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Austrian–Hungarian Astronomical Observatories Run by the Society of Jesus at the Time of the 18th-Century Venus Transits

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Abstract. The Venus transit in June 1761 was the first one to be observed on a truly international scale: almost 250 astronomers followed this rare celestial event (e.g. Wulf 2012, p. 115), and at least 130 published successful observations of it (Aspaas 2012, p. 423). The present paper deals with the astronomical observatories built by the Society of Jesus in its eighteenth century "Provincia Austriae", at which the 1761 transit could be observed. Five Jesuit observatories are being presented in this context: three in today's Austria, namely, two in Vienna and one in Graz; one in Trnava in today's Slovakia and one in Cluj in today's Romania. Thereafter, we briefly examine which of these observatories submitted any Venus transit observations for publication in the appendix to Maximilian Hell's "Ephemerides astronomicae ad meridianum Vindobonensem" for the year 1762.

1. Historical background

The Society of Jesus (*Societas Jesu*) is well known for its efforts to promote scientific research and teaching in catholic countries (as well as on mission) since its foundation in the sixteenth century. Jesuits were active as astronomical observers and authors of scientific articles also in the Habsburg monarchy long before the eighteenth century; however, it was only in the course of the eighteenth century that they actually founded permanent (or semi-permanent) observatories there. Most of these observatories flourished on a time scale of decades only, if they flourished at all, before the Society of Jesus was suppressed in 1773. Given that the Jesuit observatory in Vienna – the oldest one of those examined here – was founded in 1733, the time span covered by this article is only four decades (1733–73).

As far as the geographical scope of our article is concerned, the term *Provincia Austriae* still needs to be explained. In terms of modern country borders, this region essentially comprised today's Austria, Hungary, Slovakia, Slovenia, Croatia, as well as the western part of today's Romania, small parts of Ukraine and a part of north-eastern Italy. It is noteworthy that the Czech Republic with the ancient imperial city of Prague (where a Jesuit observatory was founded in 1722) was not part of the "Austrian Province" of the Society of Jesus.

The observatories of the *Provincia Austriae* are not very well known internationally, and apart from a recent study, there are not many source-based studies of their history (cf. Aspaas et al. 2013). Within the context of the Venus transits, their role has been virtually ignored until now.

2. The observatories

2.1. Vienna

As mentioned above, Vienna – at that time the residence of the Habsburg empire – was the first of the cities here examined to host a Jesuit observatory, namely since the 1730s. The construction works began in 1733 and were finished in 1735. In the latter year, Charles VI, Holy Roman Emperor, came to visit the observatory (Hamel et al. 2010, p. 173). The first observations were carried out in 1736. The first director of this observatory was Joseph Franz SJ (occasionally spelled Frantz), who was born in Linz in 1704 and who had held a chair of mathematics at the University of Vienna since 1734. Franz continued to be observatory director until 1755 (cf. ADB 1878).

The observatory site was close to the geometrical center of the city: less than 400 m to the East of Saint Stephen's cathedral, at the junction of today's Postgasse with today's Bäckerstraße. The observatory building was a tower (like most eighteenth century university observatories), erected on top of the pre-existing Jesuit college (which had a height of 21 m), adding three floors to it and thus reaching a total height of 45 m. The observation chamber in a narrower sense was located on the last of the three additional floors, was 86 m^2 large and had a height of 11.5 m. Unfortunately, nothing is left of this certainly impressive tower, which is known to have existed at least until 1786.

Among the instruments used there, one was especially remarkable, namely a mural quadrant with a radius of 10 foot (3.1 m). It was equipped with a telescope and a micrometer. Another noteworthy instrument at this observatory was a mobile azimuthal quadrant that had once been used by Tycho Brahe.

The observatory also possessed a celestial globe, about 1.4 m in diameter, on which stellar positions were charted, according to the Jesuits' own observations. The famous German author Johann Christoph Gottsched wrote an impressive Latin description of this celestial globe (Gottsched 1750, pp. XXV–XXVII).

The observations made at the old Viennese Jesuit observatory were published in different journals abroad, but also, from 1756, in the *Ephemerides astronomicae ad meridianum Vindobonensem* edited by Maximilian Hell.

The successor to Joseph Franz in 1755/56 was Joseph Liesganig. He was born in 1719 in Graz and had become professor of mathematics at the university of Vienna in 1752. His merits were mainly in geodesy, where he participated, among many other projects, in the triangulation from Vienna to Paris, cooperating with Cassini de Thury in the early 1760s – around the time of the first transit of Venus in the eighteenth century (see below).

At the time when Liesganig became director of the Jesuit observatory, in 1755, the Austrian Empress Maria Theresa founded yet another astronomical observatory in Vienna, namely the so-called "Imperial and Royal Observatory of Vienna" (Latin name: *Observatorium Caesareo-Regium Viennense*; we will refer to it as the Vienna University Observatory, see Fig. 1). One year before, in 1754, another important scientific institution had been founded in Vienna: the Botanical Garden (in Latin: *Hortus Botanicus Vindobonensis*). The foundation of the new, state-owned observatory also coincided with the construction of a new central campus house for the university, on top of which it was erected. The new observatory was thus again built on top of a building whose lower floors were used by other institutions of the university (notably, its assembly hall was located at a lower floor). With the observatory on top, the maximum height of the new building amounted to 38 m (7 m less than the older Jesuit observatory).

The above mentioned J. Franz was heavily involved in the construction of the new observatory; but it was Maximilian Hell SJ who was to become the first director of this institution (and to remain director until his death in 1792). Continuous observations at the Vienna University Observatory began in 1757. The university observatory was run by Jesuits until the suppression of the Society of Jesus, in the same way as all other observatories described here; however, its fate after the suppression of the order was quite different from that of the others: as a state-owned (public) observatory, it was supposed to "survive", and as an institution it did so until the present time (physically, however, Vienna's University Observatory was transferred to the outskirts of the city in the 1880s, where a very large new observatory was to be built in the 1870s).

As for the Venus transit in 1761, astronomers followed this celestial event both at the Jesuit observatory and at the University Observatory in Vienna. The following observers were present at the older Jesuit observatory: César-François Cassini de Thury (director of the *Observatoire de Paris*) with his own, 9-foot telescope (*tubus dioptricus*, equipped with a micrometer); J. Liesganig, at that time director of the Jesuit observatory as mentioned above; Archduke Joseph Prince of Austria (who would become Emperor in 1765); Karl Scherffer SJ; Karl Mastalier SJ; Anton Steinkellner SJ; and Joachim Richtenburg SJ. At the Imperial and Royal Observatory, Father Herberth SJ, professor of physics at the university, Magister Rain SJ, and Abbé Lysogorski, a Polish priest, were observing, each of them of course with his own telescope (Hell 1761, pp. 17–18).

The remarkable presence of the then only 20 years old Archduke Joseph is also mentioned by Cassini de Thury in his observation report; he writes (Cassini 1763, p. 410, our translation):

> While I was waiting for the Sun to become visible again, I was honored by the presence of his Excellence Archduke Joseph, who had left [his residence] Laxenburg at 4 a.m. in order to witness my observations; fortunately, the Sun re-appeared and the Prince observed Venus several times and posed several questions which proved the extent of his knowledge.

Hell himself used yet another observing platform, i.e. another tower within the university campus, attached to the former university library (now university archive). In his observation report, he calls it a place remote from the crowd (*aedes aliae ab omni tumultu segregatae*) and says that he had his instruments transferred to this place on the second of June already (Hell 1761, p. 1). Hell used a 5-foot telescope equipped with a micrometer. Observations of δ Orionis (passing through the field of view) had yielded a field-of-view value of 30 arcminutes for this instrument. The accuracy of time measurements, according to Hell, was better than 1 second (Hell 1761, p. 2).

2.2. Graz (Graecium)

The University of Graz was founded in 1585 in the course of counter-reformation, which aimed at repelling the Protestants in many areas of society, among them higher education.

Back in the sixteenth century, there was however nothing like an astronomical observatory at the University of Graz, whose old main building dates from the years 1573–1609. The Protestant Johannes Kepler (who came to the higher Protestant school in Graz – one might also call it a "university" – in 1594 but was expelled in 1600 for religious reasons) and the Roman Catholic Paul Guldin SJ both made

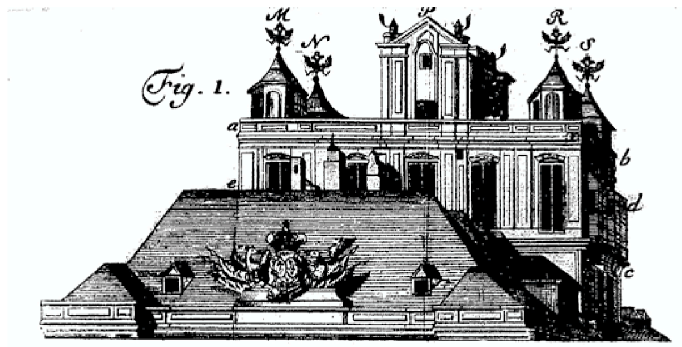

Figure 1. The Vienna University Observatory, founded in 1755, and built on top of the contemporary central campus. View from about 1772. After Bernoulli (1777).

important contributions to astronomy and mathematics. Kepler, however, did not construct any astronomical observatory in Graz, and little is known about the small observatory built by Guldin in the first half of the seventeenth century (Guldin died in Graz in 1643).

The actual Jesuit observatory of Graz University was constructed in 1745 (cf. Steinmayr 2011, also for the following). It was built on top of the west wing of the above-mentioned courtyard house that had been finished in 1609. It is possible, but could not be proven so far, that Joseph Franz, at that time director of Vienna's Jesuit Observatory, was also involved in the planning of the Graz Jesuit Observatory. The observatory's layout was 42 m long and 18 m wide; it had a height of 12 m (again, on top of the pre-existing floors), resulting in a wide panorama. The first floor hosted a museum of mathematics and physics, where "physics" is to be understood in a wider sense than today, i.e. as science in general. More specifically, a rich collection of minerals and insects was a part, and actually the most important part, of this museum (Flügel 2006). The mineral collection contained more than 800 minerals and fossils and was among the first ones in Austria. The second floor was designed in such a way that those astronomical observations that required only a narrow azimuth range could be carried out (measurements with mural quadrants, meridian circles, etc). One of the quadrants used there had a radius of about 2.5 m. The top floor, finally, consisted of a platform in the form of a walkway, where portable instruments could be placed. Further instruments used at this observatory included precise clocks, a planet clockwork, gnomons, globes, meteorological instruments as well as a camera obscura.

Less than 30 years after its foundation, in 1774, the Jesuit Observatory in Graz was closed down, and the chair of astronomy was abolished. In 1782, the University of Graz was downgraded to a lyceum (which it remained until 1827); in 1787, another unfortunate event took place: the demolition of the observatory upon the order of the government.

Still 10 years before, in 1777, Anton Mayer SJ, the last director of the Jesuit observatory in Graz, had made an appeal to the university administration and had asked for the institute's conservation, arguing that a lot of money had been invested, that it still contained valuable collections of scientific instruments, minerals, plants and insects, and that it could still serve the purpose of spreading scientific knowledge (cf. Krones 1886, p. 456ff). Mayer's appeal, however, had no lasting effect; it could not prevent the demolition of the observatory a decade later, in 1787. Figure 2

Figure 2. The courtyard of the old university in Graz, founded in 1585, with the west side in the background, on top of which the Jesuit observatory was located between 1745 and 1787. Contemporary photograph by Th. Posch.

shows a contemporary view of the old Jesuit university courtyard, with hardly any traces of the former observatory left.

2.3. Trnava (Tyrnavia)

Trnava is located in today's Slovak Republic. Before the twentieth century, it used to be an important city in Upper Hungary, a part of the Austro-Hungarian empire. Trnava – in Latin called Tyrnavia, in Hungarian Nagyszombat, in German Tyrnau – lies about 100 km east of Vienna.

A Jesuit college was founded there in 1561; in 1635, this college achieved the status of a university, which existed there until 1777, when it was transferred to the city that we call Budapest today ("Buda" at that time).

Tyrnavia became the location of the first astronomical observatory in the Hungarian Kingdom in the years 1753–1755, when an astronomical and mathematical tower was attached to the "Collegium Tyrnaviense". In 1756, the Jesuit Franciscus (= Franz = Ferenc) Weiss was appointed director of this new observatory. Weiss in Trnava and Hell in Vienna thus both had five years as newly appointed observatory directors to prepare for the Venus transit in 1761.

Franciscus Weiss was the most important figure in eighteenth century astronomy in the city of Trnava, where he was born in 1717. We shall see that it was he who submitted observations of the 1761 transit of Venus to the Viennese *Ephemerides*. He was to remain director of the Tyrnavian observatory until 1777.

The observatory building had a height of 35.6 m. The ground floor hosted a museum of chemistry (*Musæum Chemicum*), the first floor hosted a collection of instruments used in physics (*Musæum Physicum*). The second and third floor contained the astronomers' living rooms and the *Musæum Astronomicum*. On top of all these floors, the actual observatory was located, with an extra height of 18 foot and a layout of 56×40 foot (cf. Weiss, in Vargha 1992).

Among the instruments that were used at the Jesuit observatory of Tyrnavia since 1756 were a 5-foot refractor, a 4.5-foot reflector and a 4-foot reflector. In addition, even large instruments were used, e.g. reflectors of up to 8 foot, since – and this was a distinctive feature of the observatory – one of the Jesuits working there, Ferenc Kéry, was actively producing astronomical instruments. After 1768, the following instruments were also available: an 18-foot refractor, a zenith sector with 3.2 m radius, three astronomical clocks (two of which came from the estate of the Viennese astronomer Marinoni), celestial globes and a magnetic compass (Bartha 2006).

In the context of Venus transits, it must be said that János Sajnovics SJ, who accompanied Maximilian Hell on his 1768/69 expedition to observe the Venus transit in Vardø, had worked as Weiss' assistant in Tyrnavia before departing to northern Norway at the age of 35 (cf. Aspaas 2012, p. 116–117).

Finally, it is worth mentioning that still today, a professional astronomical observatory exists relatively close to Trnava – 30 km to the west, next to the village of Modra in the mountain range of the Little Carpathians (Malé Karpaty), at an altitude of 531 m. It was established in 1988 and is operated by the Comenius University in Bratislava. Areas of research in which the observatory is involved include solar physics and photometry as well as astrometry of minor planets (more than 160 asteroids have been discovered at Modra).

2.4. Cluj (Claudiopolis)

Cluj or Cluj-Napoca – in Latin Claudiopolis, in German Klausenburg, in Hungarian Kolozsvár – used to be the capital of Transylvania, a part of today's Romania, which, even though located several hundred kilometers away from Vienna, was a vital part of the Habsburg empire in the eighteenth century. Its connection with the capital, Vienna, was much weaker than in the cases of Trnava and Graz, though, and the same holds true for the Jesuit observatory built there.

In 1753, the Jesuit college of Cluj obtained the status of a university; in the same year, the foundations of an astronomical observatory were laid. The person who was in charge of the construction was no other than Maximilian Hell. After studies in Vienna, a few years (1743–45) as an assistant to Joseph Franz and a short time of being involved in the planning of the observatory in Trnava, he was called to Cluj as a mathematician and, again, as an observatory designer. The three years he spent in Cluj until becoming professor in Vienna in 1755 seem to have been too short to achieve more than "to lay the basis of an astronomical observatory" (thus stated in a much later letter written by Hell to Thomas Bugge in Copenhagen, 24 July 1789). The fact that he did not see the completion of the planned facility is proven by the circumstance that he made his astronomical observations in his private apartment during his time in Cluj.

Only in 1766 – five years after the Venus transit of 1761 and eleven years after Hell had left Cluj – the observatory seems to have been completed. At this time, a person named Ferdinand (Nándor) Hartmann, who had become a Jesuit in 1753, was appointed professor of experimental physics in Cluj. Hell, who was obviously still interested in the fate of the Transylvanian observatory, sent a movable 3-foot quadrant, a pendulum clock and a 5-foot Newtonian reflector to Hartmann (cf. Hell's letter to Jean Bernoulli III, dated 15 February 1777, University Library of Basel). However, as far as we can see, he never got any observation reports back.

Further drawbacks to astronomy in Cluj were the suppression of the Society of Jesus and a fire which destroyed the observatory tower in 1798 (Szenkovits 2006).

2.5. A network of observatories

With respect to *all* the observatories mentioned above (the two in Vienna as well as those in Graz, Trnava and Cluj), it should be noted that they were intimately interconnected by frequent exchanges of students and staff. The mathematicians and astronomers at any of the mentioned universities would typically have studied and worked at least at one of the other three places. In addition, there were other Jesuit colleges that were part of this network, and which had chairs of mathematics, but no astronomical observatories or chairs of astronomy (see Aspaas 2012 for details).

3. Selected results of the Austrian-Hungarian Venus transit observations in 1761

3.1. Venus transit observations in 1761 at Vienna and Trnava

Among the observatories presented above, only those at Vienna and at Trnava were able to deliver publishable results on the 1761 transit of Venus. At Cluj, bad weather and/or a lack of appropriate instruments may have been the cause for the lack of any printed observation reports. The observatory in Graz should have been well enough equipped in 1761 to enable successful observations, but maybe clouds covered the Sun there. It may also have been the case that observations were made without finding their way into the *Ephemerides Astronomicae* of Maximilian Hell; in fact, the relationship between the Imperial Astronomer and his colleagues in Graz seems not to have been very close (cf. Aspaas 2012, p. 86–89).

In Trnava, the weather was quite fine ("serenum") during the decisive morning hours of June 6 (Hell 1761, p. 96). Franciscus Weiss, observing the Sun with a 4-foot Newtonian telescope, managed to record the time of both the third and the fourth contacts. The difference between the two measured times yields a duration of the "emersio" phase of 18 minutes and 27 seconds.

The observational efforts in Vienna have already been described above. It might be added that the weather in the capital was variable. The Sun and Venus were covered by clouds repeatedly; however, the very last minutes of the transit could be clearly seen and time measurements could be made.

However, the time of the fourth contact was $9^{\mathrm{h}}\ 42^{\mathrm{m}}\ 35^{\mathrm{s}}$ according to Scherffer, while it was $9^{\mathrm{h}}\ 43^{\mathrm{m}}\ 10^{\mathrm{s}}$ according to Hell (Hell 1761, p. 32), implying a maximum difference between the Viennese end time results of 35 seconds. But it should be noted that similar differences between the results of different observers at one and the same location occurred in other Venus transit observation reports as well (Wulf 2012).

3.2. The diameter of Venus according to Hell's 1761 observations

A longstanding question – since the seventeenth century transits of Venus – was the angular diameter of Venus in front of the Sun. Hell gives a short summary of previous measurements, going back to Jeremiah Horrocks and William Crabtree. He reports that Horrocks had derived a Venusian diameter (during the transit) of $1'16''$ while Crabtree had found a value of $1'8''$ (Hell 1761, p. 25).

Concerning the results of the transit in 1761, Hell writes: "diametrum Veneris in disco Solis versantis non majorem, nec multo minorem apparuisse 58 Secundis Circuli maximi [...]." (Hell 1761, p. 25). In other words, he derives a Venusian diameter of 58 arcseconds, which coincides remarkably well with the corresponding present-day value.

Hell also mentions that contemporary observers had found significantly larger maximum values of the Venusian angular diameter based on observations before and after the transit (while Venus was shining from the sky and not appearing as an opaque body in front of the Sun). The differences amounted to almost 20 arcseconds! Hell correctly suspected this effect to have an "optical cause" (Hell 1761, p. 25).

Furthermore, Hell calls for follow-up observations in 1769 – not only during the transit of Venus in that year, but also before and after it, "in the whole month of May, and in the whole month of June", in order to settle this issue (Hell 1761, p. 28).

3.3. The solar parallax value proposed by Hell in 1763

At the end, we may ask the question which value of the solar parallax Hell derived from all the Venus transit observation reports that became accessible to him during the months following June 1761. In this respect, there is an interesting passage in the appendix to the *Ephemerides astronomicae* for the year 1764 (published in 1763), which reads thus: *Ex his igitur omnibus concludendum arbitror, interea, [...], assumendam ex omnibus arithmetice mediam Parallaxim, scilicet = 9.′0. Est enim [...] minima deductio = 8.′2 & maxima = 10.′2 atque adeo media = 9.′0.* (Hell 1763, p. 225).

So Hell proposes to use – until the 1769 transit of Venus would eventually deliver a better result – a solar parallax of 9.0 arcseconds. This value is, coincidentally, by only 2.34% smaller than the currently accepted value of 8.″794 (cf. USNO 2011), implying an Astronomical Unit of about 146.1 million km. It should be noted, though, that the largest parallax value mentioned by Hell, 10.″2, corresponds to an Earth–Sun distance of 128.9 million km, while the smallest parallax value mentioned by him, 8.″2, corresponds to an Earth–Sun distance of 160.4 million km, which means that the Hell's "mean value" may more appropriately be written as 146 million km ±11%.

Nevertheless, this was a significant progress compared to the results of seventeenth century estimates of the Astronomical Unit: Horrocks had derived a solar parallax of 15 arcseconds from the observations of the transit of 1639, corresponding to an Earth–Sun distance of 87 million km.

4. Concluding remarks

The Venus transit observations at the Jesuit-run observatories in the Habsburg empire are far from prominent in the historiography, and that for good reasons. The 1761 transit took place during the very early morning hours of Central Europe, meaning that only the end stage of the transit was in fact visible. The 1769 transit, occurring as it did in the middle of the night, was not observable at all. Despite the insignificance of the data sets the "Austrian" Jesuits managed to provide, the infrastructure for observational astronomy that existed within the Habsburg empire merits a mention in the global history of the transits of Venus.

The report compiled by Maximilian Hell for the 1762 volume of his ephemerides was conspicuous not so much for the observations from the "Provincia Austriae" that were included. His theoretical discussion of various lessons to be learned from the 1761 transit appears to have been far more important. However, a comprehensive analysis of the impact of eighteenth-century Jesuits within the field of theoretical astronomy falls outside the scope of the present article.

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