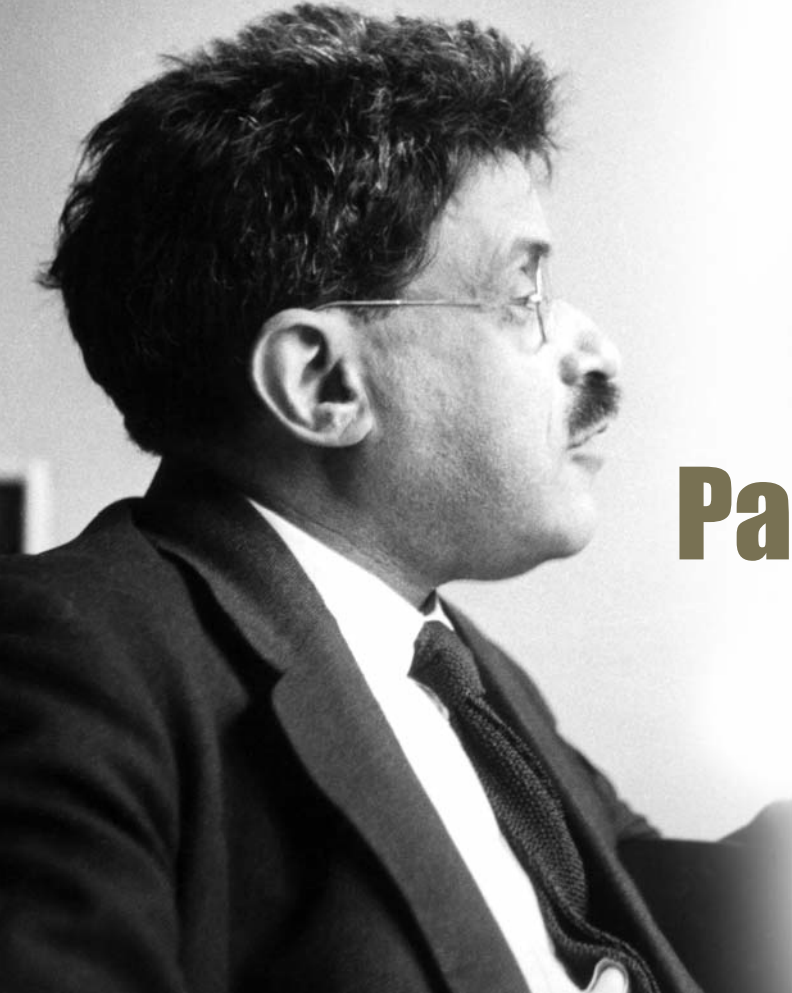




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Paul Ehrenfest's final years

Dirk van Delft

New access to his correspondence sheds light on the tragic life and death of one of the pioneers of modern physics.

"M*ein lieber, lieber Goudsmit!"* (My dear, dear Goudsmit!) With that salutation, Paul Ehrenfest (1880–1933), professor of theoretical physics at Leiden University in the Netherlands, began an emotional letter to Samuel Goudsmit on 7 March 1933. They knew each other very well. Goudsmit (1902–78), who had gotten his PhD under Ehrenfest's supervision in 1927, was now teaching at the University of Michigan in Ann Arbor.

Ehrenfest, a gifted extrovert from Vienna, was highly respected by his colleagues. Some thought him the conscience and driving force of international theoretical physics. He had contacts everywhere. But all the while he suffered from increasing depression, his private life was in turmoil, and he told Goudsmit and others that he was planning to kill himself. Six months after writing the letter, he did just that, after first taking the life of his youngest son, who was afflicted with Down syndrome.

Investigation of the personal aspects of Ehrenfest's tragic life has recently been greatly facilitated by the availability of new source material. The Boerhaave Museum in Leiden, which already housed Ehrenfest's scientific archive,¹ has now acquired a large trove of his correspondence, chiefly with family members and friends but also with fellow physicists. Through roughly a thousand newly available letters, the man, his views, and his actions become much clearer.

The letters, which include numerous, sometimes extensive reflections during academic trips through the US, come from the legacy of science

historian Martin Klein (1924–2009). They cover primarily the period after 1920. In 1970 Klein had published his Ehrenfest biography,² which deals with the period up to around 1920. It was intended to be the first of two volumes, but Klein never produced the second volume, which would have covered the later years. "Those of us who were close to Martin," says his former student David Cassidy, "believe that he couldn't bring himself to write it because it would have been too painful."

The new material emerged after Klein's death. Thanks to mediation by the Einstein Papers Project at Caltech, it was digitized and passed on to the Boerhaave Museum. A catalog and digital access to the complete archive are in preparation.

Tumultuous times

The salutation of Ehrenfest's March 1933 letter to Goudsmit is typical of his openhearted relationships with his students. The letter is a window into Ehrenfest's mind in that last year of his life. He felt himself to be living in tumultuous times. Modernism aroused ambivalent reactions in him. On the one hand, he embraced technological, artistic, and social innovations. He was full of wonder at the social aspects of the American university system. He was also a fervent supporter of planned national economies guided by mathematical models. His

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Figure 1. Paul and Tatiana Ehrenfest, seated at the ends of the front row in a gathering at their home in Saint Petersburg, Russia, circa 1910. Most of the group are colleagues from the city's Polytechnic Institute. Seated next to Paul is his friend, theorist Abram Ioffe. (Courtesy of the Boerhaave Museum.)

student Jan Tinbergen obtained his doctorate on that subject and in 1945 became the first director of the Netherlands Bureau for Economic Policy Analysis. In 1969 Tinbergen won the first Nobel Prize in Economic Sciences.

On the other hand, Ehrenfest reacted against what he perceived as the nervous commotion of the modern city. He complained of “jazz everywhere.” He feared too great a dependence on technology and embraced the cultural pessimism of Oswald Spengler’s influential 1918 book *Der Untergang des Abendlandes* (*The Decline of the West*).

Ehrenfest was born on 18 January 1880 in Vienna, then capital of the polyglot Austro-Hungarian Empire.² His Jewish parents had a successful grocery store. Although they were not particularly religious, young Paul was taught Hebrew and Jewish history. At university, he studied theoretical physics under Ludwig Boltzmann in Vienna and later under Felix Klein in Germany. He obtained his doctorate in 1904 under Boltzmann with a thesis entitled *Die Bewegung starrer Körper in Flüssigkeiten und die Mechanik von Hertz* (*The motion of rigid bodies in fluids and the mechanics of Hertz*). (See box 1 for more on his relationship with Boltzmann.)

After getting his doctorate, Ehrenfest married the Ukrainian-born and Russian-educated mathematician Tatiana Afanasyeva (1876–1964), with whom he had become acquainted during his studies in Göttingen. In 1907 the couple moved to Saint Petersburg, where he became friends with the theoretical physicist Abram Ioffe (see figure 1). But as an Austrian national, and a Jew to boot, Ehrenfest had no real prospect of a permanent academic appointment in Czarist Russia. He and Tatiana did, however, write for the German-language *Encyclopaedia of the Mathematical Sciences* an overview of statistical mechanics, Boltzmann’s great subject.³

In 1912 Ehrenfest was appointed to the theoretical-physics chair at Leiden vacated by the departure of Hendrik Antoon Lorentz (1853–1928).

The chair had first been offered to Albert Einstein, a great admirer of Lorentz, but he chose a professorship at Zürich (see my article in *PHYSICS TODAY*, April 2006, page 57).

Culture shock

For physics at Leiden, the arrival of the 32-year-old Ehrenfest was a culture shock. Whereas the cautious Lorentz only made his ideas known once they were fully refined, the extrovert Ehrenfest—albeit a teetotaler, vegetarian, and pacifist—enjoyed intellectual commotion, stimulating debate, and organized argument. Shortly after his arrival, he started a weekly colloquium at which the latest developments in physics could be critically examined in open debate without fear or favor, often in the presence of visiting eminences. It was an exciting time for physics. Einstein’s relativity and Niels Bohr’s quantum theory of the atom had turned the field on its head, and developments followed one another at a furious pace.⁴

Ehrenfest, shown in figure 2, was a gifted lecturer who seemed to do magic tricks at the blackboard. He spiced up his crystal-clear and inspiring lectures with phrases like “*Das ist wo der Frosch ins Wasser springt*” (That’s where the frog jumps into the water) to underline key points. He was very selective when it came to accepting undergraduates and PhD students. From those he did choose, he expected complete commitment and dedication; his aim was to achieve collaboration on an equal footing as quickly as possible. (See box 2.)

Discretion was foreign to Ehrenfest’s nature. He wanted to know everything about his students, including their personal lives, even to the point of meddling with their choice of marriage partners. On Ehrenfest’s initiative, Goudsmit published a scientific paper while he was still a second-year undergraduate. Theirs was a close relationship in which each confided in the other about intimate personal matters. Goudsmit’s enduring scientific reputation rests largely on his introduction, with George Uhlenbeck, of electron spin in 1925, when both were still Ehrenfest’s students.

The visit to Kharkov

In Ehrenfest’s dealings with Goudsmit there was no clear distinction between personal and professional matters. The 7 March letter began with “professional matters.” Toward the end of 1932, Ehrenfest had visited Kharkov, in the Ukraine, where three years earlier a physical institute had been established with his assistance. In Stalin’s newest “five-year plan,” industrialization was paramount, and physics was required to make a contribution to that end. Ehrenfest was planning to visit Kharkov for a few weeks each year to help advance the institute.

Box 1. Ehrenfest and Boltzmann

On the walls of Paul Ehrenfest's study in his Leiden home hung portraits of Leo Tolstoy, James Clerk Maxwell, Fyodor Dostoyevsky, Swiss theorist Walther Ritz (a friend who died young), and Ludwig Boltzmann, his teacher and thesis adviser. Boltzmann was his inspiration. It was a terrible blow to Ehrenfest when, just two years after he received his PhD, his mentor hanged himself while on vacation in Italy in September 1906. The rejection of Boltzmann's statistical mechanics by eminences such as Wilhelm Ostwald and Ernst Mach is thought to have deepened Boltzmann's repeated episodes of depression.

Although Ehrenfest had much to thank Boltzmann for and regarded him as a shining example, there are no personal comments about his teacher either in the obituary notice he wrote in 1906 nor in all his later writings. Ehrenfest's student Hendrik Casimir wrote in his autobiography⁷ that he couldn't remember ever hearing Ehrenfest say anything personal about Boltzmann in any of their many conversations—some of them even touching on suicide.

Was the personal relationship with Boltzmann difficult? Did Ehrenfest feel guilty? Did he resent Boltzmann for killing himself? Did he not want to talk about Boltzmann's death because he had a premonition that he, likewise plagued by depression, would end up going the same way? We simply do not know. Whatever the case may be, it's striking that Ehrenfest defended Boltzmann's work with almost exaggerated loyalty while playing down the seminal contributions of Josiah Willard Gibbs.

The memory of Boltzmann's suicide may have haunted Ehrenfest for the rest of his life. But the circumstances of his own death were completely different. Unlike Boltzmann, he never had to put up with manifestly hurtful criticism from colleagues. Ehrenfest was the victim of his own merciless self-criticism.

In his view, the institute had “an American future” ahead of it.

The Soviet Union was close to Ehrenfest's heart. His years in St. Petersburg (renamed Leningrad) had been the happiest of his life. After the 1917 Bolshevik Revolution, he very much wanted to help the country move forward. What Kharkov needed, thought Ehrenfest, was fresh-minded, flexible physicists who were willing to put in the hours. “Not sneering snivelers,” he told Goudsmit, but cheerful young people with ambition and a sense of camaraderie.

That description matches well the type of people with whom Ehrenfest liked to surround himself. It was precisely for that reason that he had gone to Kharkov. The aim of his trip was to secure a definitive appointment as a theoretical physicist in the Soviet Union.

There was, he thought, nothing left for him in Leiden. His professorial chair was “in the gutter.” He had totally lost contact with the prime movers in the new physics. He told a colleague that he felt “just like a dog completely exhausted from chasing a tram with his master on it.” The direction in which theoretical physics was heading went completely against his grain. Those awful abstractions! That incessant focus on tricks and techniques! The “mathematical plague” that erases all powers of imagination! To avoid even further decline, it was high time to leave Leiden for good.

An additional element in his decision was that Tatiana was already in the Ukraine. In October 1932 she had started work in Vladikavkaz, 1000 km south-east of Kharkov, as a geometry teacher. Ehrenfest had a clear image of how he would be able to teach at a number of physics centers in and around Kharkov. At last he'd be useful again. But to his disappointment and frustration, all his plans came to nothing. Ioffe, still leading the way in Russian physics, wanted to send him to research centers where, he felt, he would be superfluous. So Ehrenfest refused. With matters unresolved, he returned to Leiden in January 1933.

In the letter to Goudsmit two months later, physics and personal problems are intertwined. Goudsmit, still in Ann Arbor, was expecting a child, which raised questions about his future. Ehrenfest applied those questions to himself, because his own life was in turmoil. “The older we get,” he wrote, “the more industrialized does physics become, and the more the worries of the world increase. So it becomes harder to escape into your work. In response we start doing things we had been neglecting, for example rediscovering nature, traveling, reaching out to art and extending our circle of contacts. Amazed, we realize that such activities lend color to an otherwise grey life.”

Ehrenfest went on to reveal a romantic involvement with a woman eight years his junior, the art

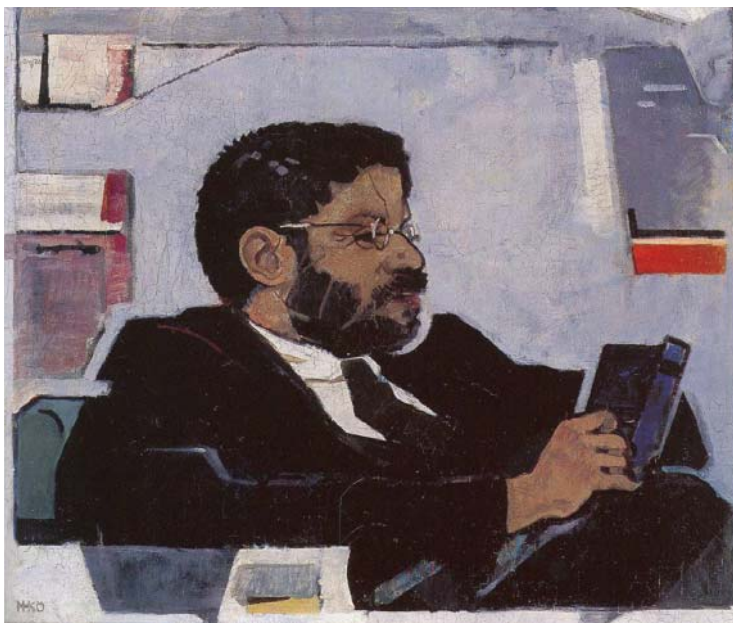


Figure 2. Paul Ehrenfest in Leiden, the Netherlands, painted in 1920 by Harm Kamerlingh Onnes, nephew of Heike Kamerlingh Onnes, the discoverer of superconductivity. (Courtesy of the Boerhaave Museum.)

historian Nelly Posthumus Meyjes (1888–1971). He wanted to come clean at home, but he recognized that “love is such a mightily divisive element. All the suffering it brings! Surely it’s one’s duty to put an end to his life as soon as possible, before causing hideous destruction.”

“One’s duty”

Nelly, the “industrialization of physics,” and the Nazis were the themes that governed the last year of Ehrenfest’s life and eventually led him to actually carry out his “duty.” Thanks to the extensive epistolary material in Klein’s legacy, we can do some justice to that dark episode from the history of modern physics.

Let us start with industrialization. We have already mentioned the application of physics to the goals of the Soviet Union. But Ehrenfest was also applying the term to physics itself. He attached great value to the *Anschaulichkeit* (visualizability) of its principles. In 1928 he wrote to the young J. Robert Oppenheimer that he was welcome to visit Leiden again, under certain conditions: He didn’t want Oppenheimer to “shoot immediately at a problem with a gigantic calculating cannon, instead of first thinking through an example—as simplified as possible—eagerly and joyfully.”

Referring to Oppenheimer’s stay in Leiden the previous year, he added, “If you intend to mount heavy mathematical artillery again during your coming year in Europe, I would ask you not only

Box 2. Ehrenfest’s style and contributions

Paul Ehrenfest’s physics was characterized by his unique style.⁸ He was always keen to carry out sharp, logical analyses of fundamental hypotheses to establish matters that had been left unresolved. He explained general principles with simple but ingenious examples. He would illustrate the second law of thermodynamics by a model featuring fleas jumping between two dogs. It had to be graphic.

At the weekly colloquium he instituted in Leiden, he kept asking questions for as long as it took to arrive at clarity. Leiden’s weekly *Colloquium Ehrenfestii* still survives, including the wall with the signatures of all the speakers over the years. When J. Robert Oppenheimer was planning a visit in 1928, Ehrenfest wrote that “if you want to spend at least your first few months patiently, comfortably, and joyfully in discussions that keep coming back to the same few points, chatting about a few basic questions with me and our young people—and without thinking much about publishing—then I welcome you with open arms!!”

Ehrenfest’s most important contribution to physics was his theory of adiabatic invariants. With that concept from classical statistical mechanics, he wanted to generalize the ad hoc quantization rules of the old quantum theory. He published the idea in a 1916 paper, but it only attracted attention after Niels Bohr used it two years later in a groundbreaking paper on the quantum theory of line spectra.

Ehrenfest made other important contributions to quantum theory, in particular with regard to phase transitions. The “Ehrenfest theorem” of 1927, relating the expectation values of quantum mechanical operators to classical Poisson brackets, provides support for Bohr’s correspondence principle. And there’s the “Ehrenfest time,” which characterizes the departure of quantum dynamics from classical dynamics. The nagging “Ehrenfest paradox,” concerning rotation of a disk in special relativity, though first posed by him in 1909, still incites debate.

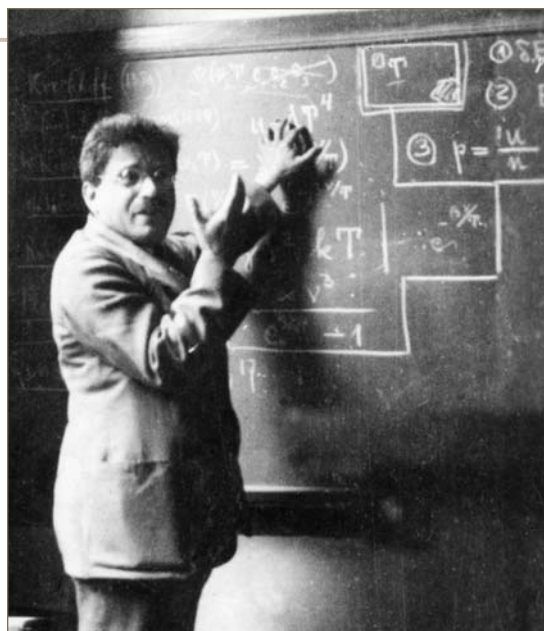


Figure 3. Paul Ehrenfest lecturing in Ann Arbor, at the University of Michigan’s 1930 physics summer school. (Photo by Samuel Goudsmit, courtesy of the AIP Emilio Segrè Visual Archives.)

not to come to Leiden, but if possible not even to Holland, just because I am really so fond of you and want to keep it that way.”

Ehrenfest was constantly in search of the heart of the matter, which he liked to call “*der springende Punkt*” (the leaping point). Deriving a result by logical means is not enough; that’s like “dancing on one leg,” he would say. “The essence lies in recognizing the connections in all directions.” Uhlenbeck said of his master teacher, “For Ehrenfest, understanding was an interwoven structure.”

In the final years of his life, Ehrenfest was exhausted. His merciless self-criticism never ceased. In a letter dated 16 May 1930—and possibly never sent—the 50-year-old Ehrenfest sang his woes: “*Lieber Die-Gou-Uhl!*,” he began characteristically, addressing his former students Gerhard Dieke, Goudsmit, and Uhlenbeck. They had invited him to take part in a summer school in Ann Arbor. Ehrenfest hung onto his intellectual offspring desperately, with all his ebbing strength. “Every new issue of the *Zeitschrift für Physik* or the *Physical Review* immerses me in blind panic,” he wrote. “My boys, I know absolutely nothing.” Whereupon the tormented professor went on to produce a long summary of subjects from the world of new physics that were, he said, completely beyond his powers of understanding. He called it his list of “*Erkundungsfragen*” (inquiry questions).

To the suggestion that he deliver those questions as a formal talk at the Ann Arbor gathering, he responded that he wouldn’t dream of it. “The very thought of doing so plunges me into hysterical self-doubt. I’d rather be dead. The pressure I’m living under is inconceivable.”

But he did attend the 1930 summer school and speak there informally about his list of questions (see figure 3). In October he converted the list into a con-

Figure 4. A conference at Niels Bohr's Copenhagen institute, just weeks before Paul Ehrenfest's suicide in September 1933. Seated left to right in the front row are Bohr, Paul Dirac, Werner Heisenberg, Ehrenfest, Max Delbrück, and Lise Meitner. Directly behind Ehrenfest is Meitner's nephew Otto Frisch. (Photo courtesy of the AIP Emilio Segrè Visual Archives.)



tribution to the *Zeitschrift für Physik* entitled *Einige die Quantenmechanik betreffende Erkundigungsfragen* (Some inquiry questions concerning quantum mechanics).⁵ In response, prominent colleagues including Wolfgang Pauli and Rudolf Peierls described Ehrenfest's questions as anything but meaningless.

As to Ehrenfest's bouts with depression, whenever he left Leiden, they seemed to disappear like melting snow. The June 1930 summer school in Ann Arbor was the starting point for a major tour through the US. He sent letter after cheerful letter to his family and to Goudsmit and Uhlenbeck. He wrote of his satisfaction with his lectures at Caltech and his impression that his American hosts had received them with "real pleasure." Similarly, during his visits to European physics centers in the early 1930s, his letters often sounded lighthearted.

Things usually went wrong when he came back home. Just how depressed Ehrenfest had become is reflected in two letters addressed to friends and colleagues in mid-August 1932. The first was addressed to Einstein in Berlin, Bohr in Copenhagen, Ioffe in Leningrad, and several others. But it was never sent. The second, comparable in its depression but less intense in its detail, was intended for 10 of his closest Dutch colleagues, many of them his former PhD students. Sixty years later, former students Hendrik Casimir and Jan Tinbergen declared that they had never received the letter.

But Jan Burgers, another former student, did receive that letter. In it, Ehrenfest bade farewell to his academic "children." In the course of the coming year, he wrote, he would be obliged to commit suicide, since he saw simply no other way out. Further postponement was impossible despite the "moral and financial damage" his suicide would cause his wife and children. He went on to ask his friends, wherever possible, to support his children—in par-

ticular Pawlik (Little Paul, in Russian diminutive), the prospective physicist. He closed with the words, "Please forgive me for my weakness as a human being."

And then the Nazis

On 7 April 1933 the Hitler regime in Germany, barely two months old, proclaimed the *Gesetz zur Wiederherstellung des Berufsbeamtentums* (Law for the restoration of the professional civil service). From one day to the next, all government jobs held by Jews were clearly at risk. At the universities, all of them state institutions, waves of dismissals began promptly.

Three days after the introduction of the new law, Ehrenfest wrote to Goudsmit with a bizarre proposal. Having expressed his expectation that the "remarkably open and carefully planned extermination (*Ausrottung*) of the Jewish plague" from German art, science, jurisprudence, and medicine would quickly be 90% effective, he launched the following macabre idea: What if a group of eminent, elderly Jewish academics and artists collectively commit suicide, without any demonstration of hatred or issuance of demands, in order to prick the German conscience?

First of all, Goudsmit bemoaned the fact that Ehrenfest was yet again talking of suicide. Furthermore, he considered the idea absurd. "A group of dead Jews can do nothing, and their deaths would merely delight the other Germans (*das teutonische Volk*)."

In the last months of his life, Ehrenfest made every effort, via his international network, to whisk Jewish physicists out of Germany by providing them with employment elsewhere. At the invitation of a "marvelous non-Jewish colleague," he spent several days in Berlin in early May, to test the waters. Then

Figure 5. Paul Ehrenfest in Amsterdam, sometime in 1933, probably taken by his former student Arend Rutgers. (Courtesy of the Boerhaave Museum.)



he swung into action in several ways. In practice, it proved anything but easy to find even temporary positions for emigrating physicists. Above all, Ehrenfest was disheartened by the difficulties the distinguished Göttingen professor Max Born was experiencing. Not until October 1936 did Born finally manage to acquire a permanent position, at the University of Edinburgh in Scotland.

The family, and Nelly

The Ehrenfests were a globetrotting, internationally oriented family. Their home base in Leiden was a Russian-style villa designed by Tatiana. They had four children. Tanja (1905–84), the eldest, obtained a doctorate in mathematics. After a peripatetic year in Göttingen (as Born's assistant), Moscow, and Hamburg, she became an assistant at the University of Technology in Delft in 1933. Much to the annoyance of her father, she responded rarely to his letters, commenting that it was simply impossible to keep up with his flood of "chatty nonsense notes."

Her artistically talented younger sister, Galinka (1910–79), was quite different. As part of her development, Ehrenfest sent her on a trip around the US and Canada that took several years. She corresponded regularly with her father about theater, music, film, and painting. They discussed filmmaker Sergei Eisenstein and various movements in painting. Ehrenfest was constantly recommending books to her. He wrote often of the relationship between art and science. "Cézanne," he wrote, "paints like a physicist or mathematician who, with much

effort, achieves progress by continually adapting his roughed-out calculations on new sheets of paper."

Pawlik, born in 1915, followed in his father's footsteps; in 1932 he began working toward a physics degree. Paul was greatly concerned about Pawlik's future. He constantly called on colleagues in the Netherlands and abroad to look after his son. Pawlik survived his father by less than six years. He died in a skiing accident in 1939.

Wassik, Ehrenfest's youngest, was born in 1918 with Down syndrome when Tatiana was already 42. Wassik outlived his father by only a few hours.

Ehrenfest's remarkable interest in painting had everything to do with Nelly, the unmarried woman with whom he had started a relationship in 1931. She gave lectures and tours at museums in Amsterdam. She and Paul spoke of his correspondence with Galinka. Having attended a course by Nelly on the development of modern painting, he himself gave a lecture at the Kennemer Lyceum on "style development in the physicists' world view." Expecting other physicists to be among the audience, he experienced considerable nerves during the preparation of that lecture.

In his letters to Nelly, Ehrenfest made no secret of his depression. "Why are people like me condemned to continue living?" Or "If you or Tatiana were to ask me whether I love you, there's only one answer, and Tatiana knows it already: In utter helplessness I crave your proximity, and if that craving gives me neither warmth nor strength, then I am overcome by desolation." Nelly had encouraged him to write down his childhood memories in the hope that it would help him overcome depression.

Tatiana was aware of Paul's relationship with Nelly. She even had him pass on her regards. Nonetheless, in the summer of 1932, between stays in Russia, she applied for a divorce. Following repeated appeals from Paul, she withdrew the application at a point when the divorce proceedings were already in full flow. Her one condition was that Paul end his relationship with Nelly.

Paul agreed. But as the months passed and his depression worsened, he found it increasingly difficult to stick to that undertaking. Finally, he gave up. In July 1933 he himself applied for the divorce. But matters never got that far.

The fateful day

Ehrenfest settled his financial affairs. Then on 25 September 1933, he made the short trip to Amsterdam. First he visited his former PhD student Arend Rutgers. In the afternoon he went on to Professor Waterink's Institute for Afflicted Children, where the 15-year-old Wassik was housed. He had brought along a pistol. In the institute's waiting room, Ehrenfest first shot his son in the head and then killed himself. The boy survived for a few hours.

Wassik had been transferred in June to the Amsterdam institute from a clinic in Jena, Germany. The boy's care and treatment represented a severe financial burden. Ehrenfest's view of the situation was revealed in a letter to Nelly dated 22 March 1932. "Surely you understand my wish that Galinka and Tanitschka should not in the future have to work

themselves to the bone simply to keep their idiot brother alive?"

In a letter to Einstein, Ioffe, and Bohr, dated 14 August 1932, he was more explicit about suicide.⁶ If he couldn't find employment in Russia, it was the only way out. Ehrenfest explained that by this point, he had started to focus on suicide "in ever increasing detail . . . after having first ended Wassik's life." One year later he put those words into action.

Just two weeks before his tragic end, Ehrenfest had traveled to a conference in Copenhagen organized by Bohr. (See figures 4 and 5.) He must have made the final decision there. His departure from Copenhagen left an impression of great agitation. Paul Dirac remembered how he had tried to offer words of encouragement to the tormented Ehrenfest by praising him for his mediation efforts at such conferences. As an example, Dirac cited his mediation during quantum debates between Bohr and Einstein. Ehrenfest grasped Dirac by the arm and, in tears, spoke of the importance of such praise to a man who had lost the will to live.

On the fatal day, a letter from Ehrenfest dated 24 September was delivered to Burgers. It had been written in the full realization that by the time Burgers read it, the writer would no longer be alive. "Lieber, lieber Burgers!" reads the opening. The letter goes on to request that Burgers take charge of his correspondence concerning the German-Jewish physicists. Pawlik would know where to find all the papers.

The letter draws to an emotional close. Ehrenfest saw a soulmate in Burgers, his first student. "You and I are unable to survive without contact with actively religious individuals. Their proximity strengthens us. We perceive deeply religious people, searchers for truth, as a home—perhaps the one we've lost."

One last time, Ehrenfest calls on Burgers to support Pawlik "with advice and guidance!" And then he ends his farewell letter: "Sei umarmt, sei glücklich mit den Deinen. Dein P. Ehrenfest." (Be embraced [by me], be happy with your family. Your P. Ehrenfest.)

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