Book Review

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Meeting Venus—a Collection of Papers Presented at the Venus Transit Conference, Tromsø 2012

Christiaan Sterken and Per Pippin Aspaas, eds., 2013, 256 pages, paperback, ISBN 978-82-8244-094-3, Vrije Universiteit Brussel, and University of Tromsø, available in open access (http://www.vub.ac.be/STER/JAD/JAD19/jad19_1/jad19_1.htm).

On June 6, 2012, the planet Venus passed across the face of the Sun, as seen from the Earth. The brightness of the Sun (if you could measure it precisely) would have decreased by about 0.001 magnitude, adding to the Sun's status as a variable star. More to the point: a transit of Venus (or Mercury) is a graphic demonstration of what an exoplanet transit would look like, if we had sufficient power to resolve it.

Transits of Venus are brief and rare. Kepler's and Newton's laws made it possible to predict them. Jeremiah Horrocks was the first to observe one, in 1639, based on Kepler's prediction, and his own refinement thereof. Edmond Halley, building on a suggestion by James Gregory, showed that it would be possible to measure the absolute size scale of the solar system by observing a transit of Venus from multiple sites across the Earth, and this led to a number of expeditions to observe the 1761 and 1769 transits, notably James Cook's expedition to Tahiti in 1769. It was the "space race" of its day. Specifically, the project was to measure the *solar parallax*—the angle subtended at the Sun by the mean radius of the Earth, now known to be 8.794143 arc seconds. The solar parallax is inversely proportional to the *astronomical unit*, the average distance between the Earth and Sun, in km. Nowadays, there are still some scientific benefits to observing transits of Venus—mostly related to the interpretation of observations of exoplanet transits—but their main appeals are their rarity, and their many historical and cultural connections. The parallax observations were repeated at the 2004 transit, but as an educational project.

This book is the proceedings of a symposium, held in the city of Tromsø, Norway, on June 2–3, 2012, just before the 2012 transit—the last one until December 10–11, 2117. I looked forward to receiving this book, because we also held a transit of Venus symposium here in Toronto. Ours was just one day, April 28, and was a partnership with our Institute for the History and Philosophy of Science and Technology. We did not publish a proceedings, but the lectures can be found on *YouTube* (http://transitofvenus.nl/wp/2012/05/17/toronto-transit-talks/). The symposium was broad in scope, including a keynote address by Jay Pasachoff, and papers on transits of Venus across the centuries; the astronomical politics in the UK at the transit of 1874; comments by Victor Davies, composer of the opera *Transit of Venus*; educational applications of transits; observing transits safely; and transits in the modern (exoplanet) era. The symposium was accompanied by a talk on, and exhibit of historical astronomical instruments from the University of Toronto Scientific Instrument Collection (www.utsic.org).

The viewing on June 6 was extraordinarily successful; over 5,000 people gathered in the University's Varsity Stadium, and viewed the first two hours of the transit with suitable solar glasses, as well as on the stadium jumbotron. Many smaller telescopes were set up for solar viewing, including one dating from 1830. There was extensive local and national media coverage. The event won two awards from the Council for Advancement and Support of Education (CASE).

The problem with conference proceedings is that their content usually depends on who attends, and what they present. In this case, the contributions provide a very interesting account of both a rare astronomical event, and a part of the world that most of us are not familar with. Collectively, they are well focussed; there are none which are off-topic.

Why Tromsø? First: because northern Norway figured prominently in early transit expeditions, especially that of the Viennese Jesuit astronomer Maximilian Hell, who travelled to Vardø, in Norway. Halley's method for determining the solar parallax depended on getting observations from a very wide range of latitudes and longitudes. Second: because, on June 6, the Sun is circumpolar as seen from Tromsø, and the entire transit could be viewed, including the onset at the time of "the midnight Sun"—weather permitting. Was it clear? Find out in Section 3 of this review!

I am reviewing the present book as an astronomer with an interest in transits of Venus, and the history of astronomy in general. I specifically mention topics which I find particularly interesting. I am not qualified to judge the fine details of the scholarly work in the historical chapters.

The book begins with a useful, exhaustive overview of the geography of Scandinavia, and the political organization in the 18th and 19th centuries. The editors provide a complete list of those who observed the historical transits from Scandinavia, plus those, mentioned in the book, who observed them from elsewhere. The book ends with a brief remembrance of astronomer Hilmar Duerbeck, who was to have been a speaker at the conference, but passed away on January 5, 2012. The rest of the book is divided into the following three sections.

1. Historical observations of transits from Scandinavia

Editor Per Pippin Aspaas reviews the state of astronomy in Denmark-Norway in the 18th century; they were a single Kingdom at that time. Denmark had a long tradition in astronomy, dating from the work of Tycho Brahe, through the establishment of Copenhagen's Round Tower Observatory in 1642. By the 18th century, Denmark-Norway was scientifically isolated, and a second-rate power in astronomy, as compared with Sweden and Russia. But Denmark-Norway made the interesting decision to contract Maximilian Hell, the Jesuit "Imperial and Royal Astronomer of Vienna," to observe the 1769 transit from Vardø, in northern Norway (latitude +70.4 degrees). His observatory was the first state-funded observatory in Norway. Hell was eminently successful, though, at one point, it was suggested—incorrectly—that he had faked his results. Nevertheless, it was still clear that Denmark-Norway lagged behind their neighbors, astronomically speaking.

Hell's expedition was scientifically successful; he observed the transit, and also gathered much useful information about the natural and cultural history of the "northern fringes of the realm." But it was also controversial, and this topic is well described by László Kontler. Hell was born in what is now Slovakia; he worked in Austria, which was part of the Austro-Hungarian Empire. He was a servant of two masters: Christian VII of Denmark-Norway, who had contracted him to lead the expedition, and his regular employer Empress Maria Theresa. One of the objectives of the expedition was to study the language and culture of the Sami (Lappian) people, and the results of that part of the expedition were published by Hell's associate János Sajnovics in his *Demonstratio*. Unfortunately, the possible linguistic and cultural connection between the Sami and the Hungarians was politically sensitive, and Sajnovics's book opened a "can of worms" among the various factions in the Empire—especially the Hungarian nobility.

By contrast, Sweden (which included Finland at the time) was becoming a major power in astronomy, and in science in general, in the 18th century. Sven Widmalm outlines how this was part of an "enlightenment research policy," and makes some interesting parallels with science policy today, including the motives for state funding of research. These new policies were in part due to the influence of a new political party—the "Hat Party." The Swedish Royal Academy of Sciences was founded in 1739, the Uppsala University Observatory in 1741, and the Stockholm Academy Observatory in 1753. Celsius and Linnaeus were familiar names in these developments. Pehr Wilhelm Wargentin, the most notable Swedish astronomer of the time, was important, but is less well known today. Sweden participated in the observation of both the 1761 and 1769 transits in a significant way. Wargentin's ability to network was a major contributor to their success. By the end of the 18th century, however, science in Sweden was on the decline.

Osmo Pekonen describes the work of Anders Hellant, a Swedish amateur astronomer who set out to observe the 1761 and 1769 transits. He was well-educated and, in his "day job," played an important administrative and economic role in northern Sweden. He had broad interests as an amateur scientist, had an excellent library, and established a small observatory in Tornio—at the time, the northernmost permanent observatory in the world. Among other things, he observed the variable star Mira, and made important studies of the aurora. His observations of the 1761 transit were successful, and were sent to Wargentin who forwarded them to Paris for analysis. But they proved "scattered, unreliable and virtually worthless." In 1769, he and Frederik Mallet, a professional astronomer, attempted to observe the transit from north of the Arctic circle, but were clouded out.

As described by Gudrun Bucher, Tsarina Catherine II of Russia made a special effort to encourage and support transit expeditions in 1769, in part to re-establish the reputation of Russian scientists, and the Russian Academy of Sciences. Though the expeditions were complicated by the fact that they had significant natural-history and ethnographic objectives as well as astronomical ones, they generated a large output of scientific knowledge and publications. (It's interesting that, as I write this review, the Russian Academy of Sciences is under threat of dissolution by the current Russian government!)

Nils Voje Johansen describes an expedition sent by the Royal Society of London to observe the 1769 transit at the North Cape of Norway (latitude +71.5 degrees), with astronomers William Bayly and Jeremiah Dixon (of Mason-Dixon line fame) aboard the Admiralty's *HMS Emerald*, commanded by Captain Charles Douglas. Dixon and Mason had observed the 1761 transit from the Cape of Good Hope. Observations of the transit from the two portable observatories were only partially successful, but Douglas also took some novel measurements of the temperature of the sea water at different depths, and was enquiring about the possible existence of giant "sea worms" (the locals claimed to have seen them). He also kept a "spying log," reporting on his observations of defences, commercial information, charts and soundings of ports, and supply possibilities ("watering and wooding") for territories that they were visiting. And apparently the locals were spying on the English as well. So surveillance is not just a "today" thing!

Swedish astronomer Anders Lexell is perhaps best known for his study of the orbit of Comet Lexell, discovered by Messier in 1770. Lexell showed that the comet had made a close approach to Jupiter in 1767, which drastically changed its orbit. A second close approach to Jupiter in 1779 further changed its orbit, and it was never seen again. Johan Stén and Per Pippin Aspaas describe Lexell's role in analyzing the large and diverse set of observations of the 1769 transit, in competition and debate with astronomers much more senior (but not necessarily more competent) than him— including Hell. The authors usefully describe how the observations were actually used to derive the solar parallax, and hence the solar distance.

2. Historical observations of transits from elsewhere

This section opens with a chapter, by Steinar Thorvaldsen, which addresses the transition from Kepler's Laws, to precise predictions of transits of Mercury and Venus. Kepler's *Rudolphine Tables* enabled the prediction of the 1631 transit of Mercury, and the 1639 transit of Venus and, although these were not widely observed, the few observations that were made validated and refined Kepler's predictions. One of the most remarkable things about Kepler's and Newton's Laws is that they allow for the prediction of the exact circumstances for phenomena such as eclipses and transits—something that should constantly amaze both us and the public.

This section also includes an interesting and fundamental chapter, by Suzanne Débarbat, which reviews the methods by which the solar parallax (or the average distance from the Earth to the Sun, in km) has been determined over the ages, and how the accuracy has improved. Prior to the 17th century, the accepted values were an order of magnitude too small! Improvement was helped by Napier's invention of logarithms in the early 17th century. It continued with a measurement of the parallax of Mars at close approach, in 1672–1673, and with the measurements of the 1761 and 1769 transits of Venus (with observations of transits of Mercury as useful "practice"), and with continued measurements of the parallaxes of Mars and Venus at close approach. The accuracy gradually improved from 10% to 5% to about 3%. Observations of the 1874 and 1882 transits improved the accuracy to 1–2%, though the *black-drop effect* always limited the accuracy which could be obtained. For the next few decades, several strategies were used, but the best was to measure the parallax of near-Earth asteroids, notably Eros in 1930–1931. Now, the scale of the solar system is determined by bouncing radar waves off the inner planets. This chapter ends by reprinting IAU Resolution B2, passed at the 2012 IAU General Assembly in Beijing: the average distance of the Sun (the Astronomical Unit) is *adopted* to be 149,597,870,700 meters.

Désbarbat's chapter emphasizes the role of French astronomers. That theme is continued in a chapter by Simone Dumont and Monique Gros, who describe the important role of Joseph-Nicolas Delisle and Joseph-Jérôme Lalande in organizing the international observations of the 1761 and 1769 transits. Halley suggested how these could be used, but passed away in 1742. Guy Ratier and Sylvain Rondi describe observations of Venus and Mercury transits from the Pic-du-Midi Observatory in the Pyrenees. It was founded in 1882, but clouded out for the transit that year but, with its excellent seeing conditions, went on to make many other important contributions to solar and planetary astronomy, including the discovery of the 4-day retrograde rotation of the atmosphere of Venus. I had always assumed that this discovery was made from space, by *Mariner 10*.

Co-editor Christiaan Sterken describes the work of his countryman Jean-Charles Houzeau, who developed a new approach to measuring the solar parallax: a "heliometer with unequal focal lengths." He used one such instrument to observe the 1882 transit from San Antonio, Texas, and sent another to Santiago de Chile. These were the first major expeditions in the history of Belgian science. Both expeditions were at least partially successful, and produced a value of the solar parallax which was within 1.3% of the true value. Parts of the heliometers still survive, and are on display at the Royal Observatory, Belgium. A slightly-inaccurate plaque marks the site of Houzeau's observations in Texas.

Thomas Posch and colleagues provide more information on five Jesuit observatories in central Europe, and on the work of Maximilian Hell who observed the 1769 transit from northern Norway. Three of the observatories were in present-day Austria, one in Slovakia, and one in Romania. The Jesuits were well known for their efforts to support scientific research and teaching, and they still operate the Vatican Observatory (with branches in Italy and Arizona) today. Hell observed the 1761 transit, measured the angular diameter of Venus, and analyzed some of the international observations of the 1761 transit, obtaining a solar parallax only a few percent different from the true value.

David Dunér contributes a fascinating chapter on the evolution of the belief that Venus might be inhabited. Galileo observed mountains and valleys on the moon; might it be inhabited? The heliocentric theory showed that the Earth and planets all orbited the Sun; were they not all "worlds"? Dunér is especially interested in the cognitive processes which lead to "belief"—a topic that is still relevant today. In his paper, he discusses the impact of two kinds observations of Venus: (1) the *ashen light*, a supposed glow on the dark side of Venus, and the *black drop effect* which is observed at transits; these suggest that Venus might have an atmosphere (which it does, though the historical observations of the black-drop effect continue to be controversial); and (2) supposed observations of markings on the planet (which, like the "canals" on Mars, are an optical illusion). Even Percival Lowell (of Mars canals fame) claimed to see markings on Venus, though he believed them to be natural features. Many eminent astronomers and writers of the 17th, 18th, and 19th century weighed in on the "plurality of worlds" debate, and Dunér does an excellent job of reviewing and commenting on them.

3. Observing the 2012 transit from Tromsø, and beyond

Aside from the historical connections to earlier transit expeditions, June transits have the advantage that the Sun is circumpolar in Tromsø. The whole transit can be observed (weather permitting), even at midnight.

Three observers planned to observe the transit over North Cape, from a small plane; they could observe from above the clouds if necessary. Sadly, their camera malfunctioned, even though they had double-checked it. Lesson learned: always take a spare camera.

A larger group set out to follow in the footsteps of Maximilian Hell, who observed the 1769 transit from Vardø. Their expedition is described at length, in vivid detail, and profusely illustrated, in "A Voyage to Vardø. A Scientific Account of an Unscientific Expedition." The purpose was *not* to make scientific observations, but to commemorate and re-enact historically-significant observations—a growing trend for historians of science. The expedition was undertaken by boat (*MS Lofoten*—a national historical monument!), with stopovers at Hammerfest and North Cape, both of which figured in expeditions, 250 years earlier, and have other historical, cultural, and scientific significance. The 2012 trip was ten times faster than Hell's! In Vardø, many dignitaries and visitors gathered; there were public lectures and demonstrations, television interviews, a concert, banquet, and religious service, and finally the viewing of the transit. Sadly, only the last hour or two of the transit was visible, through partly cloudy sky. Weather is always a factor. Otherwise, a good time was had by all.

The main viewing of the transit was from Tromsø, and the conditions were perfect. Visitors came from across Europe. Observing sites included a cable car station, an auroral observatory, a soccer field on the Island of Tromsø, and in the case of one observer, a nearby mountain peak. At the soccer field, there was a big screen, about a thousand people, and a film crew from Norwegian national television. On television, about 160,000 people followed the entire 6-hour transit, almost 900,000 watched some part of it, and 50,000 followed the live stream in the Internet. First contact was about midnight, with the Sun only about two degrees above the horizon. But the times of first and second contact could still be measured on the projection screen. Real-time comparison between the local image and the image streamed in from Hawaii showed the parallax effect clearly.

4. Commentary

This book can be enjoyed at several levels: as an account of the challenge of making astronomical observations over the centuries, or as an introduction to the history of astronomy in northern Europe, or simply as a travelogue in an interesting but out-of-the way part of the world. The chapters are scholarly, rather than "popular," and assume some understanding of world history and politics. But that's part of the strength and appeal of the book; it demonstrates that astronomy is not done in isolation, but is embedded in and connected to world affairs.

I commend the organizers of this conference for conceiving and planning it, and the editors for their excellent work in producing an interesting, attractive, and well-organized book. The chapters are edited to a common format; they are profusely illustrated with maps (both historical and modern), images of historical documents, buildings, instruments, and observations and, in the third section, formal and informal pictures of the participants enjoying their surroundings. The chapters are extensively referenced, and there are good name, subject, and author indexes.

I especially applaud the editors' willingness to make the book freely available as an open-source document. The on-line document is set up so that you can download whichever chapters you are interested in. Everyone will find something of interest in this book.

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