Museum „Physicalisches Cabinet“

One of three collections of historic instruments in the faculty of physics is located at the foyer in front of the lecture halls. It showcases the history of physics in Göttingen, from the beginnings of systematic research in the 18th century to its most famous period as the world-leading center for physics and mathematics in the first half of the 20th century.

Physics in the early years of the university

The witnesses of more than 275 years of the physics tradition in Göttingen give us unique insight in the university teaching and research in the 18th and 19th century. The first physics lectures were given by the philosopher Samuel Christian Hollmann (1696-1787) in 1734, preceding the official founding of the university in 1737. He came as a well-known critical mind from the University of Wittenberg to teach ethics, psychology, logic and metaphysics and established the tradition of well-visited lectures on natural sciences. Due to the approach of the newly funded university to appoint researchers with fresh thoughts, Göttingen became a well-known German university for advanced education of students. Researchers in the spirit of the period of enlightenment were gathered in Göttingen. One of them was Tobias Mayer (1723-1762) who joined in 1751. His field was applied mathematics and astronomy and he developed an outstanding reputation for his first precise moon observations, fixed star map using and lunar tables, later earning him the title “Mayer Immortalis”, nicknamed by Gauß. His quadrant holding the telescope made by Bird (London 1756) was at the first observatory in the city, which can still be seen in the new physics building.

18th century: Lichtenberg

When *Georg Christoph Lichtenberg* (1742-1799) came from Darmstadt as a student in 1763 for three years, the lectures he listened to were mainly devoted to mathematics, but he was also introduced into astronomy. In 1778 Lichtenberg assumed the lectures on physics from his colleague, the natural scientist Johann Polycarp Erxleben (1744–1777), and gave his famous experimental physics lectures from 1778 to 1799. A novelty at that time, he put the experiments in focus, giving the first experimental physics lectures. He had more than hundred students listening in his private rooms at that time, out of the university’s a few hundred in total, which stands as a testament to his popularity and for the popularity of over 600 demonstration experiments investments at that time purchased from private funds. They ranged from small demonstration experiments in mechanics and energy conservation, density of liquids and thermal expansion, spectrum of light and optics to the demonstration of magnetic forces (a selection is given in Fig. 1; the full Lichtenberg collection can be found online at http://snail.ph4.physik.uni-goettingen.de/MathNatFak/phycab.php). His most expensive instrument was a vacuum pump crafted by Naire and Blunt (London 1782) which was an investment

Fig. 1: Historic instruments from Lichtenberg’s collection “Physicalische Apparate”, built up in between 1771-1779.

Fig. 2: Vacuum pump (manufactured by Naire and Blunt, London 1782). It was the most expensive piece of equipment in Lichtenberg's collection, reaching a vacuum of 0.5 mbar.

corresponding to one year of his salary (Fig. 2).

It allowed the demonstration of the effect of evacuation, which inhibits the propagation of sound of a metal bell in the evacuated glass jar. This experiment prompted a maidservant to repeat the experiment with a captured nightingale, a situation depicted on a contemporary copperplate print. In 1777 he started to work in the field of electricity. He bought his first apparatus, an electrostatic generator, and experimented with large isolating dielectrics (electrophorus) to produce electrostatic charge via electrostatic induction. The flat 'cake' of resinous material like tar pitch on a metal plate (Fig. 3) is rubbed with a cat's fur which builds charge in the dielectric. He could study electric discharges 70 cm in length. By accident, he recognized that the plates decorated by the resin dust showed two well defined shapes: one fine-structured and symmetric looked positive and the other rather unstructured viewed as negative. With this important discovery he could show that there two types of electric charges, which are not connected to the material but reveal a general character. In 1789, Lichtenberg sold his impressive collection of instruments to the university, which formed the basis for demonstration experiments in the following years and the foundation of our current collection.

19th century: Gauss and Weber

It was *Carl Friedrich Gauß* (1777-1855) who set new standards in astronomy, mathematics and physics. Born in Brunswick, his school tuition was financed by his duke, who recognized his mathematical talent. At the age of twenty, he was in the first league of mathematicians already. His mathematical knowledge allowed him to calculate the orbit of the small planet Ceres with data of only 41 days of observation. He predicted the position for its rediscovery, which founded his worldwide fame as an astronomer. Since the electorate of Hannover wanted to fund a novel observatory, his appointment as a professor in 1807 was accelerated and he moved into the newly built observatory outside of Göttingen a few years later. Besides mathematics and astronomy the third field of his strong contributions was in physics. Inspired by the observation that sunlight reflected by the St. Michaelis church in Hamburg could be observed as a bright spot while he visited Lüneburg about 50 km away, he developed a new method to measure distances for a land survey campaign in the kingdom of Hanover. The instrument developed by him, the so called Vizeheliotrop, can be seen in its original in our collection (Fig. 4). With this sensitive instrument, he could measure the spherical excess of the curved surface on 100 km distance. In fact, this inspired his work on conformal maps in the field of mathematics, later addressed by Riemann in detail. Following a discussion with Alexander von Humboldt, exploration of the earth's magnetic field became another topic of interest. Through the coordination of the exploration of the earth's field components at hundred places around the world, it was possible for Gauß by using his mathematical knowledge to calculate a map of the full magnetic field of the earth in its components (Fig. 5, from a publication of the magnetic society "atlas of the earth magnetism" 1840).

This was at a time when *Wilhelm Eduard Weber* (1804-1891) had been appointed as a professor for physics in Göttingen, the former chair of Lichtenberg. As a candidate strongly supported by Gauß, they developed a fruitful collaboration. Weber's novel research field at Göttingen "electromagnetism" was stimulated by Oersted's finding of a force in between live wires. With Weber's experiments (Fig. 6) precise measurements of the strength of the magnetic field in absolute units became possible and his definition of the current is still valid. It allowed Weber and Gauß to realize a unit system connecting electric and magnetic quantities to the basic units of length, time and mass. Webers theory, which he completed in experiments together

Fig. 3: Electrophorus and cat fur on the left at around 1780. With the tin foil coated wooden plate the charge could be separated and impressive electric sparks up could be generated. Lichtenberg figure for a positive charge on the right.

with Rudolf Hermann Kohlrausch (1809-1858) contained only one parameter connecting the force between static and dynamic charges. The determination of this parameter was the first electric determination of the propagation speed of light, later verified by Maxwell’s theory. To satisfy Gauß’ and Weber’s need for highest quality optical and electric apparatuses, local fine mechanics workshops florished. One most famous instrument maker was Moritz Meyerstein (1808–1882), who made the transportable magnetometer developed by Gauß to ensure the highest possible sensitivity (Fig. 5). This laid the foundation for many companies of Göttingen’s measurement valley like Lambrecht, Sartorius and other companies founded later in the periphery of the university. Ernst Abbe, founder of the world renowned Zeiss, was a student of Weber and Riemann. Another example of the excellent engineering skills of Weber and Gauß is the first telegraph, built in 1833. They put up a one kilometer long wire in-between the observatory outside the town walls and Weber’s institute, transmitting messages by using an induction transducer and detection of the binary coded current pulses by a mirror galvanometer. This setup was shown at the world exhibition in Vienna 1873, during a dispute on patent rights, and can be visited in the museum (Fig. 7).

20th century: birth of quantum mechanics

At the turn of the century, aims of experimental research were to understand the nature of electric conductivity (“electron gas” in metals), the study of cathode rays to determine the nature of the electron (e/m) and spectroscopy to access the nature of the atom. A collection of various spectrometers and X-ray tubes of the first generation remain from that time and are exhibited in the museum.

The mathematics institute with Felix Klein (1849-1925), David Hilbert (1862-1943) and Hermann Minkowski (1864-1909) was

Fig. 4: Gauß’s Vizeheliotrop (manufactured by Troughton, London, 1810). It was on the back of the 10 DM note. It was developed for a measurement campaign in the kingdom of Hanover, and its sensitivity allowed the study of the spherical excess of the curved earth’s surface.

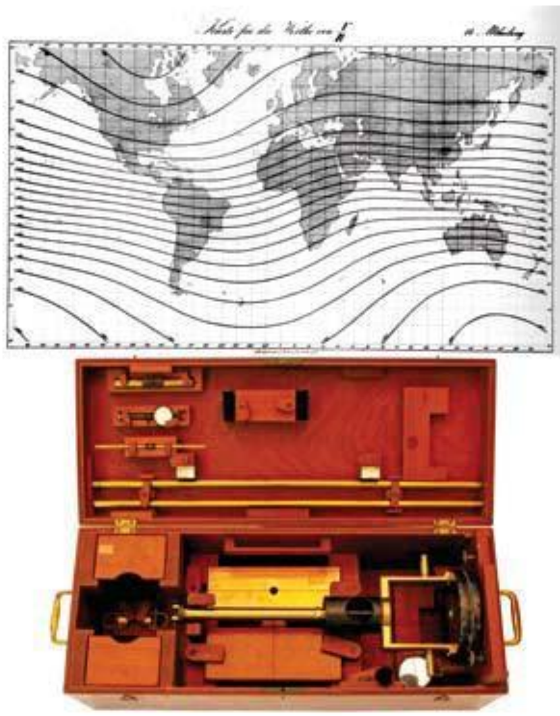

Fig. 5: Transportable magnetometer from Weber (manufactured by Meyerstein Göttingen, 1839). It was motivated by Alexander von Humboldt to map the earth’s magnetic field component, which was deduced from 100 experimental stations all over the world and printed in Gauß’ and Weber’s atlas of the earth’s magnetism.

Fig. 7: Gauß-Weber telegraph as shown at the world exhibition in Vienna 1873.

a well-known international centre of mathematics. Belonging now to Prussia, the ministry at Berlin wanted to further develop Göttingen as a centre for mathematics and physics. These sciences were on the verge to become an important motor for industrial developments. Klein and Hilbert wanted to get Max Born (1882-1970) for the position of theoretical physics as a successor to *Peter Debye* (1884-1966). With Born, *James Franck* (1882-1964) came to Göttingen. Together with *Robert Pohl* (1884-1976), they led the three physics institutes (I., II. and theory). In the 1920's. Göttingen was one of the birthplaces of quantum mechanics and attracted important people from outside. The interaction between Hilbert, Born, Franck and Pohl created a unique atmosphere. Their seminar on the "structure of matter" brought all physicists and mathematicians together. These famous years of quantum mechanics ended abruptly by the devastating rise of National Socialism in Germany in the 1930's. The beginnings of atomic physics and solid state physics are the latest exhibits found in the museum. Some of

Fig. 6: Weber's instruments to measure the magnetic field generated by the circular current loop from 1837. With the Tangentenbussole (Bussole = compass), sensitive deviations of the needle were be determined thus it was the first practical instrument to measure the magnetic field generated by the current through the wire loop. The wiring can be seen at the bottom.

the most important work on quantum mechanics of that time is displayed permanently in the foyer of the museum.

The Museum

The history of the museum begins when the exhibits were moved from Michaelishaus to the new physics building on Bunsenstrasse. Being in an naturally acclimatized cellar they luckily survived mostly undisturbed. In the last century, when the university had its 250th jubilee the "Sammlung Physicalischer Apparate" of the I. Physics Institute was described and newly catalogued by Prof. von Minnigerode and Prof. G. Beuermann. The collection of historic instruments of the early days of physics in Göttingen was built up and found a new home in the museum „Physicalisches Cabinet and Lichtenberg collection“ in the new physics building. In addition, the museum hosts exhibits of the collection of historical instruments of the astrophysics observatory "Historische Instumente der Sternwarte", from geophysics, "Geophysicalische Historische Sammlung", and on the birth of quantum mechanics. It is opened to the public on a regular basis. The unique contemporary witnesses of more than 275 years physics tradition of the University of Göttingen are found there and were newly arranged by Prof. M. Münzenberg, now at the University of Greifswald. One can imagine Lichtenberg sitting at his desk taking notes, an electrophorus nearby, surrounded by dull leather, misty glass and fragile brass. It is the hands on experience that makes a tour through 275 years of physics in Göttingen an impressive experience. Most recently the digitization of the collection of Lichtenberg and Gauss was completed. These are now available online as high resolution images, with some even as 3d-animated objects. Weber's instruments are in preparation.

Guided tours with the current curator, Prof. K. Samwer, I. Physics Institute, can be arranged. (Tel: 0551 39-7602, http://www.uni-goettingen.de/de/47114.html).

[1] Friedrich Hund, *Die Geschichte der Göttinger Physik*, Göttingen 1987, in Göttinger Universitätsreden, Vandenhoeck Ruprecht.

[2] Ausstellungskatalog: *Die Göttinger Sieben. Eine Ausstellung der Georg-August-Universität Göttingen*, Hrsg. von H. Wellenreuther, Göttingen 1987.