

Vol. 41, No. 1

March 2012

# PLANETARIAN

Journal of the International Planetarium Society

## TRANSIT OF VENUS MARCH.

JOHN PHILIP SOUSA.



Copyright MCCCXCVI by J. W. Pepper.



# John Philip Sousa

Large Orchestra (16 Instruments), 75c. Small Orchestra (10 Instr)  
Full Brass and Reed Band, 50c.  
Piano Solo, 50c.

PUBLISHED BY  
**J. W. PEPPER**

PHILADELPHIA:  
Eighth and Locust Streets.

COPYRIGHT, MCCCXCVI, BY J. W. PEPPER

# Going all out for

# Venus



**Chuck Bueter**  
**Transitofvenus.org**  
**Granger, Indiana USA**  
**bueter@nightwise.org**

## We can tie historical lessons to today's exploration

The 2012 transit of Venus brings new opportunities for the planetarium community to lead the public in astronomy exploration. While the rare alignment of Earth, Venus, and the sun is historically significant, we continue to value the transit method for its leading-edge science, specifically now for revealing new planets around distant stars.

Plan now to quench the thirst of an eager public who wants to experience this last transit of Venus in our lifetimes.

### The second of a pair

Transits come in pairs that are eight years apart, separated by a span of 105.5 or 121.5 years. While suggestive artifacts hint at sightings in ancient times, in the era of the telescope the first recorded observation came from Jeremiah Horrocks and his friend, William Crabtree. Horrocks first predicted, then safely projected and observed Venus cross the sun in 1639 during the last 30 minutes of a Sunday.

Stripped of the glare in which it was usually enveloped, Venus in silhouette stood out starkly as a well-defined circle. From that first sighting, Horrocks must have mused like ensuing witnesses, "That's it? It's just a dot—smaller than I expected."

True, the planet is small against the monstrous sun. At  $1/32$ nd the sun's diameter, Venus is only about an arcminute across, which is near the visibility limit of the human eye. Rather than bemoan the diminutive size of the planet—indeed, nearly the size of Earth—one should exalt the enormosity of the sun behind it. Over a million of those black planetary spheres would fit inside the sun.

Edmond Halley realized (and did the math to show) that one could determine the distance from the sun to the Earth, the Astronomical Unit (AU), if observers timed the duration of the transit from known locations around the world. He exhorted his astronomy colleagues to rise to the occasion when the 18th century pair of transits came around.

Like seeing the return of his famed namesake comet, observing the transit of Venus would elude Halley, but his call for a global quest struck a chord and was carried out 20 years after his death.

For the 1761 and 1769 transits of Venus, hopes were high as nations sent a fleet of observers to remote destinations. Halley's vision of accuracy, however, was hindered by the "black drop" effect. (See accompanying story.)

A new century brought the new tool of photography, and in 1874 and 1882 intrepid

astronomers again set out on a global quest to quantify accurately the elusive distance to the sun. The relevance of the transit of Venus as a method for determining the AU was on the wane, however, as other avenues, like asteroid occultations, gained favor.

### Twinkle, twinkle, Kepler star

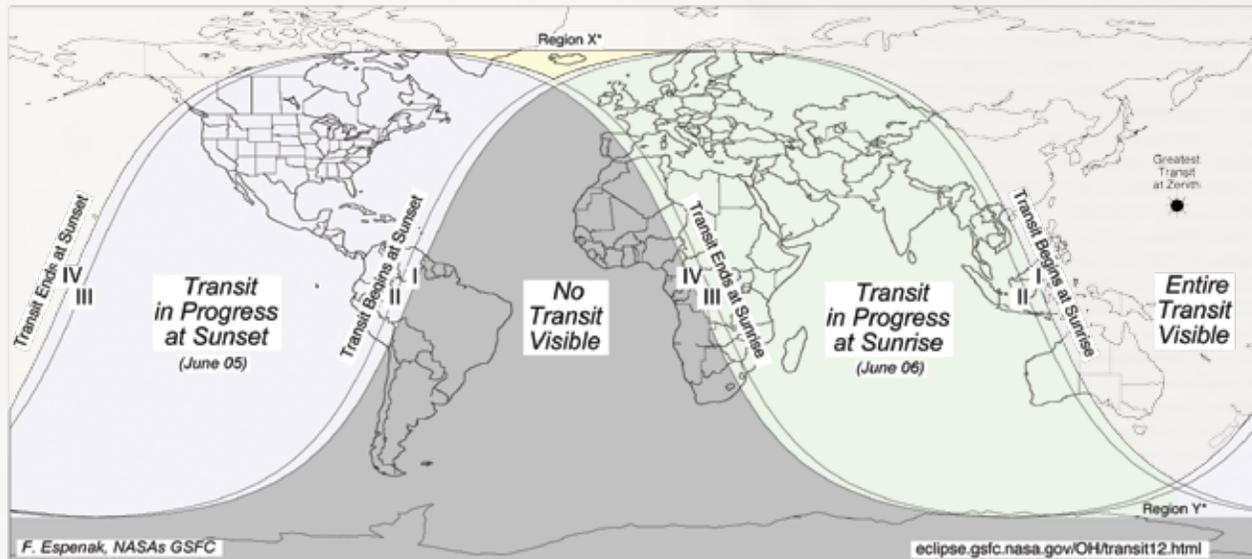
New techniques would seem to make the transit of Venus an historical artifact for serious-minded scientists, but for the 21st century planetarian and others, it retains utility.

With the AU issue resolved, a modern question that attracts the attention of astronomers and the public alike is whether Earth-like planets capable of harboring life exist. With the 2012 transit of Venus, we can enjoy a live, close-up view of this revealing alignment as it demonstrates how we're looking for life elsewhere.

The Kepler spacecraft is peering at about 150,000 stars simultaneously, seeking telltale dips in brightness to indicate planets are crossing their faces. It's like looking down from a skyscraper and trying to discern a periodic dimming in the streetlights that are a few miles away when flying gnats repeatedly encircle the lights.

In December 2011 the Kepler team an-

## Global Visibility of the Transit of Venus of 2012 June 05/06



\* Region X - Beginning and end of Transit are visible, but the Sun sets for a short period around maximum transit.

\* Region Y - Beginning and end of Transit are NOT visible, but the Sun rises for a short period around maximum transit.

nounced detection of the first sun-like star with a planet in the habitable zone, that area where a surface temperature of about 72 F/22 C degrees would allow potential water to be the wet and sloshing type. Suddenly the life-elsewhere notion gets more traction in the realm of possibilities.

The Kepler spacecraft is a transit-lover's dream. Although transits can be detected only in edge-on systems, there are thousands of stars to sample and potentially hundreds of systems that aligned to the craft. While we marvel at our humble transit of Venus during its six-plus hour sojourn across the sun, the Kepler spacecraft will concurrently track more than one hundred suspected exoplanets at some point in their respective transits.

For anyone who is in the dark, literally, during the transit of Venus, you can try to target those parallel star systems in your telescope. Refer to Sten Odenwald's Space Math page at [spacemath.gsfc.nasa.gov/Transit2012.html](http://spacemath.gsfc.nasa.gov/Transit2012.html).

Joining the legions of earthbound telescopes participating in the transit of Venus, the Hubble Space Telescope will apply local lessons to distant stars. Just two days prior to the transit is a total lunar eclipse, so the waning gibbous moon will still be fairly in line with the Earth-Venus-sun line up. Hubble will be aimed at the moon like a giant photometer so astronomers can measure the decrease in sunlight reflected off the moon.

And, if you thought the penumbra during a lunar eclipse was hard to see, imagine this: Hubble will also use a spectrometer to "sniff" the chemical composition of Venus' atmo-

sphere. If you happen to see a fat moon mid-transit, realize some of that moonlight may have been strained through our neighboring planet's clouds.

### On the dome

On his own time, Patrick McPike, multimedia artist and technical director at the Adler Planetarium in Chicago, Illinois, has crafted a short *Transit of Venus* trailer to be viewed either on a flat-screen or in a full-dome format for digital theaters. "I'm working to get people excited and interested in the upcoming transit of Venus," McPike said.

"More effort should be put into informing the public about interesting astronomy and science related activities that they can participate in. To me, it is just as exciting knowing that something I created inspired someone to go out and take part."

The 4-minute micro-show, which introduces the role of transits in our quest to understand our place in the cosmos, is available for free download, with details at [www.transitofvenus.org/planetarian](http://www.transitofvenus.org/planetarian).

It also features the song "Morning Star" by the band Transit of Venus out of New Zealand.

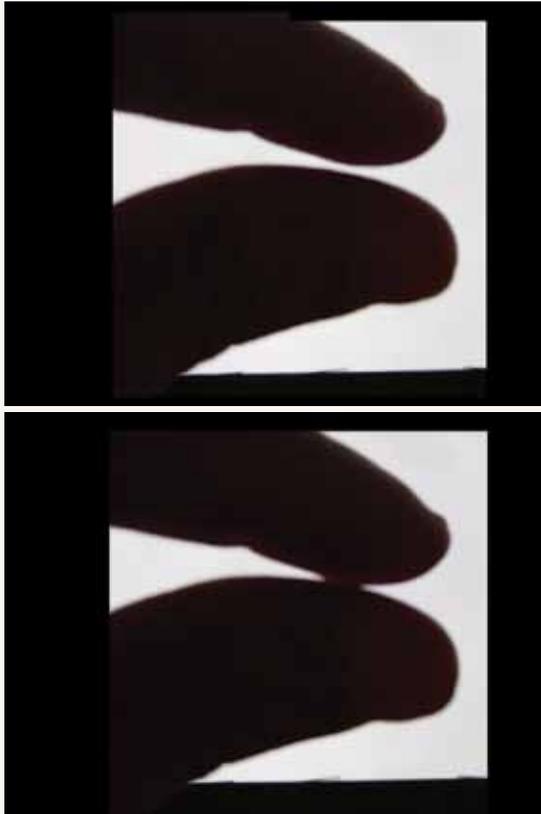
I invite you to show the free trailer, with or without narration written by this author, to all of your audiences as a bonus to your regular programming.

As of this writing, there are a few commercial planetarium programs that feature exoplanets, such as *Extreme Planets* by Clark Planetarium Productions and *Undiscovered Worlds*:

The date of the 2012 transit of Venus depends on your location. For example, for North American observers it occurs on Tuesday, June 5, whereas for Australian observers, all six-plus hours unfold on Wednesday, June 6. Observers at a small northern patch around Iceland will see the transit begin, the sun set, the sun rise, and then the transit end.

Beware that some astronomical tables list the transit as being on June 6, for the naming convention is to title a celestial phenomenon according to the Universal Time of mid-event. If you live in the Americas and you waited until June 6, you'd miss it.

Image courtesy Fred Espenak, NASA/GSFC



## Demo the “black drop” effect

When the disk of Venus is just inside the sun’s limb, it may appear to stretch out to form a ligament with the solar edge. You can simulate the effect by nearly pinching your thumb and finger together while holding them close to your eye and in front of a bright background.

Just before they touch, a black bridge seems to form between them.

Atmospheric perturbations have often been blamed for the “black drop” effect. However, during the 1999 transit of Mercury, the TRACE (Transition Region and Coronal Explorer) spacecraft recorded the telltale smearing even though the spacecraft was above Earth’s atmosphere and Mercury has none.

Astronomers now attribute the conundrum to the combined effects of point-spread function and solar limb darkening. First, all telescopes have inherent smearing of an image from each point spreading out, though less in today’s telescopes than in scopes from previous centuries. Second, the extreme edge of the gaseous sun appears darker in part because the light rays coming from the limb are skimming through more solar atmosphere (analogous to the reddening of the moon at moonrise).

The light we receive from the center portion of the sun, on the contrary, is emanating from deeper within the sun, and is thus hotter. Contributing to limb darkening, the further out you go from that edge, the cooler and darker it gets.

See [www.transitofvenus.org/history/black-drop](http://www.transitofvenus.org/history/black-drop).



Photos by author

*The Search Beyond Our Sun* from the Boston Museum of Science. Both include the transit method.

Bays Mountain Planetarium is working on a transit-specific program called *When Venus Transits the Sun*; see page 64 for more details.

There may be more programs in the works; apologies if I have missed mentioning them.

The Kepler mission, through the Lawrence Hall of Science Planetarium, has been distributing the show *Strange Planets*, with script and media (still images, movies, animations, music) available for free download.

See the article “Share the Hunt for Other Earths” in the March 2009 issue of *Planetarian*, written by Alan Gould, Toshi Komatsu, Edna DeVore, David Koch, and Pamela Harman, for details about the Kepler mission and the show.

This author and planetarian Art Klinger produced the *Transit of Venus* program for the 2004 event with support from the Great Lakes Planetarium Association.

Intended for small venues, it features on DVD a video that is segmented into two dozen chapters so the user can grab the pertinent content. An accompanying CD has individual images, audio, and animations. Made specifically for the 2004 transit of Venus, some of the text is dated and references that year’s celestial alignment.

### Rallying the public

Since the transit is a sun-gazing event that requires addressing safety concerns, planetari-

ums have a front line role in guiding the public.

If you provide telescopes or other equipment for viewing the transit, you will encounter a bottleneck for time at the eyepiece around the four benchmark moments—from the start of the celestial event at first contact through the all-important second contact, then again at the third contact through the end of the event at fourth contact.

To alleviate the crowding at the critical times, I encourage you to build a Sun Funnel, which allows multiple people to view the sun’s projection concurrently without encountering the path of intense sunlight. If you keep a Sun Funnel on a scope next to you, the public can view the transit of Venus continuously while you gaze into your own scope’s eyepiece to time the internal contact.

Instructions written by Richard Feinberg for making a Sun Funnel are available on the Transit of Venus website under the Eye Safety tab, as are other suggestions for safe viewing methods. A workshop for building Sun Funnels is scheduled at the MAPS conference in Toms River, New Jersey, May 16-19, 2012.

Doug Duncan, director of the Fiske Planetarium in Boulder, Colorado, encourages planetariums to build fundraisers around the distribution of viewing aids. For one solar event he got a local newspaper to put 600,000 solar shades\* in the Sunday paper. Another museum, he writes, “bought advertising which was printed on the cardboard temples of the glass-

es. The paper made money, the museum got a big boost in attendance. Their ad said to bring in the glasses for a discount on admission.”

Duncan has a sample letter posted for others to tailor to their respective community newspapers as well as fundraising suggestions. See [casa.colorado.edu/%7Eedduncan/wp/?page\\_id=454](http://casa.colorado.edu/%7Eedduncan/wp/?page_id=454).

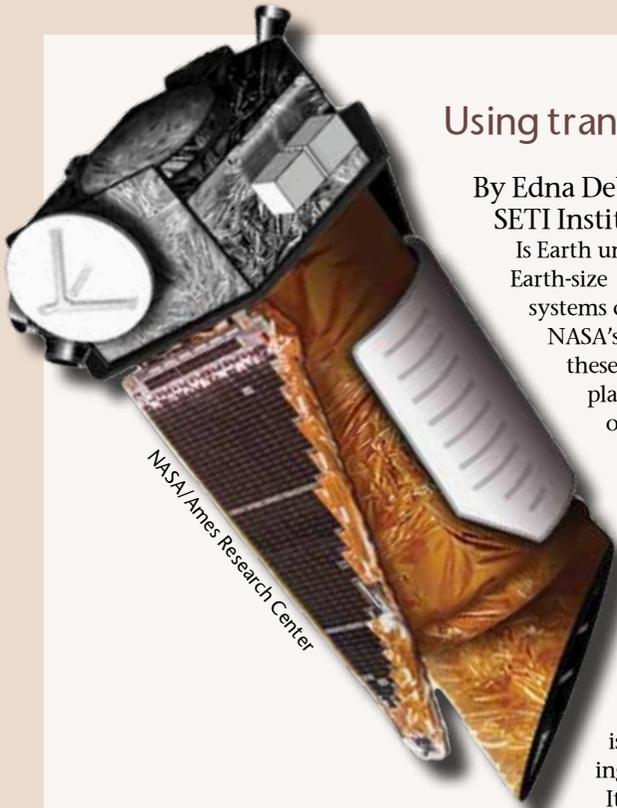
The transit of Venus is a great opportunity to haul out all of those low-grade telescopes that have languished in people’s homes for years. Because gathering light is a non-issue, and because the sun is easy to find even with a poor mount, anything that magnifies sunlight safely can be pressed into service. Obviously, the only caveat is that all properly filter the sun.

### What if it’s cloudy?

A transit of Venus experience should not rely on actually seeing the sun on June 5 or 6. I encourage planetariums to coordinate enough related attractions to overcome any weather- or geography-induced disappointment.

For example, in my community there will be an art exhibit, a small collection of historical artifacts, a lecture series, an orchestral performance of John Philip Sousa’s *Transit of Venus March*, planetarium mini-lessons, in-school activities, and telescope observing during the transit.

If that sounds too complicated, at least be  
(Continues on Page 14)



## Using transits to discover other worlds: NASA's Kepler Mission

By Edna DeVore  
SETI Institute

Is Earth unique in the universe? How many Earth-size planets exist? Are exoplanetary systems common, and what are they like?

NASA's Kepler Mission seeks to answer these questions by searching for exoplanets, especially Earth-size planets, orbiting in the habitable zone of Sun-size stars.

Launched in 2009, the Kepler spacecraft is a specialized, wide-field telescope equipped with an extremely sensitive 96-megapixel photometer. By precisely measuring changes in a star's brightness, the Kepler team discovers planets as they cross in front of their stars. This is the "transit method" for detecting planets.

It stares continuously at more than 150,000 stars so it won't miss a transit.

From the transit data, scientists can determine the size of the planet, the length of its year, and calculate the planet's distance from its star. Combined with Earth-based observations of radial velocity for some planet candidates, the planet's mass, density and possible surface temperature can be determined.

In some of the multi-planet systems, astronomers

observe that the orbital periods vary as the planets interact gravitationally. This is the same sort of orbital variation observed for Uranus that led to the discovery of Neptune. From this analysis, the mass of the planets can be determined.

As of December, 2011, the Kepler team announced 2,326 planet candidates transiting 1,792 stars.

### Kepler and the transit of Venus

The Kepler Mission is named for Johannes Kepler (1571 -1630), who is often honored as the first astrophysicist. A German astronomer and mathematician, his laws of planetary motion were key discoveries in establishing modern science.

Laws I and II show that planetary orbits are elliptical and that the orbital speed of a planet varies according to its distance from the sun. Law III states that the average distance (semi-major axis) of a planet from the sun can be calculated from the planet's year-length.

Today, Kepler mission scientists still use Law III to determine the semi-major axis for each exoplanet from its repeated transits.

In 1627, Kepler published the Rudolphine Tables, a star catalog and tables of planetary positions, and first predicted the transits of Mercury (1631) and Venus (1639).

Johannes did not live to see the transits, but others did. Today, the Kepler Mission uses transits to discover planets circling distant suns. Surely, Johannes Kepler would be pleased and amazed. ☆

## Website references

The 2,326 Planet Candidates in Hi-Res: look for Earth-size planets	<a href="http://kepler.nasa.gov/images/graphics">kepler.nasa.gov/images/graphics</a>
Kepler Exoplanet Discoveries: learn more about discoveries	<a href="http://kepler.nasa.gov/Mission/discoveries">kepler.nasa.gov/Mission/discoveries</a>
Making Transits: demonstration and modeling	<a href="http://kepler.nasa.gov/education/activities/gr68/detectingPlanetTransits">kepler.nasa.gov/education/activities/gr68/detectingPlanetTransits</a>
Explore the Kepler Planet Candidate Data: dive into data	<a href="http://kepler.nasa.gov/dataexplorer">kepler.nasa.gov/dataexplorer</a>
The Real Stuff: the scientific archive of Kepler data at Space Telescope Science Institute	<a href="http://archive.stsci.edu/kepler/">archive.stsci.edu/kepler/</a>
Planet Hunters: join citizen scientists seeking planets	<a href="http://www.planethunters.org">www.planethunters.org</a>
Kepler in the News: popular press and announcements	<a href="http://kepler.nasa.gov/news/nasakeplernews">kepler.nasa.gov/news/nasakeplernews</a>
Kepler Planet Simulator: learn the steps to discovery	<a href="http://kepler.nasa.gov/multimedia/Interactives/keplerFlashAdvDiscovery">kepler.nasa.gov/multimedia/Interactives/keplerFlashAdvDiscovery</a>
Kepler Orrery: watch the systems go!	<a href="http://kepler.nasa.gov/multimedia/animations/scienceconcepts/?ImageID=136">kepler.nasa.gov/multimedia/animations/scienceconcepts/?ImageID=136</a> and <a href="http://kepler.nasa.gov/multimedia/animations/scienceconcepts/?ImageID=137">kepler.nasa.gov/multimedia/animations/scienceconcepts/?ImageID=137</a>
Cruise the Gallery: graphics, animations, models, video productions—higher res versions available upon request	<a href="http://kepler.nasa.gov/multimedia">kepler.nasa.gov/multimedia</a>
Build a Model Kepler Spacecraft: get crafty	<a href="http://kepler.nasa.gov/education/ModelsandSimulations/papermodel">kepler.nasa.gov/education/ModelsandSimulations/papermodel</a>
Kepler Star Wheel: find stars with exoplanets	<a href="http://kepler.nasa.gov/education/starwheel">kepler.nasa.gov/education/starwheel</a>
Lessons and Activities: learn and have fun	<a href="http://kepler.nasa.gov/education">kepler.nasa.gov/education</a>
Space Math: stretch your brain	<a href="http://spacemath.gsfc.nasa.gov/SpaceMath.html">spacemath.gsfc.nasa.gov/SpaceMath.html</a>
Who Was Johannes Kepler? hint: he lived long ago!	<a href="http://kepler.nasa.gov/Mission/JohannesKepler">kepler.nasa.gov/Mission/JohannesKepler</a>
Get Ready for the Transit of Venus: make your plans	<a href="http://www.transitofvenus.org">www.transitofvenus.org</a>
Twitter: get official Kepler Mission tweets	@NASAKepler
Facebook: join the crowd!	<a href="http://www.facebook.com/NASAsKeplerMission">www.facebook.com/NASAsKeplerMission</a>

## Sun Earth Day 2012 Transit of Venus: "Shadows of the Sun"



Wikimedia Creative Commons

Join scientists and educators from the top of Mauna Kea, Hawaii, which is the best viewing spot in the world for the 5 June 2012 transit of Venus.

NASA's Sun-Earth Day Team and its partners will bring you a live webcast so that you won't miss this last-in-our-lifetime event, as the transit will not be visible again until 2117.

The transit of Venus is important for both its rarity and its role in helping scientists to determine the distance of Earth from the sun, the "astronomical unit" from which the distances to all the other planets could be derived. The transit method is also used to discover exoplanets as they pass in front of their host stars.

If your planetarium or museum is planning events for the transit of Venus, please add them to our Google Map so that others in your area can join you for the preparation or celebration.

Scientists, amateur astronomers, and educators may sign up on the Sun-Earth Day website to receive e-news and to download education and presentation materials. Visit [sunearthday.nasa.gov](http://sunearthday.nasa.gov) for further information. ☆

(Transit, Continued from Page 12)

prepared to broadcast the NASA Sun-Earth Day live webcast from atop Mauna Kea in Hawaii. Live video and expert commentary will partially compensate for the frustrations of cloudy weather, as well as complement your program if you have clear skies on transit day. (See accompanying story.)

Be sure to upload your event to the Sun-Earth Day Event Locations map. The NASA Sun-Earth Day ([sunearthday.nasa.gov/2012](http://sunearthday.nasa.gov/2012)) team is also mailing free resources to educators who sign up, including people outside the United States, while supplies are available.



Modeled after a window at St. Michael Church in Hoole, England, the [transitofvenus.org](http://transitofvenus.org) website has several activities using this unique shape. "Create Your Own Stained Glass Window" provides a fill-in template; another is a poster that you can customize for your facility. Courtesy the author.

### There's an app for that

Each century the transit of Venus came along, scientists brought new tools—from telescopes to photography to satellites—to the task of manipulating the spectacle to gain valuable information. In 2012, we have new assets that did not exist a mere eight years ago, particularly in communications.

Steven van Roode of the Netherlands has been especially valuable for offering local observing circumstances for observers, for his prolific contributions to a transit of Venus blog, and for initiating the Transit of Venus phone app ([transitofvenus.nl/wp](http://transitofvenus.nl/wp)).

Rather than having a handful of trained scientists around the world at known locations timing the transit, as was done in the past, the free phone app allows citizens to tap a button on their smartphones, which then send the GPS locations and observed contact times to a database to quantify the AU. Astronomers Without Borders is partnering with van Roode to implement this project.

There is a deep pool of math into which educators can wade with the transit of Venus. Two good resources are van Roode's *Transit of Venus Workbook* and Sten Odenwald's (NASA GSFC) *Transit Math* series on the Sun-Earth Day website. For middle school students and above, the Kepler team coordinates a hunt for exoplanets, and the demonstrations with a photometer and orrery are especially engaging with kids.

More education ideas are under the Teacher Resources menu at [www.transitofvenus.org](http://www.transitofvenus.org) and listed in the Website references box on page 13. The Transit Frequency Activity uses a simple paper plate to explain the strange but regular pattern in which transits come in pairs separated by 105.5 or 120.5 years.

An easy activity to do immediately after the transit of Venus is the Stained Glass Win-

dow Activity, in which observers draw their impression of the experience in a roundel printed on a transparency, akin to the windows honoring Jeremiah Horrocks at St. Michael's Church in Hoole, England. In the banner write commemorative words, then simply color remaining panes segments and affix to a window.

### The Venus illusion

After the 2004 transit of Venus, the one observation which people were most eager to share with me was their sighting Venus in transit when the sun was at the horizon. A Venus illusion, akin to the moon illusion, enthralled observers who had an ideal, clear horizon.

I know it is contrary to all advice about looking at the sun with the naked eye, but I also know everyone has looked at a sunset, when the edge of the sun makes its own contact with the distant edge of Earth. If your location has those circumstances, witness Venus at sunset and write down your observations for later reference.

### Seize the daylight

If the 2012 transit of Venus trends like its 2004 cousin, expect a huge surge in popularity in June.

Sure, you should guide your community to experience safely this elegant celestial rarity. But don't let the burdens of accommodating an audience at a sun-aimed telescope prevent you from enjoying Venus' moment in the sun. Savor the sight; bask in your good fortune to witness it; share your experience in writing afterward.

The planetarium landscape will likely be vastly different in 2117 and 2125, but the awe elicited by Venus passing in front of the sun is timeless. ☆