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Maximilian Hell and the Northernmost Transit of Venus Expedition of 1769

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Abstract

A short biography of the Jesuit astronomer Maximilian Hell (1720–1792), founder and director of the Astronomical Observatory in Vienna and editor of the Viennese Astronomical Almanac is presented. He was the leader of the expedition to Vardö Island for observing the transit of Venus of 1769. The journey of the participants, the preparations for observing the important phenomenon and its successful observations are described. Hell's scientific merits won him the membership in several European Academies, and his name is found on lunar maps.

1. Introduction

Among the many expeditions which were organised in order to observe this rare phenomenon in 1769 was the one to Vardö, which was led by Maximilian Hell, director of the Astronomical Observatory in Vienna.

Maximilian Hell (Fig. 1) was born on May 15, 1720 in Bánska Štiavnica, Slovakia[1], where his father, Matei Kornel Hell, who was originally from Bohemia, had established himself as a mine engineer. Maximilian grew up into a family environment which favoured the development of his technical skills. He attended the local school in his native town and at Bánska Bystrica as well, where he graduated from the secondary school in 1738. In the same year, he joined the Jesuit Order in Trenčín (German Trentschin), where he made his noviciate. He studied philosophy, mathematics, and astronomy in Vienna, and assisted

[1]Schemnitz in German, since Slovakia belonged at that time to Austria-Hungary.

in the observations of Joseph Franz, the director of the Jesuit Observatory, and in the organization of a museum of experimental physics. He later also studied theology, and the order entrusted to him some missions. As a teacher of humanities at the secondary school in Levoče (Slovakia) (German Leutschau), he founded an astronomical observatory at Trnava (Slovakia). He stayed for three years as a mathematics teacher at the Jesuit College in Cluj (German Klausenburg, Transylvania), where he published two manuals: *Elementa mathematica naturali philosophiae Ancillantia ad Praefixam in Scolis nostris normam. Tomulus I. Elementa Arithmeticae numericae & literalis seu Algebra,* and *Exercitationes mathematicarum. Pars I. Exercitationes arithmeticae.*

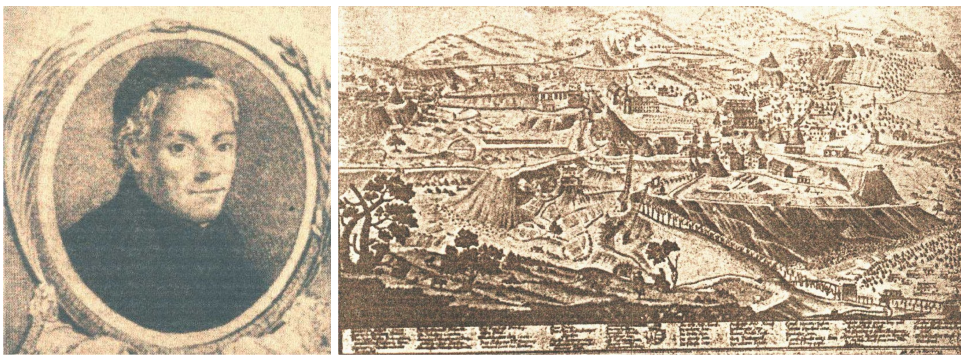


Figure 1. *Left:* Maximilian Hell (1720–1792). *Right:* Bánska Štiavnica at that time, Hell's native town.

When he returned to Vienna in 1755, almost his entire future activity would be dedicated to astronomy. He founded the Astronomical Observatory of the Viennese University, becoming its life-long director, and was paid 300 golden crowns per year. He was in charge of the institute building, was in charge of making regular astronomical observations and reducing them, maintaining connections with the international scientific world, teaching every Sunday a lesson of astronomy in the amphitheatre of the Faculty of Philosophy, and publishing the results of astronomical observations and studies.

A short time after the Astronomical Observatory was founded, he issued the first almanac *Ephemerides astronomicae anni 1757 ad meridianum Vindobonensem*[2] (Fig. 2), which he would publish every

[2]10 years before the *Nautical Almanac*.

Figure 2. Title page of the first Viennese Astronomical Almanac.

year until 1786 (except in the years he was absent from the country, when it was edited by Anton Pilgram), and in which pages his observations were published as well as those of other foreign astronomers.

2. The Transit of Venus Expedition

The most important astronomical event of his life was the transit of Venus on June 3, 1769. Hell showed a great interest in this phenomenon, and even published in the Viennese almanac a memoir concerning the previous transit *De singulari phoenomeno Transitus Veneris per discum Solis die 5 Junii 1761.* In the astronomical world, a polemic was

evolving about the so-called satellite of Venus. In his work *De satellite Veneris* he showed that "the satellite" which some astronomers claimed to have observed is just the secondary image of the very brilliant image of the planet, reflected into the telescope by the cornea of the eye.

As a world-famous astronomer, Hell received many proposals to lead an expedition to observe the phenomenon of 1769, and he accepted the one offered by king Christian VII of Denmark and Norway through his messenger, count Bachoff, an expedition which would be financed by the Danish Royal House. This royal financing suggests the high costs entailed by such an expedition. It was necessary that queen Maria Theresa assented, something she did gladly. The place where the transit would be observed was situated in Norwegian Lapland, beyond the Polar Circle, in the most remote populated settlement, Vardö Island.

Hell chose as a companion in this expedition the Jesuit Jan János (Johannes) Sajnovics from the Astronomical Observatory in Trnava, who would keep the journal of the expedition. After an audience at the Viennese Royal Court on April 28, 1768, the two scientists started the journey in a carriage drawn by four horses, carrying with them their personal luggage and a small instrument, the big instruments being sent directly to Lübeck. Their journey took place on the route Prague – Dresden – Meissen – Leipzig – Hamburg – Lübeck to Copenhagen (Fig. 4). The scientists enjoyed the attention of personalities in these towns and visited some institutions and churches. In Prague they visited the astronomer Joseph Stepling and his observatory. In Dresden they visited the Zwinger Museum and attended a theatre performance. In Meissen they visited the famous porcelain factory and in Leipzig, at the University, they met prominent personalities like the professor of mathematics Gottfried Heinsius who, before settling in Leipzig, had been an astronomer at the Observatory of Sankt Petersburg.

They were welcomed at Copenhagen and after a short sojourn they were transported to the Swedish border in three post-chaises together with the astronomical instruments from Vienna, to which were added those borrowed from the Astronomical Observatory of Copenhagen. During this trip they were accompanied by the director of the observatory himself, Christian Horrebow. Then they crossed the Swedish land and crossed the border to Norway. At Christiania (Oslo) they were enthusiastically celebrated. Their astronomical observations showed that the latitude of the settlement was two degrees less than indicated on the maps. Crossing Miösen See, they reached Trondjem where they determined the latitude. From this point, the expedition was enlarged with the governor of the Finnmark province, the young Danish student

Figure 3. Map of the expedition itinerary.

Borgrewing, a cook, two servants and four sailors, and they embarked on a very well equipped ship. Following the king's advice they were provided with means of living for one year.

The trip proceeded on the water, having both good weather and also storms, which retained them on the land where they explored the

fauna and flora of the marine coast and measured the geographical latitudes. On October 11 they arrived at Vardö Island, the observation location proposed by the Danish king, and were welcomed by the governor, the vicar, the local garrison and the population. In this northern settlement where the Sun remains above the horizon for two months around summer solstice and for two below the horizon around winter solstice, they immediately began building an observatory, a job mainly done by the light of torches. They built a gnomon and a thin wall that marked the meridian of the place. They installed the clocks (from Vienna and Copenhagen) which were very well protected in order to avoid damage from the salty humidity of the ocean, and on June 2, 3 and 4, their running was carefully controlled. Using the equal altitude method, aided by a gnomon, they determined apparent noon on June 3 and 4. The precise location of the observatory was determined by the quadrant, the astronomers observing pairs of stars with known declinations, which culminated at the almost same altitude; thus they determined the latitude of $70°22'35''$, and the longitude, $28°46'30''$ with respect to the meridian of Paris Observatory, and $48°40'15''$ with respect to the first meridian of Ferro.

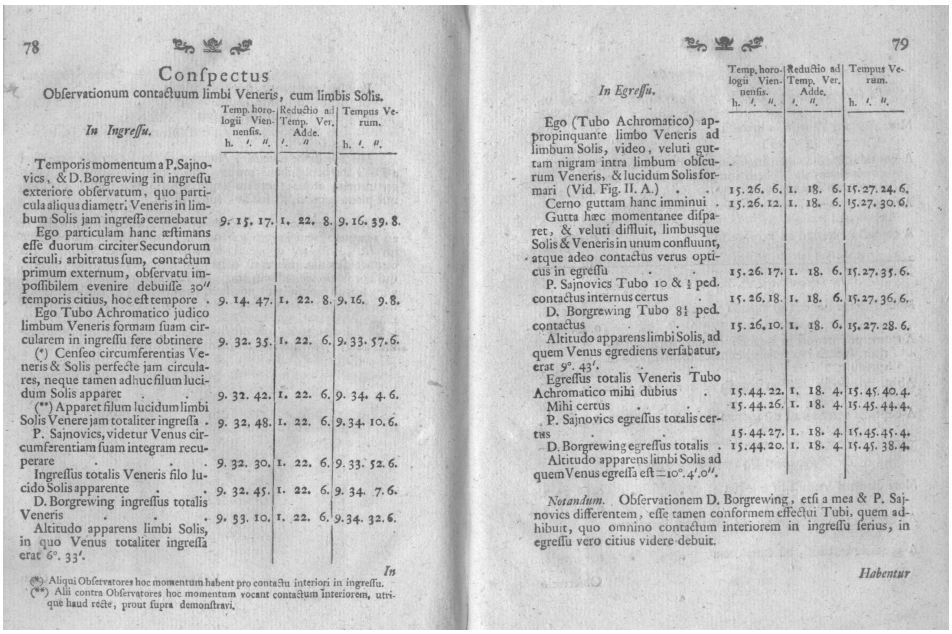
The observations of the transit were carefully prepared, and should be done by Hell, Sajnovics and Borgrewing with three different telescopes, equipped with diaphragms. The week before the transit was completely clouded and did not give them high hopes. But on June 3, the weather improved and the immersion of the planet on the solar disk was almost simultaneously reported by Sajnovics and Borgrewing. But since the moment of the first external contact was impossible to observe, Hell, estimating the time needed by the planet for traversing an arcsecond in its motion to be 15 seconds of time, deduced that it must have happened 30 seconds before the report. Then Hell observed the first internal contact with the achromatic 10 feet Dollond telescope, Sajnovics with the $10\frac{1}{2}$-feet telescope, and Borgrewing with the $8\frac{1}{2}$-feet telescope equipped with a micrometer.

Then they compared the two clocks, and permitted the entry of visitors to the observatory to contemplate – with necessary caution – the planet Venus situated entirely in front of the Sun.

During the time between the second and third transits, the weather became unfavourable, but before third contact the sky became clear and they could observe under good conditions, even the visitors had the possibility to follow the phenomena. The two Jesuits attributed this unexpected clearing of the sky, which allowed them to observe completely the phenomenon, to God's mercy.

3. The Results of the Expedition

The four contact observations are summarized in Fig. 4. The observing of the four contacts was the main result of Hell's expedition, the cannon of Vardö fortress announcing it as an important event. The Jesuits left the island on June 27, the report of the expedition was presented at the Academy of Copenhagen in November and published the following February (*Observatio Transitus Veneris Ante Discum Solis Die Junii Anno 1769 Wardoehusii*, see Fig. 5).



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Conſpectus

Obſervationum contactuum limbi Veneris, cum limbis Solis.

In Ingreſſu.	Temp. horologii Vienenſis. h. ′. ″.	Reductio ad Temp. Ver. Adde. ′. ″	Tempus Verum. h. ′. ″.
Temporis momentum a P. Sajnovics, & D. Borgrewing in ingreſſu exteriore obſervatum, quo particula aliqua diametri Veneris in limbum Solis jam ingreſſa cernebatur	9. 15. 17.	1. 22. 8.	9. 16. 39. 8.
Ego particulam hanc æſtimans eſſe duorum circiter Secundorum circuli, arbitratus ſum, contactum primum externum, obſervatu impoſſibilem evenire debuiſſe 30″ temporis citius, hoc eſt tempore	9. 14. 47.	1. 22. 8.	9. 16. 9. 8.
Ego Tubo Achromatico judico limbum Veneris formam ſuam circularem in ingreſſu fere obtinere	9. 32. 35.	1. 22. 6.	9. 33. 57. 6.
(*) Cenſeo circumferentias Veneris & Solis perfecte jam circulares, neque tamen adhuc filum lucidum Solis apparet	9. 32. 42.	1. 22. 6.	9. 34. 4. 6.
(**) Apparet filum lucidum limbi Solis Venere jam totaliter ingreſſa	9. 32, 48.	1. 22. 6.	9. 34. 10. 6.
P. Sajnovics, videtur Venus circumferentiam ſuam integram recuperare	9. 32. 30.	1. 22. 6.	9. 33. 52. 6.
Ingreſſus totalis Veneris filo lucido Solis apparente	9. 32. 45.	1. 22. 6.	9. 34. 7. 6.
D. Borgrewing ingreſſus totalis Veneris	9. 33. 10.	1. 22. 6.	9. 34. 32. 6.
Altitudo apparens limbi Solis, in quo Venus totaliter ingreſſa erat 6°. 33′.			

In

(*) Aliqui Obſervatores hoc momentum habent pro contactu interiori in ingreſſu.
(**) Alii contra Obſervatores hoc momentum vocant contactum interiorem, utrique haud recte, prout ſupra demonſtravi.

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In Egreſſu.	Temp. horologii Vienenſis. h. ′. ″.	Reductio ad Temp. Ver. Adde. ′. ″.	Tempus Verum. h. ′. ″.
Ego (Tubo Achromatico) appropinquante limbo Veneris ad limbum Solis, video, veluti guttam nigram intra limbum obſcurum Veneris, & lucidum Solis formari (Vid. Fig. II. A.)	15. 26. 6.	1. 18. 6.	15. 27. 24. 6.
Cerno guttam hanc imminui	15. 26. 12.	1. 18. 6.	15. 27. 30. 6.
Gutta hæc momentanee diſparet, & veluti diffluit, limbusque Solis & Veneris in unum confluunt, atque adeo contactus verus opticus in egreſſu	15. 26. 17.	1. 18. 6.	15. 27. 35. 6.
P. Sajnovics Tubo 10 & ½ ped. contactus internus certus	15. 26. 18.	1. 18. 6.	15. 27. 36. 6.
D. Borgrewing Tubo 8½ ped. contactus	15. 26. 10.	1. 18. 6.	15. 27. 28. 6.
Altitudo apparens limbi Solis, ad quem Venus egrediens verſabatur, erat 9°. 43′.			
Egreſſus totalis Veneris Tubo Achromatico mihi dubius	15. 44. 22.	1. 18. 4.	15. 45. 40. 4.
Mihi certus	15. 44. 26.	1. 18. 4.	15. 45. 44. 4.
P. Sajnovics egreſſus totalis certus	15. 44. 27.	1. 18. 4.	15. 45. 45. 4.
D. Borgrewing egreſſus totalis	15. 44. 20.	1. 18. 4.	15. 45. 38. 4.
Altitudo apparens limbi Solis ad quem Venus egreſſa eſt = 10°. 4′. 0″.			

Notandum. Obſervationem D. Borgrewing, etſi a mea & P. Sajnovics differentem, eſſe tamen conformem effectui Tubi, quem adhibuit, quo omnino contactum interiorem in ingreſſu ſerius, in egreſſu vero citius videre debuit.

Habentur

Figure 4. The table summarizing the contact observations.

But its result was not in agreement with those of other observers, respectively, the value of the parallax of the Sun deduced from the inclusion of this transit in *De parallaxe Solis ex observationibus transitus Veneris anni 1769* which proved to be the most accurate at that time. The delay with which Hell made known the result of the expedition stirred the suspicion of Joseph Jérôme de Lalande, who made himself the promotor of the missions made on the occasion of this astronomical event in front of European governors. He was not aware of Hell's expedition (the Danish Court wishing to keep this mission a secret) until the moment when the report was presented to the king. Lalande

objected against the result obtained by Hell, but he withdraw his criticism, publishing after the latter's death (with whom he had meanwhile reconciled) a panegyric where he wrote:

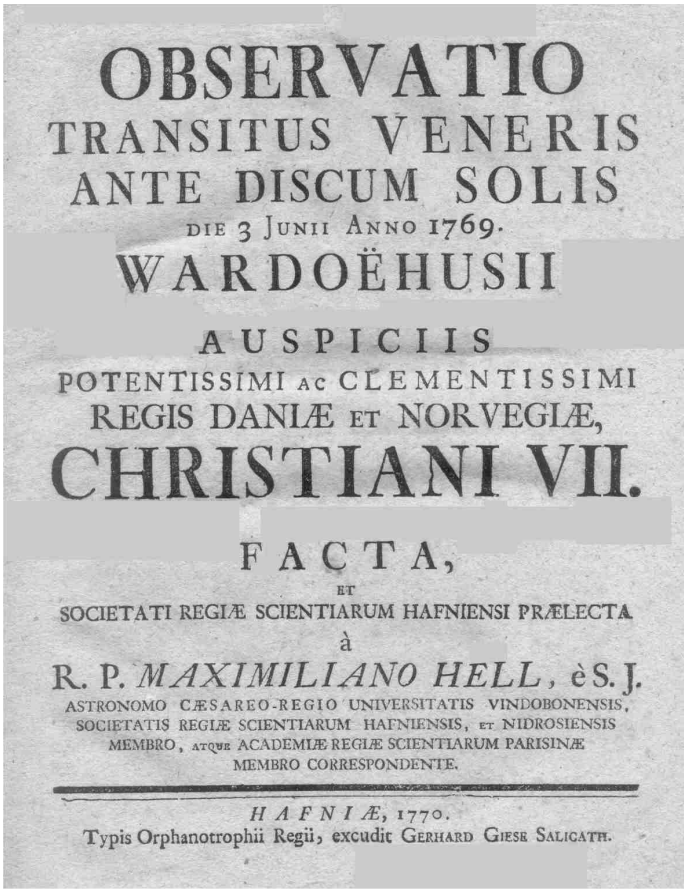
> "L'observation du P. Hell réussit complètement, elle s'est trouvée une des cinq observations complètes faites à de grandes distances, et où l'éloignement de Vénus changeant le plus la durée du passage, nous a fait connaître la véritable distance du Soleil et de toutes les planètes à la Terre".

However, the suspicion still remained in Johann Franz Encke's publication of 1824 *Der Venus-Durchgang von 1769*, and in 1835 Carl Ludwig von Littrow, assistant at the Astronomical Observatory of the Viennese University published the translation in German of Sajnovics' journal and, strange enough, used this opportunity to attack the integrity of Hell, saying that the latter had corrected his observations in order to make them agree with the best values found. This accusation was removed only in 1883 by Simon Newcomb, himself an observer of the transits of 1874 and 1882. When he came to Vienna to examine the new telescope, during cloudy nights he searched in the observatory's library for Hell's original manuscripts, and upon inspection became convinced that the correction of the data in the manuscript was not a subsequent one, but done on location. Newcomb published his findings in Monthly Notices, May, 1883.

After an absence from the country of two years and 3 months, Hell came back to Vienna on August 12, 1770. The extremely poor weather conditions during his stay at Vardö did not prevent the skilful researcher from taking care of many other problems to which this unique circumstance of his life opened the way. In this poorly known northern region, everything was interesting, and Hell studied magnetism, the tides, the winds, etc. He wanted to present the results of the expedition in a work *Expeditio litteraria ad polum arcticum*, but the suppression of his order in 1773 foiled this intention. Part of the observational material that he had gathered served to elaborate a new theory about the aurora borealis, which he published in 1776 (*Aurorae Borealis theoria nova*).

4. Hell's Remaining Years

In Vienna, Hell resumed his former activities. He also participated in the debates about building an Astronomical Observatory at the High School in Eger (Hungary), and he planned the establishment of an



OBSERVATIO
TRANSITUS VENERIS
ANTE DISCUM SOLIS
DIE 3 JUNII ANNO 1769.
WARDOËHUSII
AUSPICIIS
POTENTISSIMI AC CLEMENTISSIMI
REGIS DANIÆ ET NORVEGIÆ,
CHRISTIANI VII.
FACTA,
ET
SOCIETATI REGIÆ SCIENTIARUM HAFNIENSI PRÆLECTA
À
R. P. *MAXIMILIANO HELL*, è S. J.
ASTRONOMO CÆSAREO-REGIO UNIVERSITATIS VINDOBONENSIS,
SOCIETATIS REGIÆ SCIENTIARUM HAFNIENSIS, ET NIDROSIENSIS
MEMBRO, ATQUE ACADEMIÆ REGIÆ SCIENTIARUM PARISINÆ
MEMBRO CORRESPONDENTE.
HAFNIÆ, 1770.
Typis Orphanotrophii Regii, excudit GERHARD GIESE SALICATH.

Figure 5. Title page of the work presenting the results of the expedition to Vardö Island.

Academy of Science under the leadership of the Jesuits, but the order being suppressed, the idea was given up. Also, when the University was moved from Bratislava to Buda, Hell chose the location for the Astronomical Observatory.

After enjoying a very good health, on April 14, 1792 he died from pneumonia and was buried at Enzersdorf near Vienna. His scientific work contains 26 memoirs and was almost entirely written in Latin.

Maximilian Hell, whose character traits were the love for mankind and humanitarism, manifested a great tolerance towards the Protestants. As a scientist he enjoyed the appreciation of his contemporaries, becoming a corresponding member of the Academy of Sciences of Paris

and an active member of the Academies of Copenhagen, Göttingen, Stockholm, Trondheim and Bologna. As his highest homage, his name was attributed to a lunar crater.

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