telescopic characteristics on timing accuracy. Please report times to 1-second UT precision, and include your observing site's position (to 0°.01 or 1 arc-minute latitude and longitude); your telescope's optical type, aperture, and focal length; any stops or filters used; and atmospheric seeing and transparency, preferably reported on the standard ALPO scales. Please also give your address – postal, email, or both – in case any questions arise later.

Drawings, or film or electronic images, either still or video, of the transit are a useful permanent record of the rare event, particularly if the following guidelines are followed:

• Submit your drawings, photographs or images to the ALPO Mercury/Venus Transit Section.

• Frames showing the entire disk of the Sun will be at too small a scale to show useful detail for Mercury itself. Use sufficient magnification/EFL to show only the planet and the area of the Sun immediately surrounding it.

• Do not employ any digital sharpening algorithm, which can create artifacts such as a bright halo around the planet or a light patch within its disk.

• Record the time for each image to 1 second UT. Include the same information as asked for with contact timings.

• We need to know the orientation of images or drawings; the direction of celestial north and east and whether the image is reversed. Also record the mode of imaging (afocal, prime focus, eyepiece projection, etc.) with the effective focal length or magnification, along with the image-recording method (camcorder, digital still camera, etc.).

• When stacking video frames taken during ingress or egress, avoid compositing so many frames that the planet moves significantly during the interval. A reasonable limit might be 5 seconds (50 frames at 10 f.p.s.), during which the relative motion will be a half arc-second.

• To make sure that none of the tonal range is lost, no portions of the image should be completely black (0% brightness) or completely white (saturated; 100% brightness).

Transits of Mercury average about thirteen per century and are thus even more rare than solar eclipses. As with solar eclipses, the most interesting phases of transits – ingress and egress – are compressed into a few minutes and present a challenge for timing contacts, making drawings, or recording images.

Appendix: Visibility of the 2006 Nov 08-09 Transit of Mercury
from Selected Metropolitan Areas.

(C1 and C4 refer to the First and Fourth Contacts; SR indicates local sunrise and SS local sunset. All times are 2006 Nov 08 UT; 24h indicates Nov 09 00h. Times to 0.1-minute precision and italics refer to contact times; those to 1-minute and in plain type are local sunrise and sunset times)

Metropolitan Area	**Visibility Limits**	**Visibility Period (Nov 08 UT)**
GEOCENTRIC	*C1-C4*	*19:12.0-24:10.1*
UNITED STATES		
Atlanta, GA	*C1*-SS	*19:12.3*-22:38
Austin, TX	*C1*-SS	*19:12.4*-23:37
Baltimore, MD	*C1*-SS	*19:12.3*-21:56
Birmingham, AL	*C1*-SS	*19:12.3*-22:48
Boston, MA	*C1*-SS	*19:12.3*-21:27
Buffalo, NY	*C1*-SS	*19:12.4*-21:57
Charlotte, NC	*C1*-SS	*19:12.3*-22:21
Chicago, IL	*C1*-SS	*19:12.4*-22:35
Cincinnati, OH	*C1*-SS	*19:12.4*-22:28
Cleveland, OH	*C1*-SS	*19:12.4*-22:12
Columbus. OH	*C1*-SS	*19:12.4*-22:20
Dallas-Ft. Worth, TX	*C1*-SS	*19:12.4*-23:29
Denver, CO	*C1*-SS	*19:12.5*-23:49
Detroit, MI	*C1*-SS	*19:12.4*-22:16
Hartford, CT	*C1*-SS	*19:12.3*-21:34
Honolulu, HA	*C1-C4*	*19:12.7-24:09.8*
Houston, TX	*C1*-SS	*19:12.4*-23:28
Indianapolis, IN	*C1*-SS	*19:12.4*-22:33
Jacksonville, FL	*C1*-SS	*19:12.3*-22:32
Kansas City, MO	*C1*-SS	*19:12.4*-23:08
Las Vegas, NV	*C1-C4*	*19:12.6-24:09.5*
Los Angeles, CA	*C1-C4*	*19:12.6-24:09.5*
Louisville, KY	*C1*-SS	*19:12.4*-22:35
Memphis, TN	*C1*-SS	*19:12.4*-22:58
Miami, FL	*C1*-SS	*19:12.2*-22:33
Milwaukee, WI	*C1*-SS	*19:12.4*-22:33
Minneapolis-St. Paul, MN	*C1*-SS	*19:12.5*-22:50
Nashville, TN	*C1*-SS	*19:12.4*-22:43
New Orleans, LA	*C1*-SS	*19:12.4*-23:06
New York, NY	*C1*-SS	*19:12.3*-21:43
Oklahoma City, OK	*C1*-SS	*19:12.4*-23:27
Orlando, FL	*C1*-SS	*19:12.3*-22:34
Philadelphia, PA	*C1*-SS	*19:12.3*-21:49
Phoenix, AZ	*C1-C4*	*19:12.5-24:09.5*
Pittsburgh, PA	*C1*-SS	*19:12.4*-22:07
Providence, RI	*C1*-SS	*19:12.3*-21:30
Richmond, VA	*C1*-SS	*19:12.3*-22:03
Riverside, CA	*C1-C4*	*19:12.6-24:09.5*
Rochester, NY	*C1*-SS	*19:12.4*-21:52
Sacramento, CA	*C1-C4*	*19:12.6-24:09.6*
Salt Lake City, UT	*C1-C4*	*19:12.6-24:09.6*
San Antonio, TX	*C1*-SS	*19:12.4*-23:41
San Diego, CA	*C1-C4*	*19:12.6-24:09.6*

San Francisco, CA	*C1-C4*	*19:12.6-24:09.6*
San Jose, CA	*C1-C4*	*19:12.6-24:09.6*
Seattle, WA	*C1-C4*	*19:12.7-24:09.6*
St. Louis, MO	*C1*-SS	*19:12.4*-23:41
Tampa-St. Petersburg, FL	*C1*-SS	*19:12.3*-22:39
Vir. Beach-Norfolk-Portsmouth, VA	*C1*-SS	*19:12.3*-21:58
Washington, DC	*C1*-SS	*19:12.3*-21:58
CANADA		
Calgary, Alta.	*C1-C4*	*19:12.6-24:09.7*
Edmonton, Alta.	*C1*-SS	*19:12.6*-23:46
Montréal, Que.	*C1*-SS	*19:12.4*-21:30
Ottawa, Ont.	*C1*-SS	*19:12.4*-21:39
Toronto, Ont.	*C1*-SS	*19:12.4*-21:58
Vancouver, BC	*C1-C4*	*19:12.7-24:09.7*
LATIN AMERICA		
Belo Horizonte, Brazil	*C1*-SS	*19:11.5*-21:07
Bogotá, Colombia	*C1*-SS	*19:12.0*-22:36
Brasilia, Brazil	*C1*-SS	*19:11.6*-21:17
Buenos Aires, Argentina	*C1*-SS	*19:11.5*-22:28
Cali, Colombia	*C1*-SS	*19:12.0*-22:47
Caracas, Venezuela	*C1*-SS	*19:12.0*-22:01
Curitiba, Brazil	*C1*-SS	*19:11.5*-21:36
Fortaleza, Brazil	*C1*-SS	*19:11.6*-20:24
Guadalajara, Mexico	*C1-C4*	*19:12.4-24:09.4*
Lima, Peru	*C1*-SS	*19:11.8*-23:09
Medellin, Colombia	*C1*-SS	*19:12.0*-22:40
Mexico City, Mexico	*C1*-SS	*19:12.3*-23:58
Monterrey, Mexico	*C1*-SS	*19:12.4*-23:54
Porto Alegre, Brazil	*C1*-SS	*19:11.5*-21:51
Recife, Brazil	*C1*-SS	*19:11.6*-20:15
Rio de Janeiro, Brazil	*C1*-SS	*19:11.5*-21:08
Salvador, Brazil	*C1*-SS	*19:11.5*-20:36
Santiago, Chile	*C1*-SS	*19:11.6*-23:15
Santo Domingo, Dominican Rep.	*C1*-SS	*19:12.1*-22:03
São Paulo, Brazil	*C1*-SS	*19:11.5*-21:24
AUSTRALIA-NEW ZEALAND		
Adelaide, Australia	SR-*C4*	19:38-*24:10.5*
Auckland, New Zealand	*C1-C4*	*19:12.1-24:10.1*
Brisbane, Australia	*C1-C4*	*19:12.2-24:10.4*
Melbourne, Australia	*C1-C4*	*19:12.1-24:10.4*
Perth, Australia	SR-*C4*	21:14-*24:10.7*
Sydney, Australia	*C1-C4*	*19:12.1-24:10.4*
EAST & SOUTHEAST ASIA		
Bangkok, Thailand	SR-*C4*	23:18-*24:10.9*
Beijing, China	SR-*C4*	22:53-*24:10.6*
Chongqing, China	SR-*C4*	23:14-*24:10.8*
Guangzhou, China	SR-*C4*	22:37-*24:10.8*
Ho Chi Minh City, Vietnam	SR-*C4*	22:47-*24:10.8*
Hong Kong, China	SR-*C4*	22:33-*24:10.8*
Jakarta, Indonesia	SR-*C4*	22:26-*24:10.9*
Manila, Philippines	SR-*C4*	21:55-*24:10.7*
Osaka-Kobe, Japan	SR-*C4*	21:26-*24:10.5*
Seoul, South Korea	SR-*C4*	22:06-*24:10.6*
Shanghai, China	SR-*C4*	22:16-*24:10.7*
Shenzhen, China	SR-*C4*	22:33-*24:10.8*
Tianjin, China	SR-*C4*	22:48-*24:10.6*
Tokyo, Japan	SR-*C4*	21:11-*24:10.5*
Wuhan, China	SR-*C4*	22:44-*24:10.7*

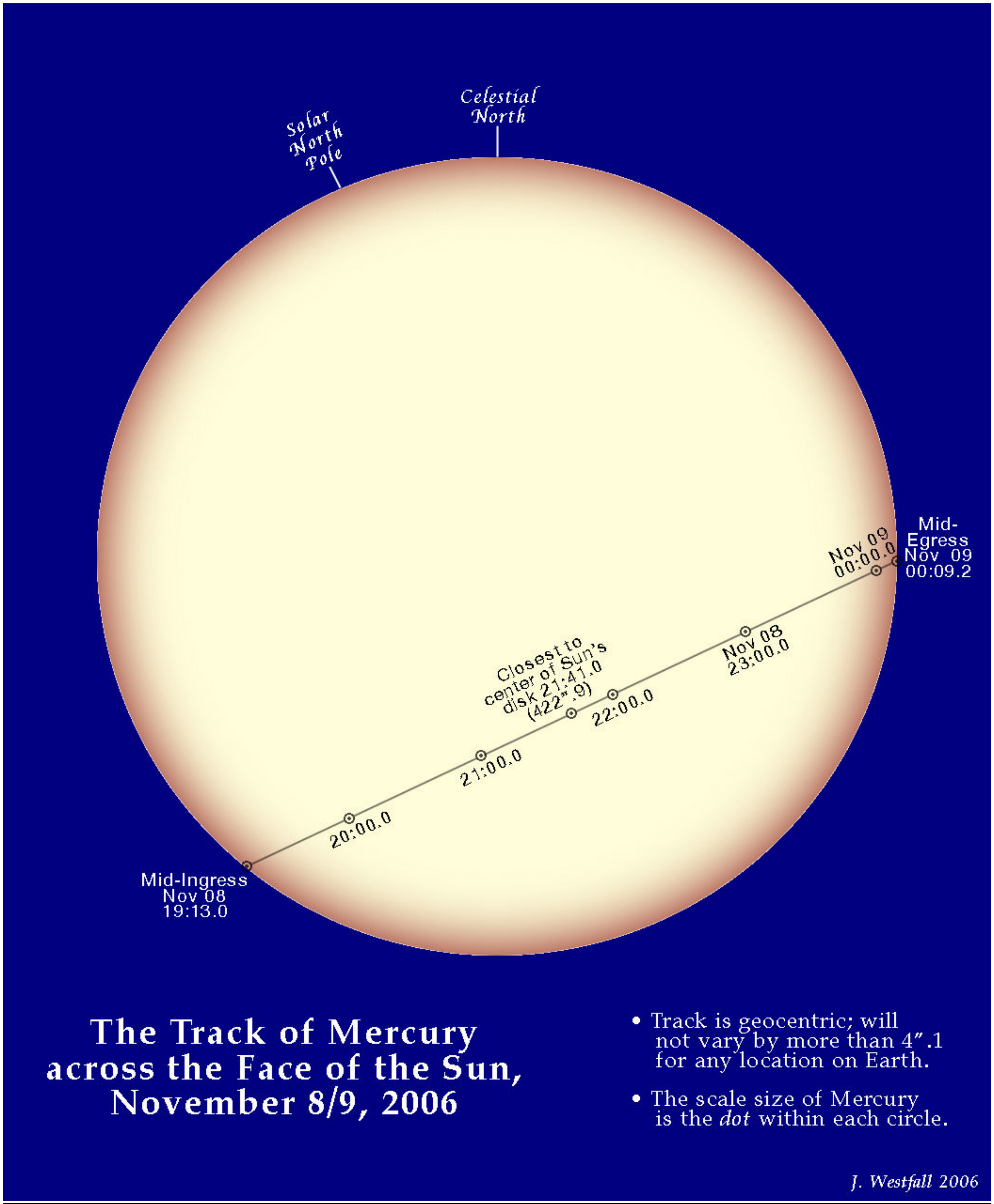

Figure 1. Apparent path of Mercury during its transit across the face of the Sun on 2006 NOV 08-09. All times are UT (Universal Time). Celestial north at top. Mercury is the small dot within each circle and is to scale with the disk of the Sun.

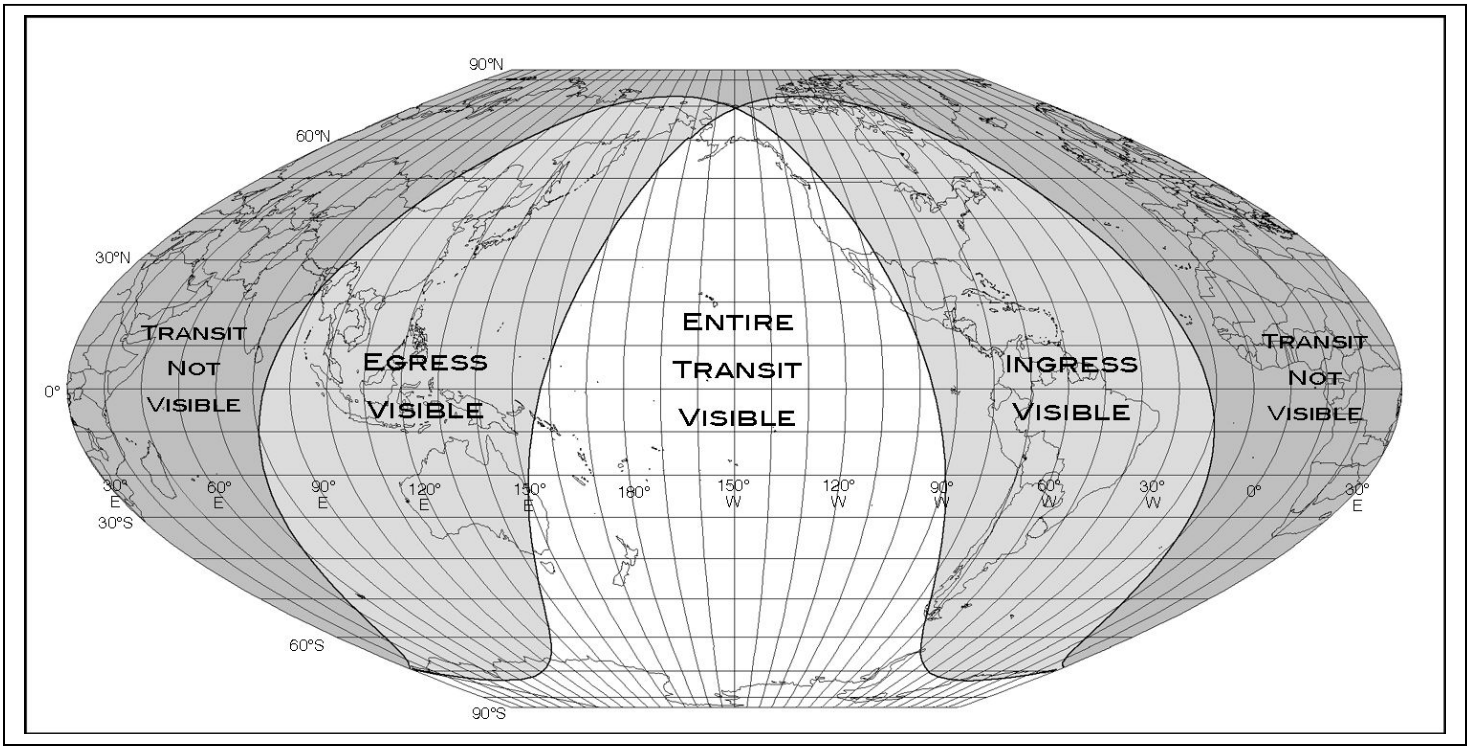

Figure 2. Worldwide visibility map of the transit of Mercury, 2006 NOV 08-09.

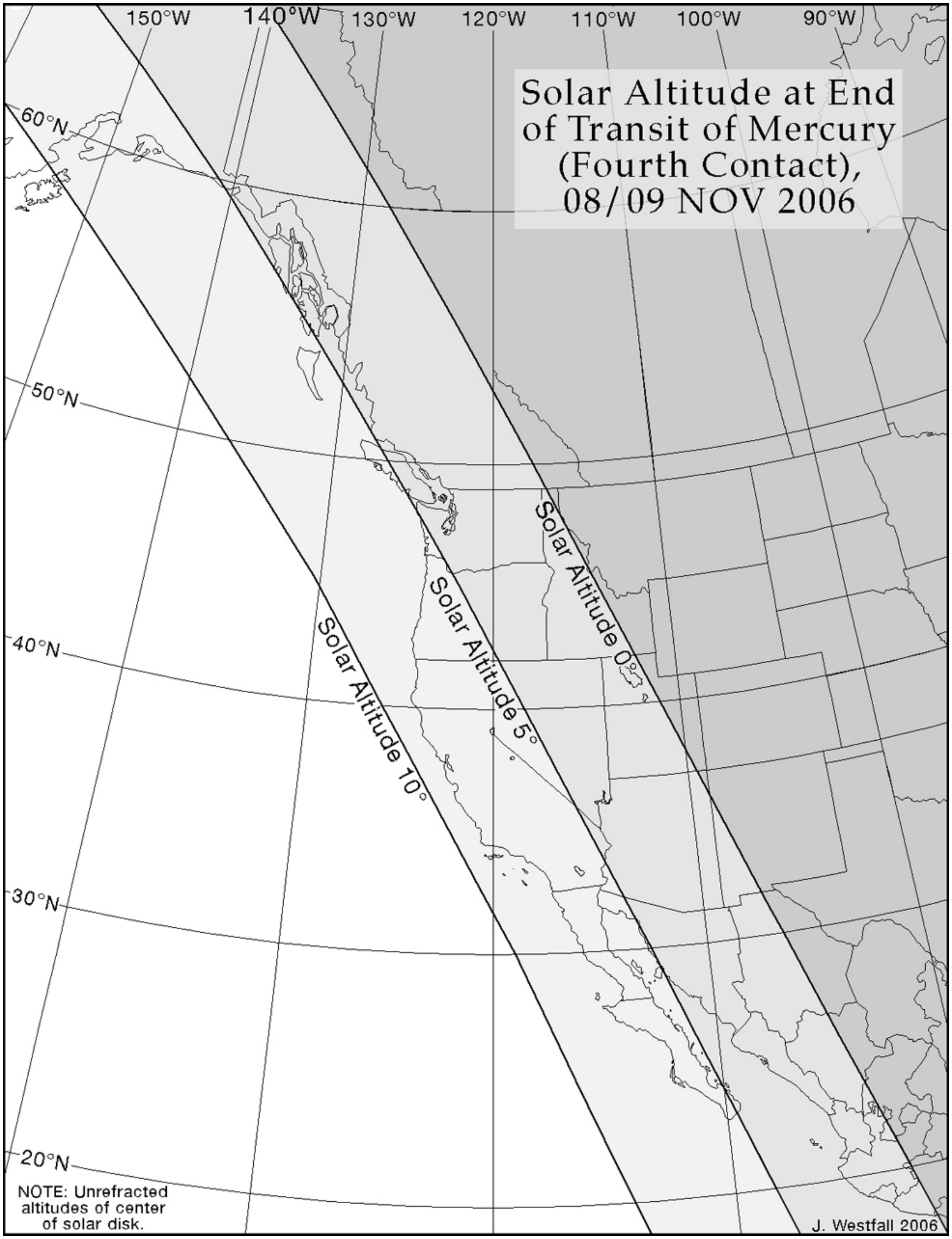

Figure 3. Western and Northwestern North America, showing the altitude of the Sun above the local horizon at the end of the 2006 NOV 08-09 transit of Mercury.

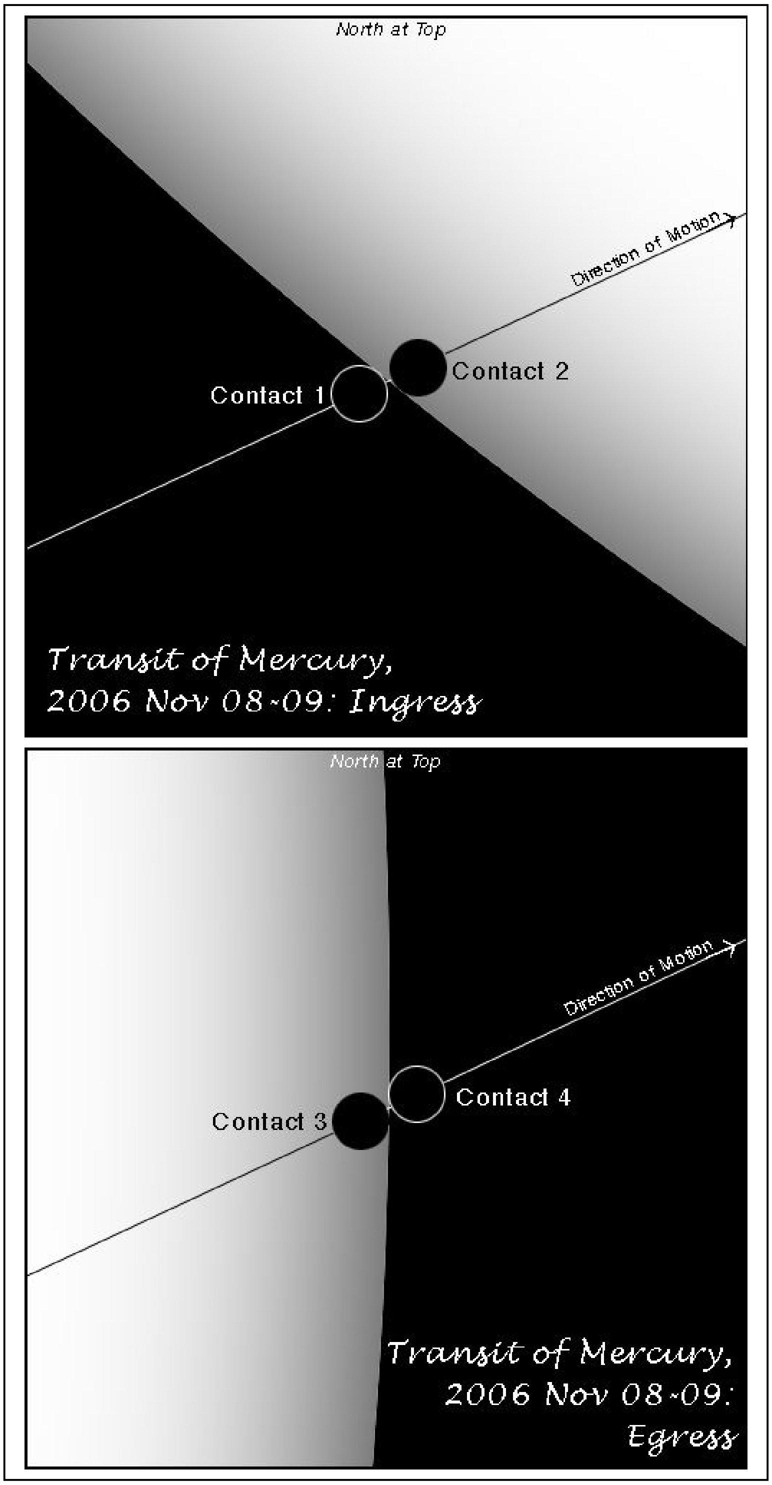

Figure 4. Diagram of the four contacts of the 2006 NOV 08-09 transit of Mercury. Mercury is drawn to scale relative to the Sun. North at top.

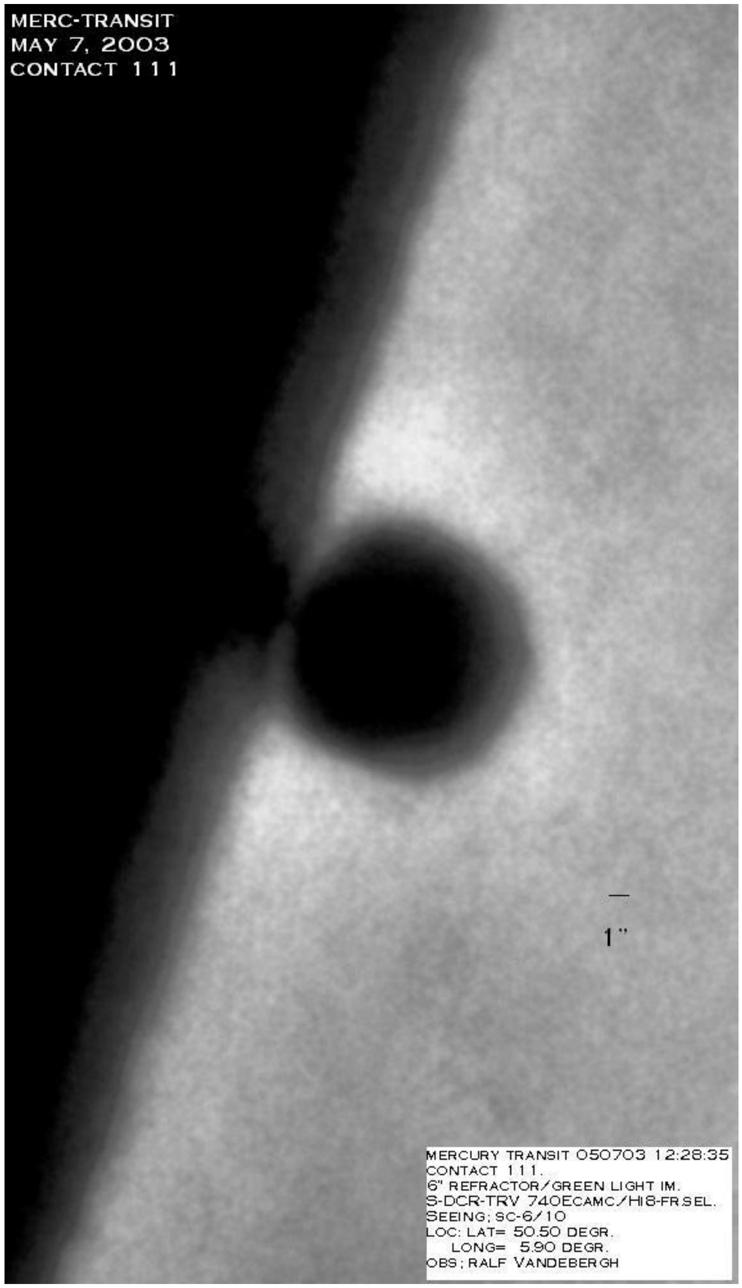

Figure 5. Sample high-resolution large-scale webcam image of a transit of Mercury. This view shows the egress phase of the 2003 MAY 07 transit, taken by Ralf Vanderbergh.

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