The Introduction of Geodesy and Astronomy as an Academic Discipline in Norway in 1814

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SUMMARY

Based on handwritten sources in several archives we discuss events that influenced how geodesy and astronomy came to be an academic discipline at Norway's first university in 1814. In addition to curriculum requirements, political and military evaluations set the trend. This occurred at a turbulent time for Norway, when a declaration of independence was in effect for 10 months in 1814. A geodetic reference frame established 1779-1813 by the Geographical Survey of Norway came under dispute and a need for astronomical verification emerged. This led to small observatories being established in Oslo and Bergen. In the course of a decade they improved the longitudes from an error of 20' to 1'. Eventually, this led to a permanent observatory at the University of Oslo, which came to serve as the national reference meridian for surveying and mapping during a century. Geodesy remained a major component of the astronomical activities at the University of Oslo during the 19th Century, including national participation in the Struve geodetic arc and the Mittel-Europeische Gradmessung. It took 40 years before classical astronomical observing programs grew to significance, i.e. positional astronomy, orbits of asteroids and comets, stellar position catalogues.

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1. INTRODUCTION

The first geodetic reference frame in Norway was established between 1779 and 1813 by military surveyors of the Geographical Survey of Norway (Pettersen 2009). Using geographical circles for triangulation and astronomical latitude determinations, they covered the circumference of southern Norway between 58º<latitude<64º, including the eastern border to Sweden and the entire coastline to the west and south (Fig. 1). Baselines were measured on selected frozen lakes. Reference meridians were established astronomically at five sites by observing eclipses of the sun and of the moons of Jupiter (Pettersen 2010).

This dataset was analyzed by Benoni Aubert, director of the Geographical Survey of Norway from 1810 to 1832. He derived two values of the longitude difference between the reference point at Kongsvinger in the east and Bergen on the west coast. 6º40'04" was derived from the geodetic arc going north via Trondheim. 6º40'13" was derived from the geodetic arc going south along the coast via Kristiansand and Oslo. The values agreed to within 9".

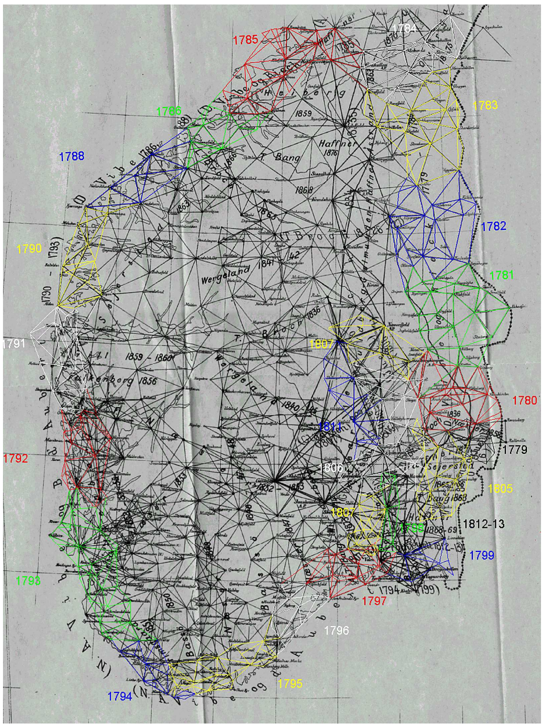

Fig. 1. Geodetic triangulations of southern Norway 1779-1813.

Aubert requested funds for an astronomical observatory in Oslo to verify the geodetic result. His application was received by the Danish-Norwegian Ministry of Finance in December 1813. He never received a reply because Norway seceded from Denmark a month later at the peace treaty of Kiel which settled issues following the Napoleonic wars. Norway was given to Sweden, but resisted this decision by declaring independence. During the first half of 1814 Norway established a constitution and elected a king. This was unacceptable to Sweden who mobilized troops to occupy Norway. The situation was resolved in the Fall by negotiations. The king resigned and left Norway. A twin monarchy was formed under the king in Stockholm.

2. THE FIRST NORWEGIAN UNIVERSITY

Several decades of political preparations and a successful private fundraising campaign finally convinced Fredrik VI of Denmark-Norway to sign a declaration on 2 September 1811 that allowed Norway to establish a university at home. The first professors were appointed in 1812 and teaching began in Oslo in 1813. Several young lecturers were added in 1814. One was Christopher Hansteen in applied mathematics. His specialty was the geomagnetic field and its variations in time and space. He was assigned to teach astronomy to first year students. The study plan required all students to study a broad collection of disciplines before selecting specialized tracks to major in law, theology, medicine, or languages. The first year included mathematics and sciences, philosophy, religion, classical languages, and history. The astronomy curriculum contained topics like spherical trigonometry, celestial coordinate systems, earth rotation, planetary motion, time determination, and geographical positioning based on observations of celestial objects.

The production of almanacs in Denmark-Norway was a monopoly granted to the University of Copenhagen since 1636. This monopoly was transferred to the Norwegian university in 1812. In 1813 there was no astronomer present in Oslo to carry out the computations and publish the almanac, and the Danish version was unavailable because all ship traffic to Norway was hindered by English and Swedish war ships. The viceroy ordered Benoni Aubert to compute the 1814 almanac for Norway. It was published in Oslo at the end of 1813. Aubert also prepared the one for 1815. When Hansteen arrived Oslo in July 1814 after an illegal, but successful crossing from Copenhagen, he became the university astronomer and thus responsible for the almanac. This immediately brought him in close contact with Aubert who resided at the Geographical Survey of Norway, just a short walk from the University. During the Fall of 1814 Hansteen was also introduced to the geodetic results by Aubert. They decided to collaborate to set up an astronomical verification.

3. A POLITICAL INTERMEZZO

The peace treaty in Kiel on 14 January 1814 separated Norway from Denmark and handed Norway over to the king of Sweden. A group of influential Norwegians immediately met with the viceroy, prince Christian Frederik of Denmark, and agreed to declare independence for Norway. They called for a national assembly to establish a constitution and appoint Christian

Frederik as the king of Norway. This was done on 17 May 1814. Since it violated the Kiel treaty Sweden prepared a military occupation of Norway. Norwegian defense forces mobilized. The war was avoided by a negotiated settlement in August. Norway and Sweden were united under the king in Stockholm. Christian Frederik abdicated in October and left Norway. He later became king of Denmark.

Between February and April 1814 Christian Frederik, then acting king, prepared and reorganized the Norwegian state for independence. He established a governmental ministry structure, a national bank, and requested status reports from existing government agencies to obtain an overview of the state resources and finances. One such agency was the Geographical Survey of Norway, then a military unit with a separate budget. It also served civilian society, e.g. mapping of natural resources and matriculation for tax purposes. Handwritten documents in various archives in Norway have revealed an interesting succession of events.

Benoni Aubert submitted a detailed report in March 1814 describing budgets, activities, and results of the Geographical Survey. He highlighted the results of his own analysis of the geodetic and astronomical observations along the periphery of southern Norway which had started 35 years earlier. The Norwegian reference frame was claimed to be among the most accurate ones in Europe. It had allowed the production of maps along the entire coast for safer shipping and fisheries. It had also allowed detailed mapping of the military theater along the border to Sweden. Aubert then discussed the needs for different map scales required by different tasks and separated economic matriculation mapping from the needs of military planning. In his view the latter was in good shape, but the first was in its infancy and would require decades to complete. He proposed to the king that the Geographical Survey of Norway be continued primarily as a military mapping agency.

The king asked one of his generals to review the report. He agreed with Aubert that the geodetic reference frame was well founded, but proposed that a longitudinal arc be measured directly from east to west to improve the results further. He also prioritized military needs over matriculation mapping, but proposed not to close the latter completely. A minimum of activity would allow future expansion when the state finances had improved.

Fig. 2. King Christian Frederik (left) and Benoni Aubert (right).

Although the proposal of a longitudinal arc was a sensible and useful one, Aubert denounced it as unnecessary in his response to the king in May 1814. He stated that such a proposal in a subtle way questioned his own statement of high accuracy of the Norwegian reference frame. Aubert explained in detail how the geodetic longitude difference between Bergen and the reference point had been derived and quoted numbers to demonstrate the high accuracy. He remarked that it took over a century of astronomical observations to produce a similar result between the two best observatories of Europe, and concluded that no further verification was required. He seems to have felt that the general had stepped into his exclusive geodetic circles and thus had interfered with his area of responsibility. Aubert's prestige was at stake.

At this point a general mobilization was in effect. The officers of the Geographical Survey were ordered to their regiments and all surveying operations halted. At the end of the year Aubert had to relate to the king in Stockholm, who initiated further reorganizations of the Norwegian state within the new twin-kingdom.

We propose that the challenges to his prestige and position felt by Aubert became a driving force to set up an independent (astronomical) verification of the geodetic result. Aubert wished to prove beyond all doubt that he was right. Two months later Hansteen arrived Oslo to lecture astronomy at the University and was also made editor of the almanac for Norway. This brought Aubert and Hansteen into collaboration, and just weeks later Hansteen was actively practicing to improve his skills as an astronomical observer. A year later, with Aubert's help, an interim observatory was in place. The same summer Aubert activated a skilled geodetic observer residing in Bergen. He taught the art of observing to a mathematics teacher who quickly produced results. Two years later he was employed by the University as an assistant to Hansteen and established his own observatory in Bergen.

4. THE FIRST UNIVERSITY OBSERVATORY IN OSLO

Hansteen was lecturing astronomy to the students every week during the last half of 1814. Simultaneously he began circum-meridian observations of the Sun with a sextant and chronometer to determine local time. He quickly discovered that public clocks in Oslo had to be corrected, and thus demonstrated the immediate use of an academic discipline. He argued that the coordinates of Oslo had to be determined accurately so that the capital of Norway could be put on the world map with the other nations. The symbolism and the contribution to nation building was evident. Funds were granted and an interim university observatory was prepared during the spring of 1815 (Pettersen 2002). Aubert served as an architect for the small observing hut by making available the drawings from his proposal in 1813. Equipped with a transit instrument, pendulum clock, sextant, and Gregorian reflector, Hansteen provided a time service and collected observations to derive the latitude and longitude of Oslo. He developed a method of time determination at high latitudes involving the pole star (Hansteen 1828). Hansteen was promoted to professor in 1816 and during the next decade he repeatedly received funds to acquire better instruments from abroad. His observational results, published in Astronomische Nachrichten and Magazin for Naturvidenskaberne (The Norwegian Journal of Science), eventually matched the accuracy of other small observatories in Europe and compares well with modern results obtained by GPS (Pettersen 2002).

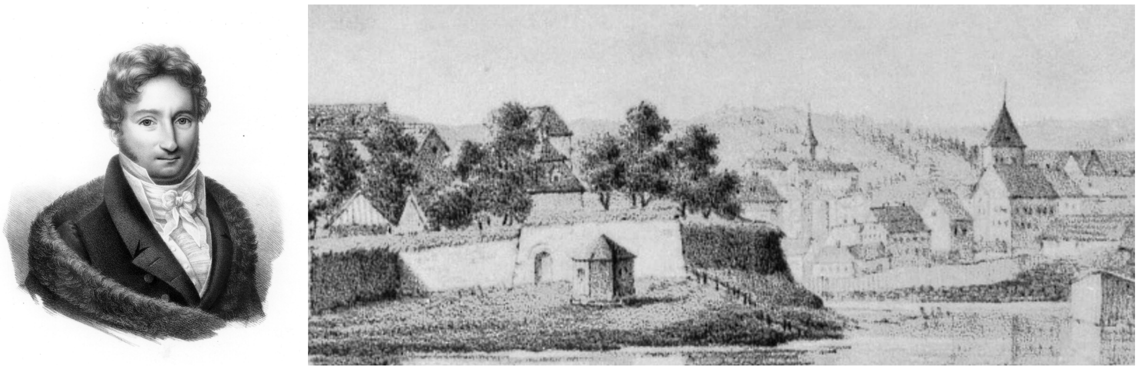

Fig. 3. Christopher Hansteen and the interim University observatory in Oslo 1815-1828.

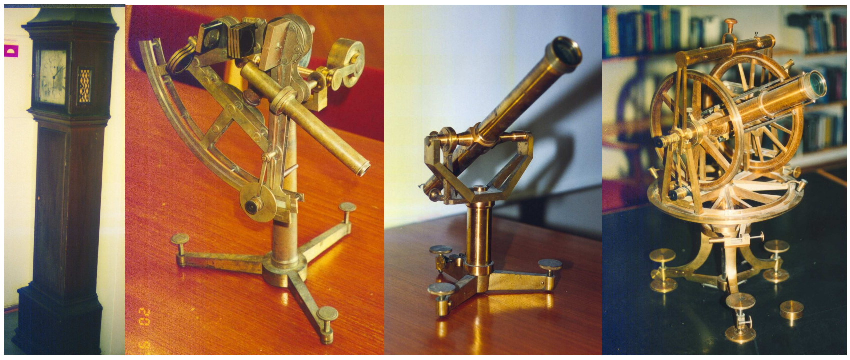

Fig. 4. Observatory instruments.

5. THE UNIVERSITY FIELD STATION IN BERGEN

Aubert also needed a collaborator in Bergen to improve the coordinates for astronomical verification of the geodetic results. As the commander of the Norwegian Brigade of Engineers, Aubert knew that engineering captain Hans Jørgen Wetlesen resided at Bergenhus fortress. His previous engagement with the Geographical Survey of Norway had left in his possession a geographical circle and other surveyor's tools. During the summer of 1814 he began circum-meridian observations of the Sun to improve the latitude of Bergen. Collaborating with him was mathematics teacher Gottfried Bohr. He was immediately fascinated by the complexity of observational and computational astronomy and soon took the lead. Using a small refractor he timed eclipse shadows on lunar craters to derive a longitude. This was improved by observing eclipses of Jupiter's moons and lunar occultations. In early 1816 Bohr made an extended visit to Oslo and met with Hansteen (now a professor) and Aubert (now a colonel). A proposal was submitted via the University to the king in Stockholm to appoint Bohr as an astronomical observer in Bergen. This was sanctioned in March 1816 and represents the first (part-time) university assistantship outside Oslo. In August, Bohr applied to local authorities of Bergen to obtain funds for an observatory. He argued that this was required to carry out the task assigned to him by the University and the king, i.e. to determine accurate coordinates for Bergen. He stressed that this was most beneficial also to the city of Bergen, then the most important harbor in Norway and the westernmost harbor in northern Europe. An observatory would offer a time service to Bergen and to visiting ship captains. The observatory, a copy of the building in Oslo, was ready in 1817. Aubert contributed additional instruments from the Geographical Survey of Norway, i.e. a transit instrument and a pendulum clock. The University thus obtained its first field station. Bohr, who was assigned the title of Observator, spent the next decade observing eclipses and lunar occultations to improve the longitude. He used a geographical circle to determine the latitude. During a visit in 1821 Hansteen brought his sextant for verification and further improvement of the latitude. Bohr published his results in national and international journals between 1814 and 1826, e.g. Astronomische Nachrichten, Transactions of the Swedish Academy of Sciences, and Magazin for Naturvidenskaberne (The Norwegian Journal of Science).

Fig. 5. The observatory in Bergen 1817-1832. (Detail from a painting by J. F. L. Dreier.)

Fig. 6. H. J. Wetlesen (left) and C. F. G. Bohr (right) with instruments in Bergen.

6. RESULTS

Aubert had calculated the longitude difference between Bergen and the reference point at Kongsvinger by dividing the periphery of Norway into a northern and a southern succession of geodetic triangles. The average value was 6º40’09”. The difference between the two results was 9”. GPS-measurements at the two sites yielded longitudes of 12º00’41” (Kongsvinger) and 5º19’49” (Bergen) east of Greenwich, i.e. a geodetic longitude difference of 6º40’52”. Aubert’s value thus represents a relative error of 1:560.

At the time of Aubert’s dispute he had no astronomical longitude difference between these two sites. What he did have access to were eclipses of Jupiter’s moons observed in Oslo in 1780 and in Bergen in 1792-93. They yielded a longitude difference between Oslo and Bergen of 5º36’ by combining with observations elsewhere in Europe and 5º42 by combining with predicted eclipse times for Berlin (Pettersen 2010). Both estimates have an uncertainty of ± 20’. The current geodetic value for Kongsvinger was 1º16’10” east of Oslo, suggesting a longitude difference between Kongsvinger and Bergen of 6º52’ to 6º58’, with a relative error of 1:21.

After 10 years of observations in Oslo, Hansteen had obtained the following results:

The longitude derived from solar eclipses in 1818 and 1820:	10º44’14” ± 56”
The longitude derived from lunar occultations 1816-1827:	10º44’49” ± 39”
Chronometer expeditions to Copenhagen and Stockholm:	10º44’25” ± 24”
The modern GPS (geodetic) longitude is	10º44’28”

The initial observations in Bergen by Bohr and Wetlesen improved the uncertainty of the longitude to ±5’. After 10 years of observations in Bergen, Bohr had obtained the following results:

The longitude derived from solar eclipses in 1818 and 1820:	05º18’02” ± 54”
The longitude derived from a lunar occultation in 1822:	05º16’46”
The modern GPS (geodetic) longitude is	05º18’35”

Simultaneous observations of two solar eclipses in Oslo and Bergen thus yielded a longitude difference of 5º26’12”. From one lunar occultation in Bergen and several in Oslo the longitude difference is 5º28’03”. The geodetic GPS-difference is 5º25’35”. The mountains east of Bergen cause a deflection of the vertical of 27”. In Oslo the effect is 5” in the opposite direction. The estimated astronomical longitude difference from GPS-data is thus 5º26’25”.

Hansteen and Bohr had brought the errors down from 20’ to 1’ in ten years. The longitude difference is very close to the modern value. The first project of academic astronomy in Norway thus contributed to the verification the geodetic result, as requested by Aubert. However, Hansteen had realized in the early 1820s that the small portable instruments set serious limitations to the accuracy that could be obtained. He began planning for a permanent astronomical observatory equipped with the best instruments that could be acquired from abroad. The University Observatory was inaugurated in 1833, one year after Bohr had passed away in Bergen. Hansteen used the meridian circle to further improve the latitude, and a refractor to determine the longitude from lunar occultations and solar eclipses. From 1841 he was assisted by an Observator, and in 1847 a series of chronometer expeditions between Oslo and Copenhagen was made by a steam liner to further improve the longitude value. A detailed account was published two years later (Hansteen and Fearnley 1849). These coordinates defined the reference meridian for all surveying and mapping operations in Norway during the next 100 years. The Observator, Carl Fredrik Fearnley, visited leading observatories in Europe for further training and started several astronomical programs at the Observatory in Oslo. He was appointed observatory director in 1861 and promoted to professor of astronomy in 1865. Nevertheless, he expanded the geodetic activities at the observatory. He brought Norway into the "Mittel-Europeische Gradmessung" in 1863 and led the Norwegian efforts till 1890. He was a driving force to install tide gauges to establish an orthometric height system.

7. CONCLUSIONS

We have demonstrated from archival sources that the early directions of geodesy and astronomy at the first university in Norway was the combined result of formal requirements in the university curriculum and the needs of a young nation to accurately map its topography and natural resources. The production of an official almanac brought competent individuals in contact. An unnecessary(?) dispute among high-ranking army officers set focus on the accuracy of the Norwegian geodetic reference frame. The need for an astronomical verification led to observatories in Oslo and Bergen, and to a major improvement of the longitude difference, in support of the geodetic result. The primarily geodetic application of academic astronomy was a direction defined by this situation. It provided funding for instruments and eventually of a permanent observatory. The geodetic focus was present during the entire 19th Century. Research in astronomy began in 1844 (30 years after the university started teaching astronomy) in positional astronomy and orbital motions of asteroids and comets. This continued for about a century, when astrophysics took full focus first theoretically and later also observationally.

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BIOGRAPHICAL NOTES

Dr. Bjørn Ragnvald Pettersen majored in astronomy at the University of Oslo (1978) and obtained his doctorate in astrophysics at the University of Tromsø (1986). As an astronomer he has been affiliated with the universities of California (Berkeley), Oslo, Texas (Austin), and Tromsø. In 1992 he was appointed chief scientist in geodesy at the Norwegian Mapping Authority. He established a VLBI-observatory at Spitzbergen and headed the computational efforts to establish a national satellite-based geodetic reference frame. In 1998 he was appointed professor (chair) of geodesy at the Agricultural University of Norway (name changed in 2005). He heads a research group employing GNSS, absolute gravimetry, and satellite gravimetry to study the gravitational field of the earth and its changes in time and space on regional and global scales. Pettersen has published more than 150 scientific papers in astronomy, geodesy, and history of science and has (co-)edited 5 proceedings. He is a member of IAU, EGU, and several academies/societies.

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