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The 2012 transit of Venus

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"...Thy return
Posterity shall witness; years must roll
Away, but then at length the splendid sight
Again shall greet our distant children's eyes."

(Jeremiah Horrocks, writing of his first observations of a Transit of Venus, that of 1639)

The evening of June 5 in the western hemisphere (US/Canada/Central America/Northwest South America), or during the day of June 6 in the eastern hemisphere (Europe, central and western Asia, eastern Africa, far western Australia), marks the return of one of the rarer celestial alignments.

This is the transit of Venus, when the Sun, Venus and the Earth are lined up, so that Venus appears to pass across the Sun, as viewed from Earth. Over an interval of six hours, observers on the Earth (with appropriate safe viewing equipment) will witness the silhouette of Venus slowly cross the brilliant solar disk.

Unlike many celestial chance alignments, this event has attracted some global press. Although the 2012 transit is of far less scientific significance, the eighteenth century transits of Venus occasioned the first truly global international scientific expeditions—and the first clash of organized scientific enterprise with the division of the world into rival national states.

The contemporary picture of our solar system, with elliptical planetary orbits about the Sun, was developed conceptually by Copernicus and first concretized mathematically in the three laws of planetary motion published by Johannes Kepler in 1609 and 1619. These laws established the relative scale of the orbits of each of the Sun's planets in relation to their orbital periods, but said nothing about the absolute distances involved.

The Earth-Moon distance itself had been measured two millennia earlier, by the classical Greek astronomer Hipparchus, in the second century BCE. He used the method of parallax, in which two separated observers measure the apparent displacement of a nearer object against a distant background. The Moon's relative nearness allowed Hipparchus to coordinate observations within the relatively small Greek empire that showed the Moon slightly displaced against the background stars: his measurement comes to within 10% of the modern value.

The Moon orbits at a mean distance from the Earth of 385,000 km (240,000 miles). The solar system, however, is on a significantly larger scale. The apparent lack of parallax of the planets against the background stars demonstrated to observers of that epoch that planetary distances were significantly greater.

Kepler's theory of the solar system, though it did not give absolute distances, immediately predicted that the closest approach of any other solar system body to the Earth was that of Venus as it passed between the Earth and the Sun. If that distance could be measured with accuracy, the entire edifice of the solar system would then be sized at the appropriate scale and the first accurate quantitative model of the local universe would be completed.

This measurement of Venus's displacement against a distant background could be made in a number of ways. Venus could be observed against a background of distant stars by distant observers some weeks from its close approach, when its distance from the Sun still permitted observations at dusk with Venus still in the sky and the Sun beneath the horizon. But Kepler himself had predicted that Venus would occasionally be seen to cross the solar disk itself. By 1663, Scottish mathematician James Gregory had noted that observations of Mercury transits could be made by astronomers almost the full diameter of the Earth apart: some 11,000 km (7,000 miles), at the exact time of closest approach of Mercury to the Earth. But Mercury is three times further away than Venus at close approach.

Edmund Halley, actually observing a Mercury transit in 1676, concluded that the much rarer transits of Venus offered the only accurate way, given the limitations of seventeenth century technique, to calibrate the scale of the solar system with any reasonable accuracy. Venus was thought to make a close approach of some 20 million miles; thus its parallax was 100 times smaller than that of the Moon, presenting challenges both to obtain larger separation between ground observers and to use the very best available technique and instrumentation.

The transits of Venus obey a peculiar periodicity: in the present epoch, transits occur in pairs separated by 8 years (the last previous transit before this week's occurred in 2004). Between pairs, an interval of either 121.5 or 105.5 years takes place.

For Halley, the next transit of Venus would not occur until 1761: too late, since he died aged 85 in 1742. But Halley's call for a coordinated program to observe the 1761 transit (and the later of the pair in 1769) found wide resonance among world astronomers, and also became tied up in considerations of national prestige.

Amidst the worldwide dislocations of the Seven Years' War (1756-1763), astronomers from most European countries, the Americas, and Russia (Catherine the Great dispatched no fewer than eight expeditions) found patronage and ventured to distant points of empire (or sought accommodation in friendly territories), enduring every deprivation and risk that accompanied international travel of that era.

Deep contradictions beset these expeditions. Military ships and crews carried scientists to locations where disembarkation would be difficult or impossible due to national conflicts. Captain James Cook, the famed British navigator and captain, was dispatched in 1766 ostensibly to carry a scientific expedition on his first voyage to the Pacific for the 1769 transit. He carried sealed orders, however, to secretly set search for the rumored but unknown rich southern continent of "Terra Australis" following the transit observations.

The tales of personal sacrifice connected with the efforts to observe the eighteenth century transits of Venus have filled several books. One such story must serve here:

French astronomer Guillaume Le Gentil set sail for the French-controlled port of Pondicherry in India in 1760. Arriving only two weeks before the transit, he found the port taken by the British, and going ashore was impossible. Le Gentil's observations from the rolling boat proved valueless. He decided to wait in India for eight years for the second transit of the pair, during which time Pondicherry was retaken by the French. This second attempt at observations failed, and after a near breakdown, Le Gentil returned to Paris in 1771, to find his estate divided up amongst his heirs, who had thought him dead.

Although the transit measurements themselves proved more difficult than forecast, they established the scale of the solar system to about 1 percent accuracy, inaugurating modern precision cosmology, if only for the solar system.

Once the size of the solar system was known, the diameter of the Earth's orbit, calculated at 300,000,000 km (186,000,000 miles), could be used as the baseline for the same parallax technique, on a far vaster scale, to determine the size of the world outside the solar system.

Using this technique, Friedrich Bessel succeeded for the first time in 1838 to detect the displacement against background stars of the comparatively nearby star 61 Cygni, which he measured to be 107 trillion km (67 trillion miles) distant.

The accurate scale of the solar system also permitted for the first time a measurement of the speed of light itself. The speed of sound in the Earth's atmosphere had first been measured by William Derham in 1708. The speed of light is over a million times faster and requires vastly improved technique. Laboratory measurement of this speed would not take place until 1849, by Hippolyte Fizeau.

But Danish astronomer Ole Rømer had noted in 1676 that the clockwork motions of Jupiter's moons seemed to slow and speed as Jupiter's distance from Earth grew and fell through the mutual motions of Jupiter and the Earth. He correctly interpreted this as a changing delay due to a fixed speed of light itself. Without accurate knowledge of the absolute size of the solar system, however, his observations could not provide a measurement of the speed of light itself. With the 1761 transit of Venus observations, this velocity, so vital to physical law today, was determined to similar accuracy as the scale of the solar system: about 1 percent.

In the twenty-first century, distances in the inner solar system can be determined directly, by painting planetary surfaces with radar beams and observing the reflections. Some positions are known to the meter or better. Accordingly, direct observations of the transit are now relegated to a historical curiosity.

The contradictions between scientific exploration as a generous impulse of human curiosity and the negative impact of nation-state competition remain, however. In February 2012, NASA reminded scientists receiving US government funds that according to the language attached in 2011 and 2012 appropriations bills, they were forbidden to "develop, design, plan, promulgate, implement, or execute a bilateral policy, program, order, or contract of any kind to participate, collaborate, or coordinate, bilaterally in any way with China or any Chinese-owned company unless such activities are specifically authorized." Universities are further required to sign Assurances of Compliance with these instructions.

The chilling effect of such language is clear. The highest levels of scientific work, being necessarily international, can only be conducted after science is freed from the fetters of the restrictions placed upon it by competing nation-states. As with the reorganization of industrial production for public need rather than private profit, a rational realignment of scientific work can only be accomplished by the independent mobilization of workers and scientists to fight for a socialist reorganization of the whole of society.