Media contact: Jay M. Pasachoff, eclipse@williams.edu; cell: 617 285 6351 (Hawaii time zone: EDT–6)

Astronomers and students from Williams College to study the transit of Venus

WILLIAMSTOWN, Mass. -- The June 5 transit of the planet Venus across the face of our Sun, a rare event that won't recur until 2117, is the subject of detailed study by a team of faculty and students from Williams College and their collaborators around the country and the world. They will be observing the event from the 10,000 foot location of the University of Hawaii's Mees Solar Observatory on Haleakala, a dormant volcano on Maui, in a Science Park of telescopes there that is soon to contain the Advanced Technology Solar Telescope. Their work is sponsored by a research grant from the Committee for Research and Exploration of the National Geographic Society.

Jay Pasachoff, Field Memorial Professor of Astronomy at Willliams College, and Glenn Schneider, of the Steward Observatory of the University of Arizona, have made extensive studies of the 2004 transit of Venus and the 1999, 2003, and 2006 transits of Mercury, and published articles in scientific journals about their results. They solved the problem of the black-drop effect that had bedeviled astronomers for hundreds of years by preventing accurate timing of Venus's entry into and exit from the solar disk, and analyzed Venus's atmosphere as it emerged into view in spacecraft observations of the 2004 transit of Venus, the first to occur since 1882. Pasachoff reports that "It was fun for Glenn and me to be able to solve a problem in astronomy that was hundreds of years old, but we are now more interested in a 21st-century topic that can be uniquely studied at the transit: conditions in a high level of Venus's atmosphere of which we will be able to observe a long arc at the same time that a spacecraft will be sampling a smaller portion." Also, "In recent years, thousands of exoplanet candidates have been found around other stars by their transits across their parent stars, and it is clear that the most detailed possible observations of the coming transit of Venus as seen from Earth can inform exoplanet researchers about the details of what is going on when they observe transits around stars thousands of light years away."

Pasachoff is already working on Haleakala with Dr. Bryce Babcock, Research Associate in the Astronomy Department of Williams College, and undergraduate student Muzhou Lu '13 (from Brooklyn, NY), where they are being joined by Schneider. They are coordinating with observations to be made by Williams College alumnus Kevin Reardon '92, of the Arcetri Observatory in Florence, Italy, with the giant Dunn Solar Tower at the National Solar Observatory's Sacramento Peak Observatory in Sunspot, NM. Pasachoff, Babcock, Lu, and other Williams College undergraduate students visited that site last week, following their observations of the annular solar eclipse at the nearby Jansky Very Large Array, also in New Mexico. Reardon will be using an imaging spectrograph known as IBIS, which is capable of high-resolution observations of Venus's atmosphere. Grants from the National Geographic Society and the American Astronomical Society allowed the purchase of a special filter for IBIS at the wavelength of carbon dioxide, the major constituent of Venus's atmosphere but not a normal part of the solar astronomers' repertoire.

Pasachoff and Schneider are collaborating with scientists who operate several spacecraft that study the Sun on transit observations. Their 2004 observations, published in *The Astronomical Journal* in collaboration Dr. Thomas Widemann of the Observatory of Paris, were based on observations with NASA's Transition Region and Coronal Explorer spacecraft, known as TRACE. They had published an article about the black-drop effect with Dr. Leon Golub of the Harvard-Smithsonian Center for Astrophysics, who designed and built the main imaging telescope on both that spacecraft and its successor, NASA's Solar Dynamics Observatory. Though they had aimed their 2004 TRACE observations at testing their conclusions about the source of the black-drop effect, which turns out to have a lot to do with the solar limb darkening, an effect resulting from the gaseous nature of the solar atmosphere, their 2012 observations are directed more toward Venus's atmosphere. Pasachoff was coauthor with Paolo Tanga of the Observatoire de la Cote d'Azur in Nice, France, with Widemann and Bruno Sicardy of the Observatory of Paris, and others about a more detailed analysis of space-based and ground-based observations of Venus's atmosphere at the 2004 transit of Venus.

For the 2012 transit of Venus, Pasachoff and Schneider are working with Golub and other colleagues about the observations in the extreme ultraviolet to be made with the Atmospheric Imaging Assembly of the Solar Dynamics Observatory; with Dr. Philip Scherrer of Stanford University about the observations in visible light of the Sun and its magnetic field to be made with the Helioseismic Magnetic Imager of the Solar Dynamics Observatory; with Dr. Alphonse Sterling of NASA's Marshall Space Flight Center and others about observations to be made with the high-resolution Solar Optical Telescope, an instrument on the Japanese Hinode ("Sunrise") spacecraft developed with US collaboration; and Golub and Dr. Kathy Reeves of the Harvard-Smithsonian Center for Astrophysics about x-ray observations to be made with the XRT instrument also aboard Hinode.

Further, Pasachoff and Schneider are collaborating with scientists who have spacecraft in orbit that measure the total amount of energy coming from the Sun each second, known as the Total Solar Irradiance. They are again working with Dr. Richard Willson of Columbia University and NASA's Jet Propulsion Laboratory in the intepretation of the data he gets with his ACRIMsat in orbit. Their joint article in *The Astrophysical Journal* about the Total Solar Irradiance observations at the 2004 transit, which showed a drop in the solar intensity of 0.1% when Venus was on the solar disk and also showed the result of solar limb darkening, was an analogue to the types of transit observations made by scientists using NASA's Kepler spacecraft and other instruments on the ground and in space. For the 2012 transit, they are also collaborating with Dr. Greg Kopp of the University of Colorado on the interpretation of data from his Total Irradiance Measurement device on NASA's Solar Radiation and Climate Experiment (SORCE) spacecraft, known as SORCE/TIM.

Pasachoff, Schneider, Babcock, and Lu will be joined in their observations on Haleakala by Aram Friedman (AnsibleTech, Princeton, NJ), Michael Kentrianakis (New York), Robert Lucas (University of Sydney), and Ronald Dantowitz (Dexter Schools, Brookline, MA). They are collaborating on Haleakala on a variety of imaging projects with Rob

Rakowski of the Observatory, and at the Mees Solar Observatory with University of Hawaii solar scientists Jeff Kuhn, Stuart Jefferies, and Garry Nitta, who are providing three MOTHs (Magneto-Optical filters at Two Heights) that can measure the polarization of Venus's atmosphere, each at a specific wavelength. Joel Moskowitz and Craig Small will join the group on Haleakala to make observations, as will Naomi Pasachoff, Phyllis Babcock, Raisha Friedman, and Nira Small.

Pasachoff and Schneider are also in liaison about transit observations with Dr. Phil Goode of the New Solar Telescope at the Big Bear Solar Observatory at Big Bear, California, represented by Dr. Joseph Gangestad '06, now of Aerospace Corp.; and with Dr. Mark Giampapa of the National Solar Observatory on Kitt Peak, Arizona.

The wind weather atop Haleakala is a major potential problem for the observers of the transit, which will begin shortly after noontime in Hawaii. Winds have reached 65 miles per hour recently, and could be strong enough to prevent the opening of the telescope dome, as happened for a part of the 2006 transit of Mercury there when Pasachoff and Schneider and undergraduate Suranjit Tilakawardane observed from the same location. The air is thin at the 10,000 foot altitude of Haleakala, ideal for astronomy but difficult for observers. (It is less difficult for observers, though, than the 13,800-foot altitude of the Mauna Kea Observatory, home of many nighttime telescopes.) Mountaintop weather in Hawaii is very different from the oceanside weather many people associate with the Hawaiian islands.

Following the transit, Pasachoff will lecture at 7 pm two days later at the Kahilu Theatre in Waimea, on the Big Island of Hawaii, part of the Makana Series of lectures hosted by the Keck Observatory. The following Monday, June 11, at 8 pm, Pasachoff will address the meeting of the American Astronomical Society in Anchorage, Alaska, about the transit, and he has been promised preliminary results and observations from most of the variety of professional observational telescopes and spacecraft that will study the transit.

The transit of Venus will be visible in part across the continental United States, though its whole six hours are visible only from Hawaii and Alaska west across the Pacific to New Zealand, eastern Australia, and most of western Asia. Major public outreach programs are under way, including Sun-Earth Day sponsored by NASA (sunearthday.nasa.gov), about which Pasachoff has collaborated with Lou Mayo and Elaine Lewis of NASA's Goddard Space Flight Center. Their website includes a Google map that shows locations where telescopes will be made available to the public for observation of the transit. One location, for example, is the High Line in New York City (http://www.aaa.org, for the Amateur Astronomers Association of New York).

Pasachoff has a website about past, current, and future transits of Mercury and Venus at http://www.transitofvenus.info. Other excellent transit websites are Chuck Bueter's at http://www.transitofvenus.org and Steven van Roode's at http://www.transitofvenus.nl. The latter includes a link to an iPhone app with which people can participate in a worldwide effort to use a 1716 method of Edmond Halley to find the distance from the Earth to the Sun. Though that distance is now well known through other means, finding

it with this method was the reason for hundreds of international expeditions in the 18th and 19th centuries, with the black-drop effect a major limitation to the resulting accuracy.

Pasachoff has collaborated with Dr. William Sheehan, a historian of science from Minnesota, on analyzing the original discovery of Venus's atmosphere. They have concluded, and published in the current issue of the Journal of Astronomical History and Heritage, that the great Russian scientist Mikhail Lomonosov, who is widely credited with discovering Venus's atmosphere at the 1761 transit from St. Petersburg, probably saw only an artifact related to the type of blurring involved in the black-drop effect, but advanced the idea that Venus had an atmosphere because of his religious belief in the plurality of worlds. Philadelphia astronomer David Rittenhouse was one of those 18th-century astronomers who actually did see and report on Venus's atmosphere. A variety of antique telescopes from decades or hundreds of years ago will be used to make modern measurements of what observers from historical times could have seen. A major set of such observations with antique telescopes will be made from Mt. Wilson, California, site of the major 100-inch telescope and other telescopes built in the early 20th century. Mike Simmons and John Briggs are heading that effort. A coronagraph telescope of Pasachoff's at Williams College is being brought by Briggs to the Mt. Wilson site to attempt observations of Venus's atmosphere in the 10 minutes or so before Venus entirely enters the Sun's disk.

Pasachoff and Babcock are also participating in a worldwide network of observers organized by Tanga of Nice and Widemann of Paris with 9 identical coronagraphs specially made for the transit. These devices hide the ordinary solar disk to make structure above the solar limb better visible; Haleakala, with its high altitude and clean air in mid-Pacific, has long been one of the world's best coronagraph sites. In addition to the Williams College site at Haleakala, Widemann will have one of the instruments in Hokkaido, Japan; Tanga and Sheehan will have two of the instruments with yellow (visual) filters at the Lowell Observatory in Arizona; and other instruments will be at the Moondara Observatory on Mount Isa in Queensland, Australia, with an infrared filter; Tien Shan Observatory in Kazakhstan with a blue filter; Taiohae, Nuku Hiva in the Marquesas Islands in mid-Pacific with a red filter; Svalbard, the Arctic Norwegian island that will be the main site for total-eclipse observations in 2016 with an infrared filter; and the Udaipur Observatoryu in India with a red filter. A different coronagraph will be used in Ulaanbaatar, Mongolia with a red filter.

Note that for the entire transit, observers are looking directly at the Sun, which will be dimmed by only a tenth of a percent, so safety instructions for eye protection will always be in effect. Observers should use special solar filters that cut out all but about one part in 100,000 not only in the visible part of the spectrum but also in the invisible infrared. Among the devices NOT safe to use are sunglasses (no matter how many pairs are stacked in sequence), color film, black-and-white fogged and exposed film that doesn't have silver contact, and smoked glass (since the smoked area can smear). A safe method of observing the transit includes use of a pinhole camera, in which you stand with your back facing the Sun and look at an image on a wall projected from a hole about 1/4" or 1/2" across in paper or aluminum foil. Similarly, binoculars or a telescope can be used to

project such an image, with observers being careful not to look through the binoculars or telescope at the Sun but to look away from the Sun at the projected images. Some information on safe solar observing, which is the same for the transit of Venus as it is for solar eclipses, at Pasachoff's website for the International Astronomical Union, of which he is Chair of the Working Group on Solar Eclipses, at http://www.eclipses.info.

_____

Pasachoff's outreach sites:
http://www.pbk.org/home/FocusNews.aspx?id=885
which includes a 22-minute lecture about transits of Venus

http://365daysofastronomy.org/2011/06/05/june-5th-transit-of-venus/
which includes a description from one year in advance; a 2012 podcast will be available on the http://365daysofastronomy.org website before transit day, tentatively May 30.

http://www.academicminute.org
"The Academic Minute" to be broadcast June 4 on Public Radio, or subscribe to the program's podcast.
http://maps.google.com/maps/ms?hl=en&ie=UTF8&msa=0&msid=218117814923339210114.00049eb26e3add8477d53&ll=37.300275,-96.152344&spn=31.755358,56.513672&source=embed

http://transitofvenus.nl/wp/2011/10/16/four-giants-talk-about-transits/
Watch the video series "Four Giants Talk About Transits," a series of four talks about the transits of Venus from last October's meeting of the American Astronomical Society's Division of Planetary Science in Nantes, France.

http://newswatch.nationalgeographic.com/2011/03/01/watch_planet_transit_2012_venus/
Interview on National Geographic's Breaking Orbit blog

http://www.nytimes.com
Op-Ed piece by Prof. Pasachoff expected on June 2 or 3

http://www.sciam.com
postings expected a few days before transit day

A chapter of Pasachoff's *Complete Idiot's Guide to the Sun* is devoted to the transit of Venus; the whole book is available free online at
http://books.google.com/books?id=SRnPp61DDRQC&pg=PA120&lpg=PA120&dq=nasa+image+imager+magnetopause+aurora+2004+july+26&source=bl&ots=_SBRlQrrAa&sig=ZzOICvFTx3QC8JjtxCUjIzU7dN4&hl=en&sa=X&ei=UNZfT8GSOIK40gHMqcnHBw&ved=0CCAQ6AEwAA#v=onepage&q=nasa%20image%20imager%20magnetopause%20aurora%202004%20july%2026&f=false

Pasachoff, Jay M., 2012, "Transit of Venus: Last Chance From Earth until 2117," Physics World, 25 (5), 36-41, May.
http://physicsworld.com/cws/article/indepth/2012/may/01/venus-its-now-or-never

Pasachoff, Jay M., 2012, "Transit of Venus: Last Chance to See," *Nature* **485**, 303-304, 17 May;
http://www.nature.com/nature/journal/v485/n7398/full/485303a.html

Central for Inquiry, Toronto, Canada
Episode 5: The Transit of Venus, with Jay M. Pasachoff
www.starspotpodcast.com

Website at Williams College and the International Astronomical Union Working Group on Eclipses
http://www.transitofvenus.info

_____

Some other websites about the transit:
http://www.transitofvenus.org from Chuck Bueter
http://www.transitofvenus.nl from Steven van Roode
http://venus2012.de from Udo Backhaus
with applet Applet: The Transit of Venus on 2012 June 6
http://sunearthday.nasa.gov from NASA's Goddard Space Flight Center

http://www.eclipse-maps.com from Michael Zeiler
or directly to: http://www.eclipse-maps.com/Eclipse-Maps/Transits.html
with the best map of all that are currently available at:
http://www.eclipse-maps.com/Eclipse-Maps/Transits_files/ToV2012map_1.jpg

http://eclipse.gsfc.nasa.gov/OH/transit12.html from Fred Espenak, retired from NASA's Goddard Space Flight Center

http://www.space.com/15541-venus-transit-sun-2012-guide-infographic.html
from space.com

Calculators of local circumstances (EDT=UT–4 hours; PDT=UT–7 hours); Hawaii Standard Time = UT–10 hours):
Xavier Jubier has a calculator at
http://xjubier.free.fr/en/site_pages/VenusTransitCalculator.html
Steven van Roode has a calculator at:
http://transitofvenus.nl/wp/where-when/local-transit-times/

_____

financial ability, and the college provides grants and other assistance to meet the demonstrated needs of all who are admitted.

To visit the college on the Internet: http://www.williams.edu/ Williams College can also be found on Facebook: http://www.facebook.com/williamscollege and Twitter: http://twitter.com/williamscollege

At www.forbes.com/top-colleges/list/
1 Williams College
2 Princeton University
3 West Point
4 Amherst
5 Stanford University
6 Harvard University
7 Haverford College
8 University of Chicago
9 MIT
10 Air Force Academy
with methodology at
http://www.forbes.com/sites/michaelnoer/2011/08/03/americas-top-colleges

At colleges.usnews.rankingsandreviews.com/best-colleges
for National Liberal Arts College
1 Williams College