

Paul Ehrenfest's Rough Road to Leiden: A Physicist's Search for a Position, 1904–1912

Pim Huijnen and A.J. Kox*

Paul Ehrenfest (1880–1933) received his Ph.D. degree at the University of Vienna in 1904 and moved with his wife and young daughter to St. Petersburg in 1907, where he remained until he succeeded Hendrik Antoon Lorentz (1853–1928) in the chair of theoretical physics at the University of Leiden in 1912. Drawing upon Ehrenfest's correspondence of the period, we first examine Ehrenfest's difficult and insecure years in St. Petersburg and then discuss his unsuccessful attempts to obtain a position elsewhere before he was appointed as Lorentz's successor in Leiden.

Key words: Paul Ehrenfest; Tatyana Alexeyevna Afanassjewa Ehrenfest; Hugo Ehrenfest; Ludwig Boltzmann; Theodor Des Coudres; Peter Debye; Albert Einstein; Gustav Herglotz; Abram Fedorovitch Joffe; Felix Klein; Hendrik Antoon Lorentz; Max Planck; Arnold Sommerfeld; University of Vienna; University of St. Petersburg; University of Leiden; anti-Semitism; quantum theory; statistical mechanics.

Introduction

Paul Ehrenfest (1880–1933) succeeded Hendrik Antoon Lorentz (1853–1928) in the chair of theoretical physics at the University of Leiden in 1912 and until his death maintained Leiden as one of the principal centers of theoretical physics in Europe. He is remembered as an outstanding theoretical physicist, brilliant teacher, and sharp critic of his own work and that of his contemporaries.

Ehrenfest's road to Leiden was long and rough. It took him eight years from the time he received his Ph.D. degree at the University of Vienna in 1904 to his professorship in Leiden, his first permanent position. During most of this period he lived in the Russian capital of St. Petersburg, where he moved with his wife, the Russian mathematician Tatyana Alexeyevna Afanassjewa (1876–1964), in the summer of 1907. The next five years were turbulent ones for Ehrenfest. The political atmosphere in Europe was tumultuous, the developments in physics – grappling with the new quantum ideas – not less so. Most of all, this was a stormy period in Ehrenfest's development as a per-

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son and as a theoretical physicist. He seemed unable to secure a position – or even to start a career – in his chosen field of theoretical physics owing to a range of factors, partly external ones, but also – and not to be underestimated – partly ones linked to his often difficult personality. In any case, the longer he failed to obtain a satisfactory position, the more he doubted himself as a physicist, and the more he suffered from the tension and frustration generated by his self-doubts. During his years in St. Petersburg he became more and more ensnared in a vicious circle, which resulted in at least one terrible depression.

Ehrenfest's period in St. Petersburg has not received much attention in the historical literature. Martin J. Klein devotes a chapter to it in his biography of 1970,¹ which is still by far the most important work on Ehrenfest, basing his discussion essentially upon Ehrenfest's small notebooks, in which he jotted down things he was afraid he might forget. Later, Ehrenfest elaborated many of these notes in voluminous letters, especially to his wife Tatyana while he was on various trips between 1907 and 1912. His letters, in other words, contain facts and mention thoughts that he did not write down in his notebooks and thus offer new insights into his circumstances and thinking. We will look closely at Ehrenfest's correspondence below, which presents an image of the young Ehrenfest as an extremely insecure physicist who capriciously, in an almost neurotic way, is looking for something to hang onto – a family, a profession, a home – and who almost always fails to do so because he is at war with himself.

Life in St. Petersburg

[We] went to Russia, because Tania had been called back to her old position – for me an interesting (though dangerous) experiment.... After all, it's all fairly unstable and risky – the main argument remains, of course, that I don't have a real Heimat anywhere – whereas Tania really belongs here. We'll see. At worst one or two years and a corresponding amount of money get wasted.²

An “interesting (though dangerous) experiment,” Ehrenfest called his move to the Russian capital of St. Petersburg in the summer of 1907, making clear to his old university friend in Vienna, Heinrich Tietze (1880–1964), that the worst-case scenario would be the loss of two years of his life and a heap of money – after which he would be back in Europe looking for a job: Several of Ehrenfest's friends did not even view St. Petersburg as being in Europe at this time.³ In short, Ehrenfest felt that he just had to sit out one or two years there. Why then did this Austrian theoretical physicist move to Russia in the first place?

Three years earlier, in June 1904, Ehrenfest had received his Ph.D. degree in theoretical physics at the University of Vienna, in his hometown and lively center of the Austro-Hungarian Empire where he was joined by his fiancée Tatyana, whom he married at the end of that year (figure 1). Two years of unemployment followed, after which they and their little daughter (also named Tatyana after her mother) decided to try their luck in Göttingen, Germany, where they had met in 1902 while both were students at the university. It took them a year in Göttingen to find out that they would not be able to begin their professional careers there. Tatyana then was offered the oppor-



Fig. 1. Tatyana Alexeyevna Afanassjewa (1876–1964) and Paul Ehrenfest (1880–1933) at the time of their wedding in 1904. *Source:* Klein, Ehrenfest (ref. 1), Fig. 4, facing p. 16.

tunity of getting her old job back as a mathematics teacher in a girl's school in St. Petersburg.

Ehrenfest's main reason to move to faraway St. Petersburg, however, was a negative one: Nothing kept him in Göttingen, or even in Germany or Austria – the concept of a *Heimat* was largely strange to him. Contrary to his wife Tatyana, who was delighted by the idea of returning to her hometown, he had no special feelings at all for his own hometown of Vienna. Thus, during a stay with his family in Vienna in the summer of 1906, just as they were making plans to leave for St. Petersburg, he wrote to his wife:

I enjoy staying here for a few days – it's a pleasure seeing them all again. But if I've ever doubted whether it would be a good idea to move to your *Heimat* – having my *Heimat* here under my nose, I'm all of a sudden completely sure.⁴

This *Heimatslosigkeit*, this homelessness, was a tragic emotion that accompanied Ehrenfest throughout most of his life and sunk deep roots while he was living in St. Petersburg. That does not mean that he did not try to make the Russian capital his hometown. On the contrary, by bringing Tatyana back to her *Heimat*, he also made it possible for his little daughter to secure one of her own, and he naturally hoped that it would become his own *Heimat* as well.

At this time there were approximately one hundred physicists in the whole of Russia, the best of whom resided in Moscow. St. Petersburg was home to the erudite professor of mathematics Vladimir Andreevich Steklov (1864–1926), whom Ehrenfest soon met, and who together with Steklov's colleague Andrei Andreevich Markov (1856–1922) had established a mathematics faculty that had a much higher reputation than the mediocre physics faculty of Orest Danilovich Khvolson (1852–1934), Ivan

Ivanovich Borgmann (1849–1914), and Nikolai Aleksandrovich Bulgakov (1867–1931). This is probably best illustrated by an anecdote about comments that Khvolson made concerning the ambitious plans of one of his students, telling him that he should repeat previously done experiments instead of devising his own.⁵

Ehrenfest's arrival in St. Petersburg did not go unnoticed. The articles he had written between 1904 and 1907, though not large in number, had earned him a reputation of being a progressive physicist, especially as viewed against the background of the rather backward physics faculty at the University of St. Petersburg. Ehrenfest's reputation rested most of all on his paper, "On Planck's Radiation Theory," which he had published in the summer of 1906 in the *Physikalische Zeitschrift*.⁶

Max Planck (1858–1947) had introduced the concept of energy quanta in 1900, which he showed was indispensable for understanding the behavior of blackbody radiation, and Albert Einstein (1879–1955) had proposed his revolutionary light-quantum hypothesis in 1905, which implied a far-reaching revision of accepted ideas on the nature of light. Ehrenfest took a different tack in his 1906 paper. As its title indicates, he gave a thorough analysis of Planck's train of thought, which meant that his analysis was much less profound than Einstein's, but he did come to a similar conclusion, namely, that Planck's work, in the words of Thomas S. Kuhn, would "require the development of a discontinuous physics."⁷ Ehrenfest thus became one of the first physicists to endorse Einstein's radical results. For Ehrenfest, as for Einstein, the quantum hypothesis was not merely a mathematical aid; it represented physical reality.

The circle of physicists in St. Petersburg welcomed Ehrenfest enthusiastically. That, however, did not lead to a job for him. Ehrenfest's background was much too different from their own: He was a foreigner who hardly spoke Russian; he did not hold a Russian doctoral degree; and he was officially nondenominational – which was a relic of his marriage to Tatyana. He had been forbidden to marry her by the Austrian authorities, because Jews were not allowed to marry Christians in the Austro-Hungarian Empire. Ehrenfest was Jewish by birth and Tatyana Russian Orthodox. They had circumvented the Austrian law by both officially declaring themselves nondenominational.⁸

Ehrenfest's decision here may also have been influenced by a feeling that having no religious affiliation could not possibly be more degrading than retaining his old one. Atheists were discriminated against in the Austro-Hungarian Empire and had no prospect of acquiring positions of high social status, but their opportunities were no more restricted than those of Jews, so that a desire to increase his social status could not have caused Ehrenfest to abandon his Jewish faith. Perhaps he was even influenced by a negative argument, namely, that he had little reason to retain his Jewish confession since he had not been raised in a religious family environment, and since the anti-Semitic atmosphere in Europe at this time was becoming more oppressive.

Once in St. Petersburg, Ehrenfest tried to make up for his shortcomings as a non-Russian as best he could. He tried to fit into Russian society almost symbolically by growing a beard and long hair (figure 2). More productive was his learning the Russian language, which he succeeded in doing fairly well. Most constructive of all, he tried almost immediately to commit himself to the University of St. Petersburg in all sorts of ways. On Steklov's invitation he gave several lectures on mathematical subjects; he earned a little money by publishing some of his lectures; and he became a member of



Fig. 2. Paul Ehrenfest (1880–1933) and Stephen Timoshenko (1878–1972) in St. Petersburg. *Credit:* American Institute of Physics Emilio Segrè Visual Archives.

the editorial board of the *Journal of the Russian Physical-Chemical Society*, working especially for its supplement, *Problems in Physics*. As a member of the editorial board he also regularly attended meetings of the Russian Physical-Chemical Society and published several articles and book reviews.⁹

Ehrenfest and Abram Fedorovich Joffe (1880–1960), who became close friends, also founded a physical discussion circle in the fall of 1908, which met at the Ehrenfests' home every two weeks, and which maintained Ehrenfest's contacts with local physicists and served as a forum for discussing his scientific work. They must have been inspired most in founding this discussion group by the miserable state of physics teaching at the University of St. Petersburg. This was clearly illustrated by an incident that Joffe recalled about his own student days there concerning a lecture in theoretical physics by Bulgakov, who was still a professor in 1908:

N.A. Bulgakov was, as it was told, good at figures and was able to carry through complex calculations in his head, but he didn't understand physicists. As a student I once heard him give a lecture at the Technological Institute about the theory of electricity, in which he caused such confusion that he himself begged us to erase all of our notes on the lecture that he had just given.¹⁰

Besides their biweekly discussion group, which was attended by ten-to-twenty physicists and chemists, Ehrenfest also organized a seminar in which students presented reports on a regular basis, mostly on Ehrenfest's own favorite topics: quantum theory, relativity theory, and statistical mechanics. Most of the students heard about some of

these subjects – such as Einstein's revolutionary work – for the first time in Ehrenfest's seminar.

Ehrenfest soon discovered, however, that a regular position at the University of St. Petersburg could only be obtained by someone who held the Russian *Magister* title, which he did not. To obtain it, he had to take the *Magister* examinations, so together with Joffe, who had finished his studies under Wilhelm Conrad Röntgen (1845–1923) at the University of Munich in 1905 and thus also did not hold the Russian *Magister* title, he decided to take these long, difficult, and out-of-date examinations. Nonetheless, having worked halfway through them, he suddenly and surprisingly decided not to write the final thesis, the *Examsarbeit*, and thus obtain the *Magister* title, because meanwhile Joffe and others had arranged for him to be asked to teach a seminar at the Polytechnic Institute in St. Petersburg during the summer semester of 1909. Ehrenfest did not hesitate: He immediately stopped taking his examinations and worked at the Polytechnic Institute for almost a year, teaching differential equations of mathematical physics for two semesters.

Ehrenfest's sudden dismissal then came as a great shock to him. He had at last found what he had longed for, a good teaching position. All the worse was that his dismissal was partly his own fault. Instead of networking and making valuable contacts with members of the Institute's governing board, he crusaded against its old-fashioned practices and rigid procedures. His noble fight made a lot of enemies in high places, which eventually cost him his precious job.

That typifies Ehrenfest's behavior: first not finishing the examinations that would have significantly increased his chances for a temporary or permanent university position, and then letting one slip out of his hands so easily through his own fault. Ehrenfest gives the impression of someone who does not know what he wants – or perhaps better, of the exact opposite: He seems to want everything at once, dropping anything that interests him at the moment as soon as something new draws his attention. As a result, he slipped more and more into a suffocating depression, which paralyzed his work: "I live here *absolutely idle, without a single trace of ideas in my head.*"¹¹ This pattern would be repeated during Ehrenfest's years in St. Petersburg.

During this difficult time Ehrenfest remained in touch with his old friend Gustav Herglotz (1881–1953). They had known each other since their Gymnasium days in Vienna (figure 3), but then had gone their separate ways. Herglotz became a professor of astronomy at the University of Leipzig in 1909, after alcoholism and a resulting state of idleness had driven him from Vienna. His new position and change of environment – in which he finally recovered his "ability to enjoy" life and work, as he told Ehrenfest that year – unfortunately had not lasted. His description of his situation in 1910 must have resonated with Ehrenfest: "I'm physically in perfect health, but emotionally terribly tired, not able to take up anything and think about it for a longer time."¹² He told his friend in St. Petersburg that he hoped that a stay at the health spa in Bad Kissingen that summer would do him some good. That must have sounded like a good idea to Ehrenfest, because he immediately asked his old friend to arrange a room for himself there as well.¹³

That would be Ehrenfest's first trip to Germany since he and his wife Tatyana had moved to St. Petersburg in 1907. He arrived in Bad Kissingen on August 11, 1910, in



Fig. 3. The four inseparable students in Vienna in 1900, *left to right*: Hans Hahn (1879–1934), Heirrich Tietze (1880–1964), Gustav Herglotz (1881–1953), and Paul Ehrenfest (1880–1933). *Source*: Klein, Ehrenfest (ref. 1), Fig. 3, facing p. 16.

good shape physically (“My health is *absolutely* all right,”¹⁴ he wrote to Tatyana on his way there) but not mentally. He placed his hopes on the two-and-a-half weeks of leisure he would spend in Bad Kissingen under a doctor’s supervision. “I’m extremely curious whether [this rest cure] will finally lead to mental liveliness. Theoretically I’m convinced of it.”¹⁵ But he then found it hard to cope with the doctor’s diagnosis that there was nothing wrong with him medically. “He found me simply in perfect condition – I heard this with mixed feelings – where now should I hope to recover greater joy in work[?]”¹⁶

In Bad Kissingen Ehrenfest started contemplating his life and career in St. Petersburg, which along with his discussions with Herglotz made him slowly realize that it

was time he accepted the necessity of something that had long been slumbering inside him, a thought he first shared with his wife Tatyana in a rather enigmatic way:

I clearly feel I'll destroy my life if I don't succeed in pulling myself together. Every time I have a chance to review my affairs, I see some sort of chaos in front of me – a gambler or alcoholic has to see similar pictures when sober.¹⁷

Just as an alcoholic who would rather remain intoxicated than face his alcoholism, Ehrenfest hesitated to speak out loud the one option that he felt would make him better: leave St. Petersburg. Not only would that upset Tatyana's plans terribly; it also would be a fearful step into the unknown for him. Having chosen Russia as his new *Heimat*, he told Tatyana, "I [have] lost all mental and material connections to Germany and Austria." Still, "In Russia, any sort of normal development (work and earnings) would be for me extraordinarily unlikely.... If we wouldn't have children, it would be unpleasant for me, but it wouldn't worry me as much as it does now," he finally confessed. "You see, this is what always makes me so sad, when you ask me what's wrong and when you believe I'm hiding something from you."¹⁹ In fact, already since he had been dismissed from the Polytechnic Institute, Ehrenfest had toyed seriously with the thought of leaving St. Petersburg. Sharing these thoughts with Tatyana now must have been a relief to him.

After their productive and insightful time together in Bad Kissingen, Ehrenfest and Herglotz traveled to their hometown Vienna for a short period, where Joffe (figure 4) joined them as well. After almost three years, Ehrenfest finally had a chance to see his relatives again and to get his mind off his worries. During a lonely walk through the city one evening, a Zionist meeting drew his attention, and he decided to attend. His reaction to what he heard at it was typical for his ambivalent attitude toward his Jewish heritage, for he not only was glad that he had left his Jewish past behind him a few years earlier, he had just written to his wife from Bad Kissingen about his annoyance with the Jews he saw there:

There are a lot of Jews here – German, Polish(!) and Russian – the Polish Jews are far less fatalistic than the German and Russian Jews – they behave in an extremely unpleasant way so that I am very depressed: If a Russian would come here, he can unfortunately easily tell himself – thank God that our barbaric exclusionary laws are getting these people off our back.²⁰

His views grew only stronger when he thought about showing his Jewish friend Joffe the situation in Vienna and Boskovice:

It will be very enlightening for me to go to Vienna and Boskovice especially with Joffe – because he would never believe my descriptions of the anti-Semitism there, and above all the descriptions *of the circumstances that justify his belief* – Now they'll demonstrate everything to him *ad oculus* [and] may he then correct history philosophically!²¹

Completely contrary to his expectations, however, when he heard about colonizing Palestine at the Zionist meeting in Vienna he became highly enthusiastic about it. At first the speaker had confirmed his antagonism toward fanatical Jews: "Hadn't I had a



Fig. 4. Abram Fedorovich Joffe (1880–1960). *Credit:* American Institute of Physics Emilio Segrè Visual Archives, Frenkel Collection.

closer look at him and hadn't I spoken to him, I would almost certainly have identified him with those hundreds and hundreds of others who I believe I'll never be able to love,"²² but as he listened more and more he grew so enthusiastic that he made plans to dine with the speaker the next day, and in succeeding days he attended more lectures on Palestine. He even briefly saw himself as the founder of the first Polytechnic Institute of Palestine. Thus, Ehrenfest's ambivalent – not to say opportunistic – character reveals itself again. He fundamentally rejects his Jewishness one moment and capriciously embraces it the next.

Ehrenfest's new-found interest in Zionism, nevertheless, was genuine. He wrote to Tatyana about how delighted he would be if Jews had their own state, which would free them from the increasing anti-Semitism in Europe:

Then you'll understand that I'm very, very delighted about it, for it's a fact that anti-Semitism is increasing everywhere and assimilation would be feasible only for individuals, not for the masses who have so much talent. If, however, Jews really learn to supply farmers – thoroughgoing tillers of the soil, and if particularly the Russian-Jewish elements would initiate it – if this all is no utopia but actual technical result – imagine what 5–6 million Swedes are achieving – and there are 13 million Jews.²³

Back in St. Petersburg, Ehrenfest again had to confront his troublesome personal situation. He received unexpected help in this matter. One month after he returned from Germany and Austria, in early October 1910, he received a letter from his ten-year-old brother Hugo Ehrenfest (b. 1870),²⁴ who lived in St. Louis, Missouri, where he was a successful gynecologist. Paul had written to Hugo now and then but never received an answer. Hugo's letter now represented an accumulation of several letters that he had written to Paul over the past year and a half but had never mailed. Paul must have mentioned his idleness and depression in his letters to Hugo, since Hugo now gave Paul a precise medical diagnosis of his illness based upon what he had written and upon Hugo's recollection of their time together in Vienna.

According to Hugo, Paul unmistakably suffered from neurasthenia with symptoms of depression, "as we find it often described nowadays as 'psychasthenia'." The mental illnesses neurasthenia (nervous weakness) and psychasthenia were frequently diagnosed in patients in *fin-de-siècle* Vienna. Hugo's letter was particularly helpful, however, because he gave a detailed analysis of how he thought Paul's illness could be cured. His starting point was his belief that Paul's problems stemmed from his lack of joy in his work: "I can imagine that with a 'constant' joy in work your entire life, your successes, and as a result your mood and (like a vicious circle) finally your joy in work itself will satisfy you."²⁵

To recover his joy in work, Hugo told his brother to take a drastic measure: leave Russia. Paul's attempt to adapt to Russian society could be considered a failure, which had been inevitable, according to Hugo, because for a Jew adaptation could never turn into assimilation. There thus was only one conclusion. In Russia too many factors had influenced Paul's productivity negatively. Improvement could not be expected there, so Paul had to leave St. Petersburg as soon as possible – as Hugo told him directly in shorthand: "Choose a new environment = emigration.... You chose a new Fatherland for yourself [and] it doesn't want you – your choice was unlucky – you shouldn't be surprised."²⁶

Thus, after his disappointing diagnosis in Bad Kissingen, where the doctor could find nothing wrong with him, Ehrenfest finally got a satisfying diagnosis of what had been bothering him for more than half a year, and an unequivocal prescription of what to do about it. With his natural tendency to vacillate between two extremes, as illustrated by his feelings in Vienna on the Palestine question, or to run around in circles, as his professional perambulations in St. Petersburg could be characterized, Ehrenfest now had received the kind of push that he needed more than anything else to move forward.

Convinced of the validity of his brother's diagnosis, Ehrenfest now focused on leaving Russia. What he had to do now was to find a university at which he could habilitate

and thus become a *Privatdozent*,* which would allow him to earn some money from student fees and make broader connections with his professional colleagues. He then would be able to compete for a university professorship.

Preparing to Leave St. Petersburg

Hugo got almost more than he wished for. He had given his younger brother Paul the final push that convinced him to leave Russia. Almost a year later – and still in St. Petersburg – Paul set his unsure eyes for a time on Hugo's own present homeland, the United States:

I won't write about what it is that lures me to America although there are infinite things – I feel perfectly well, what it would mean for me to come out of the atmosphere of eternal *inhibitions* in every way, into an atmosphere of *progress* in every way. I can feel perfectly well, what it means *to be able to realize one's initiatives*.²⁷

Hugo, never an enthusiastic letter writer, now hastily warned his brother against coming to America. “Yes, you can make [it] here, but don't forget, you have to start at the bottom.”²⁸ That was more or less a gentle way of saying: don't come! “America either changes your ways and makes you hard-working, or if you're lazy, you'll be lying on the ground pretty soon, trampled under by those who inconsiderately push forward.”²⁹ Knowing Paul's personality, Hugo feared it would be clear where his brother would wind up. Paul must have gotten the message, since after receiving his brother's letter he gave up his brief American dream.

Meanwhile, Ehrenfest had suffered further setbacks. His old friend Hans Hahn (1879–1934), now professor of mathematics at the University of Czernowitz (now Tsjernovtsi, Ukraine), asked Ehrenfest to join him there in the fall of 1910.³⁰ Only a few months later, however, Hahn had to disappoint Ehrenfest: A professor's title for Jews and nonreligious faculty members was excluded in Czernowitz, and the position of *Privatdozent*, which might lay within Ehrenfest's reach, did not carry a salary.³¹

Ehrenfest then set his mind on Germany. Herglotz had told him that the local theoretical physicist at the University of Leipzig, Theodor Des Coudres (1862–1926), would welcome Ehrenfest's request for habilitation under him. Herglotz would welcome Ehrenfest's presence in Leipzig even more. Herglotz's stay in Bad Kissingen had helped him overcome his depression only for a short time, and it now had returned at full strength. He would welcome Ehrenfest's company enormously: “You can imagine how much I'd enjoy not to be so completely alone by myself in Leipzig.”³² Here too, however, Ehrenfest met with disappointment. Des Coudres welcomed the possibility of Ehrenfest's coming to Leipzig (“I'd be delighted if the Leipzig physical orchestra would be reinforced by you”³³), but the University of Leipzig stubbornly refused to accept his Austrian doctorate, which prevented him from habilitating there.³⁴

* Habilitation at a German or Austrian university required the writing of a second thesis, which if accepted by the faculty resulted in the receipt of the *venia legendi* (right to teach) as a *Privatdozent* (lecturer) whose only income derived from student fees.

Herglotz also told Ehrenfest that there were no vacant positions at the University of Leipzig, so he had already inquired if there was a possibility of one for Ehrenfest at the University of Munich, where the highly respected Arnold Sommerfeld (1868–1951, figure 5) held the chair of theoretical physics.³⁵ One of Sommerfeld's former students and now assistant, the Dutchman Peter Debye (1884–1966), showed genuine interest in Ehrenfest's fate and promised he would put in a good word for him with Sommerfeld. Debye himself was leaving Munich just then to become Einstein's successor at the University of Zurich.³⁶ Sommerfeld, however, made clear to Ehrenfest through Debye that he too did not have room for him in Munich.³⁷ He had already filled Debye's position with Planck's former student Max Laue (1879–1960). Further, he felt that there were many more possibilities to habilitate and become *Privatdozent* at the Universities of Göttingen, Berlin, and Leipzig than Munich. He knew, for example, that Des Coudres had no one who was then habilitating with him at Leipzig. Sommerfeld thus advised Ehrenfest not to focus on Munich but to look elsewhere for a position – words that must have struck a sour note in Ehrenfest's ears, since he had already been rejected at Leipzig. Still, Debye was the bearer not only of bad news from Sommerfeld: He also told Ehrenfest what Sommerfeld thought of him as a physicist:

Of course I'd find the presence of Ehrenfest in Munich very stimulating[;] to listen to his lectures would be the same pleasure for me as to read his articles, which are pure delicacies.³⁸

Sommerfeld, in fact, knew what he was talking about: He was the reader of an article that Ehrenfest was writing for the fourth volume of the prestigious *Encyklopädie der mathematischen Wissenschaften* and thus was familiar with his scientific capabilities. The editor of this volume, the great mathematician Felix Klein (1849–1925) at the University of Göttingen, had met Ehrenfest in Göttingen in 1906 and had asked him to write the article on statistical mechanics in place of his mentor Ludwig Boltzmann (1844–1906) who tragically had taken his own life. Together with James Clerk Maxwell (1831–1879), Boltzmann had founded the field of statistical mechanics and had just published an article in the *Encyklopädie* on the kinetic theory of matter but had not discussed in it the theoretical foundations of statistical mechanics.³⁹

Ehrenfest had shown himself to be a devoted student of Boltzmann at Göttingen in his lectures and papers and thus could count himself lucky that Klein had asked him to write the article on statistical mechanics for the *Encyklopädie* in Boltzmann's place – an article that would become the definitive article on the subject, as Sommerfeld clearly recognized.⁴⁰ Debye himself added:

I hope the above words will show you the value Sommerfeld sees in your work. And you know indeed as well as I do, that he's not alone in this opinion[.] Therefore I'm convinced you'll easily find a university that is prepared to welcome you with open arms.⁴¹

In Leipzig, Herglotz, fearing that Ehrenfest would give up on his search for a position in Germany, told him excitedly of a new plan he had just conceived. Instead of asking Sommerfeld to supervise his habilitation thesis, he should ask Sommerfeld if he could complete a second doctoral degree under his supervision. That then would enable him

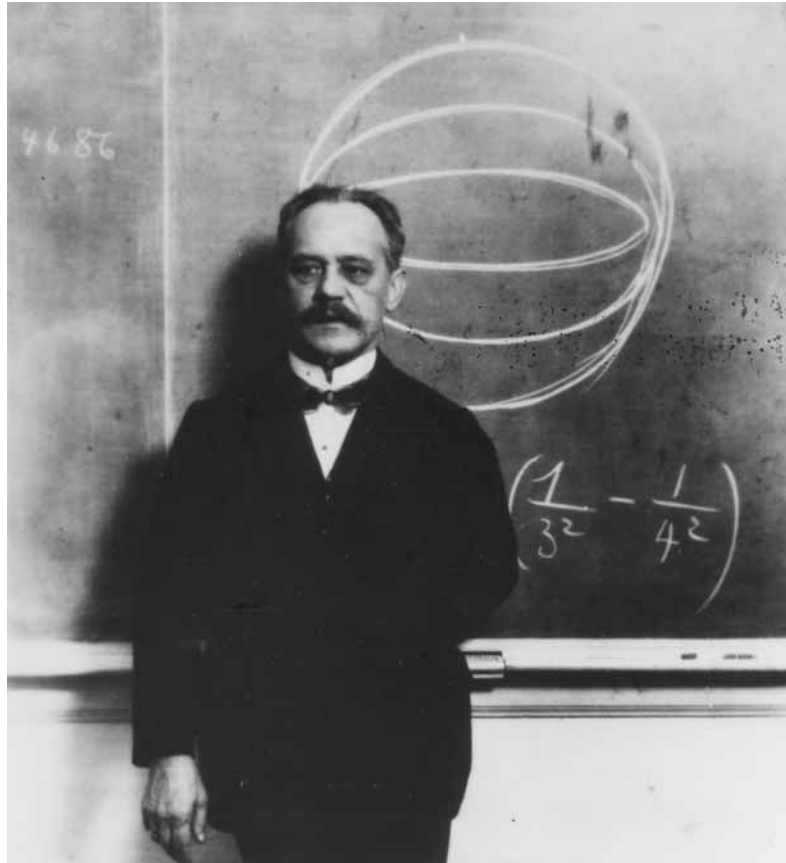


Fig. 5. Arnold Sommerfeld (1868–1951). *Credit:* American Institute of Physics Emilio Segrè Visual Archives, Physics Today Collection.

to habilitate later under Des Coudres in Leipzig. Ehrenfest liked the thought of becoming one of Sommerfeld's students, since Sommerfeld had recently shown great interest in the new quantum theory, thanks especially to the work of his protégées Debye and Laue. Sommerfeld, on his part, happily agreed to supervise Ehrenfest's second doctoral thesis.⁴²

Having thus now decided to earn a second doctoral degree in Germany, Ehrenfest would not have been Ehrenfest had he not begun almost immediately to doubt his decision. Nothing really drew him to Leipzig, except the presence of his friend Herglotz there. Munich, of course, would be interesting, but had he not left Germany eagerly and willingly four years earlier? Herglotz, however, did not want to hear about Ehrenfest's new doubts and scolded him for them, in a way that revealed as much about his own fears of losing the chance of Ehrenfest's company in Leipzig as about Ehrenfest's feelings of insecurity:

Naturally everything you write is nonsense – really, I'll explain it to you – you already no longer have clear and natural judgment about the simplest things – your thoughts turn nothing but somersaults. It's high time that you get into “well-regulated” conditions – you simply don't have the strength to live in Russia indefinitely, especially as a non-Russian – you spend too much of your energy on doing all sorts of things that to a greater or lesser degree get on your nerves, and then you complain about not being able to work!⁴³

Herglotz's chastisement worked. Ehrenfest became convinced that earning a second doctoral degree under Sommerfeld in Munich was the most logical next step for him to take.⁴⁴

Sommerfeld, though content with the prospect of his new student, warned Ehrenfest not to lose sight of his priorities. For someone who already had received a Ph.D. degree from the University of Vienna seven years earlier – and who already had published over twenty scientific papers – to obtain a second doctorate should not involve more than overcoming a formal obstacle to give his career a boost. Ehrenfest realized that Sommerfeld had a good point here and decided that instead of beginning research on a completely new subject, as he had originally intended, he would just turn his article, “Which Consequences of the Light-Quantum Hypothesis Play an Essential Role in the Theory of Heat Radiation?”⁴⁶ into his second doctoral thesis. This was a topic of great interest not only to Sommerfeld but also to Planck and Einstein. Before starting on it, however, Sommerfeld urged Ehrenfest to finish his article on statistical mechanics for the *Encyklopädie der mathematischen Wissenschaften*. Sommerfeld had heard from Klein that all Ehrenfest actually would have to do would be to give his permission for its publication. “A postcard would do.”⁴⁷

By then Paul and Tatyana Ehrenfest had worked on this article for almost five years and were having a difficult time finishing it. They finally completed the first draft in January 1910, but then were asked to supplement it by also discussing recent developments. That had taken them almost another year and a half – during which Ehrenfest had fallen into a paralyzing depression. In August 1911 he wrote to his brother Hugo that, “Now I have something ... *really* urgent to finish – but for weeks I keep putting it off.”⁴⁸ He finally finished his work on the article the following month and then gave Klein permission to publish it, as Sommerfeld had urged him to do.

Ehrenfest thus again had needed someone he trusted to push him to make an important decision. He would have helped himself a great deal if he had finished this article expeditiously: A publication in the prestigious *Encyklopädie der mathematischen Wissenschaften* would have brought him precisely the professional attention he was so desperately seeking. Instead, he let his work on it drag out for almost seven years. At last, in early 1912, his and Tatyana's article, “The Conceptual Foundations of the Statistical Approach in Mechanics,” appeared in print.⁴⁹ They had succeeded in providing a penetrating critique of the foundations of statistical mechanics by analyzing the two main theories of the subject, those of Ludwig Boltzmann and of J. Willard Gibbs (1839–1903).

The Ehrenfests, in providing this theoretical overview of statistical mechanics, had succeeded where Boltzmann himself had not. This was a subject of increasing signifi-

cance for theoretical physicists, because more and more applications of Boltzmann's statistical interpretation of the second law of thermodynamics were being found. The reception of their article thus was widespread and highly positive. It established Ehrenfest's name as an analytically and theoretically gifted physicist and as an authority on statistical mechanics. Even though Boltzmann's and Gibbs's work on statistical mechanics was no longer new by 1912, the Ehrenfests' treatment of it clearly identified Ehrenfest as belonging to the new generation of outstanding theoretical physicists.

Meanwhile, however, Ehrenfest still had not begun work on his second doctoral thesis, which at the end of December 1911 made his friend Herglotz fulminate:

Now listen, regarding the thesis! I really start to believe that you crossed the boundary of the pathological and landed at *inertia foetida* [fetid inertia]. Please really be ashamed of yourself: for that you can take 2–3 days, but afterwards please loll about and just scribble it all down. It's really outrageous! The thing is really finished: it only comes to writing it down. You have no excuse with your nerves-disorganization or something else, if you can do other things, as is the case.⁵⁰

Ehrenfest, however, did not listen to his friend this time. By then he was not planning to write his second doctoral thesis at all. After years of self-doubt, of constant hesitation among various options and opinions, the sheer positive reception of his and his wife's article on statistical mechanics in the *Encyklopädie* seems to have given him a new degree of self-confidence. He therefore thought that now would be the best time to try again to persuade his German colleagues to arrange a reasonable position for him. To do so, he planned an extensive trip to the most important universities in the German-speaking world. This, however, would not be just another effort to get a job – it would be his *final* effort. That becomes clear if we note that he traveled third-class by train, tried to stay with friends and colleagues as often as possible, and fretted if he had to incur any unforeseen expenses.⁵¹ In short, he could not afford to make a second such trip.

Ehrenfest left St. Petersburg on January 6, 1912. His first destination was Berlin, where he hoped to meet Planck, who held the chair of theoretical physics at the University of Berlin. Ehrenfest requested a meeting with Planck, which Planck (figure 6) happily granted. He invited Ehrenfest to his home in Berlin-Grunewald, where they dined together and talked for hours. Ehrenfest was greatly impressed with this meeting, as well as with Planck himself. He had a chance to talk with Planck about his new article, which was scheduled for publication in the *Physikalische Zeitschrift*,⁵² in which he would argue that Einstein's light-quantum concept made the ether superfluous. "It was mostly all new to him,"⁵³ he wrote excitedly to Tatyana.

Ehrenfest and Planck also talked about Ehrenfest's article on the consequences of Einstein's light-quantum hypothesis for the theory of heat radiation that he had submitted to the *Annalen der Physik* in July 1911.⁵⁴ Ehrenfest told his wife how impressed Planck was with this article, as if it had made Planck realize for the first time the far-reaching consequences of his discovery of the quantum of action eleven years earlier:

He was really surprised and very interested that I've proven that Wien's formula is also based upon energy levels. Especially all of the results I had in that direction

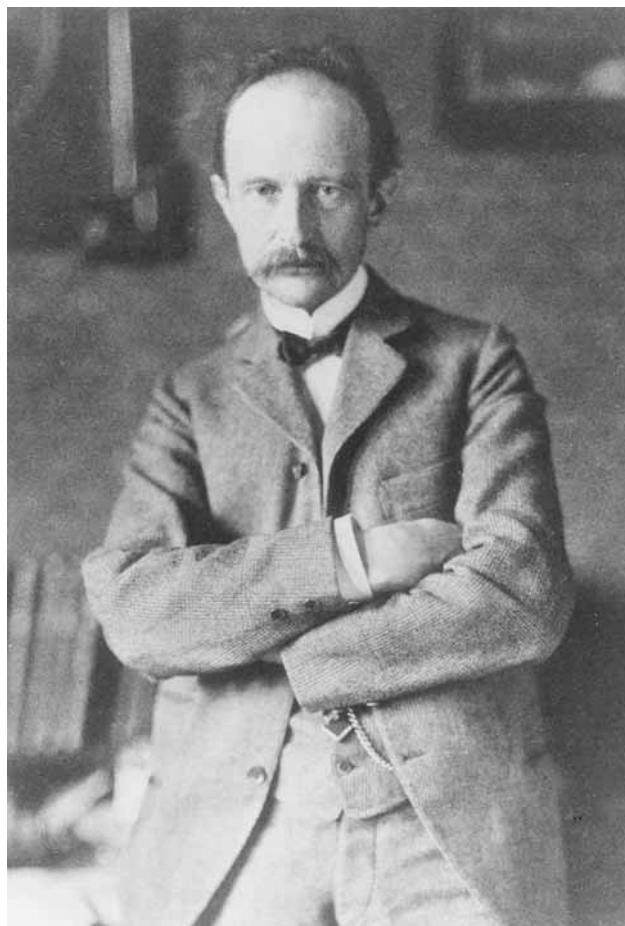


Fig. 6. Max Planck (1858–1947). *Credit:* American Institute of Physics Emilio Segrè Visual Archives, W.F. Meggers Collection.

were totally new to him: which features of Planck's theory are indispensable, which dispensable. The conversation was such that I clearly saw how astounded and delighted he was that I very precisely understood all of its nuances, and how I've succeeded in exactly extending his ideas.... *He told me he never really knew which features of his theory managed this and that – now it's all very clear.*⁵⁵

As for a position in Berlin, Planck directed Ehrenfest to Heinrich Rubens (1865–1922), director of the physical institute at the University of Berlin. Planck made it clear to Ehrenfest that he would welcome Ehrenfest in Berlin with great pleasure.

When Ehrenfest spoke to Rubens a few days later, however, Rubens told him that it was up to Planck himself whether Ehrenfest would be allowed to habilitate at the University of Berlin. Planck, notwithstanding his enthusiasm for Ehrenfest, now had to

disappoint him, since Planck meanwhile had found out that it would be impossible for him to habilitate or obtain a position in Berlin for all sorts of reasons – most of which Ehrenfest had heard before.

Ehrenfest left Berlin for Leipzig (the sight of which made it clear to him that he would never be able to live there) and then went on to Munich, where he met Sommerfeld and Röntgen, and Zurich, where he spoke with Debye – all to no avail. Most memorable, however, was his visit to Prague, where he was welcomed by none other than Albert Einstein (figure 7), whom (like many other physicists) he had never met before. Ehrenfest had simply written a letter to Einstein, telling him that he was on his way to Prague and asking him for a meeting. Einstein, of course, knew about Ehrenfest's work from his articles, which often dealt with Einstein's theories.

Ehrenfest's visit with Einstein was inspiring – for both of them. Ehrenfest was greatly impressed by Einstein's way of thinking. As he reported to Tatyana:

I've learned a great deal these last days. He [Einstein] is inexhaustible in his ideas and more and more impressive is the uncommon *cohesiveness* of his thought. I had a completely wrong idea of his way of thinking: for him all of his thoughts are connected in an all-encompassing organic unity. And without interruption he works on this unity from every possible angle. That is why any remark I make instantly prompts uncommonly greater significance in his head than in mine. He's very happy, being able to argue with me. Argument with me really seems to mean a certain stimulus for him. It's only too bad that I'm wrong almost every time.⁵⁶

Einstein's admiration of Ehrenfest was mutual, particularly after he had heard Ehrenfest give a lecture at the German University of Prague. He was so impressed by Ehrenfest's extensive knowledge of physics and his great gift for communicating it to others that he spontaneously offered Ehrenfest a job. Einstein had just accepted a new position in Zurich, this time at the Federal Institute of Technology (*Eidgenössische Technische Hochschule*), so that his chair in Prague now was vacant. What Einstein thus was offering Ehrenfest was neither an opportunity to habilitate, nor a vague promise, but a concrete position: Ehrenfest only had to say "Yes" to become Einstein's successor and a professor in Prague. Only one minor point had to be settled: as Ehrenfest told his wife, he would have to return "into Abraham's lap."⁵⁷

Einstein had gone through the same formalities. According to his Swiss passport, he also was nondenominational, but that had made no difference to him. He had officially accepted his Jewishness, as the Prague authorities had required. Now, much to Einstein's surprise, Ehrenfest firmly refused to do the same. That must have had something to do with all of the trouble his being nondenominational had brought him in the past. To give up that status so easily now would have felt like a betrayal of his principles. Further, it is typical for Ehrenfest's often devastating rigidity and egocentrism that he assumed his wife would agree with him in this – even though he realized that he would not easily get another similar chance for a professorship:

I trust you won't reproach me for this later, even though without a doubt it reduces enormously the probability of getting a chair somewhere and sometime. Nevertheless, we'll stick to our principles, won't we darling.... I feel that if I'd decide on such

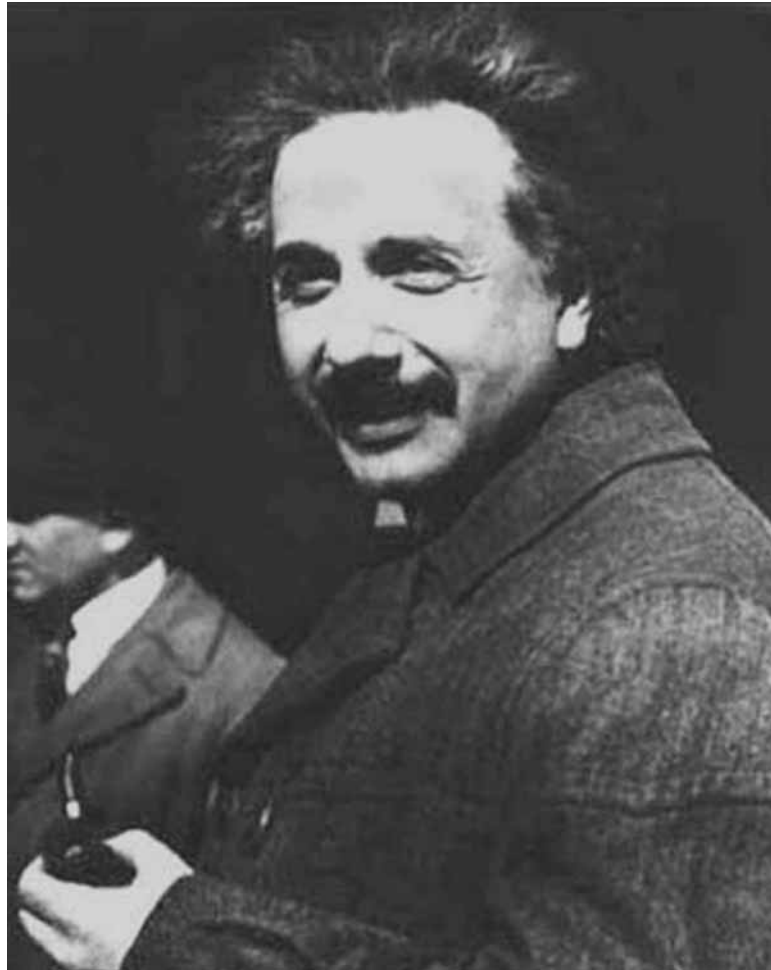


Fig. 7. Albert Einstein (1879–1955). *Credit:* American Institute of Physics Emilio Segrè Visual Archives.

a profitable lie now, I wouldn't know how to stand up to corresponding temptations in other instances at all.

We do not know how Tatyana reacted to her husband's decision, but Einstein was bitterly disappointed with it: "Your stubborn refusal to acknowledge any religious affiliation really *bugs* me..."⁵⁹ To Einstein, this was just a formality, after which Ehrenfest could easily "revert to this strange hobby horse of yours..."⁶⁰ He trusted that Tatyana would talk some sense into her husband and told Ehrenfest to listen to her carefully. His old friends Hans Hahn and Gustav Herglotz gave him the same advice,⁶¹ all in vain. Ehrenfest had made up his mind. Instead of at last accepting a position that he

had always dreamed of finding, his admiration for Einstein now impelled him to impulsively follow the revolutionary scientist to Switzerland – without the least concrete prospect of finding a position there.⁶²

One could again say that this was a typical decision for Ehrenfest. The main difference between the insecure opportunism and capriciousness that characterized his behavior earlier and his behavior now was that his present opportunism and capriciousness seemed much more reckless. The thought that he would not be able to care for his family financially was suddenly outweighed by the prospect of having stimulating discussions with Einstein in Zurich. Typical also for Ehrenfest was that it did not occur to him, even briefly, that his wife might not agree with him: “You’ll see: the way Einstein is, it will be an inexhaustible source of courage and *joie de vivre* for you too,”⁶³ he wrote enthusiastically to Tatyana, trying to persuade her of his latest impulsive decision. In any case, Ehrenfest had realized the goal of his long journey: He returned to St. Petersburg in early March 1912, but had now found an alternative to remaining permanently there.

Einstein’s disagreement with Ehrenfest did not diminish his high regard for Ehrenfest’s abilities as a theoretical physicist. Having therefore accepted that he could not persuade Ehrenfest to become his successor in Prague, Einstein tried to help him find a job in Switzerland. An opportunity in that direction had already arisen, in fact, because Debye had accepted a call to the University of Utrecht at the beginning of February 1912, not long after Ehrenfest had talked with him in Zurich at the end of January. Debye, however, had not mentioned his forthcoming move to Ehrenfest, because he knew that Alfred Kleiner (1849–1916), the head of the physics faculty at the University of Zurich who was in charge of finding Debye’s successor, did not think much of Ehrenfest – even though he had asked Einstein, Sommerfeld, and Planck, all of whom had a high opinion of Ehrenfest, to assist him in his search. In the event, Max Laue, who had received his doctorate under Planck in Berlin and who had been a *Privatdozent* in Sommerfeld’s institute in Munich, was appointed as Debye’s successor.

Einstein felt that Kleiner had made a mistake. As he wrote to his friend Heinrich Zangger (1874–1957), “So Laue is now coming to Zurich to the university.... I almost believe that it would have been smarter to appoint Ehrenfest as an *Extraordinarius*.”⁶⁴ In the end, however, Laue’s appointment did not work out too badly for Ehrenfest, since Sommerfeld now offered Ehrenfest an opportunity to habilitate in Munich. Even before Laue had definitely left Munich for Zurich, Sommerfeld had written to Ehrenfest:

There is a certain prospect that Laue will be called to Zurich in Debye’s position. In that case, the conditions have been created in which I would welcome your habilitation in Munich most happily.... I understand this request not contingently, *i.e.*, in case Laue actually goes (for you wouldn’t really be helped by that), but definitely. So even if Laue doesn’t leave, you would have to try to manage together and with the present younger *Privatdozenten* here.⁶⁵

Sommerfeld’s promise to Ehrenfest did not please everyone. Remarkably, Debye (figure 8), the new professor in Utrecht, warned Sommerfeld against Ehrenfest, whom he characterized as a Jew “of the ‘high-priest’ type who can, with his seductive Talmudic



Fig. 8. Peter Debye (1884–1966). *Credit:* Archive for the History of the Max Planck Society, Berlin.

logic, exert an extremely pernicious influence.”⁶⁶ Debye seems almost jealous of Ehrenfest when he writes about him in this vile way. Perhaps he had begun to fear that Ehrenfest would become a serious competitor to him in theoretical physics. Debye’s view had no influence on Sommerfeld, however. Sommerfeld’s opinion of Ehrenfest remained as positive as ever, and he did not hesitate to convey it to others, as he did more than once to Lorentz in Leiden in early 1912.⁶⁷ In these letters to the Nobel Laureate Lorentz, one of the greatest theoretical physicists of the period, Sommerfeld dwelled at length on Ehrenfest’s outstanding scientific qualities.

Ehrenfest was overjoyed with Sommerfeld’s offer, which he accepted without hesitation. Although he found it difficult to abandon the idea of joining Einstein in Switzerland, Einstein himself was as happy as he could be with Ehrenfest’s new opportunity. He was relieved, he told Ehrenfest, that “by habilitating with Sommerfeld, you will also win the well-deserved respect of my jellyfish compatriots.”⁶⁸

By the spring of 1912, therefore, it appeared that Ehrenfest’s luck had finally changed. Further, during the same week that Sommerfeld had made his offer to Ehrenfest, Ehrenfest received a letter from Lorentz, who inquired about Ehrenfest’s future plans.⁶⁹ Lorentz’s interest in Ehrenfest, of course, did not come out of nowhere. The



Fig. 9. Hendrik Antoon Lorentz (1853–1928). *Credit:* Algemeen Rijksarchief, The Hague; courtesy of American Institute of Physics Emilio Segrè Visual Archives.

two had met once before, during a short visit that Ehrenfest had made to Leiden in 1903, but they had not corresponded with each other thereafter. Lorentz's unfamiliarity with Ehrenfest's present situation probably was why he addressed him as a Russian professor.

Lorentz (figure 9) was planning to give up his chair in Leiden and to move to Haarlem to concentrate on his work for the Teyler Institute. He thus had to find a qualified successor to himself in Leiden, preferably one who belonged to the new generation of theoretical physicists who could adapt to new developments in the field more easily than he himself could, as he confessed to Einstein when he had approached Einstein for the position:

When one gets older, and one's creative powers gradually decline, one admires all the more the cheerful, enthusiastic, creative urge of a younger person, and for that reason it would be extremely appealing to me to hear a great deal about your work and thoughts....⁷⁰

Einstein, though flattered, had to disappoint Lorentz, because he had just accepted a salaried membership in the Prussian Academy of Sciences in conjunction with a professorship at the University of Berlin. Moreover, even had this not been the case, he once confessed that he doubted he would have accepted Lorentz's offer, questioning how anyone would be able to succeed the most important theoretical physicist of the period without feeling inferior to him.⁷¹ Remarkably, Lorentz then turned to Ehrenfest, perhaps because he had been deeply impressed with Ehrenfest's sublime article on statistical mechanics in the *Encyklopädie der mathematischen Wissenschaften*, which dealt with some of the fundamental problems that had been discussed at the first Solvay Conference in Brussels in October 1911 – a conference that Lorentz had chaired and was attended by Einstein and many of the other leading physicists of the day.⁷²

Sommerfeld's praise of Ehrenfest and his intention to bring Ehrenfest to Munich also may have served as a catalyst for Lorentz to act, since Ehrenfest now seemed to be in demand elsewhere. Still, one can only speculate on Lorentz's true reasons for asking Ehrenfest, seemingly a relatively minor theoretical physicist with no real job experience, to fill such a major position. Debye, however, thought that he knew why Lorentz had chosen Ehrenfest. To Sommerfeld's question as to why Lorentz had not chosen *him*, Debye answered that Einstein had proposed Ehrenfest to Lorentz, and that it all had been a "matter of race."⁷³ In the event, Ehrenfest was delighted to accept Lorentz's offer, although he had to delay his arrival in Leiden until September 1912. When he was finally installed as the new professor of theoretical physics in Leiden, he had good reason to be exceedingly happy that his period of turmoil and insecurity in St. Petersburg had come to an end.

Conclusion

According to Joffe, once in Leiden Ehrenfest

became the attraction for the most eminent physicists of the world. They used to come to the little room on the top floor of Ehrenfest's residence, lived there, and signed the white wall. There one could see the names of famous physicists, starting with Bohr and Einstein; all countries were represented, from the Soviet Union to the USA. Many of the ideas produced here were developed further and left their traces in the history of physics. Everywhere Ehrenfest's contributions can be traced: in the deepening of problems, in their clear formulation, and so on.⁷⁴

Ehrenfest (figure 10) was indeed a worthy successor to Lorentz. He established his name in Leiden as an incisive critic and marvelous teacher – among his students were such future luminaries as Hendrik A. Kramers (1894–1952), George E. Uhlenbeck (1900–1988), Hendrik B.G. Casimir (1909–2000), and Nobel Laureate Jan Tinbergen



Fig. 10. Paul Ehrenfest (1880–1933) in his office in Leiden. *Credit:* American Institute of Physics Emilio Segrè Visual Archives, Margrethe Bohr Collection.

(1903–1994). As Joffe noted, physicists from all over the world visited Ehrenfest in Leiden. Einstein remained one of Ehrenfest's closest friends throughout his life, and Niels Bohr (1885–1962) became one as well. And Ehrenfest's prestige brought reflected glory to the University of Leiden. Einstein, for instance, accepted a visiting appointment in Leiden in 1920 because of Ehrenfest's presence there. The University of Leiden became one of the leading centers of theoretical physics in the world.

Ehrenfest's suicide in September 1933 came as an enormous shock to everyone in the world of physics, especially because one of the reasons for it was his deep dissatisfaction with himself as a theoretical physicist. Ehrenfest never lost his feeling of inferiority, that he would never be able to step out of the shadow of his predecessor Lorentz. At a certain time in his life, he began to feel that he had outlived his personal idea of what theoretical physics should look like, and that he was unable to get a firm grasp of new developments in the field. That must have felt to him as being the ultimate betrayal of Lorentz's faith in him, even though Lorentz himself had died five years earlier. It seems that the only way we can reconcile this feeling of Ehrenfest with his great prestige and genius is to link his suicide to his insecure and often tormented and depressed personality, character traits that were already present in him in the period we have explored here.

Acknowledgment

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Note on archival sources: ESC stands for Ehrenfest Scientific Correspondence, EPC for Ehrenfest Personal Correspondence, ENB for Ehrenfest Notebooks, and EMS for Ehrenfest Manuscripts, all of which are deposited in the Museum Boerhaave (Rijksmuseum voor de Geschiedenis van de Natuurwetenschappen en van de Geneeskunde, Leiden, The Netherlands). ESC9, S9, 356, for example, stands for ESC Microfilm 9, Section 9, Item 356, as listed in Bruce Wheaton, *Catalogue of the Paul Ehrenfest Archive at the Museum Boerhaave Leiden* (Leiden: Communication 151 of the National Museum for the History of Science and Medicine "Museum Boerhaave," 1977). MPG-Archiv stands for Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin-Dahlem. Unless otherwise indicated, all translations from the German into English are our own.

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