Skywatchers Await the Fleeting Shadow of Venus

On 8 June, Venus will cross directly in front of the sun for the first time in 122 years

Venus usually shines like a brilliant beacon in the morning or evening sky. But on 8 June, our sister planet will assume a darker guise: a circular blot, slowly crossing the sun's face in a dramatic 6-hour "transit."

No one alive has seen this mini-eclipse, which last occurred in 1882. Astronomers of that era launched lavish excursions to capture the event with newly invented cameras. This time, some researchers will use the transit as a dress rehearsal for studying extrasolar planets; others will probe the causes of an odd optical distortion. Space agencies also plan observing campaigns to educate the public about the workings of our clocklike solar system.

Part of that clock is the sporadic timing of Venus transits. The planet rarely crosses a direct line between the sun and Earth, because its orbit tilts 3.4 degrees relative to the plane of Earth's path around the sun. When a transit does occur, a second one usually happens 8 years later. Those who miss the show in June will have another chance in 2012—the last alignment for 105 years.

After the first sighting of a transit in 1639, each one grew in cultural impact. The 1874 and 1882 events were such phenomena that composer John Philip Sousa wrote a march called "Transit of Venus," and a *Harper's Magazine* cover depicted Appalachian children watching the sun through a smoked pane of glass.

Astronomers were captivated as well. "It was like a space race in the 19th century to make accurate measurements of the transits," says NASA chief historian Steven Dick, formerly of the U.S. Naval Observatory in Washington, D.C. Indeed, the U.S. Congress funded eight expeditions in 1874 for a princely $177,000, and Russia fielded a whopping 26 teams. Their goal was the same: to measure the exact moments when the full circle of Venus entered and exited the sun's disk. Once they gauged those times at many places on Earth, astronomers could use surveying methods to calculate the Earth-Venus distance. Then, Johannes Kepler's orbital laws would yield the long-sought "astronomical unit" (AU)—the distance between Earth and the sun.

The answers were close to what is now known to be the true value of about 150 million kilometers, but scientists were skeptical. The problem was the "black-drop effect": a distortion that stretches the silhouette of Venus into the shape of a water drop when the transit begins and ends. "The black-drop effect makes it extraordinarily difficult to determine when the planet's edge actually touches the inner edge of the sun," says astronomer Edward DeLuca of the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts. By the 1890s, other methods for measuring the AU were deemed far more accurate.

Many popular accounts blame the optical tricks on Venus's thick clouds, but astronomers agree that the planet's atmosphere can't bend light severely enough. Sharp observers in the 18th century first suggested another source: Earth's own blanket of air, a deduction confirmed in 2001 by astronomer Bradley Schaefer of Louisiana State University in Baton Rouge. Using computer models, Schaefer showed that smearing within Earth's atmosphere—which also makes stars twinkle—blurs Venus's disk in the telltale way during transits. Diffraction of light within a telescope adds more warping, he noted.

But that's not the full story. When a satellite far above the atmosphere watched a transit by the planet Mercury in 1999, it also spotted a black-drop effect, according to a recent study in *Icarus*. Astronomers Glenn Schneider of the University of Arizona in Tucson; Jay Pasachoff of Williams College in Williamstown, Massachusetts; and Leon Golub of CfA concluded that the effect came from the spread of light within the satellite's camera and the dimmer appearance of the sun's edge, an effect called "limb darkening."

The same satellite—NASA's Transition Region and Coronal Explorer (TRACE)—will observe the Venus transit in June to reveal the relative impacts of each distortion once and for all. "It will solve the black-drop mystery totally," says DeLuca, a TRACE scientist.

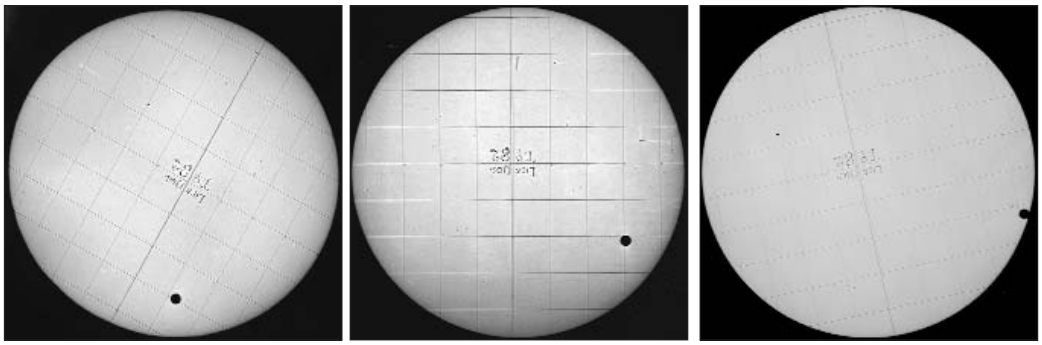
Others on the ground also plan to watch. Astronomers Wolfgang Schmidt of the Kiepenheuer Institute for Solar Physics in Freiburg, Germany, and Timothy Brown of the National Center for Atmospheric Research in Boulder, Colorado, will use a 0.7-meter solar telescope in the Canary Islands to take detailed spectrographic images. They will try to measure wind speeds in the upper atmosphere of Venus by detecting Doppler shifts in the spectral lines of carbon dioxide gas, illuminated by the bright sun behind.

"This is an unprecedented experiment," Brown says. "No one knows how it will work." Ultimately, astronomers might adopt a similar approach to study the atmospheres of transiting planets outside the solar system, he notes. Any such effort would have to be exquisitely sensitive to faint changes in the pattern of a distant star's light.

Beyond the potential research, scientists expect a surge of public interest as the transit nears. Both NASA and the European Southern Observatory are sponsoring public-viewing campaigns* and live Webcasts. Participating students will record transit times and learn how to calculate an AU. Viewers in most of Europe, Africa, and Asia will get to watch the transit from start to finish, although those in the eastern half of the United States must settle for a shorter taste at sunrise. Other Americans will miss out—but a sunset view of the next transit awaits in 2012.

Even grizzled scientists are eager for 8 June to arrive. "The romance and history of Venus transits are wonderful," says Brown. "If nothing else, this will be a great time."

–ROBERT IRION



Sic transit Venus. Skywatchers across much of the globe will see Venus drift across the sun's face on 8 June. These images, from Lick Observatory in California, recorded the last transit in 1882.

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* sunearth.gsfc.nasa.gov/sunearthday/2004 and www.vt-2004.org