Nineteenth Century Space Race

A transit is the crossing of the Sun by a planet. This is visible from the Earth only for Mercury and Venus. The 1874 transit of Venus was studied by 56 expeditions from six countries – and the eight expeditions from the U.S. eventually spent $375,000. This led Laurence Marshall of Gettysburg College to subtitle his lecture on "The Transit of Venus" to the Amateur Astronomers Association of New York at the Kauffman Auditorium of the American Museum of Natural History on 6 October 2006 "The Space Race of the 19th Century."

Marshall pointed out that transits are useful in determining relative distances in the solar system. Earlier estimates imagined the solar system to be much smaller, he noted: Copernicus' values, based on results from Ancient Greece, were about a twentieth of the presently-known values. When Pierre Gassendi saw the 7 November 1631 transit of Mercury, predicted in Kepler's *Rudolphine Tables* published that year, he was surprised how small Mercury's disk appeared. Marshall observed that Kepler missed a transit of Venus in 1639 but added that Jeremiah Horrocks both predicted and observed it. William Crabtree also observed it. Both projected the image of the transited Sun onto a wall.

Edmund Halley proposed a way, based on parallax, to use transits to determine the actual distance from the Sun, accurately to one part in 500. But this required two simultaneous measurements, not an easy feat in those days, although it could be compensated for by measuring the time duration of transit. Marshall reported that people sought to employ Halley's method with the transits of Venus in 1761 and 1769.

According to Marshall, observers of the 1761 transit of Venus included Charles Mason and Jeremiah Dixon, who observed it in Capetown after a run-in with the Royal Society in view of American-British disagreements resulting from the French and Indian War. A key observer of the 1769 transit was Capt. James Cook, who observed it in Tahiti before he discovered Australia and New Zealand. Cook noted a "black drop" on Venus which made the time of the onset of the transit uncertain by 30 seconds. This led to a four million mile uncertainty in the measured value of the Astronomical Unit (AU) -- between 92 and 96 million miles, with 95 million miles as the "best value."

Much research preceded observations of nineteenth century transits of Venus, Marshall went on to say. Janssen built a "Revolver" camera to take the equivalent of a movie of the transit. The "black drop" effect continued to plague results, but by then Simon Newcomb had developed another way to measure the AU. Marshall added that John Philip Sousa even composed a "Transit of Venus" march and wrote a story, "The Transit of Venus," about astronomers seeking to get away from women by going on an expedition.

Only a handful of transits of Venus have occurred, though Venus passes the Earth in its orbit around the Sun approximately once every 1.6 years. The reason for this, Marshall explained, is that transits occur only when Venus and Earth are both at the note of intersection of Venus' and Earth's orbit. This occurs during conjunctions that occur in June (ascending node) or December (descending node). When a transit of Venus occurs, it is usually followed by a second one eight

years later (the time for the planets to align again after five more conjunctions), but after that either 105.5 or 121.5 years must pass before the two planets are aligned for another transit. Transits of Mercury are more common, Marshall added, because Mercury is closer to the Sun; but, also because Mercury is closer to the Sun, its transits are harder to measure.

Marshall concluded by observing that distances in the solar system are measured today by parallax or the round-trip time for a laser signal. Following the most recent transit of Venus in 2004 is another in 2012, he reported, but after that comes a long waiting time. The next transit of Mercury came little more than a month after Marshall's lecture -- on 8 November 2006. Marshall stated that the "gong" telescopes transmit pictures of the Sun every four minutes to the Internet. These pictures, he noted, allow anyone to watch a transit (of either Mercury *or* Venus).