

Scientific Discussion and Friendship between Loschmidt and Boltzmann

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Loschmidt was born in 1821 in Putschirn near Karlsbad as the son of a small peasant. As a child he herded barefooted goats on the pastures of his Bohemian native place. His grammarschool teacher discovered his intellectual gifts. But during his schoolyears and his University studies in Prague and Vienna he had to suffer from financial distress and hardship. After working for a few years in various chemical firms Loschmidt returned to Vienna in 1855 where in the following year he became a highschool teacher for physics, chemistry and algebra in Leopoldstadt, which was a suburb of Vienna. In 1861 he paid from his modest salary as a teacher for the printing costs of his first publication "Chemical Studies" [6] which already contained the ring structure of benzene and the constitution formulae of 121 aromatic chemical compounds. Even Kekulé, who later got the credit for the ring structure of benzene, noticed this publication, but as it had not appeared in a scientific journal he didn't appreciate it and only dedicated a critical footnote to it.¹ Loschmidt also had to pay for his second publication "On the Constitution of the Ether" [7]. Then he found a friend and promoter in the physicist Josef Stefan. Born in St. Peter near Klagenfurt as the child of Slovenian parents, who were illiterate, Stefan had a great compassion for Loschmidt's problems. He was 14 years younger than Loschmidt but he already assisted Andreas von Ettingshausen since 1863 as Vice-director of the Physics-Institute. He made it possible for Loschmidt from now on to publish his papers in the Proceedings of the Imperial Academy of Sciences in Vienna. Already in 1865 Loschmidt presented his important paper "On the size of air-molecules" [8]. With this result he determined for the first time the number of air molecules in a ccm of air under standard conditions.² This number is nowadays called Avogadro's number after the Italian count and physicist Amadeo Avogadro, Conte di Quarenga. In German speaking countries it used to be called Loschmidt's number for many years³ following a proposal of Ludwig Boltzmann in 1899.⁴

As soon as Stefan in 1866 had become the successor of Ettinghausen and director of the Physics Institute, he gave Loschmidt the opportunity to work scientifically at the Physics Institute and to become university lecturer in physics. At the Physics Institute Loschmidt came also in close contact with Ludwig Boltzmann, who was just working on his paper "On the mechanical meaning of the second law of the theory of heat" [2]. Boltzmann also frequented Loschmidt's lectures on molecular physics. In spite of the large difference in age of 23 years Loschmidt and Boltzmann became good friends and had stimulating discussions about all kinds of scientific problems.

A few years later when Boltzmann worked at Helmholtz's Institute in Berlin he experienced, that such an unburdened friendly atmosphere as he was used to from Loschmidt and Stefan in Vienna was at that time rather exceptional in the relation

¹See ref. [11].

²This result is however not given in reference [8] but only in 'Österreichische Wochenschrift' which was a supplement of the "Wiener Zeitung".

³In fact Avogadro formulated in 1811 the hypothesis that equal volumes of different gases under the same conditions contain equal numbers of molecules, but he never determined this number. It was Loschmidt who first determined it in 1865.

⁴Boltzmann made this proposal in a speech on occasion of the unveiling of Loschmidt's bust at the University of Vienna on November 5, 1899. See ref. [1] p. 243.

between senior scientists and young researchers:

“I did not sense at that time, that for me who was still learning it was not becoming to join this friendly atmosphere. A single look of Helmholtz taught me this quite clearly when I started to speak in this easy way on the first day of my later work at the laboratory in Berlin.”⁵

Loschmidt's papers on the kinetic theory of gases initially had papers of Stefan as their starting point. But Stefan was mainly interested in those theoretical questions which were of direct relevance for his current experimental work. Loschmidt, on the other hand, who in Prague had studied philosophy under Franz Exner for a number of years, also loved to ponder about fundamental questions in the realm between physics and philosophy. Undoubtedly he contributed to raise the interest of the young Boltzmann for the fundamental questions of thermodynamics. Especially since his paper “On the theory of gases” [9] appeared in the same year 1866 as Boltzmann's first paper on this subject with the title “On the mechanical meaning of the second law of the theory of heat” [2]. In December of this year Boltzmann made his PhD and in 1867 he became Stefan's assistant. This was good luck since the fortune of Boltzmann's mother, which had been the only financial resource of the Boltzmann family, since the death of his father was now exhausted.

The k. k. Institute of Physics of the University of Vienna, which had been created under Christian Doppler in 1849 was until 1875 located at today's address Erdbergstrasse 15 in the 3rd district of Vienna. Originally this was meant only as a provisional location, because after the revolution in 1848 the imperial army used some of the university buildings in the center of the town. But as it often happens in Austria this provisional arrangement lasted for more than 25 years, even though the building was not suitable for a Physics Institute. Nevertheless the inspiring scientific atmosphere at the institute remained exemplary for Boltzmann through all his life:

“In a way the Physics Institute which was at that time located in Erdberg is a proof, that it is possible to do significant work in rather bad localities, even more so, Erdberg remained for me through all my life a symbol for earnest, experimental work reflecting a high mentality.”

Boltzmann made a lot of experiments at that time and also benefited from assisting Loschmidt in his experiments, because Loschmidt was an ingenious experimentalist. For instance in Loschmidt's paper “Experimental investigation of the diffusion of gases without porous partition walls” in 1870 we find the remark (See ref. [10]):⁶

“At these preliminary tests I enjoyed the active help of Dr. L. Boltzmann for which I would like to express my warmest thanks to him.”

About these experiments Boltzmann writes in his obituary for Loschmidt in “Populäre Schriften”:

“The fact that Loschmidt could make masterly experiments, proves, for instance, his investigation of the diffusion of gases without porous partition walls. In this experiment he solved a problem which had been tackled in vain by Graham and Bunsen. Moreover he solved it in such a simple way that we don't realize the difficulties any more. Afterwards it was easy for many other physicists to perform a great number of other

⁵See ref. [1] p. 102.

⁶A detailed account of these experiments can be found in Prof. O. Preining's contribution to this symposium.

important experiments using Loschmidt's method."⁷

In spite of Loschmidt's wealth of ideas and his diligence his list of publications shows only 21 titles which is not much, but it contains very important papers. The relatively small number results in part from the fact that Loschmidt had only very late in his life sufficient means for experiments at his disposal and some of his experiments were on the right track but did not yield the desired results. Boltzmann once mentioned this and Loschmidt replied with a statement of Faraday:

"Only the one who tries to do the improbable will find really important results."⁸

In selfirony Loschmidt also once proposed to create in Vienna a negative scientific journal, a journal which contains only abortive experiments. Indeed he would have had remarkable things to report. He anticipated for instance already the Hall-effect and the Kerr-effect and used in principle already the right detection methods, but his apparatus had not been sensible enough. About routine-experiments, whose results are foreseeable he once said to Franz Exner [4]:

"You must know, that I could also perform such experiments as some colleagues, but then I would be sorry for the time I spend for them."

His most important scientific contributions are of fundamental nature. They are his insight into the structure of organic molecules, his determination of the size of air molecules and his recurrence paradox. About the details of Loschmidt's scientific discussion with Boltzmann, especially about the recurrence paradox, I have already reported in my second contribution to this conference.⁹

Loschmidt and Boltzmann also frequented together performances of Vienna's Royal theater and opera house. Boltzmann reports the following anecdote¹⁰:

"Since I planned already my experiments with spheres grinded from sulfur and nobody could grind them, he proposed, that we should grind these spheres ourselves while we were waiting to enter the Royal theater. He was hoping that the carbonic disulphide used for this purpose would as a side effect keep the other people away which were also queueing up."

From these experiments resulted Boltzmann's paper: "On the difference of the dielectric constant of crystalline sulfur in various spatial directions."¹¹

Loschmidt is also mentioned in the correspondence of Boltzmann with his later wife Henriette von Aigentler, who was studying Physics and Mathematics at the University of Graz from 1872 until her marriage to Boltzmann in July of 1876. On January 25, 1876 Henriette wrote to Boltzmann¹²:

"A short time ago I have finished to read these lectures which Professor Loschmidt sent to me. They are really extremely interesting and instructive. Unfortunately I have right now very little time to read or study, since I was some times even in the evening in the

⁷See ref. [1] p. 232.

⁸See ref. [1] p. 232.

⁹D. Flamm: Four papers by Loschmidt on the state of thermal equilibrium, in these Proceedings.

¹⁰See ref. [1] p. 237.

¹¹See ref. [3].

¹²See ref. [5] p. 139.

kitchen of Kienzl.”¹³

A charming story is also Loschmidt's inquiry about coffee machines in Boltzmann's letter of March 4, 1876:¹⁴

“Professor Loschmidt intends to cook the coffee himself, because nobody succeeds to prepare it to his satisfaction. Thus with the right sense he asked me about a coffee machine. Probably you could tell me under what name and where you bought yours. How expensive a machine of the type of yours would be and whether the coffee which you make in your machine is really good. Also the description of your machine I only poorly remember.”

Henriette answered the day after:¹⁵

“Concerning Professor Loschmidt's coffee, I really feel pity with him. He seems to be a bit excentric. My coffee machine I bought in the petty ware shop Plentl (Herrengasse). If I remember correctly the price was 4 florins 50 farthing or a little more. By chance I have a piece of an old “Wienerzeitung” [Viennese journal] which just contains an advertisement of this coffee machine. Also the lower part of my ‘non plus ultra’ machine is still visible. [...] I can easily make a drawing how the machine looks like. [...] I have now described to you all the details of my machine and now I shall prepare a coffee for myself since the twilight has already progressed so far, that I don't see enough to go on writing.”

In a letter on June 28, 1876, Boltzmann reported about an evening which he spent together with Loschmidt on the countryside:¹⁶

“A few days ago I spent the evening in Loschmidt's company at ‘Hohe Warte’ a location on the countryside about one hour away from my apartment.¹⁷ Loschmidt has moved there to avoid the mustiness of Vienna, and he took me out there after an oral examination for a doctor's degree. I returned not until 10 pm when it was not hot any more but rather pleasant. At ‘Hohe Warte’ a band played mostly dancing music and I used the opportunity to tease him with his dancing at the ball in Peggau, of which Professor Pless had told us at Kienzl's house. But he assured me that he could not dance anything besides quadrille and that he didn't dance at all on that evening. I believed this even more so, as he confessed that he would have loved to dance, but that he felt embarrassed. Then I told him, that at that time at Toepler's house and at the ‘Naturforscherball’ [ball of the natural scientists] I also would have loved to dance. Finally he met the wish of my heart when he said: What a pleasant feeling it would be, if Jetti [Henriette] would now sit at your side and listen!”

Probably the only thing which Boltzmann criticized about his teachers Loschmidt and Stefan in later years was their lack of relations to foreign scientists:¹⁸

“Neither Stefan nor Loschmidt, as far as I remember, ever made a trip outside of Austria. At least they never frequented a ‘Naturforscherversammlung’ [meeting of german speaking natural scientists]¹⁹ and never kept closer personal relations with foreign scien-

¹³Henriette learned how to cook in the kitchen of the parents of the composer Wilhelm Kienzl in Graz, as she was preparing herself for her marriage with Boltzmann.

¹⁴See [5] p. 150.

¹⁵See [5] p. 151–152.

¹⁶See ref. [5] p. 214.

¹⁷Boltzmann's apartment was in a house in Vienna's 8th district, Leopoldstadt, Florianigasse 2.

¹⁸See ref. [1] p. 102.

¹⁹These were meetings of German speaking natural scientists and doctors which since 1822 where

tists. This I cannot approve since I believe that they could have done better keeping less separation. At least their work would have become known faster and thus would have been more fruitful.”

For Loschmidt this criticism certainly does apply. We have heard during this symposium how many good ideas Loschmidt had and for how few of them he receives international credit today. But it was a feature of Loschmidt's personality that he was satisfied when he had found a new result and he never fought for his priority.

The following letter which Boltzmann wrote from Munich on June 24, 1894, to Loschmidt²⁰ who was already retired from the University of Vienna sheds some light on the lasting friendship between Boltzmann and Loschmidt:²¹

Dear Friend,

I received your letter with great joy, I was really touched. Without using flat phrases I may say, that you have as big merits in science as in my scientific training and in my heart. I deeply regret that you are plagued in this way by illness. I shall really come to Vienna and thus I shall have the pleasure to see you again. May be I shall even succeed to rise your interest again for a scientific problem. Do you still have sufficient sharp-sightedness? I have no doubt of your brilliance. I have just something which interests me enormously and about which I cannot talk to anybody if not to you.

With my kindest regards your faithful friend

Ludwig Boltzmann

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held every year in a different city.

²⁰Loschmidt died about a year later on Juli 8, 1895.

²¹See ref. [5] p. 25.

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