



01 February 2024 16:52:05

Tatiana Afanassjewa in Vienna in 1906.  
(Courtesy of the Ehrenfest-Afanassjewa family.)

**Margriet van der Heijden** is a trained particle physicist and a part-time professor of science communication in physics at Eindhoven University of Technology in the Netherlands. A translation of her 2021 biography of Paul Ehrenfest and Tatiana Afanassjewa will be published by Oxford University Press in 2024–25.



## More is known about him than about her: **Tatiana Ehrenfest-Afanassjewa**

Margriet van der Heijden



Tatiana Afanassjewa and Paul Ehrenfest, her husband, shared their love for physics and mathematics, but their ideal of studying and working together went against the zeitgeist.

**A**lbert Einstein sat down at his home in Princeton, New Jersey, in January 1939 to write a letter to Tatiana Afanassjewa, the widow of his close friend Paul Ehrenfest. The roughly six years that had passed since the two had last seen each other—Afanassjewa was in Leiden, the Netherlands—had been hard on Einstein. He had escaped from a Europe that was teetering on the brink of a devastating war, and his stepdaughter Ilse and his wife Elsa had both since passed away. More recently, one of his two grandsons had died as well.

The events had been painful, Einstein wrote, adding that “words like these would normally not cross my lips.” He made an exception in his letter to Afanassjewa: “You are especially close to me because of some sort of inner kinship. It is a certain outsider mindset about one’s personal life and a sense of being fulfilled with objective matters, here too, away from our contemporaries—that is how we both are.”<sup>1</sup>

The words must have comforted Afanassjewa, who had her own losses to bear. In 1933, shortly after Einstein’s departure from Germany, her husband died by suicide in the waiting room of Professor Waterink’s Institute for Afflicted Children in Amsterdam, where their youngest son Wassik, who had Down syndrome, was cared for. In a desperate act, he had shot the 15-year-old boy first. In January 1939 Afanassjewa’s eldest son, Pawlik, died in an avalanche in the French Alps.

How melancholy must have been the memory for both Einstein and Afanassjewa of the years when Einstein was a regular guest in the spacious Ehrenfest house, which then was filled with music, laughter, and debates about physics. In addition to their two sons, Afanassjewa and Ehrenfest had two daughters, Tatiana and Galinka. “I have never experienced such a happy life in any other home,” Einstein wrote in a letter

to the couple in the autumn of 1919, after having spent two weeks in Leiden.

### **Vienna and Saint Petersburg**

Who were Paul Ehrenfest and Tatiana Afanassjewa? As is so often the case with couples, more is known about him than about her. The first 40 years of Ehrenfest’s life and work have been documented in a scientific biography,<sup>2</sup> and memoirs have been written by Ehrenfest’s students—among them the mathematician Dirk Struik, the physicist Johannes Burgers, and Jan Tinbergen, one of the 1969 Nobel laureates in economics. Their writings recall the vibrant and intellectually inspiring atmosphere that Ehrenfest and Afanassjewa created in their home in Leiden.

By contrast, Afanassjewa’s work and her contributions to the lively scientific debates have long gone unnoticed, even in the Netherlands. Only recently did her innovative work and contributions in the fields of thermodynamics, statistical mechanics, and mathematics education draw broader attention.<sup>3</sup> Yet an unwavering love for physics and the natural sciences was what brought Ehrenfest and Afanassjewa together in 1903, and it was what cemented their relationship thereafter.

A deep pleasure of the natural sciences guided the steady,

# TATIANA EHRENFEST-AFANASSJEWAW

more introverted Afanassjewa. Born in Kiev, then part of Russia, and raised as a single child in the wealthy Saint Petersburg household of her aunt and uncle, Afanassjewa had a love for science that led her to study at the Bestuzhev Courses, an institute of higher education for women. It also took her from Saint Petersburg to Göttingen, Germany, where she studied mathematics and physics in 1903 and 1904 and where she met Ehrenfest.

To Ehrenfest, the rational beauty of the natural sciences, particularly of physics, served as a lifeline for him, too, in a world that he frequently found overwhelming and sometimes downright hostile. His parents, who successfully ran a store selling groceries and household supplies in a Catholic neighborhood of Vienna, provided him and his four older brothers with a solid education. In a short memoir in 1932, he uses rosy terms to describe the busy household of their assimilated Jewish family. At the same time, however, the venomous antisemitism of many of his neighbors, peers, and teachers deeply hurt him. As a teenager, he was also deeply shaken when over the course of a few years, the shop was sold, his elder brothers left the house, and his parents died, one soon after the other. His love for mathematics and physics kept him afloat.<sup>4</sup>

Science became the guiding principle in their lives in Vienna, where they lived in 1905 and 1906; in Saint Petersburg, where they lived between 1907 and 1912; and in Leiden, where they moved in 1912. It motivated them to surround themselves with a large circle of friends, many of them physicists and mathematicians. And more than two decades after the move to Leiden, it was what kept Afanassjewa going after the loss of Ehrenfest and their two sons, Wassik and Pawlik.

## Subtle contributions

Despite the key role that science played in the lives of the couple, it is difficult to briefly explain the scope of Afanassjewa's and Ehrenfest's work because of the subtlety of their contributions to solving often delicate problems in complex fields. The most important paper they wrote together stems from work during their second stay in Göttingen. Toward the end of 1906, they had returned to

that mecca of mathematics and physics, after spending their first two years as a married couple in Vienna, where their eldest daughter, Tatiana Pavlovna, was born. At the time, neither Ehrenfest nor Afanassjewa had a job, but they had both inherited enough money—from his parents and from her uncle—to write and study without worries, at least for a few years.

Afanassjewa had little hope of establishing a career in academia. The Bestuzhev Courses, which she had completed in Saint Petersburg, were well known in Russia and were supported by renowned scientists, including Dmitry Mendeleev. Elsewhere in Europe, though, professors did not know what to make of that type of education and found it difficult to gauge the value of her diploma. That Afanassjewa had not been able to obtain any additional diplomas or write a dissertation during her first stay in Göttingen did not help matters.

Ehrenfest, who had studied with Ludwig Boltzmann in Vienna and who had obtained his doctorate at the end of 1904, also struggled to find a position. His misfortune was that Boltzmann, whose earlier comments on his thesis had been sparse, was no longer able to write a recommendation for him; Boltzmann died by suicide in the late summer of 1906.

In Göttingen, the couple's luck turned when they published their so-called urn model, the topic of their first joint paper.<sup>5</sup> Later Ehrenfest would simplify it further to the "dog-flea model": It illustrates entropy by imagining how two dogs lying next to each other will each end up covered in an equal number of fleas, even if initially one dog was free of fleas and even if a single flea jumps just as easily in one direction as in the other.

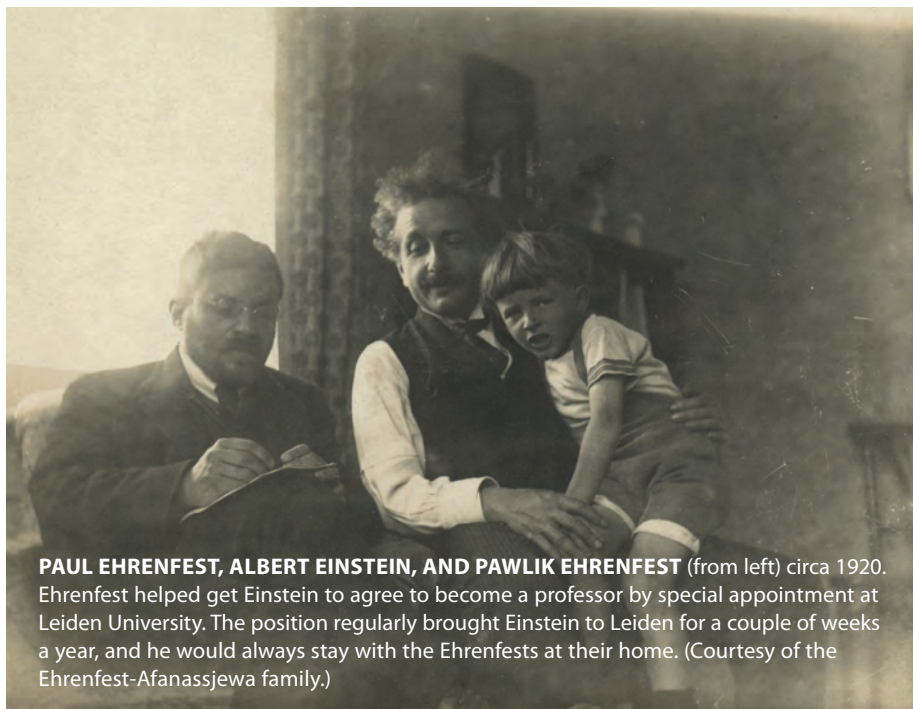
The mathematician Felix Klein was so impressed by the original urn model that in 1906 he asked both Ehrenfest and Afanassjewa—whom he explicitly included in his invitation—to write an overview of the field of statistical mechanics and of Boltzmann's work. It was to appear in the prestigious *Encyklopädie der mathematischen Wissenschaften* (Encyclopedia of mathematical sciences), in which Klein intended to present all branches of mathematics and their applications.

Undoubtedly, Ehrenfest and Afanassjewa only got the assign-

01 February 2024 16:52:05



**THE LEIDEN OBSERVATORY** in the Netherlands was built in 1861 at the initiative of Frederik Kaiser, an astronomy professor at Leiden University, who asked the architect Henri Camp to imitate the famous neoclassicist Pulkovo Observatory near Saint Petersburg, Russia. Given its proximity to Witte Rozenstraat, where Tatiana Afanassjewa lived, the Leiden Observatory must have been a reminder of her home country. (Courtesy of AWossink/CC BY-SA 4.0)



**PAUL EHRENFEST, ALBERT EINSTEIN, AND PAWLIK EHRENFEST** (from left) circa 1920. Ehrenfest helped get Einstein to agree to become a professor by special appointment at Leiden University. The position regularly brought Einstein to Leiden for a couple of weeks a year, and he would always stay with the Ehrenfests at their home. (Courtesy of the Ehrenfest-Afanassjewa family.)

ment because Boltzmann was no longer available, but they did make the most of the chance to establish a name for themselves. Letters from Hendrik Lorentz reveal that he was impressed by their joint publication in Klein's *Encyklopädie*—although it will probably always remain something of a mystery why Lorentz asked the relatively unknown Ehrenfest in 1912 to succeed him as a professor at Leiden University.

## Strengths and weaknesses

The urn model and its more playful flea variant also highlight the couple's individual strengths. The urn model aligns with Afanassjewa's inclination for mathematics, her fondness for logical reasoning, and her lifelong interest in probability. The flea model is clearly a product of Ehrenfest, who blended his charismatic personality, his sharp tongue, a Socratic line of questioning, and ingenious metaphors to brilliantly lead an audience toward a profound understanding of the essential points of a theory or publication. Such qualities also made him an excellent sparring partner for colleagues, and he became close friends with Einstein and other well-known physicists, including Niels Bohr, James Franck, Wolfgang Pauli, and Erwin Schrödinger.

Ehrenfest's tragedy was that his qualities and scientific contributions were simply not enough for him. He regretted his own "lack of creativity," and his sense of inadequacy deepened over the years. It began to culminate when a new generation of young physicists developed quantum mechanics by using mathematical tools that many older physicists found difficult to grasp. In letters to colleagues and to Afanassjewa, Ehrenfest complained almost incessantly about how family and financial matters were keeping him from working, studying, and thinking seriously and profoundly.

Surely, their circumstances obliged Ehrenfest to take on occasional jobs as an examiner and a public lecturer. Their large house in Leiden had become a burden after the Russian Revolution of 1917 had reduced Afanassjewa's Russian railway stock to worthless pieces of paper. They needed to support not only their immediate family but also Afanassjewa's aunt and mother, who had escaped from Russia. On top of that, they

needed to pay the substantial monthly bills from the Trüper Institute in Jena, Germany, where their youngest son, Wassik, was being cared for.

## Debating circles and a working group

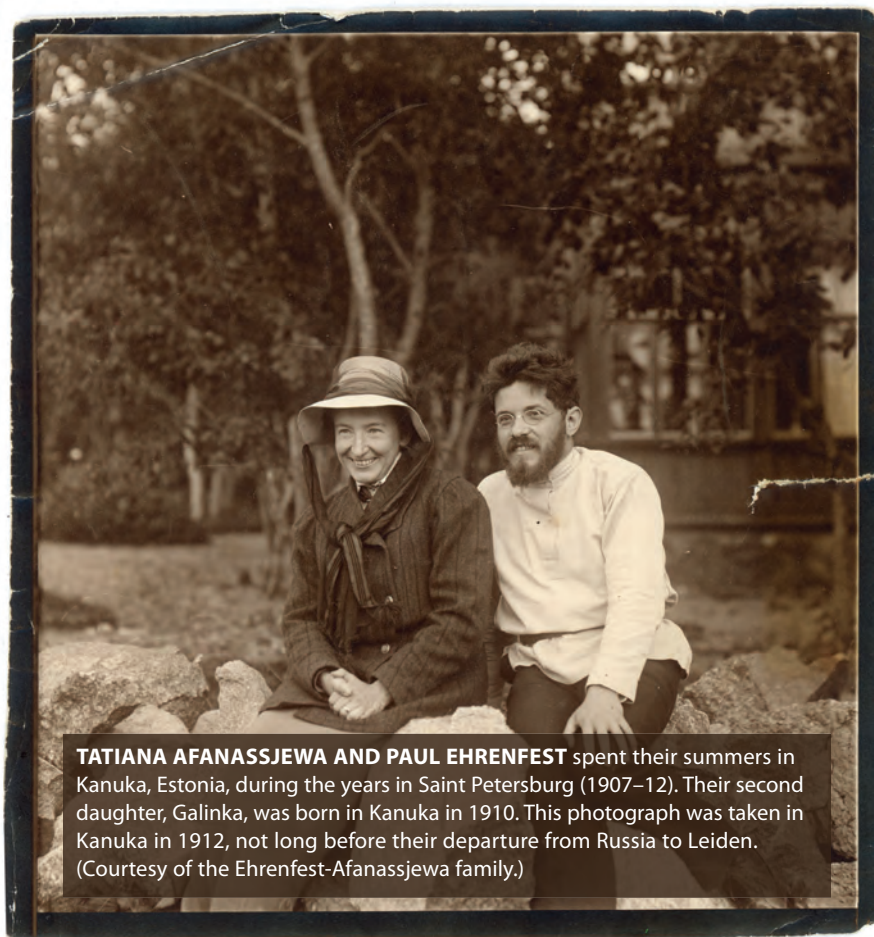
Yet the person whose wings were truly clipped was Afanassjewa. Time and again, whenever opportunities might have presented themselves, she seemed forced by her circumstances to instead become someone she was not: an elementary school teacher, a devoted housewife, a woman happy to live a quiet and secluded life in a provincial Dutch town, as opposed to a woman longing to write, debate, travel, and—most of all—think for herself. In fact, she already had to overcome adversity as a young girl. She was just a toddler when her father collapsed and was taken to a "mental asy-

lum." Her mother had to earn a living while Afanassjewa was fostered by her wealthy aunt and uncle. And since her conservative uncle was opposed to her plans to enter the Bestuzhev Courses, she could begin her studies there only after his death.

After marrying Ehrenfest in Vienna in December 1904, Afanassjewa audited lectures at the University of Vienna, but being pregnant and then a young mother, she felt out of place. In Saint Petersburg, where the university had just opened its doors to women, she finally did manage to complete an internationally recognized degree in mathematics and physics. The bureaucratic procedures, however, were so lengthy that she ended up missing an opportunity to write a dissertation. Less than a year later, in July 1910, she gave birth to daughter Galinka. Ehrenfest, meanwhile, had come to realize that he would probably never obtain a formal position in Russia, so he decided to spend the rest of the summer at the German resort Bad Kissingen.

Still, and in spite of the stress of a young family, Afanassjewa and Ehrenfest managed to gather a lively circle of physicists and mathematicians around them while living in Saint Petersburg. Their *kruzhoks*, or debating circles, became popular among many young scientists, and Ehrenfest, with the extensive knowledge of recent developments in theoretical physics that he had gathered in Vienna and Göttingen, became a leading figure among them.

Afanassjewa, meanwhile, went quietly about her own business. She organized her own *kruzhok* on probability, wrote a paper on the role of probability in physics, and found employment at the Russian pedagogical museum of one of the military academies. Its task was to educate military recruits, most of them illiterate or with only limited skills in reading, writing, and arithmetic, from all over the vast Russian empire. At the turn of the century, however, when the benefits of proper schooling became increasingly clear, the museum broadened its scope. A working group of mathematicians, among them the applied mathematician and naval officer Aleksey Krylov, had begun to debate the didactics of mathematics and organized a lecture series for secondary school teachers and for anyone else interested in education. Soon after delivering one of the lectures, Afanassjewa was invited



**TATIANA AFANASSJEW AND PAUL EHRENFEST** spent their summers in Kanuka, Estonia, during the years in Saint Petersburg (1907–12). Their second daughter, Galinka, was born in Kanuka in 1910. This photograph was taken in Kanuka in 1912, not long before their departure from Russia to Leiden. (Courtesy of the Ehrenfest-Afanassjewa family.)

to participate in the working group in Saint Petersburg. It was there that she began to develop her ideas on didactics, inspired also by lectures by David Hilbert and Felix Klein.

## A woman's place

Once Ehrenfest and Afanassjewa were in the Netherlands, after Ehrenfest's appointment at Leiden, their roles shifted to a more traditional pattern. Now it was Ehrenfest who held the formal position and Afanassjewa who had to manage on her own. She would soon discover that the Netherlands offered far fewer possibilities than Saint Petersburg had. Leiden was a provincial town, and according to unwritten but strictly applied rules, the wives of professors in the Netherlands stayed at home and devoted themselves to good causes and children. In 1924 a royal decree even formalized such habits by stipulating that women must be honorably discharged from public-service positions as soon as they married. It left Afanassjewa no choice but to work from home, independently, without the encouragement of daily encounters with colleagues, without the benefits of a salary and an office, and without a job title that would lend her prestige and a place in the historical record.

A testament to Afanassjewa's perseverance is that, despite all the setbacks, she almost immediately seized an opportunity to organize another *kruzhok*, this time with Dutch mathematics teachers. It was Lorentz—whose wife was cautiously supporting feminist causes—who had put her in touch with a group of teachers who worked with the Dutch educational

reformer Rommert Casimir. Ehrenfest had his doubts about the enterprise. "Nothing will come of the reform of mathematics education," he grumbled after one such session. "Just look how they can never agree on anything." Afanassjewa, however, was happy that the teachers debated at all; that in itself meant progress, she said.<sup>7</sup> Yet even she had to admit that professionally things developed slowly in the Netherlands, especially for herself.

By contrast, her private life was busy. In 1914 the family had moved into a large house on Witte Rozenstraat ("White Roses Street"). Afanassjewa herself had designed the house in the neoclassicist style that was so popular in Saint Petersburg. Their son Pawlik was born there in 1915, followed in 1918 by son Wassik. The two young boys required care, and Ehrenfest and especially Afanassjewa supervised the homeschooling of their daughters. Afanassjewa shared Ehrenfest's objections to the traditional school system, and she wrote in the family diary that "little good was to be expected" from the Dutch schools where children had to memorize the names of "Dutch canals" and read "saccharine little stories devoid of any poetry."

## A novel way of teaching geometry

In short, Afanassjewa was kept occupied with a multitude of duties as a wife, a mother, and a host to the many visitors and guests they received in their home. In addition, she worried about Wassik and was anxious about the Russian Revolution and the horrors of World War I, which, although it spared the neutral Netherlands, brought violence and uncertainty across Europe. All those events would distract anyone more than enough from working hard and thinking deep. It once more illustrates Afanassjewa's steadfastness that she still managed to write three papers that were read to the Royal Academy of Sciences by Lorentz and the Leiden professor Johannes Kuenen. Yet it is not surprising that it took her until 1924 to publish work with which she truly made her mark in the two fields that had been at the core of her interests for many years: thermodynamics and the didactics of mathematics.

Afanassjewa published a pamphlet in 1924 on the didactics of geometry.<sup>8</sup> The refreshing methods she proposed began with an intuitive learning stage that allowed children to explore space and its concepts. Almost immediately, her proposal led to a debate with the established mathematics educator Eduard Dijksterhuis, who fiercely defended traditional teaching methods in a lengthy rebuttal.<sup>9</sup> Soon afterward, the Dutch Inspectorate of Education assigned a national committee to investigate the secondary school science curriculum, while a new journal about teaching methods in mathematics was established as well.

In the following year, Afanassjewa's paper on thermodynamics similarly offered innovative ideas. Building on the earlier axiomatic treatment of thermodynamics by the Greek mathematician Constantin Carathéodory, the paper suggests that the laws of thermodynamics, as formulated by Lord Kelvin and Rudolf Clausius, do not exclude negative temperatures on the kelvin scale, which was a novel suggestion at the time. In addition, Afanassjewa's subtle and profound discussion of thermodynamic equilibrium and nonequilibrium states still is part of current debates about the topic among philosophers of science.<sup>10</sup>

## Escape to Russia

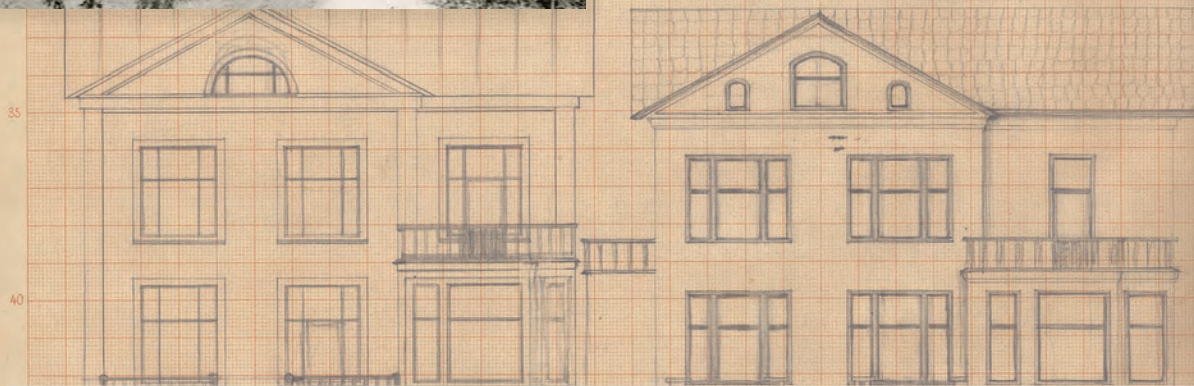
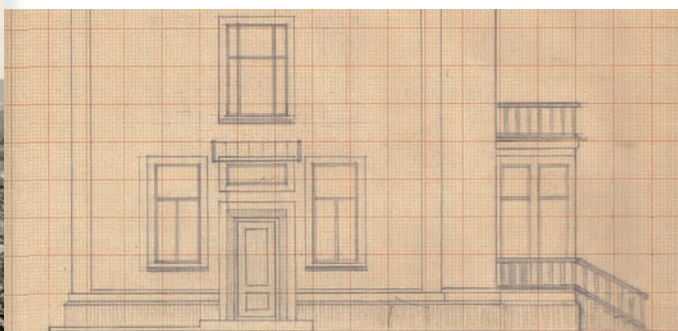
Afanassjewa must have been disappointed, however, because she was not invited to be a member of the Dutch committee on education or an editor of the new journal on teaching methods in mathematics—even though her pamphlet had been the trigger for both initiatives. She must have been equally disappointed that her paper on thermodynamics found a similarly lukewarm reception because her observations got lost in the tsunami of publications on the revolutionary theory of quantum mechanics. "It would be entertaining if all publications by my wife and myself could at one point all be [...] printed together in chrono-

logical order," Ehrenfest wrote in 1926 in a document expressing "a couple of wishes" in case of his own death. Their ideal had always been to work and study together. Yet society's expectations and their disappointments about their careers began to burden the once so unreservedly happy relationship between Afanassjewa and Ehrenfest.

Without hope of a formal position, with her daughters growing into adults, and with her husband becoming increasingly nervous and grumpy, Afanassjewa often felt lost in Leiden. In 1926 she could no longer resist the call from the Soviet Union, where her expertise was appreciated and where friends and former colleagues were happy to welcome her. It marked the beginning of a period during which she would travel to the Soviet Union twice a year for three to five months. She worked as a university professor in Simferopol in Crimea, taught prospective mathematics teachers in Ordzhaniukidze, and lectured in Moscow and Leningrad. On her way back and forth to Leiden, she would always make a stop in Jena to visit Wassik.

## Recovering in Spa

Ehrenfest, who had increasingly been growing tired of Afanassjewa's sober and intellectual lifestyle and her endless willingness to help friends in the Soviet Union, was now missing her presence in the Leiden house. Their two grown-up daughters regularly traveled abroad too. Often alone in the house, with only his young son Pawlik and old baba Katja—Afanassjewa's mother—for company, Ehrenfest



**THE EHRENFEST-AFANASSJEWHA HOUSE IN LEIDEN.** Paul Ehrenfest, Tatiana Afanassjewa, and their two daughters, Tatiana and Galinka, moved into their newly built house at Witte Rozenstraat 57 in summer 1914. Afanassjewa herself had designed the house, in the neoclassicist style that was popular in Saint Petersburg around 1900. The house also had many other Russian characteristics, including thick walls, a Russian heating system, "lazy" stairs (uncommon in the Netherlands), and Russian-style double glazing. (Courtesy of the Ehrenfest-Afanassjewa family.)

**TATIANA AFANASSJEW** TAUGHT MATHEMATICS to prospective teachers in 1933 in Ordzhonikidze, not far from the Caucasus Mountains and Georgia. She loved the mountains, but after having witnessed Joseph Stalin's Holodomor famine that killed millions, she decided to never set foot again in the Soviet Union. (Courtesy of the Ehrenfest-Afanassjewa family.)



found that his mood swings were becoming more severe. He frantically typed long letters to Afanassjewa, to almost 100 colleagues, and, in some cases, to their wives. He began to travel through Europe in an almost compulsory manner and increasingly used his sharp tongue for sarcasm rather than playful wit. In 1931 he fell in love with Nelly Posthumus Meyjes, an art critic eight years younger than him.

Once Afanassjewa heard about the affair, she tried to take it lightly. But Ehrenfest's desire to share all sorts of intimate details of his two lives with both women, and even with the children, soon created tensions. When Afanassjewa asked for a divorce, Ehrenfest plunged into a depression. Einstein visited him in September 1932 and was so concerned that he wrote a letter to the curators of the university to ask them to relieve Ehrenfest of some of his duties.

A few days later, Einstein traveled to the Belgian town and health resort of Spa, where Afanassjewa, completely exhausted for the first time in her life, had withdrawn herself. During his two-week stay, they went for long walks together, discussing marital problems and other topics. One was Afanassjewa's recently published *Übungensammlung*, a collection of simple exercises to acquaint children with geometry.<sup>11</sup> When Ehrenfest arrived, with the booklet in hand, at the end of Einstein's two-week visit and joined them for walks, Einstein must have hoped for the best.

In hindsight, such a happy outcome in such dark times seemed unlikely. In the Soviet Union, Joseph Stalin had strengthened his iron grip on the hungry and exhausted population. After the Holodomor famine of 1932–33 that killed millions of Ukrainians, Afanassjewa would never set foot in her native country again. In Germany at that time, Adolf Hitler was rising to power. Ehrenfest traveled to Berlin in May 1933, where he met Schrödinger and Max Born and drew up an extensive list of Jewish colleagues whom he hoped to bring to the attention of academic aid organizations

elsewhere in the world. In a desperate move, he also went to visit the Nobel laureate Johannes Stark, who had written papers that had once inspired him to go to Göttingen for further studies but who had now become a staunch Nazi. Would Stark “dare to ignore me disdainfully, while I am still the same Jew as before,” Ehrenfest asked rhetorically.<sup>12</sup>

Back in Leiden, spiteful young men greeted Ehrenfest at the train station shouting: *Isak! Isak! Was heb Du o Hast?* (“Isaac, Isaac, why are you hurrying?”). He wrote to his former student Samuel Goudsmit, “And these kinds of *Strassenbelastungen*—stressful events on the streets—are rapidly increasing here!”<sup>13</sup> A few months later, after breaking up with Posthumus Meyjes, Ehrenfest spent three days with his family. He then went to the Waterink's Institute in Amsterdam where they had moved Wassik to safety from the Trüper Institute in Nazi Germany, and he ended both his son's and his own life.

## Enduring love for science

“I was so very pleased with your letter,” Einstein wrote on 22 October 1945 to Afanassjewa. “Such a sturdy and steadfast personality one seldom encounters. Also, an interest in the foundations of physics has remained alive in you as if you had not experienced these harsh and threatening years.”<sup>14</sup> Einstein had been happy to learn that Afanassjewa, her daughters, and her grandchildren had all survived the horrors of World War II.

Soon a food parcel arrived in Leiden from a company in New York, followed by another and yet another. Afanassjewa wrote to Einstein, “Now we have received nice goods from you again.”<sup>15</sup> It was not until the end of 1947 that Einstein reluctantly agreed to Afanassjewa's request to send the food parcels to their colleague Edmund Bauer in Paris instead, since she had asked, “Are you planning to feed me until my death?”<sup>16</sup>

Their correspondence continued until shortly before Einstein's death in 1955. The letters must have been a comfort to

Afanassjewa, alone in her huge house in Leiden, and to Einstein, equally alone in his small house in Princeton. Writing after the death of Afanassjewa's son Pawlik in 1939, in a letter that has been carefully preserved by the Ehrenfest family, Einstein reflected on Shakespeare's plays: "Human fate is extraordinary when it is described by such a wonderful man, but one should not have to live through it oneself and be permitted to just be eyes." To the sad reflections he added words of consolation, writing about what they both shared, an enduring love for physics and mathematics that continued to give their lives meaning. "Only objective matters have retained their radiant shine for me. They appear in the same glory as the first geometry book that I received as a child. It surely is the same for you as well."



*I thank Anne Kox, Henriette Schatz, and the article reviewers for their comments and suggestions.*

## REFERENCES

1. A. Einstein to T. Ehrenfest-Afanassjewa (22 January 1939), Ehrenfest Family Archive, Amsterdam, the Netherlands. Unless otherwise noted, all unpublished sources are also from the family archive.
2. M. J. Klein, *Paul Ehrenfest: Volume I—The Making of a Theoretical Physicist*, North-Holland (1970).
3. J. Uffink et al., eds., *The Legacy of Tatjana Afanassjewa: Philosophical Insights from the Work of an Original Physicist and Mathematician*, Springer (2021).
4. P. Ehrenfest, "Memoir" (1932), file 21, Paul Ehrenfest Archive, National Museum Boerhaave, Leiden, the Netherlands.
5. P. Ehrenfest, T. Ehrenfest, *Math.-Naturwiss. Bl.* **3**, 197 (1906).
6. P. Ehrenfest, T. Ehrenfest, in *Encyklopädie der mathematischen Wissenschaften* (Encyclopedia of mathematical sciences), vol. 4, art. 32, Teubner (1911); English trans. as *The Conceptual Foundations of the Statistical Approach in Mechanics*, M. J. Moravsik, trans., Cornell U. Press (1959).
7. T. Ehrenfest-Afanassjewa, *Didactische Opstellen wiskunde* (Didactic essays in mathematics), Thieme (1961), p. 11.
8. T. Ehrenfest-Afanassjewa, *Wat kan en moet het Meetkunde-onderwijs aan een niet-wiskundige geven?* (What can and should geometry education offer a nonmathematician?), J. B. Wolters (1924).
9. E. Dijksterhuis, *Bijvoegsel Nieuw Tijdschr. Wiskd.* **1**, 1 (1924/1925).
10. J. Uffink, G. Valente, in ref. 3, p. 55.
11. T. Ehrenfest-Afanassjewa, *Übungensammlung zu einer geometrischen Propädeuse* (Collection of exercises for a geometric propaedeutic), Brill (1931).
12. E. Schrödinger to M. J. Klein (17 April 1957), Martin Klein Archive, National Museum Boerhaave, Leiden, the Netherlands.
13. P. Ehrenfest to S. Goudsmit (14 May 1933), box 8, file 61, Samuel A. Goudsmit Papers, Niels Bohr Library and Archives, American Institute of Physics, College Park, Maryland.
14. A. Einstein to T. Ehrenfest-Afanassjewa (22 October 1945), file 425, Ehrenfest Archive, in ref. 4.
15. T. Ehrenfest-Afanassjewa to A. Einstein (4 April 1946), file 425, Ehrenfest Archive, in ref. 4.
16. T. Ehrenfest-Afanassjewa to A. Einstein (22 March 1947), A. Einstein to T. Ehrenfest-Afanassjewa (28 March 1947), file 425, Ehrenfest Archive, in ref. 4. 