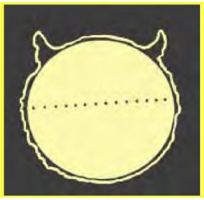

Feature Story:

May 9, 2016: The Next Transit of Mercury

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Introduction

Nine-and-one-half years after Mercury last crossed the Sun (Figure 1), the phenomenon repeats on May 9, 2016. With even a small telescope, by using either a full-aperture solar filter, or by projecting the Sun's image, most of the world can safely watch at least some of this 7-1/2-hour event.

Circumstances

Figure 2 shows the path of Mercury across the Sun during this event, at least for an imaginary observer at the center of the Earth, keeping to the following schedule:

- Contact I – 11h 12m 18s UTC (Mercury first touches the Sun's limb)
- Contact II – 11h 15m 30s UTC (Mercury fully inside the Sun's disk)
- Mid-transit – 14h 57m 25s UTC
- Contact III – 18h 39m 12s UTC (Mercury begins to leave the Sun's disk)
- Contact IV – 18h 42m 24s UTC (Mercury completely leaves the Sun's disk)

The reader may wonder why we have given circumstances for an inaccessible location. Due to the speed that Mercury's shadow (technically its *antumbra*) passes across the face of the Earth, the times for an observer anywhere in the transit visibility region will differ by less than two minutes from the geocentric times. (That is, for the universal times; the local times of the events will depend on one's time zone.)

The entire transit lasts so long – 7-1/2 hours – that over four-fifths of the Earth's surface will be able to see at least some of the transit; slightly less than one-fifth will be able to see all of the event, while a little less than one-fifth will see nothing. The world map in Figure 3 shows where these visibility zones fall.

Individuals in eastern North America, the Caribbean, most of South America, western Europe and northwestern Africa are fortunate; they can watch the entire transit. Sadly, observers staying in the Far East, Australia and New Zealand will see none of the event. Everyone else will see a portion of the transit, their visibility period including either ingress or egress, but not both.

Some Important Mercury Transits of the Past

1631 Nov 7 — The first one observed (by Pierre Gassendi).
1651 Nov 3 — Observed by Jeremy Shakerly in Surat, reported in letter to Henry Osbourne, January 1652.
1661 May 3 — Occurred on the day of the Coronation of King Charles II of England. Observed by Christiaan Huygens in London.
1677 Nov 7 — Observed by Edmund Halley in St Helena, Richard Towneley in Lancashire, Jean Charles Gallet in Avignon; as reported in letter from John Flamsteed to Johannes Hevelius 23 May 1678.
1743 Nov 5 — Coordinated scientific observations were organized by Joseph-Nicolas Delisle worldwide.
1769 Nov 9, 23:09 — Observed by Charles Green and James Cook from Mercury Bay in New Zealand. Noted that Mercury had little or no atmosphere. Source: *https://en.wikipedia.org/wiki/Transit_of_Mercury*

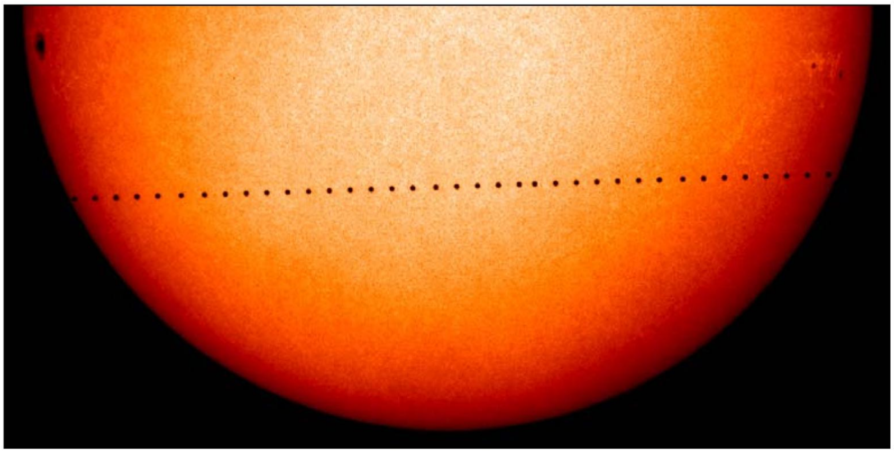

Figure 1. Mercury crosses the Sun's disk on 2006 Nov 08-09, imaged by NASA's SOHO satellite at approximately 8-minute intervals. The planet is moving from left to right; celestial north is at top.

How to Observe the Transit

Mercury's disk will be only 12.1 arc-seconds across, just 1/157th that of the Sun. It will be impossible to make out with the (suitably filtered) naked eye, despite the fact that many observers were able to spot the much larger disk of Venus during its 2004 and 2012 transits. However, with a solar filter, good binoculars should be able to reveal Mercury's disk, although a small telescope would show it more clearly.

Obviously, viewing transits of Mercury and Venus involves looking at or imaging the naked disk of the Sun, which can very quickly blind a person and damage equipment. The only safe methods to observe a transit are:

1. Using a full-aperture solar filter that rejects at least 99.99 percent of the incoming sunlight, including the visible, infrared and ultraviolet bands. (Filtering solar radiation at the eyepiece end of the telescope is *not* safe.)

2. Projecting through the eyepiece an enlarged solar image onto a white viewing surface. Solar projection is convenient for sketching and group viewing but should be done only with small apertures to reduce the danger of eyepiece damage through overheating.

Basically, use the same procedure for observing Mercury's tiny disk against the Sun's disk as you would for observing sunspots.

What to Observe During the Transit

As with the total phase of a solar eclipse, the most exciting portion of the event is its beginning and end, called the *ingress* and *egress* for a transit. These are the times of the notorious *black drop* effect, when the limbs of Mercury and the Sun blur together. The cause of the effect is simply imperfect resolution, which is inevitable due to finite-aperture optics, atmospheric seeing and the light fall-off at the Sun's extreme limb.

One project during the period between ingress and egress would be to photograph Mercury's passage at regular intervals and later combine the images to show the planet's path as in Figure 1. If sunspots are on the disk, it would be instructive to compare the supposed blackness of sunspot umbrae with the total blackness of Mercury's disk.

The transit project of the most scientific value is timing the limb contacts, particularly Contacts II and III (which are better defined than Contacts I and IV). When reduced, accurate contact times provide an independent measure of the Sun's diameter – it is still not completely clear if the solar diameter is absolutely constant or indeed whether the limb is precisely circular.

If you time contacts visually, record the moments to 1-second precision; because it will take 3.2 minutes for Mercury's 12.1-arc-second disk to complete ingress or egress, one-second precision in timing represents about 0.063 arc-second precision in the solar diameter. (At the end of this paper, we give some time sources that are accurate to 1 second or better.)

Although requiring some additional equipment, video timing provides a time precision of the duration of one video frame. What one needs for this is the same setup as used for occultation timings: eyepiece video camera, digital video recorder or camcorder and a video time inserter/GPS receiver (the last can be obtained through the International Occultation Association at *videotimers.com*; the unit will display latitude and longitude, along with UTC to 0.001-second precision, at the bottom of each television frame).

We welcome receiving observations of this event, whatever form they take. Besides the usual "metadata" (observer's name and address, instrument aperture and magnification/focal length, sky clarity and seeing) we need observers' latitudes and longitudes to 0.1 degree, or in the case of video timings, to 0.01 degree. Reports should go to either:

- Regular mail address — John E. Westfall, 5061 Carbondale Way, Antioch, CA 94131 USA/
- E-mail address — johnwestfall@comcast.net

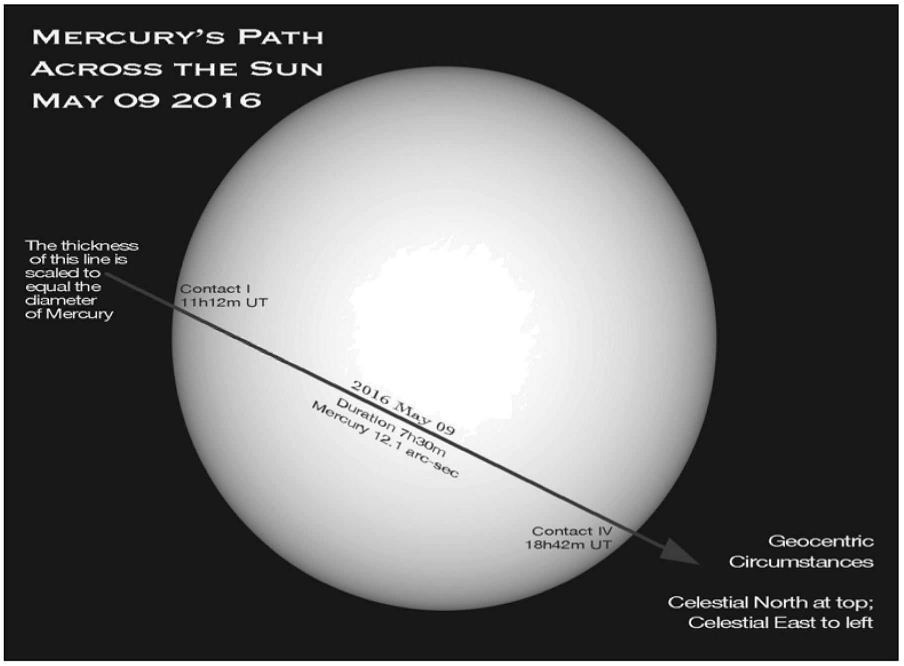

Figure 2. Mercury's predicted path across the Sun on 2016 May 09.