Wilhelm Weber: A Biographical Sketch

Heinrich Weber

Editor's Note: An English translation of Heinrich Weber's work "Wilhelm Weber: Eine Lebensskizze".[1]

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[1] [Web93a]. Weber's portrait from 1884 was taken by the German photographer Bernhard Petri (1840-1887):

B. Petri, Phot. Göttingen. Meisenbach, Riffarth & Co, Berlin, heliograv

Wilhelm Weber

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1.1 Preface

The intention was to publish this biography already earlier, but the inspection of a large amount of unsorted letters caused some delay. I hope that the friends of Wilhelm Weber will like this little book. I would like to make here some corrections to the version of the biography which appeared in the "Deutsche Revue".[5] In the footnote on page 184 in the volume from August 1892 it should read: Both professorhips (for anatomy and physiology) E. H. Weber hold until 1865 (instead of 1870), when Professor Ludwig was appointed for physiology. He was professor for anatomy for 51 years (instead of 55 years). His younger brother Eduard was associate professor and prosector for anatomy.

The author.

1.2 Wilhelm Weber's Youth 1804-1825

Weber's family originally came from Gröben a little village in Thuringia close to the market town Teuchern located in between Weissenfels and Zeitz. There the grandfather of Wilhelm Weber owned a farm. According to the custom at that time his son Michael, the father of

[2][Web93a]. See also [Web92a], [Web92b] and [Web92c]. Heinrich Weber was born on January 1, 1839, in Leipzig and died on May 5, 1928, in Braunschweig. He was a German physicist and Professor at the Ducal Technical University in Braunschweig. He was appointed Privy Councilor, was the nephew of Wilhelm Eduard Weber (son of his older brother, the physiologist Ernst Heinrich Weber (1795-1878)) and was accepted as a full member of the German Academy of Natural Scientists Leopoldina on January 8, 1901.

[3]Translated by U. Frauenfelder, urs.frauenfelder@math.uni-augsburg.de. Edited by A. K. T. Assis, www.ifi.unicamp.br/~assis. We thank Laurence Hecht and Mathias Hüfner for relevant suggestions.

[4]The Notes by Heinrich Weber are represented by [Note by Heinrich Weber:]; the Notes by Carl Friedrich Gauss are represented by [Note by Gauss:]; while the Notes by A. K. T. Assis are represented by [Note by AKTA:].

[5][Note by AKTA:] See footnote 2.

Wilhelm Weber, should have succeeded as a farmer. However the father of Wilhelm Weber already as a young man didn't show much ability and interest for farming. "Michael never will become a competent farmer, he just can study", his father said. After some reluctance he finally agreed that his son studies theology. Therefore in 1784 the just 30 year old Michael Weber was already professor for theology at the university of Wittenberg. A. M. Meyner in his History of the Town Wittenberg, Dessau 1854,[6] on page 147 attributes to him a thorough erudition, a strong sense for justice and good manners. Michael Weber's[7] religious view was based on the Revelation and until his death in 1833 he opposed Rationalism, which became more and more trendy. His serious, strongly religious but as well cheerful nature deeply influenced his children. Although Wilhelm Weber was undogmatic, he was religious and against materialism. Michael had a vast knowledge of Latin. Apart from theological writings, he translated a great number of hymns into Latin. Moreover, he wrote letters and poems in Latin to his children. His first spouse was Christiane Friederike Wilhelmine, née Lippold. Christiane is described as a gracious and delicate woman. She gave birth to twelve children. However, except Wilhelm, only four, three sons and a daughter, reached adulthood.[8] After she passed away Michael married Eleonore Friederike Henriette Pallas. Eleonore didn't give birth to children, but was a great mother for the children Michael had with his first wife. She took very good care of Michael until he passed away on August 01, 1833. It is said that Michael had a thundering voice which was very suitable for public speeches. He was president of the University of Wittenberg in 1802 during the celebration of its 300th anniversary and as well in 1807 at the peace festival on July 02.[9] After the merging of the universities of Halle and Wittenberg, Michael Weber moved to Halle and became a professor for theology. He diligently carried out his duties as a professor until his death.

Wilhelm Eduard Weber was born in October 24, 1804. At this time his parents were renting an apartment in the "Golden Ball" in Schloßstraße 5 (now number 15).[10,11] The

[6] [Note by AKTA:] [Mey54].

[7] [Note by Heinrich Weber:] C. F. Fritzsche, Narratio de Michaele Webero primo nuper Halensi theologo, Halis Saxonum 1834.

[8] [Note by Heinrich Weber:] Gustav Weber was born in Wittenberg in February 07, 1790. He was pastor in Rackith close to Wittenberg and after retirement he lived in Niemegk close to Bitterfeld. He passed away in Klein-Wittenberg November 11, 1852.

Ernst Heinrich was born in Wittenberg in June 24, 1795. From 1806 until 1811 he went to school in Meissen. He studied from 1811 until 1813 in Wittenberg and after that in Leipzig from 1813 until 1815. In 1815 he became a doctor in Schmiedeberg, when the university was relocated to this town after the siege of Wittenberg. In 1817 after his State doctorate he became a private lecturer in Leipzig. Because of an offer from the newly founded university in Bonn he became associate professor in Leipzig. When Rosenmüller passed away just a year later in 1820 he became full professor of anatomy and after Kühn passed away he simultaneously became as well professor for physiology. Both professorships he hold until 1865, when after the appointment of Professor Ludwig for physiology a special professorship combined with an institute was founded. The anatomy he later run jointly with his younger brother Eduard, who became an associate professor. Shortly after Eduard passed away, Ernst Heinrich resigned as well from this professorship, which he had hold for 51 years. Soon after he became ill and passed away January 26, 1878.

Eduard Friedrich was born in March 10, 1806 in Wittenberg. He went to the school of the Francke Foundations in Halle, became a doctor in Naumburg and since 1833 he was associate professor for anatomy in Leipzig. He passed away May 18, 1871.

Lina Weber was born April 06, 1802. She never married and passed away in July 01, 1881 in Halle.

[9] [Note by Heinrich Weber:] Meyner, Geschichte der Stadt Wittenberg, Dessau 1845, pp 147-148 and C. F. Fritzsche, narratio etc.

[10] [Note by Heinrich Weber:] According to an announcement of the mayor of Wittenberg Dr. Schild in the Göttinger Journal, August 13, 1891, No. 8634.

[11] [Note by AKTA:] In German: *goldnen Kugel*. It might refer to an old-style shot ball. A mod-

owner of this house was Professor Langguth.[12] He had the same age as Michael. Since they lived together already more than ten years in this house — because his brother Ernst Heinrich, ten years older, was also born in the same house — the two families had become good friends. We do not have much information on the early boyhood of Wilhelm. Probably he played a lot with his younger brother Eduard under the careful protection by his mother in a peaceful environment. Without doubt the relations between the families Weber, Langguth and Chladni[13] had a strong influence not just on the life of Wilhelm, but as well on the life of his brothers. Chladni had as well an apartment in the house of Langguth from 1801 until 1813. Langguth was from 1782 until 1784 a doctor and an associate professor of medicine. He then became full professor of natural history until he passed away in February 09, 1814 in Wittenberg. He owned a geological, economical, physical as well as a medical collection. His collection was renowned for its real gems, its very rare pieces but as well its usefulness for instruction.[14] Chladni was a doctor of law without tenure. From 1756 until 1827 he mostly lived in Kemberg close to Wittenberg. Both he and Langguth were sons of professors in Wittenberg and so they were good friends since their teens.[15,16] In such an environment natural science had a lasting impact on the boys. Maybe this was as well influenced by the fact that the oldest brother Gustav already studied theology in the footsteps of their father and that another brother Fritz who unfortunately died very early became a soldier. Until his death Chladni exchanged letters with the Weber brothers. Due to his influence, Eduard and Wilhelm jointly studied the theory of waves, and acoustics was the field Wilhelm Weber

ern picture of this house is shown in Figure (a) of this footnote, https://en.wikipedia.org/wiki/Wilhelm_Eduard_Weber and https://www.hmdb.org/m.asp?m=69820. In Figure (b) we show the memorial plaques. The upper one reads: Wilhelm Eduard Weber, professor of physics and inventor of electrical telegraphy, was born in this house on October 24, 1804. The lower one reads: Inventor of the electro-magnetic telegraph, Birthplace:

(a) (b)

[12] [Note by AKTA:] Christian August Langguth (1754-1814) was a German physician and physicist.

[13] [Note by AKTA:] Ernst Chladni (1756-1827) was a German physicist and musician. He is specially known for the so-called Chladni figures or Chladni patterns, that is, the modes of vibration on a rigid surface.

[14] [Note by Heinrich Weber:] Meyner, p. 43.

[15] [Note by Heinrich Weber:] Bernhardt, Dr. Ernst Chladni, der Akustiker, Wittenberg 1856, p. 39.

[16] [Note by AKTA:] [Ber56].

started his physical career.

The peaceful family life didn't last too long. Napoleon finished his terrible retreat from Russia. August 26, 1813 Blücher won the fight at the Katzbach. On August 23 and September 6 Bernadotte, Bülow and Tauentzien ended up as victors in the battles at Gross-Beeren and Dennewitz. Everywhere people started ousting the French from their positions they had occupied. The fortress of Wittenberg as well had a French garrison. In September 1813 Bülow came with his army in order to liberate the city from the French. The French refused to withdraw and a terrible bombardment was the answer. Bernardt writes about this:[17]

> On the evening September 27, 1813, the Prussians under the leadership of Bülow started the second terrible bombardment on our unfortunate town. Ten Artillery batteries distributed from the rothen Mark over the Belziger and Bruchstreet until the river Elbe were shooting with 24 cannons. During this terrible cannonade the tower of the castle church as well as the rear part oft he castle caught fire. This fire spread from there to the houses of Dörffel, Meyner and Langguth. Several families and among them the one of Professor Weber could just save their life."[18]

After this dreadful night, Professor Weber like many other Professors left the fortress on siege and escaped to Schmiedeberg in the vicinity of Wittenberg, where he stayed until the end of September 1814. After the merger of the University of Wittenberg and the University of Halle he moved to Halle.[19]

In Halle Wilhelm went to the school of the Francke Foundations and diligently studied old languages. His interest for the classical writers shows a list of Latin and Greek writers which he bought from his own pocket money. This was much more then he was obliged to do by the school. When he still went to school, he was called in by his older brother Ernst Heinrich, who already was a professor in Leipzig, to carry out experiments on wave motion. The results of these studies later formed the jointly published *Wellenlehre*.[20,21] In order to carry out these researched undisturbed, Ernst managed to achieve that Wilhelm was allowed to stay away from school for a longer time. By sharing common interests, the brothers who already had a strong family relation got so close, that they promised each other to always hold together firmly "whatever destiny will bring". Rarely people were commuting on foot so often from one city to the other on the country road between Leipzig and Halle than during the time where Wilhelm and Eduard lived in Halle and Ernst in Leipzig. They didn't care about the distance of eight hours. During the time of Easter 1821 Wilhelm probably made his first longer travel together with his brother Ernst to the Bohemian baths about which he made manifold records.

In Easter 1822 Wilhelm finished school and began studying mathematics in Halle. It is not possible to trace back which lecturers he liked most. Probably he studied mathematics with Johann Friedrich Pfaff and physics with Johann Salomo Christoph Schweigger.[22] During

[17] [Note by Heinrich Weber:] Bernhardt, Wittenberg vor 50 Jahren, Wittenberg 1863, p. 33. — Meyner, pp. 69 and 70, and mayor Dr. Schild, Göttinger Zeitung from August 13, 1891.

[18] [Note by Heinrich Weber:] The house of Langguth, the golden ball, did not completely burn down, but could be restored after a major repairing. It survived until today and is now endowed with a plaque.

[19] [Note by Heinrich Weber:] Meyner, p. 68.

[20] [Note by Heinrich Weber:] Die Wellenlehre auf Experimente gegründet, Leipzig 1825.

[21] [Note by AKTA:] [WW25]. Original title in German: *Die Wellenlehre auf Experimente gegründet* (Wave Theory Founded on Experiments).

[22] [Note by AKTA:] Johann Friedrich Pfaff (1765-1825) was a German mathematician. Johann Salomo Christoph Schweigger (1779-1857) was a German chemist, mathematician and physicist.

his studies Wilhelm made several times smaller and longer travels on foot. Immediately in the summer of 1822 he was travelling with his brother Ernst for three months to Switzerland and Northern Italy. In later terms he actively joined the physical seminar of Schweigger. Due to his preference for acoustics, he published excerpts of the papers of Savart on sound and tone in Schweigger's *Journal für Chemie und Physik*, volume 14, p. 385.[23] Meanwhile his joint studies on the propagation of waves came to an end and could be published in the year 1825 in a paper entitled "Wellenlehre auf Experimente gegründet".[24] This paper made him quite famous in the world of science and encouraged him to proceed his career in experimental research. The two editors dedicated the work to their old friend Chladny. After having received the paper, Chladni wrote to Wilhelm in August 20, 1825:

> Dear friend, thank you very much for the nice dedication of your joint paper with your brother in Leipzig on the theory of waves. I am very honoured since it is a really groundbreaking work in which it is explained much clearer and much more coherent than before what happens during this kind of movement. Moreover, it contains many new contributions enhancing our knowledge. What distinguishes your work is that you describe only the immediate results and observations in the most simple way. This is much more useful than a philosophical approach which often has not much in common with actual nature.

Not only scientists were excited, but as well the government. Altenstein which at that time was minister of education in Prussia wrote in March 14, 1826:

> I acknowledge the great merit the rich paper, which you wrote jointly with your brother, has for the advancement of science. If you need more funding just tell me.

The minister added to this letter a report of an unnamed "outstanding physicist" who refereed the paper.

The great success of his first paper[25,26] had the most advantageous consequences for Wilhelm Weber. From this time on until he moved to Göttingen, the Ministry not only funded very generously the acquisition of devices and instruments Wilhelm Weber needed for his research, but as well paid him quite well, even before he became a lecturer at the university. When he later became an associate professor, the Ministry continued its favorable treatment of Wilhelm Weber and awarded him several wage increases.

1.3 Further Years of Study 1824-1831

Wilhelm Weber obtained his PhD in August 26, 1826. Its title was "Theoriam efficaciae laminarum maxime mobilium arcteque tubas aerem sonantem etc. continens".[27] However,

[23] [Note by AKTA:] Felix Savart (1791-1841) was a French physicist and mathematician. See [Web25a] and [Web25b].

[24] [Note by AKTA:] See footnote 21.

[25] [Note by Heinrich Weber:] The Royal Society of Sciences in Göttingen is currently editing the collected works of Wilhelm Weber in Julius Springer's publishing company in Berlin. The first and second volume of six volumes in total will appear this autumn.

[26] [Note by AKTA:] The six Volumes have already been published: [Web92e], [Web92d], [Web93b], [Web94c], [WW93] and [WW94]. Most of his papers have already been translated into English in the 4 Volumes of the book *Wilhelm Weber's Main Works on Electrodynamics Translated into English*: [Ass21a], [Ass21b], [Ass21c] and [Ass21d].

[27] [Note by AKTA:] The theory of the efficiency of the most movable plates and the trumpets closely containing the sounding air etc.

Wilhelm Weber felt that Halle could not offer him what he desired for his further education. Therefore he wished to go for one year to Göttingen in order to continue his studies in mathematics and exact sciences with the famous mathematician Gauss.[28] After that he planned to go for one year to Paris where mathematics and physics flourished. In view of the favourable treatment he received so far from the Ministry of Education, he took courage to ask it for funding. However, in a letter from April 29, 1826, the Ministry refused any support. The minister of education wrote:

> For several reasons the Ministry thinks it is better for you that you first work for some time as a private lecturer at your current university and visit Paris later. In order to obtain advice and support from the Privy Counsellor Gauss for your hydraulic and related researches, it is not really necessary that you go for one year to Göttingen. Instead of that you can exchange letters with Gauss and maybe visit him during your vacation. In this way you can achieve the same result in a cheaper way.

Therefore Wilhelm Weber gave up his travel plans. He continued his researches in acoustics and published some small papers in Schweigger's Journal für Chemie and Physik. In 1827 he submitted his habilitation thesis "Leges oscilliationis oriundae etc" (The laws of vibration generation and so on..).[29] It is interesting to note that among others Johann Tobias Mayer congratulated him without knowing that four years later Wilhelm Weber will become his successor in Göttingen.[30] Wilhelm Weber was private lecturer only for a short time. Already in the autumn of the following year he became associate professor after having received shortly before his first international honour by becoming a corresponding member of the Royal Academy of Science of Turin. In September he visited the meeting of natural scientists in Berlin where he made his first acquaintances with the participating professors and lecturers. Wilhelm Weber himself gave a lecture on organ pipes published in Poggendorff's *Annalen*, volume 14, 1828.[31] His lecture impressed Alexander von Humboldt and Gauss who participated in the meeting.[32]

Wilhelm Weber still wished very much to continue his studies outside of Halle. Immediately after the meeting of natural scientists he visited Berlin for a longer period starting in October 17, 1828. This visit had a lasting impact on his future career. The personal intense exchange with colleagues of his age like Dirichlet, Dove, Magnus or Wöhler but as well senior people like Mitscherlich, Heinrich and Gustav Rose, Poggendorff, Enke, Seebeck, Steiner, Weiss, Ehrenberg, Ermann, Crelle and others had a stimulating effect on him. Especially valuable for him was that he could visit Alexander and even Wilhelm von Humboldt.[33] Alexander von Humboldt had a great interest on the young ambitious researcher. Proof of this is a note Wilhelm Weber made November 12. He wrote:

[28] [Note by AKTA:] Carl Friedrich Gauss (1777-1855) was an important German mathematician, geodesist and physicist.

[29] [Note by AKTA:] Complete title in Latin: Leges oscillationis oriundae si duo corpora diversa celeritate oscillantia ita conjungutur ut oscillare non possint nisi simul et synchronice exemplo illustratae tuborum linguatorum — The laws of oscillation arising if two bodies oscillating at different speeds are joined in such a way that they can only oscillate simultaneously and synchronously are illustrated by the example of tongued tubes. See [Web27].

[30] [Note by AKTA:] Johann Tobias Mayer (1752-1830) was a German physicist.

[31] [Note by AKTA:] [Web28].

[32] [Note by AKTA:] Alexander von Humboldt (1769-1859) was a German polymath, geographer, naturalist and explorer.

[33] [Note by AKTA:] Wilhelm von Humboldt (1767-1835) was a German philosopher, linguist and diplomat.

> Alexander von Humboldt invited me for lunch. He advised me to continue physical measurements and promised to help me with the acquisition of a balance, a measuring device and a monochord. For this purpose he sends me to Dr. J. Schulze who is working for the Ministry of Education. He will talk to him in person and write to the Ministry in case this is needed. He recommends me to travel to Hamburg to Schumacher and will write me a letter of recommendation. He further suggests I should attend Dirichlet's lectures on Fourier's theory of heat. He further invites me to visit with him his brother Wilhelm the following day at eight o'clock in the evening. According to him, I have some chance to get a position in Göttingen if there is some vacancy there.

Concerning the visit the following day Wilhelm Weber writes:

> Around 8 o'clock I went to Humboldt who showed me two new volumes of the Philosophical Transactions in which Barlow used objectives for binoculars with liquid in order to study the change of refraction of this liquid. We were riding a carriage without back seat and picked up an Englishman so that the three of us were squeezed like herrings on the only seat of the carriage. We were driving to the minister Wilhelm von Humboldt. He himself was not at home but there we met his wife, his daughter and two guests. All rooms were decorated with paintings. We drank tea, looked at some of the paintings and talked a lot in French, since the Englishman didn't speak German. After that Wilhelm von Humboldt came. He looks much older than Alexander and talks more precise and focused but less fluent than his brother. During the whole evening one held his hat in his hand. The conversation was very free and easy. Topics were the quarrel if the largest vase in Europe made of granite should be put inside or outside the museum, how Cotta could be used for the enhancement of science and so on.[34] At 10 o'clock we went home.

Another time, in December 03, Wilhelm Weber writes:

> I had an appointment to meet Wilhelm von Humboldt in the evening together with Dirichlet. Since it was beginning to thaw, Dirichlet could not come. At Wilhelm von Humboldt's house a letter of the crown prince was read and we talked about the war.[35] Alexander von Humboldt came together with Ms. von Cotta.

Wilhelm Weber had a lot of interaction with Alexander von Humboldt. Apart from Dirichlet and Poggendorff he often kept company as well with Mitscherlich.[36] Although Mitscherlich was Professor for Chemistry he was very much interested in physical researches. In his house he hosted several casual evening parties dedicated to science and people like Alexander von Humboldt, the two Rose's, Dove, Karsten, Dirichlet, Wöhler, Ehrenberg, Poggendorff, Magnus and others were participating. At such parties Mitscherlich showed new instruments, or one repeated and discussed new experiments like the one of Arago concerning

[34] [Note by AKTA:] Probably they were referring to the German publisher Johann Friedrich von Cotta (1764-1832) who published several works of Humboldt.

[35] [Note by Heinrich Weber:] Probably the Greek War of Independence.

[36] [Note by AKTA:] Peter Gustav Lejeune Dirichlet (1805-1859) was a German mathematician. Johann Christian Poggendorff (1796-1877) was a German physicist. He edited the *Annalen der Physik und Chemie* from 1824 to 1876. Eilhard Mitscherlich (1794-1863) was a German chemist.

rotational magnetism.[37] Every Tuesday evening Weber was invited to Mitscherlich. Apart from that, Weber and Mitscherlich made joint experiments in his laboratory on the tones of the chemical harmonica. For that purpose Weber ordered to send him his monochord from Halle. Moreover, they studied the speed of propagation of acoustic noise in different gases and other things. Mitscherlich had a large audience in his lectures which Wilhelm Weber attended as well. Wilhelm Weber wrote in a note:

> Mitscherlich is very much dedicated to his lectures. He discussed the main ingredients of our nutrients, gum, gluten, albumin and sugar. He speaks fluently but softly. His experiments are prepared with great care. Mitscherlich has a lot of pleasure on natural phenomena. He teaches all the little devices how to make them visible. One can profit a lot from the arrangement of his instruments.

The advice of Alexander von Humboldt to attend the lectures of Dirichlet was not in vain. Weber attended Dirichlet's lectures assiduously and soon became a good friend of him. This friendship was later 1855 a major reason for Dirichlet's move from Berlin to Göttingen.[38] Wilhelm Weber wrote in November 21 about Dirichlet:

> He sometimes stumbles in his lectures and is not as well prepared as Scherk. But one can learn a lot from him since he knows very well how to explain the subtle points of higher calculus.[39] Steiner and Dr. Scheibler are attending his lectures as well.

The lectures took place thrice a week from noon until 1 pm. The lectures were usually followed by a walk, which Dirichlet often joined. It became the habit to go in the afternoon to the coffee party "Dirichlet".

> One of us is inviting the others after the lecture to the coffee shop Dirichlet, where we enter at 2 pm or 3 pm and stay until around 6 pm in a very enjoyable atmosphere.

Steiner was from 1825 until 1863 teacher of mathematics at the vocational school and therefore a colleague of Wöhler.[40] Weber writes:

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[37] [Note by AKTA:] François Arago (1786-1853) presented his discovery at the Academy of Sciences of Paris in the meetings of 22 November 1824, 7 March 1825 and 3 July 1826, [Ara24], [Ara25] and [Ara26]. These papers were also included in his complete works, [Ara54].

[38] [Note by Heinrich Weber:] Gustav Peter Lejeune Dirichlet was born on February 13, 1805, in Düren close to Aachen. At this time Düren was French. He was the son of the commissionaire de poste. After attending high school in Cologne he went to Paris for his studies. He was a tutor in the house of General Foy but later moved to Prussia, probably at the instigation of Alexander von Humboldt. In 1827 he obtained his PhD in Bonn and got a job in Breslau. After he became in 1828 an associate professor, he obtained as well an offer from the military school in Berlin which he accepted. However, he kept his position in Breslau until 1831, when he became an associate professor at the university in Berlin. In 1839 he became full professor. In 1855 he moved to Göttingen as the successor of Gauss. He died in Göttingen 1859.

[39] [Note by Heinrich Weber:] This remark concerns the first year of Dirichlet's lectures. Later on his lectures became the role model for teaching mathematics. The author can confirm this, since he had the luck to attend some of them.

[40] [Note by AKTA:] Jakob Steiner (1796-1863) was a Swiss mathematician. Friedrich Wöhler (1800-1882) was a German chemist. See [WW41c] with English translation in [WW21], [WW41a] and [WW41b].

> Steiner who made excellent geometrical contributions to Crelle's *Journal* seems to be born in Swabia[41] and has a lot of talent for jokes. He made fun a bit of the great Ohm and told his stories about the oval.[42]

The new friends introduced Weber to more specialized communities. Dirichlet invited him to the mathematical society in the english house and Poggendorff to the humanitarian society in which Leopold von Buch gave a lecture. But despite his busy schedule with younger people, Weber still found time to communicate with older scientific authorities socially and scientifically, like the mineralogist Weiss, the two Roses, Ehrenberg, Schaffrinsky or the academician Seebeck.[43] Seebeck told him in a conversation about mathematics an interesting story about Gauss. Gauss once told Pfaff that he had his most brilliant ideas at times of greatest despair. Weber also took the opportunity to visit the mechanical workshop of Pistor, where he met Schieck, the Müller brothers, the watchmaker Tiede and huge establishments like the iron foundry, the gasworks and so on. Schleiermacher also wanted to hear Weber preach, but he was prevented from holding the service.

Wilhelm Weber left Berlin in January 22, 1829, at 7 pm having received a lot of experiences and impressions. He was well endowed with letters of recommendation from Alexander von Humboldt, Enke, Ermann and Poggendorff in order to visit Repsold and Schumacher in Hamburg and Altona. He himself describes the cold, boring, uncomfortable ride for which the carriage at this time needed 38 hours. However, the ride got much more pleasant since he met Rosenberger in Klötze probably by appointment. Rosenberger was professor of mathematics and astronomy in Halle and came via Magdeburg to Klötze in order to travel jointly with Wilhelm Weber to Hamburg and Altona. Schumacher was very friendly to his two young colleagues from Halle and showed them in detail his facilities and his instruments. Moreover, Repsold introduced them to all items and specialities of his famous workshop for astronomical devices. How long Wilhelm Weber stayed in Hamburg cannot be reconstructed, probably the two colleagues travelled from there jointly back to Halle.

Weber stayed in Halle until his appointment to Göttingen. It seems that he intended to spend the summer term of 1829 again in Berlin. He already received the approval from the Ministry of Education. As far as we can tell, the plan did not materialize since all official letters to him from Halle as well as from Berlin are sent to his address in Halle. Weber now dedicates himself especially to his lectures and researches for which the Ministry as already mentioned before offered gorgeous funding. He stayed in contact with his friends from Berlin, in particular with Poggendorff. Poggendorff's letter from January 30 and March 1830 clearly show, that Weber was not forgotten in Berlin.

> Please send in order to advance your cause your latest treatise to Humboldt. Leopold von Buch is eagerly reading your papers and talked very favourably about you in the Society.

Humboldt also asked Poggendorff to motivate Weber to write up a summary of his researches in French, which he wanted to send himself to Arago.[44] On the other hand Alexander

[41] [Note by Heinrich Weber:] In fact Steiner was born in Switzerland.

[42] [Note by AKTA:] Crelle's Journal is the common name for a mathematics journal, the *Journal für die reine und angewandte Mathematik* (Journal for Pure and Applied Mathematics). It was founded by August Leopold Crelle (1780-1855) in 1826 and edited by him until his death.

[43] [Note by AKTA:] Thomas Johann Seebeck (1770-1831) was a Baltic German physicist. See [See25] and [See26] with partial English translation in [See69] and partial Portuguese translation in [FS16].

[44] [Note by Heinrich Weber:] Humboldt as well wrote directly to Weber. However, probably Weber donated these letters as autographs.

von Humboldt sent him via Enke a paper by Poisson. Encouraged by such requests, Weber sent his papers as well go Gauss. Gauss answered in a letter from April 02, 1830, which is probably the first written exchange between Gauss and Weber, as follows:[45]

> Dear Professor, I received your kind letter together with your valuable papers on acoustics in a very busy moment, so that I had to wait with reading them until I found some spare time. Now there are vacations or more correctly for me the time of vacations. I started reading your papers. I was fascinated by the originality of your work, but realized that to understand their rich content in depth one has to spend more time than I have at the moment. Therefore I cannot postpone it for longer to thank you sincerely for your letter and to express my joy that you dedicate yourself to this interesting researches with such diligence and success.
>
> I always had the opinion that the acoustics belonged to these parts of mathematical physics in which still the most splendid progress can be made. Indeed, acoustics is concerned with relations in time and space and therefore it should be possible to treat it mathematically. But, alas, how little, how very little we know! The things which at first sight seem obvious we do not know yet how to attack. Our previous researches just treat the speed of propagation and the thickness of acoustic waves. The tone pitch depends on the ratio of these two quantities. But the distinctive specific features of a sound which is sometimes referred to as tone color and manifests itself in the most miraculous way in the articulation is until now a completely unknown continent. It seems that this can only depend on the shape of the waves of sound. What huge field of study is there to be explored by us. I am convinced that the human mind once will open this field and bring it to the same clarity which optics enjoys. One should believe that it is not too hard to bring light into this darkness for somebody who has enough diligence, mathematical strength, experimental skills and time. One only needs to understand what are the specific distinctions for different tones, not in the body which emits the sound and not in the ear, but in the elastic medium in between. Concerning the body which emits the sound the ingenious work by Kempelen[46] is a good starting point and it is astonishing that after fourty years there was not much progress in this matter.
>
> I hope that you are the one which opens up for this problem a new field of research. With my very best regards, Göttingen, April 20, 1830.
>
> Sincerely
>
> C. F. Gauss.

In November 30, 1830, Tobias Mayer, full professor for physics at the University of Göttingen, passed away. Motivated by Alexander von Humboldt's encouragement, Weber started to think about moving to Göttingen. He asked Gauss for advice on this matter. Gauss wrote:

> Dear Friend, the reason that I did not answer your friendly letter immediately is not surprising in view of the events in our town. On top of that my activity was disturbed

[45] [Note by AKTA:] See also [Gau d].

[46] [Note by Heinrich Weber:] Wolfgang von Kempelen, Mechanismus der menschlichen Sprache, nebst Bechreibung einer sprechenden Maschine, Wien, 1791.

> by heavy personal distress. However, I cannot wait longer with answering your letter. I think I showed you several times since I first met you, how much I appreciate your skills as well as your personality.

Gauss than writes that he would support Weber's appointment as soon as he has an opportunity and that he thinks it is a good idea to contact the public authority.

> Unfortunately, often one overlooks a modest meritous person in view of a writing maniac. I do not know if this can happen in the current case.
>
> With my most sincere regards,
>
> Göttingen, January 27, 1831,
>
> C. F. Gauss.

Probably later on the government in Hanover asked Gauss for advice concerning the appointment of the professorship. In any way Weber was appointed full professor at the University of Göttingen by the secret counsellor Hoppenstedt on April 29, 1831. Weber accepted the offer in May 14, although his wish to become a member of the society was not granted at the moment "since already two mathematicians Thibaut and Gauss are members of the society, but just one philologist and one orientalist." In July 05, 1831, Gauss congratulated to the appointment.

> I am very pleased that you accepted the offer. I sincerely wish you all the best, but I as well wish the best to Göttingen and myself, since I expect that the scientific and cordial interchange with you will be a major improvement of my life. If I can help you with something I am happy to do so.

Gauss added, that he is convinced, that Weber will soon become a member of the society.

As discussed before, Wilhelm Weber had a very close relationship with his brothers Ernst Heinrich and Eduard. The brothers discussed intensely every personal circumstance and every scientific examination. Therefore the decision of Wilhelm to move to Göttingen had a deep significance. Many letters show how much both sides felt the separation. We only show some excerpts. Shortly after having moved to Göttingen, Wilhelm writes to his brother Ernst Heinrich:

> In view of the current danger,[47] I repeat our promise to always keep the same interests and consider us as a single family even if we are living now far from each other. I hope that this brings you some relief. You always kept our promise. Now I have for the first time the opportunity to follow your example. Since Eduard will soon face the same situation, I believe that our alliance guarantees us complete safety. Dear Ernst, even at the most remote place I am ready to give everything that we can meet also now as much as possible.

The brothers kept their promise. Instead of the road between Halle and Leipzig, they faced now the road Leipzig - Halle - Sangershausen - Nordhausen - Heiligenstadt - Göttingen. Sometimes the brothers met at a place in between which they decided before. Sometimes they went on foot the whole distance, since there did not exist trains at that time. Of course as often as before such visits could not take place anymore. In April 1832 Ernst Heinrich writes to Wilhelm:

[47] [Note by Heinrich Weber:] Ernst Heinrich was seriously ill.

> I am busy with editing the book by Hildebrandt. There are only three folios left, but it has to appear before the fair. On top of that there are my obligations as a dean. Therefore I cannot make it now to Göttingen. Instead of that I intend to come to Göttingen during my vacation so that we can spend a longer time together. If you can manage to come from time to time to Leipzig our separation will be less painful. During the semester let us each work on his own, so that during the semester break we can exchange our results and plan new researches.

Weber had the obligation to start with his lectures in Göttingen in the winter term of 1831. First he had to officially give back the instruments which he had bought with funds from the government of Prussia. The accounting of this required a lot of his time. He first sent his furniture to Göttingen after he had the guarantee from the government in Hanover that they are exempt from customs duties. Then he went to Göttingen on foot via Weimar, Erfurt and Mühlhausen. A little adventure he recounted with pleasure. He just arrived happily in Weimar and decided to go to the theater in the evening. By chance at this day a larger crowd of students from Jena visited as well the theater. It happened that an unbiased member of a students' corps took a seat next to Weber. He thought that the slim, inconspicious newly appointed professor in Göttingen is a high school student from Weimar. Looking down self-confidently on him he meant: "Well, you probably will soon enter university." If Weber clarified the matter, we do not know.

One cannot be too much surprised about the remark of the member of the students' corps. In fact, as an eyewitness confirmed, Wilhelm Weber in between his two handsome brothers made the impression of the weakest and most unimpressive one. Nobody was expecting at that time that Wilhelm would outlive his two brothers and reach quite an old age.

Wilhelm Weber was at an important turning point in his life. A new period of his scientific exchange and his scientific researches started.

1.4 First Period in Göttingen 1831-1837

The first matter Wilhelm Weber had to deal with after arriving in Göttingen was to furnish the Physical Cabinet.[48] Moreover, he was busy with preparing his lectures in experimental physics. In connection with them, he intended to re-edit the compendium of physics by Tobias Mayer, as he was requested from the booksellers. However, this never materialized. Immediately after arriving in Göttingen, Weber started his scientific collaboration with Gauss. Despite the age difference of 27 years, the two of them started a true friendship. Some of the handwritten notes of Gauss inviting Weber for lunch are often ending with the words:

> Nobody else is coming,
>
> sincerely
>
> C. F. Gauss.

[48] [Note by Heinrich Weber:] The former Physical Cabinet in Göttingen was situated opposite to the current one. In the same building was the Museum of Natural History. When recently the library got a new building, the old house was teared down and at its place a wing of the library was constructed. It was only after the reappointement of Wilhelm Weber 1849 that he moved to the current Physical Cabinet.

On the other hand, Gauss as well often visited Weber. His sister, which did his household during the first years of his stay in Göttingen, complained in a letter to Ernst Heinrich written in June 02, 1832, about the often unprepared invitations Wilhelm made.

> Wilhelm enjoys Gauss every day as long as he wants. Gauss is very lonely and Wilhelm is welcome at every time. Gauss is such a social, educated person that he never talks about science in my presence. He discussed with us many topics from noon until 5 pm. Recently the Privy Counsellor Gauss was here for lunch for three days in a row.

In view of the enormous interest Gauss had at that time for magnetic phenomena, especially terrestrial magnetism, his friend got interested in these phenomena as well. The first outcome of these magnetic studies is the famous paper: Intensitas vis magneticae ad mensuram absolutam revocata. Gauss talked about this work on the meeting of the *königlichen Societät* (Royal Society [of Sciences of Göttingen]) December 15, 1832.[49,50]

Since that time Weber was completely excited about magnetic researches. Partly he did these researches on his own, partly he did it together with Gauss. To walk from the observatory to the physical cabinet took about 15 minutes. When working on the same topic this was very annoying, in particular, since some researches on the change of magnetic declination required simultaneous observations. Therefore many times comparisons were needed. Short notes of Gauss concerning magnetic observations show that often messengers were commuting between the two institutes. In order to improve this unpleasant situation, the first telegraph was invented in 1833.[51] Galvanic currents were used to transmit messages. Gauss reported in the Göttingischen gelehrten Anzeigen in August 9, 1834, volume 128, page

[49] [Note by Heinrich Weber:] Göttingische gelehrte Anzeigen of the year 1832, Vol. 205, p. 2041 and Vol. 206, p. 2049.

[50] [Note by AKTA:] Gauss' work on the intensity of the Earth's magnetic force reduced to absolute measure was announced at the Königlichen Societät der Wissenschaften zu Göttingen in December 1832, [Gau32] with English translations in [Gau33a], [Gau37a] and [Gau21a]. See also [Rei02, pp. 138-150].

The original paper in Latin was published only in 1841, although a preprint appeared already in 1833 in small edition, [Gau41b] and [Rei19]. Several translations have been published. There are two German versions, one by J. C. Poggendorff in 1833 and another one in 1894 translated by A. Kiel with notes by E. Dorn; a French version by Arago in 1834; two Russian versions, one by A. N. Drašusov of 1836 and another one by A. N. Krylov in 1952; an Italian version by P. Frisiani in 1837; an English extract was published in 1935, while a complete English translation by S. P. Johnson was published in 2003 and 2021; and a Portuguese version by A. K. T. Assis in 2003: [Gau33b], [Gau34c], [Gau36], [Gau37c], [Gau94], [Gau35], [Gau52], [Gau75], [Gau03], [Gau21c], and [Ass03].

[51] [Note by AKTA:] Figure (a) of this footnote shows the Astronomical Observatory (Sternwarte) of Göttingen, where Gauss lived and worked, https://de.wikipedia.org/wiki/Sternwarte_G%C3%B6ttingen. Figure (b) show the commemorative plaque. It reads: First electric telegraph of Gauss and Weber, Easter 1833:

1265 on the arrangement of the observatory and the observations made there:[52]

> We have to mention a fantastic new device which we owe to Professor Weber. Already last year he connected the physical cabinet with the observatory by two wires spanned over the roofs of the town. Now this connection gets extended to the magnetic observatory. If one includes the galvanometers at both ends, the galvanic current is running a distance of almost nine thousand feet. — The certainty and easiness how one controls by the commutator the direction of the current and the motion of the needle depending on it led already last years to experiments on applications of telegraphic signals. Even with whole words or little sentences they succeeded completely satisfactory. There is no doubt that it were possible to build a telegraphic connection between two places several miles apart. Of course here is not the place to discuss these ideas further.

One cannot say that Gauss and Weber invented the electromagnetic telegraphy. Its base are the effects of galvanic currents discovered by Örstedt in 1819 and Arago in 1820. The devices to amplify these effects (Schweigger's galvanometer 1820) and the methods to make them visible and subject to precise observations (Poggendorff's mirror galvanometer 1826) were already well-known in the year 1833. Even before Gauss and Weber, it was suggested several times to build a telegraphy based on electromagnetism (Ampère, Barlow, Green, Triboaillet, Fechner, Schilling von Cannstadt), and even some little experiments were carried out. However, in these experiments the galvanic current passed through only rather small distances and one generally believed that the galvanic current gets damped by running through longer distances in such a way that his effects could not be applied anymore for the above mentioned purpose. Only few, in particular Fechner,[53,54] advanced the view that electromagnetic telegraphy is possible through large distances. But there were no experiments confirming this view. One tells that Barlow made experiments with a wire of length 200 feet, but got a negative result.

There is no doubt that Gauss and Weber get the credit for first constructing a telegraphic connection on a longer distance with just two wires. This proved that galvanic currents can

(a)

(b)

[52] [Note by AKTA:] [Gau34a, pp. 524-525 of Gauss' *Werke*].

[53] [Note by Heinrich Weber:] Fechner, Lehrbuch des Galvanismus und der Elektrochemie, Leipzig, 1829, p. 269.

[54] [Note by AKTA:] Gustav Theodor Fechner (1801-1887) was a German physicist, philosopher, and experimental psychologist. See [Fec29].

as well be applied for long range telegraphy. Only later one got interested in the history of telegraphy and the first telegraphic experiments became known to a larger audience. Therefore there is no doubt that Gauss and Weber developed their device without knowledge of the experiments carried out before.[55,56]

Weber in particular made a lot of effort to connect the two institutes, the observatory and the physical cabinet, by a telegraphic connection. The following letters of the municipal authorities of Göttingen deal with the permission to build two telegraphic wires over the roofs of the town as far as the tower of the Johannis church and from there further to the observatory.

> The principal Ebell forwarded the helpful letter of Your Excellency addressed to him to the municipal authorities on the 15th/16th of this month. Your letter anticipated a request to explain the purpose of the equipments on the church tower you did without our previous knowledge. Although we are always willing to do our best for promoting scientific institutions, it is our duty to ask you to kindly provide an explanation on the following points. 1) Are the equipments just for a test or are they supposed to stay there forever? 2) Will it be necessary to give certain persons permission to access the tower at every time and, if yes, who are these persons? 3) Will you supplement the cords by wires and from which metal are they made of? 4) Is it necessary that the blinds you removed from the windows of the tower in future will not come back and the windows have to stay open?
>
> While asking you about your kind answer as soon as possible, we would already like to remark concerning the last point, that the tower is too much exposed to the weather such that we cannot allow to keep the windows open, since this is causing too much damage to the building.
>
> We would like to use this opportunity to express our perfect respect for Your Excellency.
>
> Göttingen, April 18, 1833.
>
> The municipal authorities to His Excellency, the Professor Weber in person.
>
> Signed G. Ebell
>
> After the explanations from Your Excellency, we happily allow you to leave your equipments on the tower of the Johannis church in the near future in order to carry out magnetic-galvanic experiments. It is fine as well if Your Excellency together with an assistant stays from time to time on the tower.
>
> With our deepest respect.
>
> Göttingen, May 06, 1833.
>
> The municipal authorities of the town Göttingen
>
> G. Ebell

In order to tell the prehistory of the telegraph in Göttingen as complete as possible, we disclose as well the documents which were published 1887 in the supplement of the Allgemeine

[55] [Note by Heinrich Weber:] A detailed history of telegraphy can be found in Zetzsche, Handbuch der elektrischen Telegraphie, Vol. 1, Julius Springer. Berlin, 1877.

[56] [Note by AKTA:] [Zet77].

Zeitung, No. 248, by an expert. They show that Weber had to face many difficulties by making his equipments.

> Documents concerning the prehistory of the invention of the electric telegraph by Gauss and Weber.
>
> I. Record of the board of trustees from the University of Hanover.
>
> "Professor Weber from Göttingen told us that the room used to carry out optical[57] experiments in the first floor of the academic museum is very limited and too dark. He asks for a different room in this building like the one where up to now the collection of paintings of Flügge were stored. Before we can make a decision, we wait for the report of the academic museum if and how this is possible under the current conditions.
>
> Hannover, February 10, 1832.
>
> Royal British-Hanoverian board of trustees of the University.
>
> Arnswaldt to the academic museum in Göttingen."
>
> II. Anwer of Blumenbach. Handwritten draft.
>
> "To the Royal board of trustees of the University. Report of the senior medical officer of health Blumenbach, February 27, 1832, concerning the rooms of the museum dedicated to Natural History. Immediately after having received on the tenth of this month the document of Your Excellency concerning a wish of Professor Weber to get a room in the middle floor of the museum, I immediately discussed this with the other custodians of the museum Privy Counsellor Hausmann, Privy Counsellor Osiander and the assistant Dr. Herbst. Dr. Herbst then wrote the following report which the two other custodians and myself strongly support."
>
> III. (Handwritten) report of Dr. Herbst.
>
> "1) The paintings of Flügge were not stored in a separate room, but were kept in two rooms which could be used less at various places, some of them beside each other, some of them in front of each other. 2) In the rooms where the paintings are were always also stored, a large part of the ichthyological collection, as well as parts of the osteological and botanical collections. In view of the tight situation in the museum, we had to add to that a part of the extremely valuable collection of fossils. 3) Many of the objects incorporated little by little to the academic museum are piled up in the other rooms waiting until the display cabinets and showcases needed are set up. 4) In addition, one of the two rooms was used for the experiments and works of the academic museum. 5) By separating one of the two rooms, the communication between the middle and upper floor of the academic museum would be disturbed. Moreover, the visit of museum would become complicated. 6) However, maybe a rather large, very bright hallway in front of the two rooms in the middle floor of the academic museum or a similar hallway in the upper floor of the museum might offer enough room and light for carrying out physical experiments."
>
> IV. Handwritten votes.

[57] [Note by Heinrich Weber:] This expression instead of "electric" is used several time due to insufficient knowledge of the matter.

"I checked the rooms in the museum and completely agree with the report of Dr. Herbst. Your most obedient Hausmann, Göttingen, February 15.

The museum would loose one of its best rooms, if one separated the hall requested by Professor Weber. The hallway of 16 feet length and 12 feet width has two windows and might be very suitable for physical experiments. I therefore completely agree with Dr. Herbst and Privy Counsellor Hausmann. Your most obedient Osiander, February 20, 1830 [sic]."

V. Letter from the board of trustees of the University.

"A copy is sent to the academic museum in Göttingen. Referring to our writing from the 10th of last month, we inform Professor Weber that no room in the academic museum can be offered to him in order to carry out optical experiments, since no room in this building can be dispensed with. However, a hallway in the middle floor of the museum which is rather large and quite bright Professor Weber can use for his optical experiments, as well as a similar hallway in the upper floor. The academic museum is informed."

Hannover, March 06, 1832, Royal British-Hanoverian board of trustees of the University.

Several years ago, the above documents were saved from a bunch of documents thought to be of no value and incorporated into the library of the University. They appeared in an article of August 12 of this year with the title "The prehistory of the introduction of the electric telegraph in England", celebrating the fiftieth anniversary of its introduction (July 25, 1837) on a longer distance of the north-east train in London using the signaling of Gauss and Weber.

Blumenbach, Hausmann and Osiander had no idea that the matter concerned an invention which now rules the world. They didn't show much cooperation by delegating the report to their assistant Dr. Herbst, in order to avoid to give a completely negative answer. Professor Herbst is now the oldest member of the University of Göttingen. Thanks to him, one found the above solution. By his modesty, Weber was satisfied with the scanty hallway. Only few people now still know where this hallway was located. Hence many errors spread around. Therefore we give a brief description where and how the facility was made. Usually one says "in the physical cabinet", and in the current physical cabinet there is as well attached a marble plaque inscribed:

First electric telegraph, Weber-Gauss 1833.

However, at this time the head of administration von Werthoff lived in this house and even later it was known by his name. The older modest physical cabinet where Tobias Meyer and Weber in his first years worked and lectured was located at the northern part of the lower floor of the Museum of Natural History. After Weber moved to the current physical cabinet, Hausmann stored there the mineralogical collection. The museum was demolished in 1881 in order to enlarge the library. At the place of the former physical cabinet lies now the northwestern corner of the library. In the above mentioned hallway in the upper floor of the museum in former times hanged the paintings of the professors in Göttingen, which are now in the assembly hall. The hallway was crudely arranged for the electric experiments. The wire was spanned from there over the old library to the tower of the Johannis church

going down on the other side to the pharmacy of the University, then over the roofs and streets to the most southeastern corner of the wall at the Geismar gate, where it was attached to a pole on a tree, descending to the little house erected for this purpose in front of the observatory. No iron nail was used for this little house. Instead of that, all nails and even the key were made of copper. Originally one was afraid that the several hundreds of rifles in the barracks nearby would exert an attracting force. However, this was not the case. Gauss was operating in this little house and Weber at the other end in the museum. The experiments were continued until the most splendid success was reached and one of the most crucial inventions of this century was made.

Strictly speaking, the marble plaque at the new physical cabinet does not indicate the precise location. However, since the actual location is floating in the air, so to speak, above the little door in the empty space of the library, it might stay were it is. In particular, after the wire was removed which was laid from here over the street to the corner of the house of Benfey. Several people might remember how, after many years, the old wire was smashed to pieces in a heavy thunderstorm. In fact, it is no fairy tale that one fiery piece hit the dress of the wife of Professor Grisebach in the Johannis street.

There are no written records about experiments in this time. Only little letters of Gauss could be found in the manuscripts left behind by Weber. Although they have no real value, we mention them here in view of the interest of the matter. In a little undated letter Gauss writes:

> Unfortunately I can only send messages to you, but not receive yours, since the magnetic bar was removed yesterday and replaced by a 20 pound heavy wooden bar. However, I send you the message in order that you have in advance a date for the position of the clocks. I hope that tomorrow the magnetic bar is restored again. G.

In a letter from August 28 at 7:30 am without specification of the year one can read:

> A lady who would like to admire our actions at a distance and is already leaving this noon has an appointment this morning in the observatory. Dear Weber, could you please send a galvanic current through the wire at 10 am? Since you know precisely the position of the clock at the observatory compared to your one, you could start the current exactly at 10:00:00 am. Some commutator changes in an interval of time of 43 seconds could probably increase the admiration. The comet I have seen and observed last night.
>
> Sincerely yours, Gauss.

In the year 1834 "words and little sentences" could be sent by wire. A problem was that through the use of Voltaic plate couples the needles started oscillating wildly, in particular, since at this time the set-up of a damper was not known. This unpleasant situation motivated Gauss to apply induction currents by displacing wire coils with respect to the poles of heavy magnets. In a report of a lecture by Gauss held at the *Königl. Societät* — Royal Society [of Sciences of Göttingen][58,59] one reads:

> The original procedure (for telegraphing) was replaced in 1835 by a different one which Privy Counsellor Gauss discovered motivated by the laws of induction and which was much better than the previous one.

[58] [Note by Heinrich Weber:] Göttingische gelehrte Anzeigen, October 30, 1837, No. 173, p. 172.
[59] [Note by AKTA:] [Gau37b, p. 356 of Gauss' *Werke*].

The new method was indeed a great success. In a little letter which Gauss seems to have written after the first experiments based on this new methods were carried out, one can read:

> I am very happy that by insertion into the red wire coil the induction appears clearly, amounting to about 12 scale parts.

This new device allowed to let the needles make in both institutions simultaneously small oscillations to the right and to the left as much as one liked. By combining these oscillations to the left and right, letters could be constructed. The devices at this time admitted to transmit 4 letters per minute, later on 8 letters. Weber connected the telegraphic device as well with an alarm clock which with the help of several consecutive current pulses started to ring and indicated the start of the telegraphing.

It is fair to say that from this moment on the telegraphic devices achieved maturity so that they could start to spread to the public. For a long time one used the telegraphic procedure described above in the amazing experiment of the transatlantic cable connecting England and America, since the usual method using stronger currents led to disturbing charge effects.

Although telegraphy was only tested at a smaller scale, already in 1835 there appeared the chance to make it applicable to public life. In this year one started to build the Leipzig-Dresden train. Ernst Heinrich Weber, Wilhelm's brother, suggested to the board to build a telegraphic connection among the stations of the train according to the Göttinger scheme. The report ends with a clear insight on the current development of electric telegraphy with the words:

> If once the earth will be connected by a net of railways covered by telegraphic lines, this net will serve similar purposes as the nervous system in the human body transmitting partly movement, partly the propagation of perception quickly as a flash.

Gauss and Weber had only accumulated experience with the telegraphs constructed by themselves. At this time they erroneously believed that for telegraphic devices the earth should be considered as an insulator. In fact experiments on the resistance of wire showed that the earth possessed a resistance several million times bigger than the one of iron. This seems to refer to the specific resistance. In a letter to Erdmann,[60] member of the Leipzig-Dresden railway society from July 12, 1835, Weber proposes to use the tracks without further isolation for the ingoing and outgoing wire. Gauss however in a letter[61] from September 15 of the same year, thinks that this proposal is difficult to carry out in practice, since the axis of the wheels of the car will serve as a conductor. For this reason, he proposes to connect the stations through a separate 1.6 mm thick copper wire or 3.8 mm thick iron wire and use the tracks only as return wire. The matter got delayed since in the board one started to doubt the feasibility of the project. In order to remove these doubts, Weber wrote in March 1836 in a second report to the board:[62]

[60] [Note by Heinrich Weber:] Records of the Leipzig-Dresden railway society, Vol. I, p. 2.
[61] [Note by Heinrich Weber:] Records of the Leipzig-Dresden railway society, Vol. I, p. 5.
[62] [Note by Heinrich Weber:] Records of the Leipzig-Dresden railway society, Vol. I, p. 13. See also M. M. Freiherr von Weber, Das Telegraphen- und Signalwesen der Eisenbahnen 1867. Here the proposal of Weber was criticized severely from a technical point of view.

> Gauss brought the theory of electric telegraphy to an end.[63] The distance of the action, the strength of the wires, the currents and things like that can nowadays be computed with the same precision as a lunar eclipse.

He meant that the facility is "not an experiment but a warranted enterprise." He claimed it for sure that

> two copper wires of a diameter of three quarters of an inch laid through the ocean to East India or America can serve as a telegraphic connection to these countries.

The facility between Leipzig and Dresden was computed by him to cost only 500 thalers, since no particular wires were needed. Although Weber was wrong at this time since he concluded from the specific resistance to the behaviour of the ground, current telegraphy proved his last assertions to be true.

The board started doubting the matter even more, after telegraphic experiments carried out by Steinheil showed a negative result.[64] Steinheil was urged by Gauss to develop further the electric telegraphy from a technical point of view. This led him to the discovery that the earth behaves like a conductor and can be used as the return path. He also was the discoverer of the first ingeniously devised printing telegraph, which is the reason that his name will always be mentioned at one of the first places in the history of telegraphy. The whole issue came to an end in October 26, 1837. The board decided against installing an electric telegraph. This was due that shortly before Master Hülsse, the later director of the Dresden University of Technology which had examined the telegraphic facilities of Göttingen in depth, made a very high cost estimate for a telegraphic connection with two isolated copper wires.

The magnetic researches[65,66] for which Gauss, due to his nature penetrating spirit, built a completely new base gained a particular significance since they inspired the foundation of a magnetic society whose intention was to examine the effects of terrestrial magnetism at different places of the surface of the earth. At the beginning, except Göttingen, only Enke in Berlin participated. However, soon Leipzig, Copenhagen and Braunschweig joined and the number of places at which corresponding observations were made grew so quickly that in the society not only geographically conveniently distributed places in Europe were represented, but as well places outside Europe. Already in October 23 and 24 in Göttingen and Leipzig corresponding observations were made. They were repeated with great care later in October 01 and 02 by Weber himself who spent his vacations in Leipzig.[67,68] Referring to them, Gauss writes in October 03.

> Dear Friend. Thank you very much for the report on the magnetic observations in Leipzig from September 23 and 24. The records of your brother and Professor Möbius are still missing whose inspection this time at some places is desirable since only very weak oscillations happened during these two days. Here the observations are rather

[63] [Note by Heinrich Weber:] Insofar in connection with the experiments in Göttingen.

[64] [Note by AKTA:] Carl August von Steinheil (1801-1870) was a German physicist, inventor, engineer and astronomer. See [Pri83].

[65] [Note by Heinrich Weber:] Gauss reports on these in the Göttingischen gelehrten Anzeigen, March 07, 1835, Vol. 36, p. 345 and October 30, 1837, Vol. 173, p. 1721.

[66] [Note by AKTA:] [Gau35] and [Gau37b].

[67] [Note by Heinrich Weber:] Poggendorff's *Annalen*, Vol. 33, p. 426.

[68] [Note by AKTA:] [Gau34b].

> painful since my son is not back yet and Professor Ulrich did not participate due to illness of one of his children. — I am looking forward very much to your return to Göttingen, dear friend. My loneliness increased since my youngest daughter is not here either. She is on the countryside since eight days.
>
> With my very best regards, C. F. Gauss.

In order to keep track of the different observations, Gauss and Weber published annually the most important findings under the title "Resultate aus den Beobachtungen des magnetischen Vereins" ("Results from the observations of the magnetic society").[69] The first volume appeared 1836 and the last one 1841. At the same time the *Resultate* offered the opportunity to discuss topics closely connected to the magnetic observations. Gauss himself published fourteen papers, among them the famous foundational ones on the potential and the general theory of terrestrial magnetism.[70] Weber contributed twenty three papers among them the one on the tangent galvanometer, the electrochemical equivalent of water, unipolar induction and the rotation inductor.[71] These papers became all seminal for later researches. Closely connected to these researches is the "Atlas of terrestrial magnetism" published by Gauss and Weber 1840, which was mainly edited by Weber and Goldschmidt.[72]

Despite Weber's enormous interest on the new field of research on magnetism opened up by Gauss, he simultaneously was busy with physical-physiological experiments together with his younger brother Eduard in the years 33-36. These results were published in Göttingen 1836 in the book "Mechanik der menschlichen Gehwerkzeuge" (Mechanics of the Human Walking Apparatus).[73] Several times the younger brother Eduard stayed for longer in Göttingen, in order to carry out experiments on walking. Also from the military side Gersdorf in Berlin provided valuable data on the size of steps, tact, the size of a usual march and a fast march and so on. The datas were growing so quickly that Poggendorff wrote to Weber February 10, 1833:

> That your theory on walking grew so much that it fills a whole book is an additional obstacle for the next generation of this world who has to learn how to move the legs according to art.

The years 1831 until 37 passed for Weber under arduous scientific activity. Then a new event occurred which profoundly changed Weber's life. This event had not just a huge impact on science, but as well on politics and led to fervent debates even outside Germany. This event was the dismissal of the seven Göttinger Professors.

1.5 The Interim 1837-1843

Under the rule of William IV, Hanover was united with England. Shortly after Ernst August as a German prince moved to his capital in June 20, 1837, he declared in July 5 that the

[69] [Note by AKTA:] See [GW37], [GW38], [GW39], [GW40b], [GW41], [GW43] and [GW40a].

[70] [Note by AKTA:] [Gau39] with English translations in [Gau41a] and [GT14], and Spanish translation in [Gau21b]; and [Gau40] with English translation in [Gau43].

[71] [Note by AKTA:] [Web39b]; [Web40]; [Web41a] with English translation in [Web21i]; and [Web41c] with English translation in [Web21j].

[72] [Note by AKTA:] Carl Wolfgang Benjamin Goldschmidt (1807-1851) was a German astronomer, mathematician, and physicist. See [GW40a].

[73] [Note by AKTA:] [WW94] with English translation in [WW92].

constitution from the year 1833 is not valid anymore, but instead of that the old constitution from the year 1819 has to be reintroduced again. First everybody cheered about independence, however soon educated people especially at the University of Göttingen in connection with the hundred years anniversary of the University in September 17 started raising some doubts. First Weber didn't care much. In a letter from August 13 in which he invites his brothers to the anniversary he writes:

> The political circumstances will not affect the anniversary except that some princes will not come. Just now, where the enemies of higher education make plans against the universities and would like to make them national schools as in Austria, this celebration arranged with royal pomp will have a political impact on the whole of Germany as a testament that universities are not old-fashioned institutions. Instead of that, they are leading the way as torchbearers of civilization which the whole of Germany follows.

In fact, the secular celebration was celebrated with great splendor in the days from September 17th to 19th. Even the king Ernst August participated at the first day at the festivities. Apart from the ministers from Hanover, Alexander von Humboldt and many deputies of other universities took part. At this occasion Gauss gave his above mentioned talk on magnetic experiments at a solemn meeting of the society in September 19.

In October 30, 1837, the parliament was dismissed and the "Royal Servants" released from their oath to the constitution of the year 1833. In November 01 the civil servants and later on the advocates as well were obliged to take a new oath. Hereupon the seven Professors from Göttingen, Albrecht, Dahlmann, Ewald, Gervinus, Jakob and Wilhelm Grimm and Weber filed a joint petition written by Dahlmann to the board of trustees of the University.[74] In this petition they declared that they are bond by their oath to the constitution from 1833. Therefore they cannot accept a different parliament as legal, and consequently they are not able to take the new oath. This famous entry reads as follows:

> To the Royal board of trustees of the University.
>
> Göttingen, November 18, 1837.
>
> Most subservient petition of some members of the University concerning the Royal Edict from November 01.
>
> The undersigned humbly feel compelled in their conscience to submit their respectful declaration to the High University Board of Trustees regarding the content of the Royal Edict of the 1st of this month.

[74] [Note by AKTA:] Wilhelm Eduard Albrecht (1800-1876) was a German constitutional lawyer, jurist, and docent. Friedrich Christoph Dahlmann (1785-1860) was a German historian and politician. Georg Heinrich August Ewald (1803-1875) was a German orientalist, Protestant theologian, and Biblical exegete. In 1830, Ewald married Wilhelmine Gauss (1808-1840), the daughter of Gauss. Georg Gottfried Gervinus (1805-1871) was a German literary and political historian. Jacob Ludwig Karl Grimm (1785-1863) was a German author, linguist, philologist, jurist, and folklorist. He was the older brother of Wilhelm Carl Grimm (1786-1859), a German author and anthropologist. The Germanist brothers were famed fairy tale and folk tale writers and storytellers, known together as the Brothers Grimm. A painting of the so-called Göttingen Seven appears in this footnote, https://en.wikipedia.org/wiki/G%C3%B6ttingen_Seven. It is a Lithograph after a drawing by the Swedish artist Carl Gustav Adolph Rohde (1806-1873), 1837/1838. Top row: Wilhelm Grimm, Jacob Grimm. Middle Row: Wilhelm Eduard Albrecht, Friedrich Christoph Dahlmann, Georg Gottfried Gervinus. Bottom Row: Wilhelm Eduard Weber, Heinrich Georg August Ewald:

Despite their due awe to the Royal word, the petitioners cannot convince themselves that the constitution is illegal and therefore invalid since the previous king did not found the whole content of it on contract, but at its proclamation did not authorize some propositions of the parliament and made some changes not approved by the parliament. The accepted legal rule that the valid thing cannot get destroyed by the invalid one implies that not the whole constitution is invalid, but only some parts of it. The same case would occur if in the constitution rights of the agnates were violated. The principle that each amendment of the constitution is subject to agnatic approval could not be established without causing a big threat to Royal rights. The most subservient petitioners would like to remember that concerning the claim that Royal rights were violated, the Royal edict from 1833 aimed in particular to ensure these rights. Furthermore the German Federal Assembly composed a committee to deal with these kind of questions. This committee never had objections but instead of that applauded to the constitution of this kingdom as an example of prudent moderation and circumspection. Therefore the most subservient petitioners after pondering in earnest on the importance of this case came to the conclusion that the constitution is still valid. Hence they cannot let it tacitly happen without violating their conscience that the constitution perishes just by way of power without further examination and vindication. Instead of that, their duty in view of their oath to the constitution is neither to participate on the election of a deputy nor accept an election or a parliament on a different legal base.

The reason that the most respectful petitioners of the University sign as individuals, is

> that they would like to avoid conflicts which every hour can bring as soon as possible. They do not doubt in the least that their colleagues share the same opinion. In their official duty they always warned students from political extremes and tried their best to foster their allegiance to the government. However, their success is not only based on their scientific value, but as well on their integrity. If their students experience that they do not take their oaths seriously, the bless of their effectiveness will be seriously damaged. What value has an oath of allegiance and obeisance for your majesty the king, if it is taken from subjects who just violated their previous oath?
>
> F. G. Dahlmann, E. Albrecht, Jakob Grimm, Wilhelm Grimm, G. Gervinus, H. Ewald, Wilhelm Weber.

In November 28, 1837, Ernst Heinrich writes to Wilhelm:

> All sympathizers read the public declaration of the seven professors with great joy. This is brave. I am eagerly awaiting the effect of this step.

One did not need to wait long to see the effect. Already in December 14 the seven Professors were dismissed and Dahlmann, Jakob Grimm and Gervinus even had to leave the country. The later ones almost had no time to bring their affairs into order. They first fled to the little town Witzenhausen in Hessia and later on they moved to Kassel.

The disturbances in Hanover already led before to protests in Baden, Bavaria, Saxonia, Hessia, Braunschweig and Württemberg. But now the whole of Germany took part on the destiny of the "Seven". Scholars and commoners as well wrote letters of sympathy and appreciation and poems celebrated their deed. But beyond just moral support, in the whole of Germany committees were built whose purpose was to collect money so that the seven professors could earn their previous salary until they found a new employment. Especially Leipzig took the lead. Berlin, Hamburg and other towns followed its example. First the seven hesitated to accept this offer, so that Ernst Heinrich Weber wrote to Wilhelm in January 07, 1838:

> I am sorry that you have concerns to accept the donated money. I am afraid that this will slow down the donation. I think it is quite honorable that such a donation takes place not just from party members, but from moderate people who often are not inclined to politics. I strongly advise you against accepting to teach as private lecturers in Göttingen or to finish your lectures. It would be a different thing if one rehabilitated you and abstained from taking the new oath. It would be a disaster if one allured you and drove you crazy. In my opinion, the seven professors can only carry out steps together.

To remember the magnanimous deed, we cite part of the document, the committee wrote in December 1842 in Leipzig,[75] when it dissolved after having achieved its goals.

> When we reported in the beginning of this year about the status of the Göttinger issue, we could not hope yet that so soon our goal would be achieved. Meanwhile Privy Counsellor Dahlmann, the only one left for which our association was still taking

[75] [Note by Heinrich Weber:] The committee of the "Göttingen Association" was built by Dr. M. Crusius, chair, E. Hirzel-Lampe, secretary and cashier, A. Dufour Féronce, Professor Erdmann, Gustav Harkort, Dr. Härtel, S. Hirzel, Karl Reimer, G. L. Preußer, Professor E. H. Weber, Otto Wigand.

> care of, found a secure new employment. The goal of our association is therefore completely achieved. We have to be proud of our common home country that it was possible to achieve our goal without the need of turmoil. In the worst case we had been still able to continue the honorable national support of the Göttinger gentlemen for a longer time.
>
> Many people supported us generously and promised continuous assistance. The total amount donated to the committee added up to 22357 Reichsthaler. Most of the supporting documents concerning the use of this money is at your disposal. As you know, Professor Wilhelm Weber waived a lot of the money granted to him in favour of his colleagues. However, after the association reached its goal, the reason for this waiving disappeared and therefore we thought it appropriate to donate him the 1400 Reichsthaler he would have received before his employment at Leipzig.[76] After the deduction of this sum, 2404 Reichsthaler remain. — We propose to donate the 2404 Reichsthaler to the seven professors, so that they can freely use them maybe to build a foundation to remember the event at Göttingen, maybe to grant stipends at one or several of the universities were they found protection and employment after their dismissal from Göttingen. We mention in passing that strictly speaking only the professors Ewald and Gervinus have a legal right to this money, since this money only heaped up by their waiving in favour of their colleagues. — After having fulfilled this last obligation, we decided to end our activity as the committee of the Göttinger association and to store the documents of our negotiations at the library of the local university.
>
> We take the opportunity to thank you for your trustfulness and kindness and sign with great respect.
>
> The committee of the Göttinger association, Leipzig, December, 1842.

Wilhelm Weber as well received financial support from private persons. Professor Fritzsche in Halle wrote in January 17, 1838, to Weber:

> Friends and former colleagues from Halle, most respected Professor, offer you 200 Thaler per annum. Every quarter 50 Thaler are paid to your disposition as a proof of our respect for you and your unforgettable father, which all of us called Father Weber. Please tell us how we can transfer this money to you. We do not know if you are still in Göttingen.

How far the sympathy for the Seven reached, little events show clearly. When Dahlmann moved from Kassel to Leipzig, he stayed overnight in the guesthouse "Stadt Rom". It turned out that the three daughters of the innkeeper were all subscribers of the Göttinger association. Mr. Ries from Leipzig immediately offered Dahlmann free accommodation. As long as Weber stayed in Göttingen unemployed, he became an honorary member of the literary museum having the rights of an ordinary member without the obligation to pay fees. The Dieterich family in whose house Weber lived at this time sent back his rent and so on. During this time (December 28, 1837) Weber received the honorary appointment of a *Doctor medicinae* from the medical faculty in Königsberg, "since thanks to his deserving researches the physiology as well received treasurable enrichment."

[76] [Note by Heinrich Weber:] Weber donated his money to a foundation at the University of Leipzig stipulated to support scientific researches with its interests.

From the many letters Weber received, we only mention a few of them. Shortly after his dismissal, E. H. Weber wrote to Wilhelm:

> We were prepared to the blow you wrote. For you it is very hard to get torn away from Göttingen with Gauss and your physical laboratory to whom you dedicated so much effort in many years. But you cannot regret to have acted as an honest man faithful to his oath. The example of the Seven has an effect to the whole of Germany and the results of this exemplary deed cannot be foreseen yet. It will have a huge impact. It would have been outrageous if justice without defending herself gave in to power. What concerns the subscription, it makes a lot of progress. Also in Berlin it started. Write to me if the money for the three expelled persons has to be sent. As soon as you come to Leipzig you will be very welcome.
>
> With kind regards, Ernst.

Similarly Steinheil wrote from Munich in December 25, 1837.

> Dear Weber, it is impossible to tell you how deeply and sadly we all are moved by the calamity which hit Göttingen and you. Let us hope, that God rewards what humans do out of their most sincere conviction and that the future will heal wounds stroke by the present. What will do Gauss? Is he staying in Göttingen?
>
> Your sincere friend, Steinheil.

Many people thought that Gauss, the most brilliant star of Göttingen, and other professors due to intolerable political circumstances would leave Göttingen as soon as they have the opportunity to do that. Concerning this matter, E. H. Weber wrote to Wilhelm:

> Dahlmann got news that the donations in Hamburg are quite gorgeous. The same happens in Berlin and Leipzig. In the Vogtland and the Ore Mountains there are donations by the poorest people like stocking knitters and so on. — I am very much against half-hearted measures. Therefore I think it is best you leave Göttingen soon. I hope that Gauss, you and Ewald can find a new employment in Berlin, Bonn or somewhere else, as soon as one knows for sure that Gauss will accept an offer.

All this kind of opinions were disproved by later events.

Concerning Gauss, he led a secluded life. Always pondering about mathematical and physical problems, he was hardly interested in politics. Moreover, as a sexagenarian, he had a strong antipathy to move to a different place. In a letter to A. von Humboldt, Gauss writes:

> To start somewhere else afresh is in my age quite difficult. At least I would lose several years which in my age are quite precious.

Probably in the scientific conversations between Gauss and Weber politics only played a minor role. In fact, when Gauss tried to undo the dismissal of Weber and keep him in Göttingen, he did not judge Wilhelm Weber correctly in political respect by describing him in letters to influential people as a harmless person not interested in politics. On the contrary, Weber was quite interested in politics during all his life and could become quite agitated by discussing political questions. The situation for Weber was quite different than the one

of Gauss. As an unmarried young man at the age of 33, he often kept company with the families of other professors where pressing questions of the day were discussed. In the houses of Ewald, Grimm, and Kraut, he always was welcome as a guest. Many letters addressed to Weber from Dorothea Grimm or Gauss daughter Minna Ewald prove this.[77] The letters from this time also contain lively political discussions with his brother Ernst Heinrich. For example in June 09 (1838?) Wilhelm writes concerning current politics in Hanover:

> The news from my last letter on the situation here needs some correction. Here the elections turned out quite badly and did not stir any interest at all, the opposite happened in the provinces. The Chamber seems to support with vast majority the constitution as proved by the presidential election, as you probably read in the journals. Concerning the negotiations you will read little in the journals since the Hanoverian Journal has to be quiet about that and according to federal law other journals are only allowed to inform about the negotiations in the Chamber what the journals of the state contain. The silence about it is therefore a clear sign what the matter is. One conjectures that the Chamber will carry out such decisive steps that it will soon be dissolved. Unfortunately the first Chamber will do nothing and therefore the effort of the second Chamber is useless. Several people think it would be better if under such circumstances the second Chamber would act less wildly. Anyway it is quite a relief that the unethical behaviour is felt by many so deeply and is outspoken. By this the Ministry will get inclined to carry out new violent measures and the sickness of the present gets even more increased. The hope for a future betterment is postponed. There are news about a petition from the president to the Chamber concerning the constitutional issues. Jacobi, the previous president of the Chamber, who established the principle that one has to have the courage to ignore any legal issue, this time only got 9 votes. The current president is senator Meier from Lüneburg.

Often the question was raised why only seven professors participated at the protest. This question Weber himself answered at the age of 85 on the request of the superintendent Schuster in Hanover.[78] Schuster discovered a letter of the philosopher Ritter from the year 1837 in which he complained that he got to know about the protest just after its publication. Weber writes:

> Among friends one often discussed this on common walks. There was no secret concerning our opinions and they spread around so that nobody can complain not to have known about them. The matter was in the air at this time. Who wanted to participate, could do it. But one knew that one was observed and therefore one avoided to take the lead to further negotiations, which could have been interpreted as propaganda. We were aware of the consequences of a possible declaration and could not take the responsibility to force others to join. It was a protest from conscience which developed in the heart. When I signed I did not know who and how many would do this as well. I myself in particular discussed this with Albrecht whose opinion as a professor of law I joined. He informed me about the protest of Dahlmann with which I agreed and therefore signed. Ritter joined the faculty in Göttingen just a year before

[77] [Note by AKTA:] See footnote 74.
[78] [Note by Heinrich Weber:] Zeitschrift des Historischen Vereins für Niedersachsen (1889).

> and it would have been strange to force him to join these disputes which were alien to him. Everybody had to find himself access to his convictions.

By the way soon after the protest of the Seven in December 13, 1837, six further teachers of the university, Müller, Kraut, Ritter, Thöl, Leutsch and Schneidewin declared that they never disapproved the step of their dismissed colleagues in sharp contrast to the way things were described in public journals. Moreover, they pointed out that many citizens did not take the new oath or just took it reluctantly. The government of Hanover did not take notice of these events probably because of the great stir the dismissal of the Seven already had in Germany.

Naturally the dismissed professors got even closer to each other than they already were before. Albrecht, Ewald and Weber first stayed in Göttingen, while Dahlmann, Jacob and later as well Wilhelm Grimm with his wife took residence in Kassel. The Grimm brothers there stayed for longer. A busy exchange between Göttingen and Kassel developed. Often Weber went there on foot or by carriage. One was afraid at this time to exchange political views by mail and preferred to discuss them orally. Weber wrote to his mother:

> You will easily understand that I could not cut immediately the friendly relations which became even stronger due to the imminent danger. As you know I still have various collaborations with Gauss which keep me here.

Since the Seven could not accept their dismissal as legal, they decided to sue the Ministry of the king to pay their salary further. However, their lawyer Dr. Grefe in Göttingen lodged the complaint not until December 1838. After several years of negotiations, no result could be achieved. Although the complaint was accepted by the judiciary of Hanover, the Ministry of the king pointed out that the issue is not a legal but a governmental matter and requested the judiciary to declare itself incompetent. However, the judiciary refused to do that. Due to this conflict which was strongly related to the constitutional dispute, the process had to be postponed. As a consequence some persons involved published rather personal political pamphlets. Therefore E. H. Weber wrote to his brother:

> The whole of Europe is following this issue. A pamphlet written by one of the seven professors should express the character of the seven professors but should not be too personal. It is fine if it contains the key idea that the reason for this step is not to get the leadership of a political party, but to provide an example for those who due to moral reasons do not want to perjure themselves. Dahlmann is working on a treatise, too.

First one could hope that a compromise between the parliament and the government could be found so that it became possible to reinstall the dismissed professors. But as longer the conflict continued this hope waned more and more. Already the government of Hanover started to find solutions for the annoyances the university faced due to the dismissal of the Seven. Weber wrote to his brother:

> The issue of the physical cabinet will probably soon find a solution. How this solution looks like is at the moment completely unclear. The board of trustees required a report from the senate. The senate unanimously requested from the board of trustees that the cabinet stays devoted to the joint experiments of Gauss with myself. Ewald wrote from London. At evenings I in turn visit Gauss, Ewald, Grimm's, Albrecht, Kraut, Müller.

Ewald which at the beginning of the year 1838 had made a travel to London accepted around Easter an appointment in Tübingen. Weber therefore lost the direct intercourse with one of his friends. However, the friendship was kept assiduously by mail and later in 1849 after the return of both of them to Göttingen continued until Ewald passed away in 1875. Weber became lonely after all of the Seven except him and Albrecht left Göttingen. The old plan to visit scientists abroad in London and Paris materialized in March 1838. Weber was traveling via Leipzig to Berlin. Here Poggendorff joined, to first visit London and later Paris. Both cosmopolitan cities were very stimulating for Weber, so that he only returned to Göttingen in August 1838. The company of his close friend Poggendorff was very precious for Weber. However, this travel almost had a bad impact on their friendship. As important the relationship of Weber with Gauss was, not everybody in Berlin appreciated it. One thought that it might be an obstacle for Weber as a scientist of his own. This opinion is also expressed in the following letter Poggendorff wrote to Weber in April 06, 1839, after a longer break.

> I am sorry for the late reply to your letter, in which you restarted the exchange between us after a long break. - - - You will surely believe that I as well after our separation in Cambridge thought quite often on you and was several times about to stop the long silence. - - - That you spend your efforts on promoting science despite the difficult exile even increases our esteem for you. I myself and all your friends here sincerely hope that this brings you some recompense for all the privations you have to suffer. You can be assured that the sympathy for you and your researches is somehow weakened among some of your friends here. Also the disagreement between you and myself and others is just due to our great interest in you. As others, I have the opinion that you harm yourself by just assisting Gauss in his research instead of doing your own one. So Gauss got the Copley Medal, where you were barely mentioned.[79] However, I cannot deny it that among the current hopefully temporary circumstances your alliance with Gauss is quite fruitful. But it would be good, that you can again be a researcher on your own, if the circumstances have changed.

There are no notes about the travel itself. Only a letter of Dirichlet shows, that Weber had discussions with Dirichlet's friends, when he was in Paris.

During this travel Gauss took a lot of effort to undo the dismissal of Weber in order to keep him in Göttingen. For this purpose Gauss contacted people close to the king. At the beginning he was quite successful as the following letter from March 12, 1838, clearly shows. Gauss wrote to Weber:

> My dear Weber, the Legation Councillor von L. already two days after your departure arrived here. He wanted to come earlier but first the election issues in the county Hohnstein had to be finalized. As far as I can see it seems quite possible to re-employ you but for that you have to be here in person. It is my great wish that this happens. It is completely compatible with your honour. However, I arranged with G. v. L. that a third person got involved. This is Müller. The two of them had a conference and L.

[79] [Note by AKTA:] The Copley Medal is the most prestigious award of the Royal Society of London. Gauss received it in 1838 for his inventions and mathematical researches in magnetism, together with Michael Faraday for his researches in electrical induction. Weber only received it in 1859 for his investigations contained in his Memoirs on *elektrodynamische Maassbestimmungen* (Electrodynamic Measurements) and other researches in electricity, magnetism and acoustics.

> explained after visiting me again that the conference was quite successful. However as mentioned before, details have to be fixed in oral negotiations. I would blame myself heavily for not having dissuaded you from departing from Leipzig if this travel would not help to release you from a certain state of unfreedom. However, I have to mention two points: 1) in the letter attached from my daughter there is mentioned a travel to London you are planning to do. You never told me about this travel and I am therefore not sure if you really intend to go there. However, I have to admit that I am afraid that if you travel to London, the negotiations have to be postponed or stopped. 2) if I remember correctly you showed me a letter of attorney to a lawyer. I have forgotten if Albrecht, you or Ewald have to fill in this letter. However, I do not see how such a lawsuit is compatible with a peaceful coming back. Apart from it that such a lawsuit will lead to no result, it seems that neither the material object, i.e., the sum of money, nor the true object, i.e., to annoy the enemy, is in any reasonable relation to what you put at risk, the coming back to the true element, i.e., the scientific one, from the false one, i.e., political action. The well-being of the Georgia Augusta and the preservation of dear friendly relations is closely connected to it. I therefore wish that Privy Counsellor Albrecht suspends the beginning of the trial as long as there is hope for a peaceful coming back. - - - Please give my best regards to Möbius and Enke, as well as to your two brothers, to Humboldt and Dirichlet.
>
> Sincerely yours, C. F. Gauss.

The favorable opinion of this letter soon changed to its opposite. Probably due to political events the government got very irritated, so that Gauss saw the only possibility to achieve the goal by directly talking to the king Ernst August. The travel of the king to Berlin offered a great opportunity for that. Gauss knew that in such a case Alexander von Humboldt will get in touch with the king and hoped that he could make some impression on the king by addressing the issue. He therefore wrote in Mai 13, 1838, a detailed letter to Alexander von Humboldt which is of great interest since Gauss explains his opinions in greater detail. Gauss writes:

> Most dear friend, your kind interest you showed on the new tools to understand terrestrial magnetism during my talk in September 19 urges me to report what happened since then. - - - On march this year in Göttingen were carried out observations on both devices, but this time other places joined. This is due to the great effort of our indefatigable friend Weber. The three other places on which observations were carried out as well are the following. 1) In Munich, Weber instructed Professor Steinheil on the installation of a magnetometer, who had built a precise copy of the one in Göttingen. 2) In Leipzig, Weber instructed Professor Fechner on its use, although he had just brought a rough model of such an apparatus. 3) In Berlin, where he had built a similar one in great haste, he supervised the measurements himself. I have the results in front of me. All four curves show an amazing agreement, I would like to say like soldiers drilled. We know this from before from declination curves. There were no large oscillations, but therefore it is even more touching to recognize the harmony in the many little ones. The last rather agitated hour from 11 am until 12 am in April 01, I spent drawing declination and intensity for each kind of curve according to the method well-known to you. With nostalgic delight I enjoyed the agreement between them.

Why do I say with nostalgic delight? I feel like having discovered a new world, having smoothed the entry to it and then at a sudden the door get shut. The continuation of our publication, the "Resultate",[80] through which at least the collective activity of the participants is held together for now, indeed the continuation of my entire scientific activity in Göttingen, crucially depends on being able to keep Weber in Göttingen.

Before I had great hopes to keep Weber in Göttingen. Now they are almost dwindled away. Basically you are my last hope. As I read in the journal our king left the day before yesterday for Berlin. Could you find an opportunity to talk to him to prevent the destruction of all my hopes and keep Weber in Göttingen? In this respect I tell you confidentially all the relevant circumstances, so that you can judge more easily the previous events and the current state.

I only mention briefly what you already know. In particular, that Weber has to be distinguished from the other Seven. I do not even exempt Ewald, my own son in law, just maybe the younger Grimm brother. Weber did nothing else than putting the five letters of his name to the petition to the board of trustees on November 18. He did not mingle into politics. He did not let print anything for justification. The topics of his lectures have no connection at all with politics. At the beginning I thought that his re-employment is possible, even easy supposed that the other side shows some goodwill. For reasons not suitable to a letter which you can guess easily, I did not address the king directly nor people most close to him. However, I tried many indirect ways. Some of the intermediaries might not have had enough power or interest to help. But once I seemed to be close to the goal.

The representative of our university Legation Councillor Lassert, who however does not live in Göttingen but in Ilefeld, discussed the matter with count Münster and told me that the later is very dedicated to it and has great hopes. But more details I got to know later when H. L. von L. was personally in Göttingen, several days after the departure of Weber to Leipzig. Count Münster did not appeal directly to the king but to the minister von Scheele, and the king seemed to agree to re-employ Weber "if Weber does the first step by apologizing for the petition". Count Münster himself meant that this condition makes a lot of sense.

I myself did not think that the cause is lost. The two expressions seemed to be rather flexible. To "make the first step" did not really imply to go to Hanover, but could mean to make a declaration for example to me, that he is willing to get re-employed. In fact this was really necessary since the king could not risk to get a rejection at his re-employment. Even to apologize seemed to let open the possibility to find a way compatible with Weber's sense of honour. However, also according to the opinion of H. v. Lassert the matter was so delicate, that it could not be discussed in letters. In particular, after Weber went from here to the atmosphere in Leipzig whose neutralization one could expect in Berlin. I therefore could do nothing else than to wait until he comes back and to write a rather general letter to him in which I warned him from any foreclosing step.

Weber's return delayed about 3 to 4 weeks. In this time matters dramatically changed. The board of trustees informed me that the king is extremely angry at the Seven and

[80] [Note by AKTA:] See footnote 69.

> very reluctant to re-employ one of them. He would be hardly satisfied with an explanation Weber would or could give. Instead of that, he insisted to re-appoint soon the positions. I do not want to get into details concerning many aspects of the last point.
>
> After Weber's return I thought it too risky to continue the matter by letter. I informed Weber about all essential points. However, my sensitivity does not allow me to ask him if he were able to write a "declaration" which looks like a revocation. In fact, I myself would not do it if I were him, even having the feeling that I acted too rashly. The question if he feels like that my sensitivity did not allow me ask. But apart from subtle sense of honour as well common intelligence forbids to do such a thing. How would such a person be considered by his colleagues and his students. There is no need to recall that I here just consider the circumstances how they are in the agitated time without expressing my own point of view about our public matters.
>
> In this situation I got despaired to achieve something by way of letters. To do something orally was not possible for several reasons. You are my last hope. You know now completely the state of matters as far as I know it myself. If you can find an auspicious moment you surely will take advantage of it. Convince the king to give back to Göttingen an outstanding, harmless scholar! Appeal to the generosity of the king, to forget about the past in recognition of Weber's great scientific value. I am convinced that this would make a favorable impression. I add that it is not too late for sure.
>
> The day before yesterday my daughter departed with Ewald for Tübingen. I did not try anything to do for Ewald, since it is against my principles to take personal favors. Ewald's departure is a great loss for Göttingen. The separation from my daughter is even infinitely more painful to me. I hope that the last tie connecting me to Göttingen is not torn. But neither place, time nor circumstances can weaken my feelings of affection and trust to you.
>
> With deep respect, C. F. Gauss.

As this try did not bring a result either, Gauss used the opportunity as the board of trustees asked him to make proposals for the re-appointment of the position to try a last time to get Weber's rehabilitation. However, this try failed as well. As a response to his report, Gauss received a letter in which all conditions were listed which were a prerequisite for the re-employment of Weber. These conditions clearly show how at this time in Hanover the "royal servant" believed to be able to behave against his citizens. Gauss himself informed Weber about this in a letter to London from July 18, 1838. However, Weber just received this letter after his return from his travel. In the letter it is written:

> Dear friend, even before having received your letter from June 18, I got one from H. (probably Humboldt), which roughly contains the same things on the negotiations as the one addressed to you. After carefully pondering all circumstances, I still could not consider his result as the last word for the following reasons. 1) Since one seems to be less flexible with respect to a person one considers hostile. 2) I have some doubts if the intermediaries took a sincere interest in the matter. At least concerning one of the intermediaries there are some reasons for these doubts. In view of this state of affairs, I did not yet comply with the request of Privy Councillor List to tell him

the person most suitable to get your position, although according to your letter you almost seem to wish that I suggest such a person. I answered to P. L. that I could tell him several qualified persons and will tell him them upon request with whom the magnetic association could continue to exist "as long as Weber continues honoring Göttingen with his presence". I pointed out however, that I have the duty to explain him first the whole state of the matter. I did this in such a way that you would surely agree with it, just in the way I explained it in my previous letter. I received an answer yesterday which I copy here so that you get all the information I have.

> "Your Excellency, I thank you very much for the detailed letter from January 28[81] you had the kindness to send me. I heavily deplore the loss of Professor Weber for my[82] Georgia Augusta and surely everybody will do that who knows the great merits of this man. I am happy to believe you that the political nuisance of our time was alien to Professor Weber and that other people induced[83] him to sign the unfortunate petition, as well that he believed that the petition was not for the public but just for the Royal board of trustees of the University. But according to the state of affairs this is not enough to re-employ him in Göttingen.
>
> Without authorization of his Majesty the King, I will tell you my thoughts about a re-employment of Professor W. [Weber]. I hope very much that Mr. W. [Weber] will be responsive to these ideas.
>
> I think that Mr. Weber has to write a detailed report to his Majesty, the King, in which he explains the following points. a) That he did not take part in political activities and disputes, but just lived for his science. b) That the question of the abolition of the constitution whose content he did not know was of no interest for him at all. c) That the agitation among his colleagues after the Royal Edict from November 01, 1837, mislead him[84] to sign the petition which was the reason for his dismissal. d) That he would have never signed the petition if he would have known that it gets public while he was convinced that it should be just sent to the Royal board of trustees of the University. e) That he feels very sorry for everything which happened afterwards since it is against his principles on the relation between subject and king.[85]
>
> The letter to the king has to be written in such a way that one could publicize a major part of it. I expect that you inform me, if Professor Weber agrees to write a letter of the kind mentioned above to his Majesty the King. In every case I wish that you have the great kindness to tell me the scholars most suitable for this position in case Weber cannot be re-employed and point out who is the most worthy among them. It is a pleasure .... L."

Dear friend, I do not want to anticipate your decision but just mention that despite

[81] [Note by Gauss:] The date is wrong. I have written the letter earlier but I do not know precisely at what day.

[82] [Note by Gauss:] Sic!

[83] [Note by Gauss:] I did not write such an assumption.

[84] [Note by Gauss:] There is no need to remark that my letter did not contain such a statement.

[85] [Note by Gauss:] It is not quite clear to me what is meant by e).

> the sentence "without authorization of his Majesty" I have no doubts that L. showed my letter to the king and wrote his answer with his previous knowledge. The answer is written very neatly so that for sure there was a concept before. It would be helpful if you could send me your answer, but I do not expect this from you. However, I ask you to enable me to answer in a way fitting with your plans. ... Please, dear Weber, make me the pleasure to write a letter soon, best with the message of your return in the near future.
>
> Yours sincerely, C. F. Gauss

Obviously the answer of Weber was negative and therefore his dismissal final. Listing got his position in the following.[86] From this time on Weber lived in Göttingen as a private citizen. Partly he was busy with the edition of the *Resultate*,[87] partly he did his own research. Concerning his own research it was quite painful for him to have no funding from the state anymore. On the advice of Dirichlet, he asked the physical class of the academy in Berlin, when he was in need of 8000 meter of copper wire for his experiments. The academy provided him the necessary money and lent him the wire.

The situation for Weber at this time was definitely not an easy one. However, he still had the hope to get a position somewhere else, if such a one got free. Already in January 1841 he got the offer of a directorship at the technical school in Dresden. Although the Ministry in Saxony tried to fulfill his wishes as good as possible, he decided against it after pondering for a long time "since he felt that his scientific career would take a completely different turn if he accepted."

> All relations between me and Gauss would be cut, since an exchange by mail could not serve as a replacement. My part on the magnetic examinations and undertakings somebody else had to do, if they should be continued. Immediately I have to resign from the co-authorship of the edition of the *Resultate*. The wire I received from the academy in Berlin I have to give back immediately. All this sacrifices would be deplored heavily, and I do not know, if I am safe from reproaches. I suppose that Humboldt would remark, if I wanted to separate from Gauss, what he does not recommend in the interest of science, another option would be to ask directly in Berlin for a position.

Much more suitable seemed to be a position in Braunschweig at the *Collegium Carolinum*, the current technical University Carola Wilhelmina. According to Blasius, which led the negotiations, the college was organized according to academic standards. However, the negotiations did not progress above their initial state in Braunschweig, since almost simultaneously Weber received offers from Halle and Leipzig. In Halle, Kämtz had decided to move to Dorpat and Weber was offered Kämtz's position in Halle officially in April 1842. However, already before Weber was negotiating with the Ministry in Saxonia about the professorship in physics at the University of Leipzig. The reason why it took such a long time was that the holder of the professorship, Professor Fechner, a common friend of all three Weber brothers, who suffered from a heavy eye complaint, had the chance to recover. In this case he would be able to continue later his own position.

[86] [Note by AKTA:] Johann Benedict Listing (1808-1882) was a German mathematician. In 1839 he succeeded Wilhelm Weber as professor of physics.

[87] [Note by AKTA:] See footnote 69.

Albrecht, whom Weber contacted because of Fechner's health condition, wrote in April 18, 1842, to Weber:

> To wait one year before accepting is definitely a good way to know better about Fechner's condition.

Of course the brothers in Leipzig encouraged Wilhelm. Ernst Heinrich writes:

> I agree that it is a great luck to work so closely with one of the greatest mathematicians which you like and admire so much. I can understand how painful it is for you to leave Göttingen. But once you have to separate. Half a year earlier or half a year later does not matter, if your current situation can be put on a more solid foundation. You did everything you could, to prolong your stay in Göttingen as much as possible.

The negotiations finally reached an end in June 18, 1842, with the appointment of Weber, under the condition, that if Fechner recovers, he can continue his former position as director of the physical institute and in the philosophical faculty, while Weber would get in this case a physical laboratory and a magnetic observatory. Although Weber missed the personal exchange with his friend Gauss, whom he admired so much, he received compensation for that through the company with the professors in Leipzig, in particular his brothers.[88]

1.6 Leipzig Period 1843-1849

In Easter 1843 Weber started his new position in Leipzig. His beloved magnetic investigations first built the main part of his research. A stimulus for that was the construction of an

[88] [Note by AKTA:] In 1998, the bronze monument of the Göttingen Seven, created by the Italian artist Floriano Bodini (1933-2005), was erected on the forecourt of the Lower Saxony State Parliament at the Square of the Göttingen Seven in Hannover. Figure (a) of this footnote shows the image of this monument, https://en.wikipedia.org/wiki/G%C3%B6ttingen_Seven and https://www.myheimat.de/hannover-mitte/c-freizeit/die-goettinger-sieben-ein-landesdenkmal-in-hannover-an-der-leine_a54843. Figure (b) shows the detail of the statue representing Wilhelm Weber:

(a)

(b)

isolated, iron-free, magnetic observatory for which the Ministry in Saxony provided funding. Moreover, he had the intention to publish a seventh volume of the *Resultate* as a follow-up to the already existing six volumes.[89] However, this intention never materialized, since the number of magnetic observatories increased in short time so drastically, that a single person could not deal anymore with all the observations. The assiduous collaborator Goldschmidt was now separated from Weber. Moreover, after Weber left, Gauss lost interest in magnetism and turned his attention to purely mathematical researches. A letter Gauss wrote to Weber in May 21, 1843, shortly after Weber moved to Leipzig, indicates this change.

> With many thanks I send you back, dear friend, the letter of Repsold and the drawing. - - - In addition to the painful loss I can never overcome due to your separation, recently an additional one occurred. Major Müller, to whom I have been quite close during the last 25 years, some weeks ago suddenly has passed away. He had the intention to collaborate this summer in the trigonometric measurements. The last half of April I had some correspondence with him about that. Two or three days before his death I sent him a pair of heliotrops. The sad thing is that one gets more and more isolated as one grows older. - - - In the last two months I was quite busy with my own mathematical speculations. This took a lot of time without that I have actually reached my first goal. Always I got lured from one direction into another one, sometimes as well by a will-o'-the-wisp, how this is often the case in mathematical speculations. I am very sorry that this activity and the need to write after that a treatise for the society prevent me from contributing to a further volume of the *Resultate*, in case you actually plan to continue them. Generally after your separation and the loss of your help, I lost interest in magnetism.
>
> With my best wishes also to your brothers, C. F. Gauss

As well other letters of Gauss from this time he wrote when sending magnetic observations to Weber show his antipathy to continue the magnetic researches. Especially a letter from January 08, 1844, in which it is written:

> Since a long time, dear friend, I did not receive any direct news. I hoped so much that in the autumn vacation you would visit me, until Ewald destroyed this hope and brought instead the other one, that you will come for sure at Easter. I am looking forward very much to that. The other reason for writing this letter is a paper by Herschel for the board of the English Association. I attached a copy, so that you do not need to send it back. After you left Göttingen, I got alienated from magnetism so that I am unable to answer the three questions. Even if I did not get alienated, I could not answer the first and third question without having a detailed knowledge about the English foreign establishments, which I am completely missing at the time. — Since you stayed much more familiar in this field and will stay so as long as I do not have the pleasure to collaborate with you again, I hope that you know how to answer the second question. I ask you therefore about your opinion on the whole matter.

The English took more and more the lead in the terrestrial magnetic measurements. They had huge funding.[90] The way they proceeded did not appeal quite to Gauss and

[89] [Note by AKTA:] See footnote 69.

[90] [Note by Heinrich Weber:] Sartorius was informed by Herschel, when visiting in 1845 the English assembly of Natural Scientists, that every year 34000 Pound Sterling were spent for magnetic purposes.

Weber. For these reasons and the above mentioned circumstances, Weber moved more and more to electrodynamics. In this field he continued working until the end. The field was not alien to Weber. Already when he was in Göttingen he did important contributions to it, like the measurement of intensity with the help of the tangent galvanometer, the electrochemical equivalent of water, or works connecting magnetism with electrodynamics, like the induction inclinometer, the rotational inductor, unipolar induction or magnetic friction.[91]

The fruits of these electrodynamical researches are seven treatises published by the Royal Saxonian Society under the title "Elektrodynamische Massbestimmungen" ("Electrodynamic Measurements").[92] It is fair to say that together with the treatises of Weber's friend F. E. Neumann in Königsberg[93,94] they were until recently the major generally recognized base of electrodynamics. Just in recent times different assumptions on the nature of electricity than the one by Weber became popular. This happened after Maxwell founded a mathematical theory based on the points of view Faraday gained from his experiments. Apart from its content, the treatises of Weber distinguish themselves as well through their form, the clear scientific approach and the consequence in the treatment of the questions which makes the seven treatises look as one connected whole. Already in the year 1844 Weber was occupied with electric researches by approaching the fundamental experiment by Alexandro Volta by a more qualitative and quantitative perspective.[95] This fundamental experiment is the base of galvanism. Weber was using for this a sphere built from two hemispheres of different metal, which he suspended in a thread in such a way that the interface was parallel to the direction of the thread. An electrical body brought close to the sphere would then cause a rotation of the sphere. However, to conclude from the magnitude of the rotation the electrical charges which the hemispheres acquire as a result of their contact, a more refined knowledge of its distribution was needed. This problem caused a lot of trouble. Gauss was very interested, when Weber told him about it. Gauss writes in January 27, 1844:

> Your experiment, which makes the electrical difference of zinc and copper directly visible, interests me a lot. I am inclined to believe that this is the starting point for very important progress in this field. Again I sadly feel how nice it were, if I could work with you directly on it.

Gauss then explains his opinions how to continue such experiments in a useful way. Weber at this time was quite devoted to the laws of galvanic currents. When visiting Poggendorff in Berlin in the autumn 1844, Poggendorff asked Weber "to explain everything about the galvanic bridge, i.e., about a conducting wire in the shape of a Wheatstone bridge", since

[91] [Note by AKTA:] [Web38], [Web39a], [Web39b], [Web40], [Web41a] with English translation in [Web21i], [Web41c] with English translation in [Web21j], [Web41d], [Web41b] e [Web42].

[92] [Note by AKTA:] The 8th treatise was published posthumously. These 8 treatises have already been fully translated into English: [Web46] and [Web21d]; [Web52b] and [Web21e]; [Web52a] and [Web21h]; [KW57] and [KW21]; [Web64] and [Web21c]; [Web71], [Web72] and [Web21g]; [Web78] and [Web21f]; [Web94b] and [Web21b].

[93] [Note by Heinrich Weber:] F. C. Neumann, Die mathematischen Gesetze der induzierten elektrischen Ströme, Abhandlungen der Berliner Akademie, 1845, as well as Über ein allgemeines Prinzip der mathematischen Theorie induzierter elektrischer Ströme, Abhandlungen der Berliner Akademie, 1847.

[94] [Note by AKTA:] [Neu46] and [Neu47] with French translations in [Neu48].

[95] [Note by AKTA:] Alessandro Volta (1745-1827) was an Italian physicist and chemist. He was the inventor of the electric battery. See [Vol00a] with English translation in [Vol00b] and [Vol64]; Italian translation in [Vol23]; Spanish translation in [Col00]; and Portuguese translation in [MA08].

he was very interested in it.[96] The scientific researches came to a first conclusion with the publication of the first treatise on the Electrodynamic Measurements, "Über ein allgemeines Grundgesetz der elektrischen Wirkung". This treatise appeared at the foundation of the Royal Saxonian Association of Science in Leipzig in 1846.[97]

In this treatise Weber starts from the interaction two currents or current elements effect on each other. Ampère in his classical treatise "Mémoire sur la théorie mathématique des phénomènes électrodynamiques uniquement déduite de l'expérience. Mémoire de l'académie royale des sciences de l'Institut de France. Année 1823", (Memoir on the mathematical theory of electrodynamic phenomena solely deduced from experience. Memoirs of the royal academy of sciences of the Institut de France. Year 1823),[98] already formulated his famous law. The law of Ampère nowadays familiar to anybody, at this time was almost forgotten. Weber himself tells that he had a lot of trouble to find the treatise of Ampère. Ampère justified his law in an ingenious way by a couple of carefully devised experiments, which however, due to the lack of exact measuring devices did not meet the requirement of exact quantitative measurements. Weber earns the credit to have invented sensible devices to give a thorough justification of Ampère's law according to measure and number. Among these devises is the electrodynamometer, which is nowadays used even for technical measurements.

We cannot enter here into details of this treatise. Therefore some general remarks are in order. At the time Weber was working on his treatise the effects of resting electric quantities according to Coulomb's law were known as well as Ampère's law treating the effects of constant currents or current elements on each other. Moreover, one was familiar with the effects of induction discovered by Faraday and an empirical law formulated by Lenz relating Ampère's phenomena to induction phenomena. F. E. Neumann had developed all induction laws qualitatively and quantitatively shortly before Weber's treatise appeared as a necessary consequence of Ampère's law in view of his refined version of Lenz law. Hence at this time there was no connection between the effects of charges at rest on each other and moving charges building a galvanic current on each other. However since all effects were due to electricity at rest or moving, one could conjecture that there is a law describing effects of electric charges on each other in the resting case as well as in the moving case. Weber managed to find such an "electric fundamental law", from which all known effects could be deduced as a necessary consequence. This law however is rather different from other laws of nature. While for other laws of nature force only depends on the amount and distance of the materials acting on each other, in Weber's fundamental law the force as well depends on the state of movement of the materials, namely its relative velocity and acceleration. Although later on one found different laws predicting the phenomena of resting and moving electricity, Weber's law has the advantage that it only depends on quantities at a given time, namely the amount [of charge], the distance, the relative velocity and the relative acceleration. This law led to scientific discussions. One got convinced that all laws of nature should be subject to a most general, superior law of nature. This superior law was

[96] [Note by AKTA:] The so-called Wheatstone bridge was invented by S. H. Christie (1784-1865) in 1833 and popularized by C. Wheatstone (1802-1875) in 1843, [Chr33], [Whe43, p. 325] with French translation in [Whe44b] and German translation in [Whe44a]. See also [Eke01].

[97] [Note by AKTA:] [Web46] with English translation in [Web21d].

[98] [Note by AKTA:] André-Marie Ampère (1775-1836). His masterpiece was published in 1826, [Amp26] and [Amp23]. There is a complete Portuguese translation of this work, [Cha09] and [AC11]. Partial English translations can be found at [Amp65] and [Amp69]. Complete and commented English translations can be found in [Amp12] and [AC15]. A huge material on Ampère and his force law between current elements can be found in the homepage *Ampère et l'Histoire de l'Électricité*, [Blo05].

first formulated by Robert Mayer and then worked out in detail by Helmholtz and Joule. It is the law of conservation of energy which should provide a criterion on the correctness of all other laws of nature. In fact under usual circumstances the fundamental law complies with conservation of energy but under certain assumptions one could construct cases were this agreement is violated. However, to conclude from this that the fundamental laws does not hold one had to show that such assumptions actually occur in nature. But recently for other reasons one started to consider Weber's law not as a fundamental law anymore. In our time the opinion on the essence of forces is changing. One comes back to points of view popular before Newton that the action of two spatially separated centers of force is not a direct immediate one, but requires a medium. In the same way as light and heat the earth receives from the sun requires the oscillations of an ether which is penetrating everything, every action at a distance should need a propagating medium. Therefore one does not think anymore that *actio in distans* happens in nature. Faraday reintroduced this point of view, Maxwell formulated it mathematically and Hertz recently provided further evidence to it. Neither the gravitational law of Newton nor Weber's fundamental law comply with it since they have *actio in distans* as hypothesis. However, it is conceivable that in the future it is possible to replace all actions at a distance by moderating media, so that these laws still keep a certain significance.

During his stay at Leipzig, Wilhelm Weber lived partly with his younger brother Eduard, who was not yet married at this time, but partly as well with his older brother Ernst Heinrich. The social interchange among the professors in Leipzig at this time was rather simple, free from the luxury of our days. A special peculiarity was the open-minded character of the different social classes in Leipzig so that people from quite different classes like merchants, booksellers, scholars, people from the municipal administration and so on came in close touch to each other. This had the effect that the public interests were quite manifold. When Ernst Heinrich Weber as a member of the first Chamber represented the interests of the university and the town of Leipzig, the city parliament welcomed him with quite honourable ovations upon his return from Dresden. Eduard wrote to his brother Wilhelm:

> Since some days Ernst is back. His return was celebrated quite impressively. Lord Mayor Dr. Müller and two distinguished merchants met him halfway in Vorsdorff in a carriage drawn by four horses. They invited him to leave the express carriage and join them. At the green tavern at the end of the cabbage gardens around 60 horsemen and many carriages welcomed them. Among them were the most distinguished merchants. After a solemn speech and thanksgiving people cheered and one returned back to town. There 300 people gathered. At the gate one cheered again.

Wilhelm Weber whose character was more quite than the ones of his brothers especially enjoyed the personal interchange at a smaller gathering which regularly took place every week at a special day. This event was initiated by Fechner. Among him Dr. Härtel from the music publisher Breitkopf and Härtel, the Weber brothers and the philosopher Professor Weise joined. Family members participated as well and questions from politics, philosophy and science were discussed in a lively way. Especially Fechner who liked to discuss very much contributed a lot thanks to his brilliancy. Due to his arduous experiments on subjective colour phenomena, Fechner suffered from a heavy eye disease, which forced him to stay in dark rooms for many years and to avoid every activity demanding his eyes. In later years luckily he could use his eyes again although just quite limited.

The politically so important year of 1848 came and had a big impact on the German people and its government. In view of these events the step of the seven professors in Hanover ten years ago was judged now quite differently and Ernst August had the intention to re-employ again the seven dismissed professors. April 16, 1848, Weber received from Hanover the inquiry if he were interested to accept again a professorship in Göttingen. Almost simultaneously he got as well a letter from Gauss in which Gauss wrote:

> I now address the most important point already suggested by Sartorius to you. It seems that Sartorius made a lot of progress to let it become true. All I know about it is the following: The university and the town as well sent a petition to the Ministry to reappoint the Seven. The current director of the board of trustees already answered that the reasons responsible for the well-known reprimand 10 years ago is now ineffective and no obstacle exists anymore that these men teach again at the University. He already received the authorization from the king to start negotiations to gain them anew. So far the rescript which I cite from memory. Unofficial news from Hanover tell that first of all you and Albrecht are meant. If this news is correct, probably you already know more about it than I do. I guess that you can make your requirements yourself. How my dear Weber can I disclose my feelings! I will follow your letter. I do not think that the main purpose is to attract many students, but the moral rehabilitation of justice. This is indeed the first condition to raise Göttingen again. That you will attract many students is obviously not to be expected, although I have no doubt that you will contribute as well. For example some weeks ago Quintus Icilius a previous student of mine who got his doctoral degree last year, left Göttingen for Leipzig solely because of you in order to study physics under your supervision. You would bring new life to the mathematical branch of our society. That we will publish as much as in these happy former years I doubt however. This is not due to my many other important works, but since I am 10 years older, rather fragile, and on the descending branch. I have to add that mainly due to that former events my enthusiasm dwindled away. I felt so lonely the last years. However, I can tell you that I will try everything I can to promote your research. Living with you and your constant attachment would be the most precious things in my life. But you have to make the decision by your own. Ewald was here 8 days ago and among us said, it seemed to me, that he will accept an offer to get re-employed if he gets one. In order to be able to bring this letter to the postal office today I have to finish quickly. I just add that I am looking forward very much to see you here soon and that you are very welcome in my house, if you do not dislike its monasterial seclusion.
>
> Yours sincerely, C. F. Gauss.

Again Weber had to make a tough decision. On the one hand the friends in Leipzig, his brothers and the thousands of contacts he had made during his stay attached him to Leipzig. He could not deny either that Gauss at the age of 72 was not able to offer him in scientific respect the same he did in former times. The ten years of separation could not be replaced. Several people urged Weber to stay in Leipzig. Poggendorff wrote:

> Do you want to follow my advice? Don't go! What do you gain. Gauss indeed. But apart from him nothing at all. Gauss is an old man who might die every day and even if he does not die he gets every day older and duller. In Leipzig people like you much. You have your brothers and rich resources which you do not need to obtain

> again from scratch. In my opinion there is no question at all, since gratitude you owe Leipzig as well as Göttingen. Leipzig helped you in hard times. This is a heavy argument. In good times it is easy to find friends.

But on the other side the personality of Gauss, "the greatest mathematician since Archimedes" had a very strong appeal to Weber. Moreover, he met there his old friends Wöhler, Sartorius and his fellow sufferers. A little town more fitted the temper of Weber than a big one. Already in June 26, 1848, Gauss could write to Weber:

> With the greatest pleasure I read in your letter I received yesterday that your matter or better our matter already almost settled in the desired way. I immediately asked Sartorius to discuss the issue confidentially with Listing. However, Listing himself came to me. He declared or better repeated his declaration that from the beginning he considered the position just as one he will give back to you once. I am convinced that he is waiting for your return with sincere joy. - - - It seems certain that Ewald comes back in autumn, although I have no direct confirmation from Hanover nor from himself.

The position of Listing, who held Weber's previous position in Göttingen as associate professor, caused some difficulties. Weber's suggestion that Listing continues to lecture on experimental physics while he himself will lecture on mathematical physics was not accepted by the board of trustees. After several negotiations, Weber received in October 16 the official offer, in which his conditions were accepted, that Listing got promoted to full professor for mathematical physics and received a special fund to acquire measuring devices. Weber himself obtained in the philosophical faculty the same position he left in 1837. At Easter 1849 he started it. In a letter from October 20, 1848, Gauss expresses his joy about the successful end of the negotiations by writing:

> Although today I suffer from a heavy headache, I cannot refrain from expressing my joyful congratulation to you, my dear friend, in the same hour, where I received the complete certainty of your return. I just read in a rescript of the faculty the great news. - - - All the best for you, dear friend. I will count the weeks until you are back in Göttingen.
>
> Sincerely, C. F. Gauss.

1.7 Second Period in Göttingen 1849-1891

After moving to Göttingen in Easter 1849 Weber had the opportunity to join the fiftieth anniversary of Gauss doctorate in July 16 not just as friend but again as colleague. Although Gauss, like Weber, had a dislike of all kinds of festivities concerning his person, there was a big celebration at this day. Apart from speeches, to which friends and deputies appeared, among them Jacobi and Dirichlet from Berlin, the award of diplomas and the appointment as honorary citizen of Göttingen and Braunschweig, Gauss was celebrated by a solemn meeting of the Royal Society of Science in which Gauss presented his paper "Contributions to a theory of algebraic equations" coming back to the topic of his thesis. This was the last paper Gauss wrote. Weber soon realized that a collaboration as in former years was not possible again. Gauss devoted most of his time to lighter pursuits, like reading fiction. In particular, he

became quite interested in the Russian language. He learned Russian so diligently that he became almost fluent in it.

In contrast to Gauss, Weber was still young and he was about to publish some of his most important works in quick succession. Following the first treatise on electrodynamic measurements, there appeared in the year 1851 in the records of the Royal Saxonian Society of Sciences the second treatise on measurements of resistance and in the following year the third on diamagnetism.[99] In the second treatise Weber introduced absolute units of measure for three quantities, which are connected by Ohm's law, namely intensity of current, electromotive force and resistance. By absolute units of measure he means units of measure just depending on the units of length, mass and time, independent of the random and varying circumstances how the measurement takes place. Gauss pioneered the introduction of absolute units of measure for magnetic quantities in his treatise *Intensitas vis magneticae*, which appeared in the year 1832.[100] Weber recognized already at this time the great advantage of absolute units of measure not just for electrodynamics, but for physics in general. In fact in his posthumous writings one can find the development of absolute units of measure for many areas in physics. After the international congress of electricians in Paris in 1881 proposed to introduce this system of units of measure into the theory of electricity in general in view of its great advantages, it seems just to be a question of time until it rules physics and even engineering. In electric engineering this is already the case now. The units used to measure current intensities, electromotive forces and resistances, namely, amperes, volts and ohms, are directly related to the absolute system of units. It must only seem strange that, while the units were named after men who had made outstanding contributions to the theory of electricity, the founders of the system, Gauss and Weber, were completely ignored.

In the third treatise on diamagnetism Weber gets in view of his experiments a more precise idea on the essence of magnetism and diamagnetism. Already Ampère showed that the so called molecular currents, namely little galvanic currents revolving without friction around the molecules of magnetic materials, can be used to explain all magnetic phenomena. In particular, there is no need to assume the existence of magnetic fluids. Weber showed that if one takes into account the diamagnetic phenomena, only Ampère's hypothesis is adequate. He got to the idea that around the molecules of magnetic materials like iron, nickel and so on molecular currents are flowing around, whose orbits are fixed around the molecules while the molecules themselves are able to rotate. On the other hand the molecules of diamagnetic materials including all nonmagnetic materials cannot rotate. They contain current-free orbits in which molecular currents can develop in case the material gets into a diamagnetic state due to magnetic forces. Although Weber drew these consequences from his experiments, he nevertheless refrained to postulate its real existence in nature. The main focus was to make the new ideas fruitful for future research. Weber writes in his Treatise:[101]

> And even if we now associate to *the electric molecular currents* in the interior of materials *reality*, same as to the ether in optics responsible for the propagation of waves, it can happen in the future by further development of science that they have to be transferred to the class of *ideal* notions.

In the year 1857 Weber published jointly with his friend Rudolph Kohlrausch the Fourth Treatise on the electrodynamic measurements, whose content is strongly related to the pre-

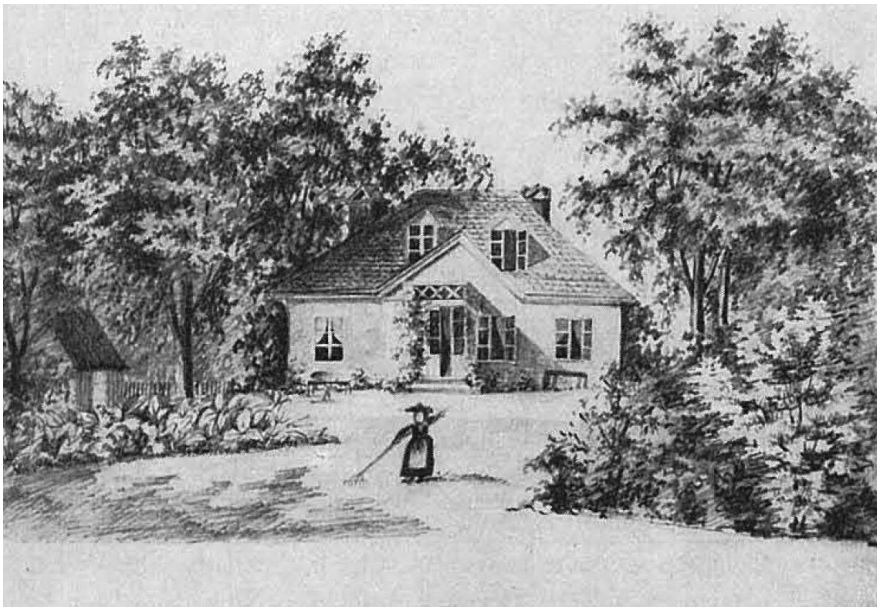
[99] [Note by AKTA:] See footnote 92.
[100] [Note by AKTA:] See footnote 50.
[101] [Note by AKTA:] [Web52a, p. 538 of Weber's *Werke*] with English translation in [Web21h, p. 68].

vious Treatises.[102] One and the same intensity of current can be measured according to three different absolute units of measure namely electrostatic, electromagnetic and electrodynamic. The question was to find the ratio among these different units of measure. With respect to the electromagnetic and the electrostatic units of measure, one obtained a number quite close to the speed of light. This fact is of great significance for the recently proposed electromagnetic theory of light. In addition, this ratio determines as well the numerical value of the constant in Weber's fundamental law. There were additional treatises on electrodynamic measurements published in the years 1864, 1871, and 1878. Their content however is rather theoretical and therefore beyond the scope of this article. A last treatise in this series Weber began shortly before his death. He could not finish it anymore.[103]

A few years after his return to Göttingen, Weber had the opportunity to buy a property with a small house originally built only for summer stays. In the middle of the town, however surrounded by gardens this small house provided Weber the peace of mind he needed to carry out his works.[104] Here in quiet privacy the drafts of his papers took shape. Experiments he mostly did during vacation, when he was not disturbed by academic obligations and could fully concentrate. Weber proceeded quite systematic. All major experiments were already prepared with great care and could be carried out in rather short time. During these events the physical cabinet was full of life. Not caring about his usual daily schedule Weber brought the prearranged series of experiments to a definite end thanks to his peculiar energy.

Dramatic incidents which Weber experienced often in his younger years did not occur anymore. However, Weber had to cope with the death of many of his friends. Not only the high age of 87 years he attained was responsible for that. He also lost younger friends. For only six years after his return he could enjoy the company of Gauss. In February 23, 1855, Gauss passed away. After a long fight with illness and the dwindling of his life force in the last half a year, this outcome was to be expected. Only a few years later Weber suffered

[102] [Note by AKTA:] See footnote 92.
[103] [Note by AKTA:] See footnote 92.
[104] [Note by AKTA:] Weber's house on Jüdenstrasse in Göttingen, in the middle of a large garden. Small drawing in the possession of the Göttingen City Museum, [Wie67, pp. 143 and 221]:



a new loss. In March 9, 1858, Rudolph Kohlrausch passed away in Erlangen. Together with Kohlrausch, Weber wrote the treatise "Zurückführung der Stromintensitätsmessung auf mechanisches Mass" mentioned before.[105] With Kohlrausch Weber lost a friend of a similar scientific spirit combined with a free view of life, with whom he had hoped very much to collaborate in further projects.

After Gauss passed away, probably the best thing Weber could do to recover from this blow was to attract Dirichlet to come to Göttingen. The unexpected happened. Already in autumn 1855 Dirichlet started his lectures at the Georgia Augusta and mathematical science boomed again. Since his stay in Berlin in 1828 Weber and Dirichlet exchanged letters. Weber visited Poggendorff regularly and each time he met Dirichlet as well in his house or the one of his brother in law Paul Mendelsohn. In December 1852 Dirichlet wrote:

> I hope that you comply with the urgent requests of your friends here to come to Berlin. They think that according to tradition they have the right, that you visit them. Unfortunately, I could not carry out your electric question since I was busy with two papers. One of them is in print soon and I am thinking about the other one. As soon as this is done, I will try to focus on your problem.

The problem mentioned was to determine the movement of two equal masses attracting each other according to Newton's law of gravitation but as well subject to two parallel, opposite and equal forces, constant in intensity and direction. Later on Dirichlet wrote to Weber about the solution of the problem:

> I am sorry that I did not try to solve your electric question earlier. I thought it is quite hard and expected that to solve it would require more time than I had available this winter, if a solution actually could be found. After pondering about the matter some days ago, I got convinced that the problem is indeed hard but luckily almost a century ago Euler and Lagrange already found a solution.

Personal friendship and common scientific interests led to a daily exchange which also involved the family members. But for how short time this lasted!

In autumn 1858 Dirichlet returned back ill from vacation. It is said that due to a too warm bath he got a heart disease which resulted in a severe disease ending with Dirichlet's death on May 05, 1859. During Dirichlet's illness Poggendorff wrote on March 11, 1859:

> If one talks here about Göttingen, the first question always is how Dirichlet does. I know, it is sad, very sad. It would be a relief if you could write soon more details about him. It would be a misery if a man in his best age already succumbed to human destiny. The almost 90 years old Humboldt is comparably well. The day before yesterday he joined the academy and 8 days ago the party at the university. Destinies of human beings are so strange!

Dirichlet's illness and his death soon later however were not the only hard blow the unhappy family had to suffer. Already during Dirichlet's illness his wife Rebekka, née Mendelsohn, passed away. A stroke, caused by inner excitation, suddenly put an end to her life. In short time the lively and stimulating exchange came to an end. Dirichlet's house became

[105] [Note by AKTA:] See footnote 92.

deserted and Weber as one of his closest friends had the sad duty to care about his younger children as legal guardian.

Apart from the obligations as legal guardian of Dirichlet's children, Weber at this time had other tasks to do which he carried out dutifully. After Gauss passed away, he became director of the observatory. Already when Dirichlet was still alive the edition of Gauss collected works by the Royal Society of Science in Göttingen was planned. A committee consisting of Stern, Riemann, Dedekind, Schering and Weber was built.[106] In this committee Weber diligently cared about details of the format of the printing and so on. Riemann's illness, which soon occurred and other circumstances led to the dissolution of the committee, and Schering alone edited the works of Gauss.

Quite early Weber recognized in Bernhard Riemann the outstanding mathematical talent and promoted him as much as he could. After Dirichlet passed away, he was convinced that Riemann would be the most suitable successor of Dirichlet. But Riemann could only take the position for a short time. Soon he got ill. On Weber's request the government of Hanover provided Riemann the means to go to Italy in order to cure his lung. The stay in Messina in the winter of 1862 was a great success. However, unfortunately Riemann went back over the Simplon. Unexpected cold led to a relapse and Riemann returned to Göttingen ill. Once more one tried to preserve the extraordinary man for science by a stay in the south, but without success. In July 20, 1866, Riemann passed away in Selasca at the Lago Maggiore.

Since a long time Göttingen was a leading place for mathematics and science. Therefore one was eager to find soon an outstanding successor for Riemann after his death. Clebsch from Giessen was appointed, but only a few years later Weber had to mourn the loss of this younger friend as well. An unusually strong attack of diphtheria brought the activity of the man in his best age to a sudden end. At this time Weber got in closer touch with Zöllner, who was teaching at the University of Leipzig.[107] Zöllner was a brilliant, warmhearted character full of ideals. He became an ardent supporter of Weber and had a strong impact on him due to his fresh mind and his enterprising scientific spirit. At first Zöllner was motivated by the most noble ideas, but in later years irritated by strong attacks he went much too far. On top of this, there were the well-known spiritualistic experiments with the American Slade at which Weber, Fechner and others participated and which led to a great stir. Weber had a honest character not depending on the opinions of others. Hence he was willing to examine all phenomena for which he had no explanation. But despite his fine power of observation, he was not the right person for this kind of experiments for which knowledge of human nature were much more important than power of observation. Just the experiments and not the experimenter were checked and neither the fervent Zöllner nor the other participants were suitable for checks of the later.

Zöllner had the localities of the observatory on the Pleissenburg at his disposal. This circumstance offered Weber who was already in his seventieth the opportunity to carry out once more major experimental work. At this time he had already given over the directory of the physical cabinet in Göttingen to Riecke who as well substituted his lectures at the Georgia Augusta.[108] In Leipzig, Weber not only had the opportunity to live together for a longer time with his brother Ernst Heinrich (the younger brother Eduard had died already),

[106] [Note by AKTA:] Moritz Abraham Stern (1807-1894), Bernhard Riemann (1826-1866), Richard Dedekind (1831-1916) and Ernst Christian Julius Schering (1833-1897) were German mathematicians.

[107] [Note by AKTA:] Johann Karl Friedrich Zöllner (1834-1882) was a German astrophysicist.

[108] [Note by AKTA:] Eduard Riecke (1845-1915) was a German experimental physicist who studied under Wilhelm Weber at the University of Göttingen. In 1881 he succeeded Weber at Göttingen University.

but could meet as well Fechner, Scheibner and Karl Neumann, with whom he already had carried out scientific exchange since several years.

In the same way as one needs a normed unit of weight, one needs a universally agreed scale of resistance and a precisely guaranteed resistance standard. At the time of the French Revolution in 1789 the kilogram became a unit for weight. For resistance Jacobi first proposed a certain standard in Saint Petersburg (Jacobi's wire), later proposals came from Werner Siemens (mercury unit) and the British Association (British Association unit). However, one realised soon that a standard resistance made of metal wire changed with time and could not meet the requirements of permanence. Already before Weber had the intention to build a wire with the property that its resistance at every time could be checked according to absolute measure. With the help of such a device one would be independent from changes of the wire. Siemens proposed to use mercury, since its specific resistance was considered to be constant. This had the advantage that one could measure its resistance according to absolute units. In order to carry out this plan, two large multipliers were mounted at the old observatory. Both of the multipliers had the same size. Their diameter was more than a meter. One served as galvanometer, the other as earth inductor. Weber himself participated with a youthful spirit at the coiling of the wire, the setup and mounting of the devices and the measurements. In order that the appliance would be used again in the future and not just for a single measurement, the wire could be winded off easily from the multipliers and the numbers of the windings and the size of the winding areas could be controlled anytime. Unfortunately Weber could only finish the first part of this work, namely the determination of the resistance of the wire. The second part, namely the comparison of this wire with other units of resistance, he had to leave unfinished, since Zöllner in 1881 suddenly passed away and the rooms and devices from the university at his disposal could not be transferred to other people for a longer time. Later on Privy Counselor Wiedemann obtained the devices and carried out the determination of the Ohm according to absolute measure. Although Zöllner did not participate much in these experiments, Weber later published the results jointly with him in a treatise "Über die Einrichtung zum Gebrauche absoluter Masse in der Elektrodynamik von W. Weber und F. Zöllner", which appeared in Berichte der Königlichen Sächsischen Gesellschaft der Wissenschaften, vol. 32, 1880.[109]

This was Weber's last experimental work. He was now old and many anniversaries were waiting for him. After he celebrated in October 24, 1873, his 70. birthday among a smaller group of people, in August 26, 1876, the 50th anniversary of his doctorate was celebrated officially. But Weber due to his modest character got irritated by personal ovations and escaped to Karlsbad. There he met his friend for many years and fellow traveller, the economist Privy Counselor Hanssen and celebrated the important day among a few close friends. But as well there a large amount of official letters from friends and former students reached him. After the celebration of the fiftieth anniversary of his promotion to full professor in Göttingen in September 24, 1883, and the 80th birthday in October 24, 1883, a dignified completion was the 60th anniversary of his doctorate, August 26, 1886. Quite extraordinary was the affection the still lusty old man enjoyed. He was honoured by deputies from the University of Göttingen, whose senior he was since a longer time, from the Royal Society of Science itself, as well as from the town, which made him a honorary citizen. Weber obtained many honorable letters from scientific associations whose member he was, from corporations and from private persons. The postal office as well as the telegraph were extremely busy to bring all these letters to Weber. Even the director of the imperial institutions, state secretary

[109] [Note by AKTA:] [WZ80].

Dr. von Stephan, who already at opportunities before showed his warm esteem to Weber, sent his congratulation. But Weber received as well splendid recognition from outside by obtaining the Grand Cross of the Order of Henry the Lion by his Royal Highness prince Albrecht of Prussia. Moreover, he was appointed as Royal Prussian real Privy Counselor with the title excellency by his Majesty the Emperor. This was a special honour since Weber was the first professor to receive this distinction without having any connection to the Court in Berlin. Count Bismarck arranged it. After he got this most splendid mark of respect for which he had not looked for, Weber retreated from the public and spent the last years in quiet seclusion.

Weber was a member of 19 academies and scientific societies and around 23 associations spreading over Germany, Austria, England, France, Italy, the Netherlands, Sweden, Denmark and Russia. He was holder of the medal from the Leopoldina (Acad. Caesar. Leopold. Caroli Herm.), the English Copley Medal, the French Becquerel Medal and he owned many orders of merit, like the Pour le Mérite or the Maximilian Order for Science and Art. When Justus Liebig sent him the later one, he added to the official letter on November 25, 1858, the following private lines:

> Dear Friend, I cannot refrain from adding the following private lines to express how deeply I feel that the honour you receive from the king of Bavaria is much below the merit you deserve for your amazing work. According to the rules of the foundation, we could not take into account your previous researches before the year 1856/57. In order to spare you further trouble, I divided the amount and sent half of it already to Kohlrausch. The poor guy is very ill, one is afraid that he might die. Please receive once more my congratulation and visit me soon in Munich.
>
> With kind regards Justus Liebig.

Often one experiences that recognition and honour are changing the character. This was not the case with Weber! Everybody who entered his simple office found the same friendly, sympathetic man, independently if he just had the title of Professor or the one of Excellency. His work and endeavour were concerned with the cause and not the person. Therefore he shunned priority disputes and was always happy to share his ideas and experiences with others to promote science. Free of needs, he led a frugal life and avoided the limelight. After he suffered in July 1871 for a longer time from smallpox, he also gave up smoking. He lived quite moderately and followed a strict daily routine. Until old age he went in the early morning for a walk. Part of his vacations he usually went hiking. His fellow travellers had often the opportunity to experience the energy and endurance Weber developed when hiking. In every undertaking, even a secondary one, Weber was always careful and followed a well-devised plan. On the other hand he was not pedantic and could as well change his plans, which he referred to as "policy of the free hand". His own scrupulousness he expected as well from others and this explains the recognition of authority of all those he once gave trust. Although benignity and tolerance were the main feature of Weber's character especially when he got old, he as well had enormous energy combined with a lively and easily excitable temper. Weber could throw a tantrum and since this was against his natural disposition, such a fit could happen for quite accidental reasons.

Although he was not married, Weber led a keen family life. Since he moved to Göttingen for the second time in the year 1849 his oldest niece with the exception of just a few years did his household. Cheerful younger and older guests frequented his house and garden. Weber

always had a strong sense for friendly exchange. This show the personal letters he wrote to the wives of his colleagues especially Ms. Dorothea Grimm, Ms. Poggendorff, the first and second wife of his friend Ewald, Ms. Dirichlet and so on. Almost everywhere he was a good friend and was consulted for advice. The closest exchange however he had with his brothers and their families. The relation between the brothers was almost ideal, especially the one to Ernst Heinrich, since Ernst Heinrich, 10 years older than Wilhelm, was his closest advisor in every circumstance since childhood. Often he mentioned full of gratitude how much he owed to him. It was quite pleasant to hear how each of them recognised the merits of the other fully. Between Göttingen and Leipzig there was therefore a lively family exchange and it was always an exception if there was not a hospitable house, which accommodated another family member. Especially when in the early 1870s Ernst Heinrich stopped teaching, the two brothers often spent most of the summer together in Göttingen. When Wilhelm as well in 1874 stopped lecturing partly and in 1876 completely, the opportunity to meet each other was used even more. The winter of 74/75 Ernst Heinrich had to spend at the Riviera and in Naples, since he suffered from asthma. Wilhelm accompanied him. It was the last travel together. Wilhelm especially enjoyed the family gatherings, which took place in Göttingen every year at Pentecost. Then Weber became young again and took part at all undertakings.

Weber was not a good speaker. However, in his lectures he fascinated his students by the peculiarity of his teaching. Starting from simple facts he developed the building of his science in a strong logical order. He focused on the flow of ideas and the methods of scientific research. He did not talk about religion and religious points of view. Although he had his religious convictions, he was quite tolerant to others. That he concerned himself quite with religion is shown by the fact that among his scientific notes there can be found as well some religious ones. Several times he mentioned the followings:[110]

> Each thought, each perception and each memory I am aware of are my property. That I can think, perceive and remember is a gift of god.
>
> Human beings are aware of every thought, every perception and every memory they have and call them their own. There is nothing what one could call his own with greater right. However, human beings are aware as well that they did not receive from themselves their thinking, their perception and their memory. They say that these are granted to them by god. Having not received their awareness, their thinking, their perception and their memory by themselves is their religious conviction.
>
> Dream is interruption of thinking. A faint memory is the interruption of matching ones thoughts, i.e., interruption of intellectual work. Our life is an intermittent existence.

To reconstruct Weber religious conviction out of these isolated sentences, is hardly possible without bringing in one's own opinion. But how could one not be touched by these sentences? As Weber was completely free of vain ambition of honour and recognition, he did not care about money and property at all, either. What would make others happy was a burden to him. His brother Ernst Heinrich took care of his small income and when Ernst Heinrich died, Wilhelm distributed all his property among the children of his brother.

When his memory started to become faint, it became hard for Weber to bear old age. He used to say:

> My memory is so faint, that when reading a book I have already forgotten the previous page, when I start reading a new one.

[110] [Note by AKTA:] See [Web94a] with English translation in [Web97] and [Web21a]. See also [Ten97].

Like Gauss, Weber started to read fiction, especially Goethe and Shakespeare interested him since a long time, but as well Chamisso, the letters of Bismarck, the correspondence of Dahlmann, Wöhler, Grimm and so on.

At the beginning of the year 1891 Weber got jaundice. He had nutrition problems and his powers were dwindling away. Although he got better once more and there was hope that he could recover completely, a new attack of this illness consumed his powers slowly so that he passed away in June 23. During this longer illness Weber did not always had to stay in bed. But he was not able anymore to get impressions from outside and therefore was alone with his own thoughts. His mind more and more detached from this world and he transferred the thoughts which absorbed him to reality. He often mentioned that he is travelling to Göttingen. If one replied that he is already in Göttingen, he said:

> This is not my Göttingen. I mean Göttingen, in which Gauss lives.

Already several days before his death, he felt that the end is near and in his selflessness he pointed out that there will be a great stir in the house, that many people will come and if one already has taken measures to deal with this. He had completed his mundane path and longed for the end. "I do not want to work anymore on this dark world", he said and asked, if the expected people are already coming. He often thought about his brother Ernst Heinrich, who already had passed away.

> God is calling. I have to go away, my brother Ernst is waiting for me.

In the morning of June 23, the first sunny day after a longer period of rain, he went supported by his niece to the garden, he liked so much, and sat in an armchair. He peacefully slept there almost the whole day in the warm rays of the sun. When the sun was setting, he raised his head and his eyes wide open were shining in a peculiar way. For a long time he watched the sky and the setting sun, like looking already to the hereafter. A few minutes later Wilhelm Weber passed away one day before the birthday of his beloved brother Ernst Heinrich, to join him, his younger brother Eduard and all his other siblings forever.

The sad news was spread by the telegraph to all directions. All who knew the deceased mourned him. The funeral took place in June 26. Many people attended. Apart from the professors, the students and the deputies of the citizens from Göttingen, many external people came to show the last respect to the beloved man, if they managed to come to Göttingen at such short notice. A large number of wreaths, palms and flowers were not just sent by scholars, but as well by individual persons and corporations. The citizens of Göttingen considered the simple, unsophisticated man since a long time as one of themselves and while still alive the deceased barely could imagine how he managed to have so many friends among all classes of people. The emperor Wilhelm let express his condolence by the trustee and prince Albrecht of Prussia let lying down a wreath in front of the grave by his adjutant. Also the secretary of state Dr. von Stephan expressed his commiseration. The preacher of the University councilor Dr. Schulz gave a moving speech in front of the coffin, which stood under the open sky among large trees.

So he left, the great and nevertheless modest man, beloved by everybody who was close to him, honoured the more he did not aspire recognition in his life. May Wilhelm Weber be a role model for the academic youth! Free of arrogance and vanity, free of social prejudice, a true German scholar. Germany will always be proud of him.

Now he rests in one of the first graves of the cemetery of Göttingen. Rest in peace![111]

[111] [Note by AKTA:] Weber's grave appears in this footnote, https://en.wikipedia.org/wiki/

Wilhelm_Eduard_Weber. It reads: Called by God to a higher activity, here rests the mortal remains of Wilhelm Weber, born in Wittenberg on October 24, 1804, and died in Göttingen on June 23, 1891:

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