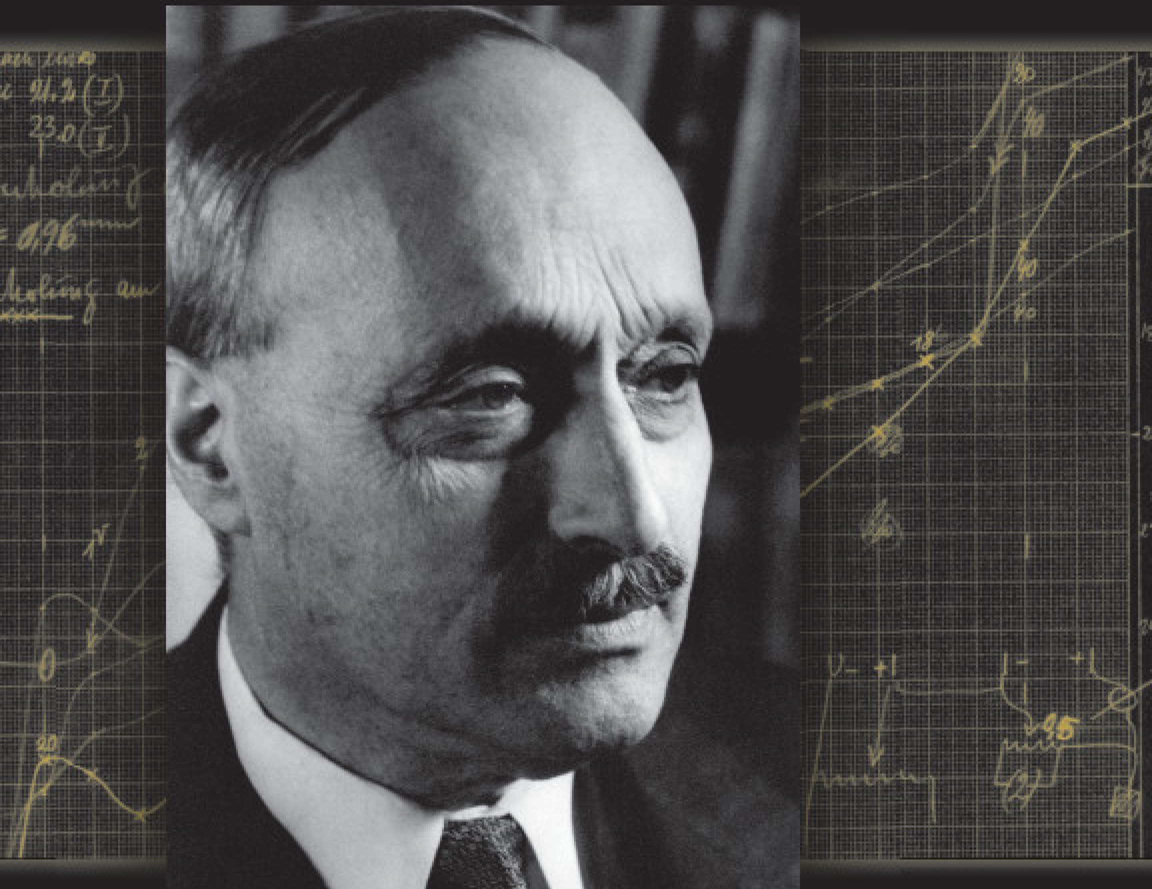
SCIENCE *and* CONSCIENCE



The Life of James Franck

JOST LEMMERICH

Translated by ANN M. HENTSCHEL

SCIENCE AND CONSCIENCE

Stanford Nuclear Age Series
General Editor, Martin Sherwin

SCIENCE AND CONSCIENCE

The Life of James Franck

JOST LEMMERICH

Translated by Ann M. Hentschel

Stanford University Press, Stanford, California

Stanford University Press
Stanford, California

Printed in the United States of America on acid-free, archival-quality paper

Library of Congress Cataloging-in-Publication Data
Lemmerich, J. author.
[Aufrecht im Sturm der Zeit. English]
Science and conscience : the life of James Franck / Jost Lemmerich ; translated by Ann M. Hentschel.
pages cm. -- (Stanford nuclear age series)
"Originally published in German under the title Aufrecht im Sturm der Zeit: Der Physiker James Franck, 1882-1964."
Includes bibliographical references and index.
ISBN 978-0-8047-6310-3 (cloth : alk. paper)
1. Franck, James, 1882-1964. 2. Physicists--Germany--Biography. 3. Nobel Prize winners--Germany--Biography. 4. Jewish refugees--United States--Biography. I. Hentschel, Ann, translator. II. Title. III. Series: Stanford nuclear age series.
QC16.F67L45513 2011
530.092--dc22
[B]

2011007309

Typeset by Bruce Lundquist in 10/12.5 Times Roman

This volume is dedicated to the memory of
Lisa and Hermann Lisco,
Dagmar and Arthur R. von Hippel, and
Heinz Kallmann, whose cooperation and contributions made it possible.

Contents

Foreword

James Franck was a great physicist and an exemplary human being, one of the twentieth century's most respected scientists. Before the First World War, he was an early leader in creating the imaginative experiments that led to a deeper understanding of the quantum energy levels of atoms. Decades later, at the end of the Second World War, he was a wise and heroic leader of the scientists at the University of Chicago who sought to prevent both the use of the atomic bomb against Japan and a postwar nuclear arms race with the Soviet Union that they predicted would be an inevitable consequence of its use. This definitive biography of James Franck's life is a welcome addition to the history of that remarkable generation of physicists who transformed our understanding of the universe and, in so doing, put life on earth at risk.

In 1914, Franck and his colleague Gustav Hertz devised and performed two key experiments—for which they received the Nobel Prize in 1926—that later confirmed the validity of Niels Bohr's theory of the atom (1913). Over the next several decades Franck and the many physicists who were drawn to work with him from Europe and the United States went on to illuminate the structure of simple molecules and how they absorb energy and dissociate (the Franck-Condon principle).

During these early productive years in Germany—despite the Great War and its harsh aftermath—Franck built his institute of experimental physics at Göttingen University. By the early 1920s, it had become one of the world's most distinguished centers of physics and had set a new standard for university physics departments worldwide. Pioneering interdisciplinary collaboration between experimentalists and leading theoreticians (including Max Born, Werner Heisenberg, and Niels Bohr), and mathematicians (including David Hilbert and

Richard Courant), Franck's Göttingen institute served as the model for all future scientific environments that produced groundbreaking discoveries. As a result, Franck was offered the leading professorships in experimental physics in Germany.

But Hitler's rise to power precipitated dramatic change. Franck, an assimilated German Jew, was a reluctant activist, having once even written to Einstein: "Any publicity is so abhorrent to me that I would gladly find excuses to avoid it." But in the post-1933 German environment his conscience drove him to risk everything. When Hitler decreed that, with certain exceptions, Jews could no longer be employed in government agencies or universities, Franck rebelled. A World War I veteran with a distinguished record, he was qualified to be exempt from this decree, but his moral outrage could not be stilled. (It is possible that his sensitivity to moral issues involving science may have stemmed from his war experiences with Germany's poison gas program.) He publicly resigned his professorship in protest against the Nazi edict and, given his reputation, his act of conscientious defiance drew sympathetic attention worldwide. But, predictably, at home it was loudly denounced, most vociferously by a group of pusillanimous Göttingen lecturers who declared Franck's action "an act of sabotage" against the Third Reich, which of course it was.

In 1935 Franck changed both his country and the focus of his research. After emigrating to the United States he chose to blaze a new scientific trail in the emerging field of biophysics. Concentrating on understanding the physics underlying biological processes, he focused in particular on elucidating how chlorophyll absorbs solar energy and converts it to the chemical energy that supports most life on earth.

But in February 1939 news of a fantastic event once again altered the direction of Franck's research, and his life. Uranium fission had been discovered by Otto Hahn, Fritz Straßmann, Lise Meitner, and Otto Robert Frisch. The discovery set off a wave of scientific inquiry within physics communities the world over. If nuclear fission was a reality, a nuclear weapon was a distinct theoretical possibility. Fragile peace still reigned in Europe. James Franck, in residence at the University of Chicago, joined Enrico Fermi, Leo Szilard, and their colleagues in the Manhattan Project's Metallurgical Laboratory, in a presumed race against German scientists for an atomic bomb.

In December 1942 the laboratory successfully completed the experiment upon which the advancement of the Manhattan Project's goal depended: a controlled nuclear chain reaction. But that success also precipitated, among the most thoughtful scientists, considerations about the consequences of a world armed with nuclear weapons. Franck was a visionary in this regard, and in June 1945 he led a small group of his colleagues in discussions of the "social and political implications" of nuclear weapons.

The result of their deliberations was a memorandum addressed to Secretary of War Henry L. Stimson. Commonly referred to as the "Franck Report," the memorandum urged that the use of nuclear weapons without warning against Japan would make a nuclear arms race with the Soviet Union inevitable. Two of Franck's coauthors, Eugene Rabinowitch and Leo Szilard, became leaders of the postwar scientists' movement for nuclear arms control. A third, Glenn Seaborg, became chairman of the U.S. Atomic Energy Commission during the Kennedy and Johnson administrations.

After the war Franck spoke out again, this time about the inadequate supply of food available to the starving German population. The U.S. government appeared to be more concerned about preventing Germany from rising again as a military-industrial power than about humanitarian aid. Franck joined other prominent American Jewish refugees in a public call for such humanitarian aid, pointing out that many children and innocents were suffering.

Readers will find within this volume a fascinating exchange of letters between Franck and Einstein in which Einstein refused to join in the call, warning that most Germans were unrepentant and "would do it again if they could." Franck, by contrast, had a more generous view and chose not to burn all bridges so impulsively. But he kept reminding his former colleagues in Germany of their responsibility to face up to the humanitarian catastrophe that Germany had set in motion and to turn over a new leaf.

James Franck was thus not only an important contributor to the development of quantum physics during its "heroic age" in the early twentieth century but also one of the scientists participating in many of the key policy debates that resulted from the midcentury confluence of fascism, war, and the invention of nuclear weapons. Franck exerted this influence effectively, whether in science or politics. His hallmark was cooperation and teamwork. Science was what made Franck famous, and his biographer has rightly provided a detailed road map of his work. But nonscientists may comfortably skim over these scientific sections and find much that is of more general interest about the role and influence of scientists and science in the making of our world. Indeed, this biography is being published in the Stanford Nuclear Age History Series because of Franck's important contribution to the secret debate inside the U.S. World War II atomic-bomb project over whether or not to use nuclear weapons against Japan.

Martin J. Sherwin, General Editor,
Stanford Nuclear Age History Series

Preface

Biographies of physicists tend to aggregate around certain figures. There are surely more than a hundred on Einstein. Numerous, too, are the books written about the lives of Galileo and Newton. A few lengthier biographical accounts have recently appeared on Lise Meitner and Werner Heisenberg; but very many other important physicists of the twentieth century are still awaiting more thorough scrutiny than an obituary or a scientific memoir. The list of Nobel laureates among them is long.

In the 1950s the physical chemist Johannes Jaenicke decided to start working on a biography of his close colleague Fritz Haber and asked friends and former coworkers for their recollections. When James Franck visited Germany in 1958, he was also interviewed by Jaenicke about his friend. Franck's remarks on that occasion could just as well apply as recommendations for a work covering his own life:[1] "There are various ways to write this biography," he told Jaenicke.

> If you choose not to write about the scientific research itself but present contributions by various people, the result is a kind of collective issue that tends to be dedicated to the living on birthdays. This is not a biography but would merely be another way of honoring Haber's memory. A biography has to be homogeneous. For such a colorful personality, the various tints have to be allowed to blend together.

Franck left no autobiographical notes, nor did he keep a diary. He gave a longer interview late in life and spoke publicly about his experiences on another occasion as well. An abbreviated biography of Franck and his friend Max Born appeared in 1982 in the catalog of an exhibition titled "The Luxury of Conscience" and celebrating the centenary of their births. It was organized by the German cultural endowment Stiftung Preussischer Kulturbesitz, with the support of the German Physical Society and the Max Planck Society in Berlin.

The preliminary research for the exhibition involved not only a close study of the papers left behind by the two Nobelists, but also a canvassing of as many people as possible with some biographical knowledge about them. A broad-scale search was conducted at the time for more material not only about Max Born, on behalf of his son Professor Gustav von Born as well as his daughter Margarete Farley-Born, but also about James Franck, for his younger daughter, Lisa, and her husband, Professor Hermann Lisco. Many of Born's and Franck's pupils and coworkers contributed further facets in the form of personal reminiscences, some having already written commemorative articles for Franck's seventieth birthday and other key anniversaries. They gratefully acknowledged his achievements as a scientist and a teacher no less than his example as a person. This latter they were better able to appreciate from their own experiences during the period between 1933 and 1945 than when they had been young members of the upcoming generation of physicists. Later in life it was easier for them to grasp what Franck had given up, what he had lost when he felt compelled to leave Germany. Important as these testimonies are, they were related or written in retrospect, after a time when physics was reaching for new horizons, partly inspired by ideas that Born and Franck had conceived, and when political developments were throwing into much sharper relief the responsibility of a scientist. After 1945, actions that had been taken from the late 1920s to the end of World War II were judged under the burden of the terrible events and Nazi crimes.

While on a visit to Germany in 1992, Hermann and Lisa Lisco asked me whether I would be willing to write a biography of James Franck. As a consequence, my collection of materials was substantially extended, and new sources were identified in the years that followed. Many conversations with Professor and Mrs. Lisco and an intense exchange of letters made possible the addition of much detail of a more private nature to this report of Franck's life as a scientist. The Liscos were closely consulted on the overall project and were fortunately able to read the first biographical part of the present work. Mrs. Karen Lieberman née Lisco kindly made further material available to me.

Albert Einstein states in his autobiography: "The world of physics is not granted, but assigned to mankind." This "assignment" characterizes the scientific evolution of James Franck's entire lifework and is a major element of his biography.[2] The report about Franck's research up to 1933 is, at the same time, essentially a history of atomic physics. In order to let the various tints "blend together," as Franck's prescription for his friend Haber's biography goes, I have quoted generously from Franck's correspondence and publications. To provide for the historical context of events directly affecting his course in life, I have consulted contemporary reports in papers that it is very likely Franck himself had read. A great many primary documents predating 1920 are unfortunately lost, and so a very limited selection of family letters had to fill this gap; consequently the depth of description is uneven. This applies particularly to Franck's attitude toward American policies between 1947 and 1960. A lack of sources precluded any incorporation of reflections on American politics within their political context.

Acknowledgments

First and foremost, I would like to thank James Franck's eight grandchildren for supporting this English translation with funds from a bequest from Heinz Kallmann. The translator joins me in heartily thanking Professor Frank von Hippel, in particular, for his careful and informed review of the manuscript. The editorial work at Stanford University Press, particularly by Norris Pope, Sarah Crane Newman, Jan McInroy, and Emily Smith, is much appreciated.

The friends of James Franck whom I must thank for their reports and recollections are many. This book was unfortunately not finished during their lifetimes: Ms. Helen Dukas, Dr. Hilde Levi, Mrs. Grete Paquin, Prof. Dr. Otto Robert Frisch, Prof. Dr. Arthur R. von Hippel, Prof. Dr. Dr. h.c. Friedrich Hund, Prof. Dr. Heinrich Kuhn, Prof. Dr. Werner Kroebel, Prof. Dr. Dr. h.c. mult. Heinz Maier-Leibnitz, Prof. Dr. Gert Rathenau, Dr. Dietrich Schmidt-Ott, and Prof. Dr. Dr. h.c. mult. Eugene Paul Wigner.

The following archives and libraries assisted me in my documentary gatherings: Akademie der Wissenschaften zu Göttingen, academy archive; Archiv zur Geschichte der Max-Planck-Gesellschaft, Berlin; Archiv der Deutschen Physikalischen Gesellschaft, Berlin; Bayerisches Hauptstaatsarchiv, Munich; Berlin-Brandenburgische Akademie der Wissenschaften, academy archive, Berlin; Bundesarchiv, Berlin; Churchill Archives Centre, Churchill College, Cambridge; Deutsches Museum, archive, Munich; Geheimes Staatsarchiv Preußischer Kulturbesitz, Berlin; Humboldt-Universität Berlin, university archive; Joseph Regenstein Library, Special Collections, University of Chicago, Chicago; Leo Baeck Institute, New York; Ludwig-Maximilians-Universität, university archive, Munich; Niedersächsische Staats- und Universitätsbibliothek, manuscripts department, Göttingen; Niels Bohr Archive, Copenhagen;

Rockefeller Foundation Archive, Sleepy Hollow; Royal Society Archive, London; Ruprecht-Karls-Universität, archive, Heidelberg; Senat der Freien und Hansestadt Hamburg, state archive, Hamburg; Springer Publishers, archive, Heidelberg; Staatsbibliothek zu Berlin Preußischer Kulturbesitz, Berlin; Stadtarchiv Göttingen, Göttingen; Universität Göttingen, university archive; and Universitätsbund, archive, Göttingen.

Thanks are also due to the Jewish National Library, Albert Einstein Archives, and the Nymphenburger Verlag of the Herbig Verlagshandlung GmbH.

For their critical scrutiny of a draft version of this book and for many useful comments, I cordially thank: Mr. Ralf Hahn M.A., Prof. Dr. Klaus Hentschel, Prof. Frank von Hippel, Mrs. Karen Lieberman, Mr. Detlef Rückeis, Prof. Dr. Heinz-Dieter Schotte and his wife, Dr. Ulla Schotte, Prof. Dr. Hans-Joachim Schulz, Prof. Dr. Friedrich Smend, Prof. Dr. Christian Thomsen, and Mr. Rudolf Ziesche.

My gratitude also goes to Mary Janzen Wilson for her detailed source guide to the papers of James Franck in the Joseph Regenstein Library, and likewise to the directors and archivists who were ever willing to address my needs for material.

Special thanks to: Dr. Finn Aaserud, Copenhagen; Prof. Dr. Dr. h.c. mult. Gustav von Born; Prof. Dr. Tilo Brandis, Berlin; Ralf Hahn M.A., Berlin; Prof. Dr. Eckart Henning M.A., Berlin; Prof. Dr. Dieter Hoffmann, Berlin; Dr. Ulrich Hunger, Göttingen; Dr. Marion Kazemi, Berlin; Dr. Wolfgang Knobloch; Mr. Daniel Meyer, Chicago; Dr. Robert Otto Pohl, Göttingen; Dr. Helmut Rohlfing, Göttingen; Dr. Charlotte Schönbeck; and Ms. Barbara Wolff, Jerusalem.

For permission to cite letters by Albert Einstein, I thank the Hebrew University of Jerusalem. I also thank Mr. Reinald Schröder, GNT-Verlag, for his expertise on the German publication.

■ ■ ■

Note: Efforts to locate the copyright holders of the illustrations have been made with due diligence. The author will, of course, honor any remaining legitimate claim.

SCIENCE AND CONSCIENCE

CHAPTER 1

Introduction

> Science is not humanity's only mission, nor is she its highest; but those under her dictate should carry out their mission wholeheartedly and with all their might. No matter what shape a scientific epoch may take, the mission always basically remains the same: to keep the sense for Truth pure and alive and to re-create as a cosmos of thoughts this world handed down to us as a cosmos of forces.
>
> Adolf von Harnack, Bicentennial address before the Prussian Academy of Sciences, 1900

Unless there was some clear link to daily life, the nineteenth-century German public took little notice of the few scientists, let alone physicists among them or their research results. Justus Liebig's Familiar Letters on Chemistry in the *Augsburger Allgemeine Zeitung* and Alexander von Humboldt's *Kosmos* are exceptions, as these authors shared a personal interest in publicizing their scientific findings. But very few people realized that progress was the work of research and physical measurement. Hermann von Helmholtz's appointment to his chair for physics at the Friedrich-Wilhelms-Universität in Berlin in 1871 and the construction of a new institute for physics on the banks of the Spree near parliament sparked more interest in the daily papers. Another occasion for reporting about the tasks of physical research and the reich's science policy was the founding of a national bureau of standards. The debates in the Reichstag for and against the project were duly recorded. When the researchers took up their work in the new Physikalisch-Technische Reichsanstalt (PTR), few people were aware of the kinds of problems, affecting both science and the economy, attached to the manufacture of standards for the meter, for example, or for the kilogram, the second, the volt, the ampère, or the ohm. The first president of this new institution in the capital's suburb of Charlottenburg was a familiar name among educated circles: Helmholtz had offered many public lectures and written many popularizing articles, such as On the Sensations of Tone as a Physiological Basis for the Theory of Music, that united the humanities with the natural sciences. His most influential papers in the areas of mathematics and epistemology lay beyond the reach of a more popular readership.

Wilhelm Conrad Röntgen's discovery in 1895 was different. The reporting on those extremely mysterious rays capable of penetrating through the human body was much more extensive. X-rays had medical significance. But the science behind them remained largely unmentioned in the press. The nineteenth-century clash between those who were knowledgeable about physics and the government or church had yet to be fully settled, and new problems only added to these tensions, even though they lay less in epistemology than in physics. These debacles between academics and the wielders of power took place in the political arena. In 1837 seven professors at Göttingen protested against a constitutional amendment affecting their professional oath of allegiance as civil servants. Their protest, directed against the local regent, the king of Hanover, Ernest August, led to the professors' dismissal and expulsion from the land. In those days the making and keeping of an oath was a highly held ethical value, so this deed by the Göttingen Seven, irrespective of its later Enlightened wrappings, was a sign of a new attitude among scholars toward state authority.

Almost forty years later, in November 1880, seventy-five notables, Theodor von Mommsen and Rudolf von Virchow among them, felt obliged to send Bismarck a manifesto against anti-Semitism.[1] It declared:

> Racial hatred and the fanaticism of the Middle Ages is now being revived and directed against our fellow Jewish citizens in an unexpected and deeply shameful way in various places, especially in the Reich's largest cities. [. . .]
>
> The legal precept as much as the honorable precept that all Germans have equal rights and obligations is being broken. Implementation of this equality does not lie with the tribunals alone but also within the conscience of each individual citizen.

At that time, Lise Meitner—born in 1878—was two years old and Albert Einstein almost one. Max Born and James Franck would be born two years later, and the Dane Niels Bohr, in 1885.

James Franck spent his entire youth—almost a quarter of his life—in the Free and Hanseatic City of Hamburg and another quarter in Berlin, where he became an accomplished scientist.[2] His first research was conducted during a period of peace. Only dystopians were painting a dark picture of the destruction of mankind and the world by scientific knowledge. Kaiser Wilhelm II's "saber rattling" was not taken seriously. The Great War then revealed the terrifyingly destructive power of modern technology in general and poison gas in particular. The war also exposed an overflowing sense of nationalism joined in by many scientists. The image of the scientific community was badly tarnished.

Franck accepted a full professorship at Göttingen at the beginning of the twenties. There his renown as a researcher grew with his importance as an academic teacher. The signs of political unrest and of latent and open anti-Semitism only gradually became perceptible in liberal Göttingen. The National Socialists' lunge for power in 1933, their illegal measures and state-ordered indignities toward Jews, first inside Germany and five years later throughout large areas of Europe as well, brought profound and fatal changes to Jewish life. Franck refused to serve under such a state and resigned his lifetime position in protest in 1933. Many of his more resourceful friends only barely escaped death under the inhumane Nazi regime, and many others became its victims. The Francks managed to emigrate to the United States with their two daughters and sons-in-law. The effect on Franck's research was drastic. His focus changed fundamentally.

The lives of those among Franck's scientific friends who had stayed behind in Germany, like Otto Hahn and Max von Laue, were hampered and endangered. These were descendants of the Enlightened men of 1880. But, unlike during the kaiser's reign, during Hitler's dictatorship they had to live under the constant awareness that if they dared to call publicly for the rights of their persecuted Jewish fellow citizens, they would be eradicated.

Most physicists were united internationally not only by a professional commitment to science but also by personal friendships. This union was broken by an unforeseen result of pure research: the discovery that neutron bombardment could cause the fission of uranium. The huge amount of released energy exposed the feasibility of an atomic bomb. Albert Einstein, prompted by Leo Szilard and Eugene Wigner, decided to urge action dictated by reason. He warned President Roosevelt of the danger that Germany was possibly building such a weapon. The American government decided to counter this threat by building its own. Franck was asked to collaborate on this project. When Germany was forced to capitulate, he and some of his former collaborators turned against the idea of deploying nuclear arms. These events banished irretrievably to the past the centuries-long period of peaceful scholarly study in the tranquillity of one's own laboratory.

CHAPTER 2

Youth and Education

Origins and Childhood in Hamburg

A second child was born to Jacob Franck and his wife, Rebecca née Drucker, on 26 August 1882 in the Hanseatic city of Hamburg. It was a boy. He was to be raised in the Jewish faith and go by the name of James.

Hamburg was the largest German seaport and second largest city of the reich. It was a vibrant place for an alert young mind to develop.[1] Since the Middle Ages, the city had been a member of the Hanseatic League together with Bremen, Lübeck, Lüneburg, Wismar, and many other cities. Its burghers and city council continued to emphasize this special standing when the league survived the Thirty Years' War with little more than its name. In the nineteenth century this tradition encouraged a certain self-importance that generated problems during a period of political change. Despite its independence, Hamburg was unable to annex the Danish town of Altona right at its doorstep without outside assistance. This quarrel with the Holstein-Gottorp lords was unwinnable. When the Austro-German war with Denmark ended in defeat for the Danes, Altona was given not to Hamburg but to Prussia. The privileged burghers of Hamburg did not feel the urge, prevalent among many Germans, for a unified state. The free city continued to maintain its own embassies in many parts of the world and to make separate trade agreements. Membership in the North German Confederation was eventually allowed, but Hamburg did not join the customs union. Why give up one's independence and fall under the dictate of Prussia, the leading voice of the *Kaiserreich* founded in 1871? Why bow to Bismarck's policies? But the creation of uniform customs throughout the regions of the reich, to which Altona and Bergedorf belonged from 1880 on, drove Hamburg's city council into a corner, and in 1881 it finally agreed to join the German empire as of 1888.

By doing so, the free city relinquished control over its currency, administered until then by its private banks. Their silver had to be exchanged for the reichsmark, causing great trepidation among bankers and the citizenry about an impending crash. The opposite happened. Trade was stimulated and the banking business flourished with it. The establishment managed by James Franck's father, Jacob Franck & Co., probably also benefited. The plan to create a large free port fed this general economic upswing. A number of old neighborhoods in the harbor area were condemned for demolition, creating a huge demand for new housing. Hamburg became not just Germany's most important seaport but the leading port on the entire continent. Only the harbor capital of its most important trade partner, England, was larger. Not even Napoleon's continental blockade could completely stop all trade with the British. Shipments continued to arrive via Altona. Hamburg's society had its share of England enthusiasts, and Rebecca Franck was one of them. The name she chose for her second child was James.

Products passed through Hamburg on their way to and from the farthest reaches of the Earth. Emigrants, mostly Germans, Russians, and Poles, traveled via Hamburg to far-off lands. In 1885 they totaled 47,118, the great majority of them embarking on ships to New York. There were years when the number of emigrants exceeded 100,000. A municipal authority working with the reich's emigration commissioner oversaw their accommodation and provisioning and also monitored the shipping lines. It was only toward the end of

Figure 1 View of Hamburg on the shores of the Alster. Old postcard.

the century that the employment situation within the reich began to improve and the exodus slowed.

With the wares from foreign lands came their peoples. Some stayed for just a few days, others came to settle. Global trade demands the ability to work with foreign partners and a certain measure of open-mindedness. In 1882 the city of Hamburg had just about half a million inhabitants. About 90 percent of them were of the Protestant faith, and the next largest religious community was Jewish, with about 3 percent members of the "Israelite Community,"[2] closely followed in number by Catholics. Baptists, Germano-Israelites, French Reformists, Mennonites, Evangelical Lutherans, Presbyterians, and members of the Apostolic Church formed other independent religious communities in 1889. Back in the middle of the sixteenth century, Jews had been driven out of Belgium, the Netherlands, Portugal, and Spain, and many of them had found refuge in this harbor town. Hamburg never had a ghetto. Portuguese Jews were not only allowed to settle down but also were soon granted equal rights. It was possible for them to acquire citizenship, which at that time was normally purchasable, and to hold public office.

The low birth rate among Portuguese Jews reduced their communities toward the end of the nineteenth century. Another factor in their decline was their tendency to set themselves apart from immigrant Jews from the East, who did not automatically receive the same rights when they came to Hamburg. But

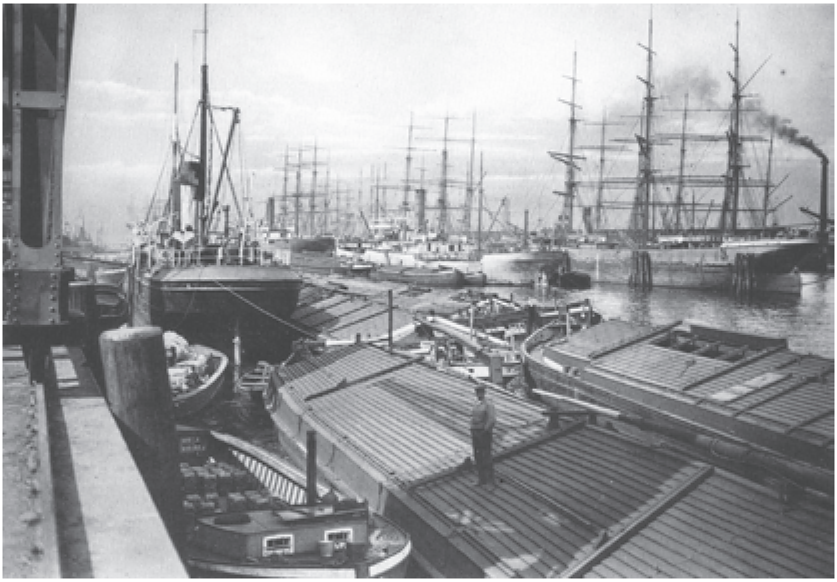


Figure 2 Hamburg harbor. Old postcard.

much had changed in the lives of European Jews since the beginning of that century under the influence of the Enlightenment. Many of Germany's kingdoms and duchies, along with Switzerland and Italy, granted the same rights to their Jewish citizens as to their fellow Christians. This equality was introduced explicitly into the Prussian constitution of 1811. One exception was the official oath, which had to be sworn "bei Gott." The sharp boundaries between the different confessional faiths became fainter, and conversions to other faiths began to be tolerated, even though conservative elements put up their utmost resistance. James Franck's future teacher of physics in Berlin, Emil Warburg, converted to the Protestant faith as a young man in 1866.

Hamburg was a site of Reform Judaism from the beginning of the nineteenth century.[3] "The New Israelite Temple Association" constituted itself there in 1817. This name was consciously chosen in reminiscence of Jerusalem. The term "synagogue" was not used, to avoid controversy. The breviary *Das Hamburger Gebetbuch*, first published in 1819 and reissued in 1842, is a legacy of these reforms. Gotthold Salomon was one of the preachers at the Hamburger Reform Temple. The new temple, built in 1844, accommodated 350 men, with room for 300 women on the balcony above. In 1859 Hamburg's burghers had 192 councillors, 10 of whom were Jewish. Dr. Isaac Wolffson later represented Hamburg as a member of the Reichstag. Gabriel Reiser was vice president of the burghers' council and chief justice. The father of the discoverer of electromagnetic waves, Heinrich Hertz, was a Hamburg senator. When James Franck was born in 1882, the community of Portuguese Jews was at the point of dissolving itself for lack of members. It decided to donate its substantial capital to a charitable endowment.[4] Hamburg's Jews were known for their social conscience and active involvement on behalf of others, not always members of their own faith, but there had been little interest among them in supporting religious education. So no lessons on Jewish theology were offered to upper-school pupils attending *Gymnasium*. The responsibility of such instruction was left to the boys' fathers.

James Franck's father was a devout Jew. Having attended a technically oriented parochial school, the Talmud-Thora Realschule, as a boy, Jacob continued to honor the Sabbath throughout his life, and kosher food was the daily fare at home.[5] He acquired full citizenship in 1881. His father also was a deeply religious man. Bernhard Jacob had first arrived in the free city of Hamburg from the locally administrated domain of Ritzebüttel in 1832. There Bernhard had operated a clothing store. Jacob's grandfather, Jacob Moses Franck, had left Franconia to settle in Ritzebüttel, obtaining the special residential permit for Jews known as a *Schutzbrief* in 1815. Grandson Jacob must have been a successful and trustworthy businessman because the banking establishment J(acob) & Co Franck, located at no. 6 Johannisstraße, began to be listed in the city directory in 1887. His brother Moses was the other partner in the enterprise. Jacob set up house with his wife, Rebecca, at no. 172 Grindelallee. Their marriage ceremony had been conducted by Senior Rabbi Stern from the German-Israelite community in 1881. A daughter named Paula was born in the same year and in 1884 their second son, Robert Bernhard. Rebecca's side of the family had been living in Hamburg since the early eighteenth century. The surname Drucker points to their occupation in the printing trade in that period. The olive complexion of their elder son, James, also indicates their descent from Portuguese immigrants.

Young James attended one of the established primary schools, of which Hamburg had over sixty. The class portrait shows him with his seventeen classmates and their teacher. There were a large number of privately run secondary schools besides the two state *Gymnasien* and the more technically oriented *Realgymnasium*. Franck entered the Wilhelm Gymnasium in the fall of 1891.[6] It was a school for boys. The school's new building on the fenland Moorweide had been opened in 1886. Admissions took place twice a year. On average there were over forty pupils to a beginning class, the *Sexta*. A total of 450 pupils were taught by fifteen teachers, who had received their training at university, plus two full-time teachers in technical subjects and three assistant instructors. Franck had to learn Latin, Greek, English, and French. The percentage of Jewish children at the school was high enough to become an issue in the papers. But there is no mention of this in James Franck's reminiscences about his school days.[7]

Figure 3 Class portrait from 1888. Franck is the second from the left in the middle row. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

1892 was a terrible year for Hamburg. Cholera broke out and the number of the sick and dying grew apace. The famous Prussian physician Robert Koch arrived from Berlin to advise on the necessary hygienic measures. Drinking water tainted with bacteria was the main source of the spreading epidemic, which claimed many thousands of lives. It did not touch the Franck family because they happened to be living in a quarter that escaped the ravages of the disease.

James Franck was not a gifted pupil. Learning things by heart was not one of his strengths; in fact, he thoroughly disliked memorizing things. As a result, he had difficulty retaining Greek and Latin vocabulary. He was more interested in how things relate to each other. It was in the middle of a Greek lesson that he suddenly realized why a grease stain he was scrutinizing on the cover of his notebook made the opaque paper become transparent.[8] He compared this effect with analogous ones, such as ice and snow, and the insight he gained impressed him so strongly that it remained clearly in his memory when he was an old man. All the same, science class did not enthuse him.

As a teenager Franck was nevertheless aware of scientific advances. In the spring of 1896 he fell down while playing with his brother and broke his lower arm. Although he received medical treatment, he decided to go—without asking his parents—to the Physikalisches Staatslaboratorium (State Physical Laboratory) on Jungiusstraße. He had heard about it before without knowing what exactly was being done there. It had become an independent city research establishment in 1885 under the directorship of C. A. Voller.[9] James Franck had read in the papers about the spectacular discovery by Professor Wilhelm Conrad Röntgen of a kind of ray with which it was possible to see through the human body. For example, exposures of hands clearly showed the bones. After asking a few people at the laboratory in vain about whether it would be possible to have his arm examined with the rays, the thirteen-year-old found a physicist, B. Walter, who kindly took up his cause. The necessary apparatus, X-ray tubes and a spark inductor for generating high voltage, had just arrived at the institute. Walter set up the apparatus right in front of the boy. Franck had to lay his arm on a photographic plate and stay very still. The photographic plate was tightly wrapped up to keep light out. The exposure worked, and a doctor noted on the plate:

> The present image produced on the 7th of April 1896 at the Physical State Laboratory in Hamburg by means of exposure (Röntgen rays) shows the fracture of the radius on the forearm of James Franck.
>
> The treat[ing] physician: Dr. Julius Sachs.

The image revealed that the arm needed to be re-broken in order for the bone to heal properly. It then mended itself without further complications. This first brush with modern physics did not have direct consequences on the boy's plans for the future.

Figure 4 X-ray image of James Franck's arm. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Franck continued along the usual course in his attendance at school. But he absorbed more knowledge about the individual subjects than he realized, and the instruction did not rob him of his keenness to deepen his general knowledge. He liked to conduct simple chemical experiments at home, and he read a chemistry textbook out of pure interest. One of his classmates, Philip Elkan, became a lifelong friend. Elkan played the violin, and Franck also took lessons but later stopped playing the instrument.[10]

As a good swimmer, Franck dearly wished to be able to sail a boat by himself. This topic came up one day while he was walking along the shores of the Alster basin with his father. But Jacob was adamant: the boy had to be able to swim fully dressed before he could even consider allowing such a thing. Without a second thought, James dove straight into the Alster to prove his proficiency to his father right then and there.

Franck was not yet eighteen years old when, by order of Kaiser Wilhelm II, the major centennial celebration took place, on 1 January 1900. There were retrospectives on achievements and forecasts for the future. An abundance of discoveries and inventions during the final decade of the nineteenth century had raised high hopes in many people. It was thought that as a result of Robert Koch's discovery of the tubercle bacterium, a permanent cure would soon be found for illnesses like tuberculosis, and that Louis Pasteur's development of a vaccine would similarly eliminate rabies. Technological progress was revolutionizing major areas of private and public life. Telephone grids in large cities put messenger runners out of work. Even the financial institution Jacob Franck & Co. had its own telephone. A network of telegraph cables encircling the globe made it possible for news to be exchanged between continents. The Italian Guglielmo Marconi's wireless telegraphy was already able to breach distances greater than 50 km. A year later he succeeded in transmitting a signal across the Atlantic from England. On 25 December 1898 the *Berliner Illustrierte Zeitung* asked its readers to answer 27 questions in assessing the closing century. Goethe was voted the greatest poet, Menzel the greatest painter; Edison the greatest inventor, and the railway the greatest single economic factor. The encyclopedic *Konversationslexikon*—not the Bible—was designated the most influential book. There were a variety of responses to the question about hopes for the coming century, but world peace was the most frequently put forward.

At Easter 1902 James Franck took his school-leaving examination—but only after having to repeat a year. His conduct and diligence were graded as "good." His performance in the separate subjects was reported in some detail:[11]

In German he followed the literature, not merely insofar as it was read in school, with interest and sufficient comprehension. His essays were written with diligence but often suffered from a lack of clarity and from clumsy expression. In Latin, although he knows the main laws of grammar, he found it very hard to apply them; only rarely did he manage to prepare an adequate essay. In his oral examination on *Cic[ero's] de oratore* he demonstrated sufficient knowledge. His knowledge of Greek is sufficient, and his performance in class was also mostly satisfactory. In the oral examination he translated not only the selected passages from Plato but also from Homer with good ability. In French he has, in general, acquired sufficient knowledge of the grammar, so his written essays were ultimately mostly satisfactory. In English his achievements met this preparatory school's requirements. In history and geography he always demonstrated zeal and generally acquired satisfactory knowledge. In mathematics his oral performance was always good, in writing less so, however. In science he is familiar with the most important phenomena and their laws. In sports sufficient.

This report mentioned that Franck was "considering studying chemistry."

When he was about to take his final examinations, his teacher of Greek told him:[12]

I hear that you want to study physics; that's why I have no objection to your being admitted to the final exams as well. If you had been planning to study anything more serious, I would have opposed admitting you to the tests.

In retrospect, Franck could not recall noticing any kind of anti-Semitism at school or having heard about the problem at home from his parents.[13] The insignificant group of professed anti-Semites in Hamburg had evidently not gained much influence, having formed within the context of societal envy rather than for racist political reasons. James probably received religious instruction from his father. It is not known whether he went to synagogue.

Like all young men, James Franck was called up by the military, but his obligatory service was postponed to 1 October 1905.[14] The reason was probably his intention to attend university.

Beginning Studies at Heidelberg

In his youth Jacob Franck, too, had wanted to study at university but had been unable to fulfill this wish for financial reasons. There was therefore no argument about his son's study plans. It was only a question of the field that James should choose. His father wanted him to study law and James initially complied. Before 1919 Hamburg had no university of its own.[15] The city's leaders had little interest in the arts and no interest in science. Efforts to change this failed repeatedly, so Hamburg's sons left for the 22 universities that were elsewhere in Germany. Around 1900, nationwide there were 32,000 matriculated students. Many of these universities followed a tradition hundreds of years old. There were four main faculties: theology, jurisprudence, philosophy, and medicine. The natural sciences were within philosophy, in which physicists and chemists therefore also had to be tested when they took their doctoral exams.

Neither the Franck family nor James's mother's family, the Druckers, could claim having raised any academics, and Jacob Franck was probably not personally acquainted with any physicists. So the professional prospects that James might expect as a physicist, besides perhaps teaching at a preparatory school, were unknown.

Bonn was the most famous university for jurisprudence, because Kaiser Wilhelm II had been there as a law student. Franck chose Heidelberg, which also had a few brilliant jurists, including Jellinek, Schröder, Affolter, Anschütz, and Bühl. The city of about 30,000 residents was beautifully situated. Franck found a furnished room, the usual lodgings for a student, at no. 2 Haspelgasse "care of Leiser."[16]

The University of Heidelberg had a teaching staff of over a hundred professors and over a thousand students. Its location in the Neckar Valley in the Odenwald Range usually attracted five hundred more enrollments for the summer semester than for the winter. Many students joined one of the numerous fraternities. These associations provided the social contact that a young man living away from home for the first time often sought, although some occasionally degenerated into locales for revelry and drinking. Some of them also fostered varying degrees of nationalistic and anti-Semitic sentiment and expected of their student members such things as duels. One historian at Heidelberg, Dietrich Schäfer, an expert on Middle German, was a known Jew basher.[17] But Franck kept his distance from all such activities and probably was unaware of Schäfer's tirades.

New students explored their interests by registering in a wide variety of courses. Another motivation was to hear well-known professors. At school James had not been granted such leeway. Now, he participated in seminars by Theodor Fischer, famed for his lectures on Goethe's *Faust* and Schopenhauer. In the sciences he attended the chemistry course by Theodor Curtius and took the accompanying laboratory or *Praktikum*. The course did not cover Svante Arrhenius's modern theory of ions from 1887, however. The physics lecture by the 65-year-old Georg Hermann Quincke had been running unchanged for

Figure 5 View of Heidelberg with the ancient bridge. Old postcard.

thirty years. The experimental physics lecture usually included many demonstration experiments. There was a collection of physical instruments for the purpose, and some professors developed their own apparatus to facilitate comprehension of the presented material or to give an impressive show of the physical effects. The success of such demonstrations was critical, but Quincke rarely succeeded and his minor mishaps were a constant source of amusement for his students. One of these students was Robert Wichard Pohl, another native of Hamburg two years Franck's junior. The two became friends and attended many lectures together.

Franck was able to benefit from Georg Cantor's and Leo Koenigsberger's mathematical lectures. He also "sipped at" zoology, as he later put it, in Bütschli's course and was particularly impressed with Salomon's lecture on geology, even though it did not inspire him to become a geologist or awaken any serious interest in mineralogy. The excursions into the beautiful surrounding countryside and to the Eifel Mountains acquainted him with landscapes entirely different from the familiar lowlands of northern Germany. As a good swimmer and diver he was able to fetch a sample from the rocky bottom of the Neckar for Professor Salomon. He also attempted to cross the rushing stream under the ancient bridge in a canoe.

In Professor Koenigsberger's course, Franck befriended a student of mathematics from Breslau of his own age.[18] Max Born was the eldest son of the embryologist Gustav Born. Franck and Born set out on tours together, with Franck busily collecting rock samples along the way. A bottle of wine was

Figure 6 Klaus Schäfer, James Franck, and Max Born sitting on the banks of the Neckar. Brüche papers, Landesmuseum für Arbeit und Technik, Mannheim.

welcome refreshment. Once they celebrated a visit by Born's sister Käthe. Born gave Franck the nickname *Strudelkopf* or "hothead" in allusion to his love for the Neckar's boiling currents and his medley of interests. On their many hikes together Franck had to endure all sorts of jokes and pranks by his friend, such as the surreptitious loading of his backpack with useless ballast. Unlike other students, these new friends were not troubled by financial worries.

Born found the lectures he was taking at Heidelberg less gripping than he would have liked, and Franck also thought his studies left something to be desired. When Franck's parents came to visit, he managed, with Born's help, to present good arguments for pursuing an academic career. He got his father's consent to exchange his studies of law for chemistry and physics. He then had to decide which university could offer him good training as a scientist. He could see from Quincke's lectures that Heidelberg was out of the question. He probably consulted with Born, who had taken a few semesters at Breslau and Zurich. But Born was still in doubt about whether he wanted to become a mathematician or a physicist. In those days Göttingen was a center for mathematics in Germany. Felix Klein was prominent among the older generation and David Hilbert and Hermann Minkowski stood out among the younger mathematicians. So Born decided to go there.

Franck was more interested in chemistry and experimental physics than in "mathematical physics," later to be known as theoretical physics. In 1903 more than one university had important researchers in these fields. Munich boasted Wilhelm Conrad Röntgen, Kiel had Philipp Lenard, and Strasbourg had Ferdinand Braun.

In Berlin, a large and modern physics institute had been erected in 1876 very close to the inner city on the banks of the river by parliament, the Reichstagsufer. It had been established especially for Hermann von Helmholtz. After the nation's metrological and research institution, the Physikalisch-Technische Reichsanstalt (PTR), was founded in Berlin in 1887, Helmholtz as its president could continue to teach only a few specialized lectures. His full-time professorship at the university in Berlin went to the experimental physicist August Kundt and, after the latter's death in 1894, to Emil Warburg. Theoretical physics was being taught by Max Planck. At the Charlottenburg Polytechnic, the *technische Hochschule* on the outskirts of Berlin, Heinrich Rubens was responsible for the field of experimental physics. No chair existed there yet for theoretical physics. Although the university in the city's center, Friedrich-Wilhelms-Universität, was not even a hundred years old, it already had a number of leading scholars in a variety of fields on its teaching staff: Hans Delbrück, a distinguished historian; Wilamowitz-Moellendorf, a Greek specialist; Werner Jaeger, a classical philologist; Adolf von Harnack, a theologian; and Gustav Neckel, who directed the seminar for Germanic studies. In medicine Max Rubner, Wilhelm His, and August Bier had reputations extending beyond Germany's borders. Among the chemists, Emil Fischer, who specialized in organic chemistry, was the most important. He had just received the Nobel Prize for 1902.

Figure 7 The physics institute at Friedrich-Wilhelms-Universität in Berlin. Old photo.

Studying Physics in Berlin

Franck decided to go to Berlin. In retrospect it was a critically important decision, and the right one for launching a successful career in physics. But chemistry was his first choice. An interview with Professor Siegmund Gabriel revealed to him how little he had learned in Heidelberg about more recent discoveries in chemistry. He was in despair about the lost time. With his friends' encouragement, therefore, he decided to change his focus to physics.[19]

The most important of Franck's teachers was Emil Warburg. Born in 1846 in Altona, Warburg had developed an early interest in science.[20] He started studies at Heidelberg and attended Bunsen's courses in chemistry and Helmholtz's and Kirchhoff's lectures in physics. He then wrote his thesis—in those days still required to be submitted in Latin—under Magnus in Berlin. He earned his postdoctoral degree (*Habilitation*) soon afterwards. August Kundt was his mentor. When Kundt received a chair in Strasbourg, Warburg soon followed him in 1872 as *Extraordinariat*, associate professor.

Kundt and Warburg wrote a number of exceptional research papers together. They were able to show, among other things, that mercury vapor is monatomic. As a result Warburg received a fully tenured position in Freiburg im Breisgau at the early age of thirty. His scientific research over the following twenty years was well above average, and he was still able to find the time to write a

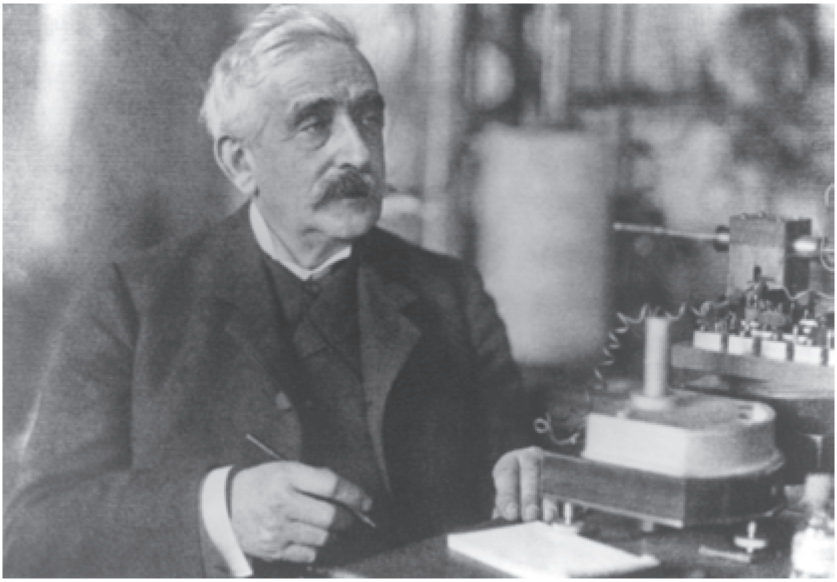


Figure 8 Emil Warburg. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

textbook on physics that was reprinted eleven times within its first seventeen years. He joined the staff of Friedrich-Wilhelms-Universität in Berlin in 1895.

Although Warburg was the head of a large institute, he still managed to do research, as well as lecturing, conducting examinations, and fulfilling other duties. He published fifteen papers during the period that Franck studied under him.

In an obituary of his teacher, Franck wrote in 1931 with reference to his textbook:

> Many generations of students, especially students of physics, learned the basics of physics from this book and gained a model for pertinence of expression and perfection and clarity of definition. But the book is not suitable for a fleeting survey. If one wishes to absorb the content, close attention is needed, as every word, every sentence has been carefully thought through. This book is typical of Warburg's own conception of science, which he also presupposes of his students almost as a matter of course. Whoever does not dedicate every bit of himself to science should keep his hands off it. [. . .]
>
> Yet Warburg not only knew how to conduct his own research, he also knew how to instill enthusiasm in his students about their work. A beginner quickly found out in the so-called Little Praktikum that knowing half can be less than knowing nothing. On his regular rounds through the practice sessions, Warburg posed short questions about the exercise that the [student] experimenter was working on. Whoever was not sure about his business was better off avoiding such an encounter as inconspicuously as possible in order to prepare himself better the next time. He never uttered any criticism; it was enough for him to assert: "Well, so you don't know that!" or in worse cases, for Warburg to turn away in silence to clearly call to the mind of the unfortunate sinner the full measure of his ignorance.

Franck did not systematically attend all of Warburg's lectures, but he participated in the whole cycle of courses on theoretical physics that Max Planck was offering on mechanics, thermodynamics, acoustics, electricity, and electromagnetism. The notes he took for the mechanics lecture were particularly sketchy.

Science fully occupied Franck at this time, and there is no more mention of happy-go-lucky trips to the outskirts of Berlin or travels around Europe.

Since the time of Helmholtz students had been coming to Berlin from all the German-speaking countries and elsewhere to study physics for at least a few semesters. This continued to be the norm. A photograph depicts Franck with the American Louis B. Tuckerman, Paul Cermak, and Robert W. Pohl.

As in Heidelberg, Franck found quarters in Berlin as a subletter, first at no. 22 Dorotheenstraße and later at no. 25 Luisenstraße. In 1905 his address was no. 10 Holsteiner Ufer. At the crossroads with Lessingstraße there was a pool in the river Spree. It was not a long way along its banks from the physics institute. On 28 July 1904 Franck saved two children from drowning in the river.[21] The police chief came in person to thank him for his courageous deed.

Figure 9 Louis B. Tuckerman, James Franck, Paul Cermak, and Robert W. Pohl. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

The best way for a student to find out about the current problems in physics was to attend the colloquium.[22] One afternoon per week professors, assistants, and more advanced students gathered around a large table in the middle of the spacious library at the physics institute. They were joined by physicists from the PTR and the polytechnic to listen to a report about an important publication or about research completed at one of the institutes. That was just the overture, however. The main action came with the subsequent discussion. Often, the first questions clarified points in the presentation, sometimes making a correction. Doubts about the results were expressed or further experiments suggested, to perhaps help clarify the issue.

Occasionally there was an unexpected turn. A bold hypothesis was put forward and accepted in the ensuing debate. An open atmosphere reigned throughout, and the otherwise formidable barriers between professors and their students were lifted. Heinrich Rubens, who had received his appointment to Berlin in the summer of 1906, devoted special attention to the colloquium. He regarded it as his obligation to carry on the tradition started by Gustav Magnus in 1843. Rubens's careful choice of topics and willingness to assume the task of posing the first question helped establish a high intellectual level. Franck was impressed by the candidness of the scientific dialogues. He was there when Einstein, Planck, and Walther Nernst later debated questions on the frontiers of physics, including the new theory of quanta.

The physical society, the Deutsche Physikalische Gesellschaft, also convened every fortnight, and Franck became a member. New developments were presented to the public there as well, but in a more formal setting. Franck and some of his fellow students soon were included among its speakers.

Toward the end of Franck's studies, in 1905, a theoretical paper, On the Electrodynamics of Moving Bodies, was published in *Annalen der Physik*, the most important German journal for physicists, by a hitherto unknown A. Einstein. The unusually long article presented what later came to be called the special theory of relativity. Franck immediately recognized the importance of Einstein's contribution. His comment to a fellow student was that they in their stupidity hadn't even noticed that the problem existed. Einstein's way of presenting it agreed with Franck's own particular proficiency: his straightforward manner of visualizing physics.

At that time, university studies were not regimented. There was no prescribed number of semesters to be completed, nor was proof demanded for actual attendance at lectures. In unpopular subjects such as theoretical physics the professor could, of course, see who was auditing his courses. The only test came at the very end, in the doctoral examinations. Examinees were required to have submitted a dissertation along with evaluations of the work by two full professors. In most cases this dissertation was the student's first piece of independent research. Its topic was supposed to be an unresolved problem. Frequently this problem, or parts of it, became a sort of leitmotiv of the author's later scientific research. This was true of Franck's dissertation.

A student was free to choose his own topic or ask his supervising professor for suggestions. In Franck's case, Warburg proposed that he measure the mobility of ions in a point discharge, an electric spark generated in air. Warburg's own research touched this area, and so he tended to set his doctoral candidates to work on related problems.[23] He also was interested in energy use in the electrical production of ozone. This question had practical importance, as some firms were already using ozone to disinfect drinking water.

The processes of electric discharges in a gas were also a major area of research for the director of the Cavendish Laboratory in Cambridge.[24] Joseph John Thomson wrote a detailed book about the subject that Franck carefully studied. Franck also familiarized himself with publications by other scientists. He even subscribed to the two most important British journals, *The Philosophical Magazine* and *The Proceedings of the Royal Society*. He therefore knew about the publication by the American John Zeleny, reporting success in deflecting ions with a stream of gas and thereby determining their mobility in gas.

Franck recorded his experiments in a laboratory notebook. According to this notebook, he began his preliminary tests on a Thursday in January 1905.[25] He first conducted observations on a visible electric discharge between a fine platinum wire point and a flat plate, using an electrostatic generator to produce a high voltage. Air was then blown perpendicularly to the discharge to deflect the ions mechanically onto an electrode that then measured the electric current. The notebook reveals how systematically Franck proceeded to study different effects, depending on whether the point was connected to the high-voltage generator's positive or negative pole. Warburg listened to Franck's reports about his observations on his regular rounds through the institute but evidently misunderstood him. He assumed that Franck intended to make these results the focus of his thesis. For some reason Warburg was unwilling to discuss with Franck his real goal, which was to clarify the processes he was measuring.

Franck saw no way to calculate the distribution of the electric field between the point and the plate. So he decided on his own to change the focus of the analysis. He replaced the point with a fine wire and the flat plate with a pipe positioned concentrically around the wire. The air current then was directed to blow through the pipe. This arrangement made the field calculable. A number of electrodes connected to a sensitive meter were affixed inside the pipe for measuring the electric current. For most of his experiments Franck used platinum wire 0.05 mm in diameter and the applied voltage was roughly 6,000 volts.

Franck took care to avoid sources of error and discussed the influence of ion diffusion and temperature. After he compared his results with Zeleny's much lower results for the ion mobility, he realized that the ions did not necessarily have to form on the wire's surface. His considerations led him to conclude that not just ions but electrons also were being emitted from the wire. He pointed out that the electrons were not being swept along by the air current but rather traveled straight through it from the wire to the pipe or meter electrode. The electrons were also capable of ionizing gas molecules along their path

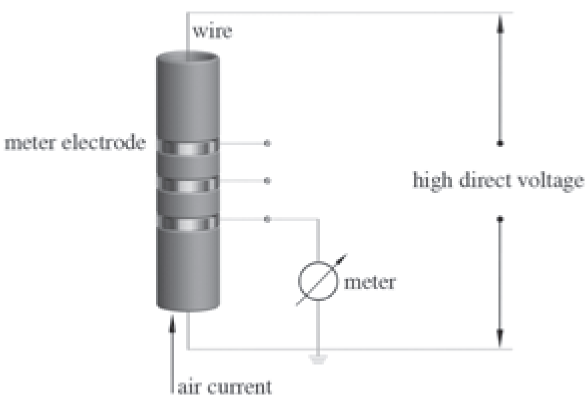


Figure 10 Diagram of Franck's first apparatus arrangement for his thesis.

between the wire and the pipe, in contradiction to the assumption that all the ions formed on the wire. Franck thought about how to remove this difficulty and decided to modify a method that Ernest Rutherford had used to measure ion velocities. Rutherford had used X-rays to excite the emission of photoelectrons, which then ionized a gas. But the ions produced in this way were not uniform in velocity. Franck wanted to measure ions moving at near zero velocity, so he designed an apparatus to meet this condition. The ions were produced within a separate volume before entering the actual measurement volume through a small hole.

In the measurement volume the ions were moved by an applied alternating voltage of known frequency *p* and amplitude *V* between adjustable electrodes separated by a distance *d*. When the ions reached an electrode, the meter indicated a flow of current. Possible sources of error were eliminated here as well. Franck devoted special thought to the possibility that the ions had an initial velocity upon entering through the hole. His new figures for the ion mobility were very close to Zeleny's values. This still did not satisfy Franck, however. He set out to calculate the length of an electron's path in a point discharge. His result contradicted, as he wrote, the often argued conception that electrons occur only in immediate proximity to the point. In a few sentences he speculated further about the process of ionization. With youthful boldness he relied on his own results to present conceptions that were at variance with assertions by other physicists.

The term "electron" appears many times in Franck's dissertation. Toward the end of the nineteenth century a few physicists had suspected that a kind of "electricity atom" must exist. In 1897 J. J. Thomson was experimentally able to measure the ratio *e*/*m* between charge and mass of these "electricity atoms."

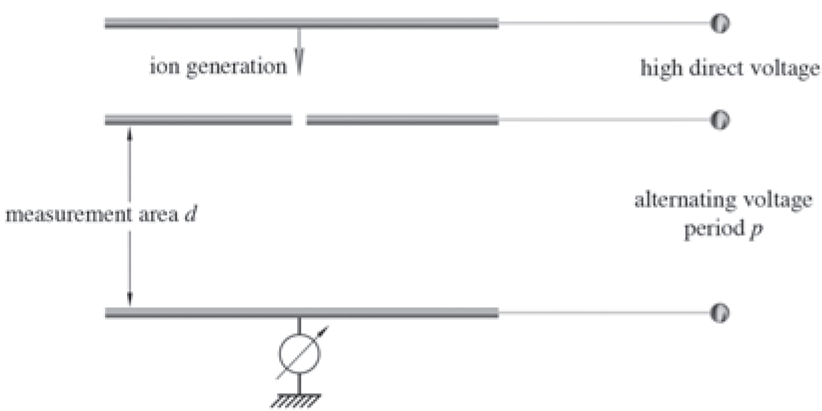


Figure 11 Diagram of Franck's second arrangement for his thesis.
mobility = $p \pi d^2/V$

The mass he obtained was very small, much smaller than anything ever known or assumed before. Thomson called the electron a "corpuscle." Warburg, who knew Thomson well, was not at all convinced by this discovery and initially did not incorporate Thomson's new findings into his own research. Perhaps it was out of consideration for Warburg that Franck refrained from mentioning the electron's small mass compared to ions in his description of the processes involved in the behavior of electrons in air currents. Warburg himself only started using the term "electron" in his publications from 1906 on.

Franck's situation changed in 1905 when Warburg was appointed to succeed Friedrich Kohlrausch as president of the PTR. Paul Drude took Warburg's place at the university. He was 42 years old when he moved from Giessen to Berlin to become a full professor.[26] Drude had proposed an electron theory of electric conduction. He incorporated this theory into his physics lectures, continuing to teach Warburg's course without any formal alteration. Drude also delivered the lectures on experimental physics daily Monday through Friday from noon to one o'clock.

Otherwise, Drude's style as director of the institute lacked the usual authoritarian attitude. When Franck once apologized to him for not wearing his jacket at a meeting, Drude waved it aside with the declaration that it would not even have mattered if he had appeared in his pajamas!

Figure 12 Paul Drude. Deutsches Museum, Picture Archives, Munich.

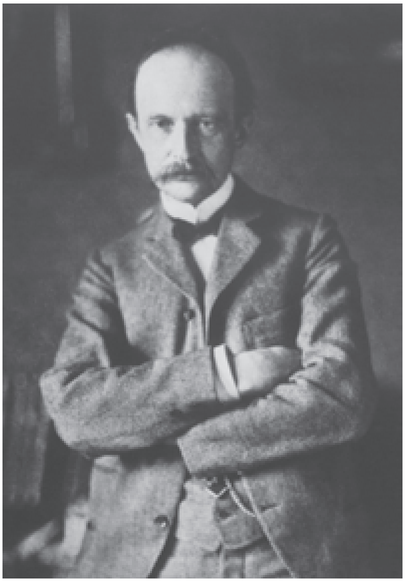


Figure 13 Max Planck. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

On 13 March 1906, Franck applied in writing to take his doctoral examinations with a major in physics and minors in chemistry and philosophy.[27] Drude would evaluate his dissertation as first referee and Planck would be the second. Drude submitted his vote on May 1 with this summary: "The author has mastered the difficulties in a very independent way and devised or modified the methods. Thus he arrived at scientifically valuable results. I therefore recommend granting the dissertation and propose the predicate 'very good.'"

Max Planck gave his approval on May 7. The defense took place on 21 May 1906. Drude took the lead, asking Franck among other things about Coulomb's law, the concepts of an absolute system of units, displacement currents and conduction currents, about measurement of the dielectric constant, reflection of light by metals, Babinet's compensator, the interference of crystal plates, Kundt's arrangement for measuring the speed of sound, saturated and unsaturated vapors, and the fundamental equations of mechanics. In his evaluation he asserted: "The knowledge was not always immediate but it was still [strikethrough in the original] properly there."

The philosopher Alois Riehl tested him on the connections between Locke, Hume, and Kant and about Kant's transcendental proof of causality. His verdict was: "The candidate's knowledge and understanding of the problems was entirely satisfactory."

Max Planck tested his major in physics: in mechanics about the laws of motion, the moment of inertia, Lagrangians; in thermodynamics about equations of state, isothermal and adiabatic compression, saturation laws, the critical point; and in electrodynamics he examined Franck about electric oscillations, self-induction, and resistance. Outcome: "The candidate's knowledge proved sufficient." His last examiner, Professor Gabriel, tested him in chemistry on the processes of qualitative and quantitative analysis with reference to gas analysis. The resulting predicate was "good." Franck received the overall grade *cum laude*. Because the field of physics was assigned to the faculty of philosophy, the final result of these examinations was to qualify Franck for the degree doctor of philosophy. The diploma was issued on June 30. As was then customary, the text of the main certificate was drafted in Latin and "James" was restyled as "Jacob." The dissertation was printed with a dedication to Franck's parents.[28] The obligatory short *curriculum vitae* begins with this statement:

> "I, James Franck, son of the businessman Jacob Franck, was born on the 26th of August 1882 in Hamburg and raised in the Jewish faith."

The wording ordinarily chosen in such a situation would have been: "I am of the Mosaic faith," therefore rather a reference to the teachings of Moses.[29] One can only surmise why Franck chose to use the word "Jewish," which focuses on national heritage. It is possible that his father tended not to use the term

"Mosaic" either. This formulation could have been in deference to his father's religious guidance. Throughout history Jewish parents followed a broad spectrum of maxims for rearing their children, just as Christian parents did. James Franck left no written record of whether or not Jacob Franck had transmitted to his eldest son a pious sense of being God's creature on earth and therefore responsible for this world. But his actions point to this in more than one instance.

Mourning overshadowed the joy of his achievements, however. On July 5 Paul Drude took his own life. The members of the faculty were deeply shaken. No one had noticed how overwhelmed Drude had been with the many responsibilities he dutifully felt he had to carry out.

Franck spoke at his grave in the name of his fellow students. Mrs. Drude wrote him afterwards:[30] "The affectionate words you expressed by the bier deeply moved my heart. It is a consoling thought for me that you, too, had been so dearly attached to him."

After taking his school exams, Franck had been able to postpone his military service. Now he was required to serve for a year. On 1 October 1906 he was assigned to the signal corps in the radio division of the First Telegraph Battalion. The recruits were supposed to receive training in wireless telegraphy. They therefore had to learn some physics, but the nonsense presented to them was an ordeal for Franck to endure.[31] In December, a minor accident on horseback saved him and he was discharged as unfit for duty.

CHAPTER 3

Research on the Atom

With an accredited dissertation in hand, Franck, barely 24 years of age, had a number of different career options. His own experiences at school dissuaded him from choosing the profession of upper-school teacher. New alternatives now existed for him, however. Research establishments had been developing within the electrical industry, and there were many such firms in Berlin. One younger physicist from the Helmholtz school, August Raps, already was employed at the electrical firm Siemens.

There were numerous applied-physics-related problems to solve, whether in the field of incandescent lightbulb development or improvements in telephony. Even electrochemistry offered tasks for a physicist; and other applications were in the offing. In 1906 Robert von Lieben, a Viennese private scholar, presented to a select group of scientists in Berlin a vacuum tube with three electrodes capable of amplifying weak currents. It was not yet foreseeable that this advance would trigger a technical revolution. It made radio transmission feasible as well as amplification of voltages and currents previously too small to measure.

Franck decided, however, to embark on an academic career. He had perceived no prejudice against devout Jews at the colloquium or among his fellow students. Indeed, renowned professors like Heinrich Rubens at Friedrich-Wilhelms-Universität and at the polytechnic were Jews. Franck was not compelled to take too seriously his father's warning that there might be obstacles to prevent him from becoming a professor. His own drive as a researcher determined this decision.[1] Franck's course in life shows how strongly his desire for scientific knowledge dictated his actions—even in old age. It also enabled him to inspire his students and whet their appetites for the quest for scientific knowledge. Whenever he encountered situations that prevented him from satis-

Figure 14 Heinrich Rubens. Physikalisch-Technische Bundesanstalt, archive, Braunschweig.

fying his urge to do science, he was able to turn down a new path. This pattern recurs at every pivotal point in his academic career.

Franck accepted an assistantship at the Physikalisches Verein in Frankfurt am Main for the summer semester of 1907. This Hessian city had no university of its own yet. But he was not at all happy there, and with Robert Pohl's help Franck was able to return to the university in Berlin and fill another position as assistant.[2] The faculty chose Heinrich Rubens to succeed the deceased Drude. Rubens had studied, taken his doctorate, and qualified for academic teaching at Friedrich-Wilhelms-Universität.[3] From 1900 he had taught as professor at Charlottenburg Polytechnic, on the outskirts of Berlin. His experiments in the area of long-wave infrared radiation had been performed at the neighboring PTR because physicists at the Polytechnic had yet to obtain research facilities of their own. Shortly after Rubens's university appointment, Max Planck nominated him as a regular member of the Royal Prussian Academy of Sciences. Despite his intensive research and teaching duties in science, Rubens was able to find the time to build his own sailboat to navigate the waterways of Berlin.

At Rubens's institute Franck had no difficulty finding a chance to do scientific research, even though the field he chose to work in—the interaction of electrons with gases—had nothing to do with Rubens's own interests. The two other assistants, Gustav Hertz and Robert Pohl, lived in the institute building. It is said that one day, at half past ten in the morning, Rubens rapped on Pohl's door to say: "I beg your pardon, Herr Doktor, would you please get up? The students are already in the practicals room!"[4]

Otto von Baeyer was another member of the institute.[5] He also was interested in problems concerning ionization and was verifying Philipp Lenard's requirement of about 11 volts for the ionization of gases. Von Baeyer used a different technique to generate electrons than had Lenard. Instead of producing the electrons by emission from a metal plate by the photoelectric effect, von Baeyer used the glow cathode invented by Arthur Wehnelt, with its glowing platinum filament in a vacuum. Upon the voltage threshold for "ionization" he could observe a current because positive charges reached the external cylinder.

However, von Baeyer's results did not yet lead to a correction of Lenard's data. Three years later Franck would devote himself to this problem and employ von Baeyer's method. At the moment, though, he was still making a start on his academic career.

The first essential step toward a professorship was the postdoctoral degree, the *Habilitation*, qualifying for academic teaching. Either the results of a single major research project or a number of important publications were submitted. Franck alludes to his choice of research approach in an obituary of Heinrich Rubens that he coauthored with Pohl. It is not possible to reconstruct exactly who wrote which passages, but the following excerpt could well serve as a description of Franck's own style of research:

> The first of these [paths] takes into account the conceptual approach of a theoretical physicist insofar as it must endeavor not to come into natural conflict with it but

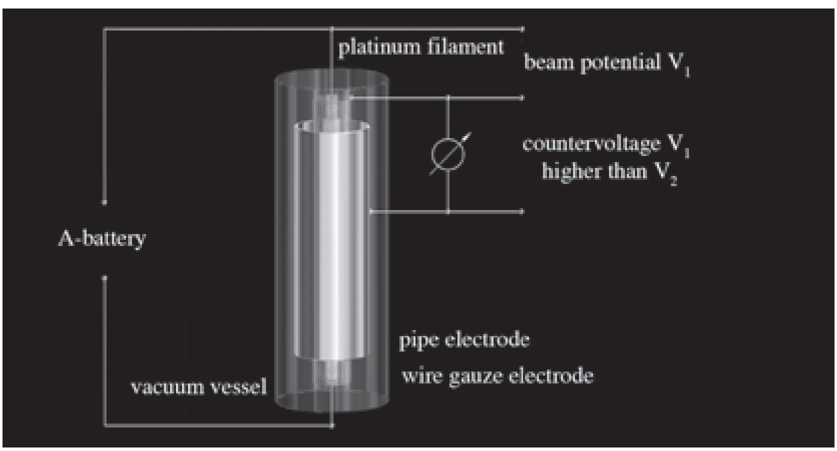


Figure 15 Otto von Baeyer's arrangement.

otherwise seeks to find new facts by purely experimental means without the intention of incorporating the individual experiment within a larger general theoretical complex. We owe many unanticipated discoveries to this kind of research orientation but it also produces much wasted energy. The second type of experimental investigation is undertaken in order to analyze a theoretically based conception of the world, to test it against experience, to confirm or refute it. It could thus appear to be a mere handmaiden of theoretical physics, a lower-ranking science; this is false. This kind of experimental research does not blindly follow assignments set by theory but draws consequences out of it and therefore it mostly forges well ahead of the mathematically theoretical study of the field.

Without exception Franck always followed the second route, and in most cases he was also the one to develop the theoretical idea according to which the experiments were designed. These theories were not mathematically formulated, however. Franck had a knack for imagining possible physical processes at the atomic level. Initially his ideas were vague and the terminology of the concepts employed unclear. The results of his dissertation made him realize how many problems in the field of ionization still remained to be clarified. His talent particularly predestined him for this field. He was able to escape a potentially long search for a promising topic for his habilitation thesis as so many problems in physics remained to be solved. The nature of X-rays, for example, was still unknown. What were β-rays, the emissions of radioactive elements? Was there such a thing as an atomic nucleus?

By 1914 Franck had published 34 articles. On some he was listed as sole author, but most were coauthored: one with Lise Meitner and one with Eva von Bahr, the rest with other Berlin physicists and Robert Williams Wood, a frequent visitor from America. There were nineteen publications with Gustav Hertz on experiments and analyses about ionization and related phenomena.

This way of publishing was generally chosen only by full professors whose doctoral students, who had frequently performed the actual research, would figure merely as coauthors. The only contribution by the professor was the topic and a few instructions. This was not Franck's way. He liked to conduct his experiments with someone with whom he could also discuss the details of the results. It was during such discussions—even when the other person was only passively involved—that Franck developed his ideas. Later, as a full professor, he consented to being named coauthor only if he had contributed substantially to the research as well.

The first two publications to appear after his dissertation were coauthored with his university classmate Robert Pohl. As a student Pohl had made a new discovery while experimenting. This had deeply impressed Franck. He was delighted to see that it was possible for even young scientists to discover something. The topic analyzed with Pohl regarded measuring the mobility of ions in noble gases.[6] These gases are monatomic, i.e., they consist of atoms, not molecules like oxygen or nitrogen. The apparatus had to be designed on a very small scale because the noble gases, especially helium, were very expensive and could be obtained only in small quantities. Franck and Pohl also wanted to measure ions of both polarities. So they modified Rutherford's method slightly again. The ions were generated by a small radioactive sample. The actual mobility measurements were carried out by the same method employed in Franck's dissertation, the alternating voltage method. They managed to obtain useful results.

The subsequent research was of an entirely different problem: the propagation velocity of X-rays.[7] The resulting paper was a detailed critique of the method employed by another physicist, Erich Marx in Leipzig. This topic was probably chosen at Pohl's request because he was considering submitting a habilitation thesis on "Roentgen rays" and was working on the unsolved problem of measuring their propagation velocity. The central piece of their apparatus was a detection device for photoelectric emissions from a metal. Franck and Pohl identified an error in Marx's arguments as well as in the way the device was functioning. They performed a few more experiments and dared to contest Marx's findings. Marx sharply rejected their results, and arguments and counterarguments volleyed back and forth between them. Marx "had the last word" in this exchange even though the scientific issue itself remained unresolved.[8]

Then Wilhelm Westphal became Franck's partner.[9] He, too, came from Hamburg, where his father was a respected tea dealer, and he, too, had taken his doctorate under Warburg. They conducted more experiments on ions, but more questions remained open than were resolved. They conscientiously checked their results against theories postulated by other scientists and discussed them.[10] This would not be the last time that Franck collaborated with Westphal. Most of their papers were published in the proceedings of the German Physical Society, whose membership included many Berlin physicists. Franck spoke to those assembled on 4 March 1910 about ion mobility in argon and how small amounts of oxygen influence it.[11] He had analyzed a mixture of a monatomic gas—argon—and a diatomic gas—oxygen—using the modified Rutherford method. He hoped to explain Warburg's general observations about the influence of oxygen on a mixed gas in point-discharge experiments. The results that Franck obtained were so strange, though, that none of the known theories were able to explain them without recourse to special assumptions. He found that even small impurities had a strong influence on the results. Again he had to assume free electrons in order to understand large mobilities, and in the case of small mobilities he assumed that an electron had "aggregated" with an atom. New results were promptly presented to his fellow members on May 13.

Figure 16 Dr. James Franck. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

The next coauthor was eleven years his senior.[12] Arthur Wehnelt probably invited Franck to collaborate with him. Having earned his doctorate under Eilhard Wiedemann, Wehnelt received an appointment at Friedrich-Wilhelms-Universität in 1906 to relieve the full professor of the practicals and physical laboratory work. In 1903 Wehnelt had invented the oxide cathode, which generated considerably stronger streams of electrons than existing apparatus had. Two years later he introduced the oxide cathode as the electron source for a cathode-ray oscillograph, and in 1908 he invented the electrostatic focusing cup for creating electron beams, now known as the Wehnelt cylinder.

He and Franck tried to find out whether Faraday's law concerning the transfer of mass in electrolysis applied to the transfer of mass in a gas discharge. They assumed that in a gas discharge at sufficiently low pressure, the almost massless electrons were the negatively charged corpuscles and the heavy gas ions were the positive charges. Johannes Stark had attempted similar experiments in 1904, but his measurements had not taken sources of error sufficiently into account. Franck and Wehnelt carefully repeated these experiments with superior apparatus, but they were unable to solve the problem definitively.[13]

The following papers were signed by Franck alone. In March 1910 he published his results on ion mobility in argon to which small amounts of oxygen had also been added. Again he had to admit failure in arriving at any final conclusions; again he had to presume freely moving electrons in the gas.[14] A number of other physicists, including Lenard and Stark, were also working in this field, attempting, partly theoretically and partly experimentally, to decipher the process of ionization even though no useful conception of the atom existed yet. It was not known how exactly it was composed of negative and perhaps also of positive particles. The differing physical terminology used by these authors only complicated comparison of their various results. In mid-1910 Franck published the outcome of his latest analyses. He conceived free electrons as occurring in noble gases at atmospheric pressure. He realized that negative ions do not form in very pure gas samples and consequently the effects of free electrons could be isolated. This insight opened the way to understanding how an electric discharge is initiated, but he was not yet willing to relinquish the idea that electrons attach themselves to gas atoms. Modern theory of electric discharges holds that the free electrons in a gas, which are constantly being formed by cosmic radiation and radioactivity, accelerate in an electric field and generate ions and other electrons.

The Beginnings of an Academic Career

Franck now had enough publications to apply for a cumulative habilitation. On December 16 he petitioned "most humbly for certification," submitting eleven articles. He asked Professors Wehnelt, Rubens, and Planck to evaluate them.[15] Wehnelt submitted his vote on 20 May 1911. It opens with the lines:

> The majority of the papers Mr. Franck has submitted involve the mobility of gas ions, which indicates a certain one-sidedness in his experimental experience. However, the results he reaches are of such great importance for the entire theory of ionization in gases that I decided nonetheless to apply for his certification, the more so since I have come to appreciate Mr. Franck's knowledge and expertise from working together with him on another occasion.

Wehnelt then reviewed Franck's submitted papers and pointed out in particular the apparatus for helium. The joint publication with Westphal also received praise. Rubens and Planck agreed with Wehnelt's recommendation. When Franck gave his required trial lecture, he was glad that Walther Nernst did not make an appearance because his criticism could have been dangerous. Franck's diploma certifying him as an academic teacher bears the date 20 May 1911.

The regulation on private lectureships obliged Franck to give lectures. He began in the winter term with one-hour lectures on Tuesdays from ten to eleven. The topic was: selected subjects in electron theory.[16] His friend Pohl offered a course on recent electrical and optical analyses. Franck taught the same subject during the winter term of 1912–13. Private lecturers were required to teach courses on specialized areas. This broadened the choice of courses without the state having to provide any compensation, yet such electives did not rob the professors of fee-paying auditors at their more fundamental lectures.

The next year was filled with experiments in what at first glance appears to be an entirely new direction for Franck. His investigation with Pohl on the velocity of X-rays was not the only time that Franck ventured away from his focus on ionization. Professor Robert Williams Wood from Johns Hopkins University in Baltimore came to Berlin in 1911 to spend his sabbatical doing experiments.[17] Wood was a brilliant experimental physicist of the first order, as Franck later described him (in his obituary on Rubens). Wood did not think much of mathematical computations, however. In Berlin, Wood worked on the fluorescence of vaporized iodine. Fluorescence had already attracted the interest of physicists in the nineteenth century. At that time the phenomenon could merely be observed. There were no useful theories about vapor excitation by light, but, more importantly, experiments on pure gases with carefully measured compositions became feasible with apparatus developed toward the end of that century.

Franck knew about Einstein's ideas regarding the photoelectric effect and the equation $E = h \cdot \nu$ (E is the energy of a photon of light at frequency ν with h Planck's constant). For Franck, exciting an element in the vaporous state to luminesce by irradiating it with light was a fascinating new experimental field. The influence of the electrodes in an electrically excited glow discharge was eliminated. That had various advantages. He would later very successfully apply the irradiation process to explain the excitation of molecules. The experimental apparatus he and Wood used was simple.

They measured the intensity of the fluorescent light from iodine vapor as a function of the pressure exerted by different added gases. It turned out that the admixed gas's affinity for attaching electrons determined the damping of the fluorescent light. They also found that, as the pressure rose, the wavelength of the fluorescent light changed from green to red. Their theoretical explanation was a rather groping attempt at understanding what was happening to the atoms. But Franck's interest had been aroused, and so the effect underwent more thorough scrutiny. The focus of the excitation was the green mercury line and the color change was observed with a spectrograph. Photographic plates served to document the results. The very different color sensitivities of the various types of plates had to be taken into account. They found changes that were difficult to interpret. Besides the resonance lines of the vaporized iodine they also observed a band spectrum, a series of extremely closely lying lines. Such bands are spec-

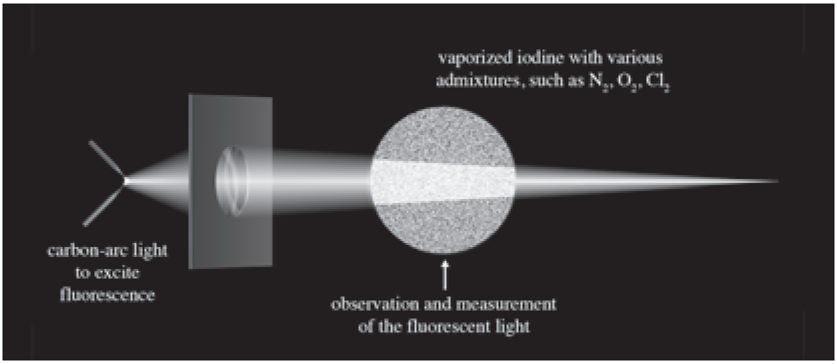


Figure 17 Schematic arrangement for observing and measuring fluorescent light.

Figure 18 In the garden at the institute. Far left, half obscured Fritz Reiche; James Franck seated in the middle under the lamp; sitting beside him Robert Pohl; far right, Wilhelm Westphal. Wilhelm Westphal collection. By courtesy of Wilhelm Westphal.

troscopically observable upon electrical excitation of gases like nitrogen N_2.[18] The theoretical explanation that Franck and Wood offered for these observations was remarkable: they assumed a transfer of energy from the primary excited system to another system. (Franck would later figure out how this process works.) Another, longer version of this paper appeared in English by Wood in *The Philosophical Magazine*. Wood returned to America, but their collaboration would be resumed for a short time twenty years later in Baltimore.

In those days, experiments often continued into the night. The doors at the institute stood ajar and there was much to and fro between the laboratory benches and plenty of discussion about the latest results. The physicists helped each other out with their measurements. The mood was often cheerful, with singing and whistling accompanying the experimenting. Rubens occasionally heralded his approach by singing a melody from one of Beethoven's works. There were breaks in the intense work from time to time as well. The young physicists would sit down together in the garden of the physics institute for a chat. One of them took photos of such an evening get-together around a long table.

There are no accounts about whether any of Franck's coworkers ever invited him to join their private family events or to come over to dine. Among the older generation of Protestants it was customary for the host to say a prayer before the meal could begin while everyone else present, even the servants, piously folded their hands. Guests would naturally join in, but a devout Jew could, of course, not. It was a moment of alienation and the only occasion in their middle-class lifestyle in which the issue of faith necessarily rose into the consciousnesses of both parties.

In Peter Pringsheim, Franck found a new collaborator for studying the electrical and optical behavior of the chlorine flame.[19] Pringsheim was a year older than Franck and had studied at Munich, taking his doctorate under Röntgen. Franck would collaborate with Pringsheim again decades later. Now their joint effort was limited to a single publication that was somewhat off the beaten path.

The analysis with Dr. Meitner was more closely related to the problem of ionization.[20] The Australian applied mathematician Edward Montague Wellisch had contended that ion mobility depends on the mass. Experiments did not prove this, but Wellisch assumed that the ion's charge temporarily transfers onto a neutral molecule. Franck questioned this. Lise Meitner was able to apply her experience with radioactivity and brought along a thorium C sample. Their measurements exploited the recently discovered effect of radioactive recoil to trace the mobility of the heavy ThC ion.

The motion of ions in an electric field can be compensated by a stream of gas in the opposite direction. Only a molecule can be displaced by a stream of gas, however, not an electron. The results of Franck and Meitner's measurements refuted the theory that Wellisch had proposed.[21]

Lisa Meitner had come to Berlin in 1907 in order to improve her knowledge of theoretical physics under Planck's guidance. Her teacher in Vienna, Ludwig Boltzmann, had passed away and she had not received an assistantship in Germany. In search of an opportunity to conduct experimental work, she applied to Rubens and was offered a position in his private laboratory. Being too shy, she declined, and so Rubens advised her to speak with the young chemist Otto Hahn, who was looking for a collaborator conversant in physics. Lise Meitner had already published two papers on radioactivity in Vienna, and her knowledge nicely complemented Hahn's. They established what was, for the time, an unusually equal and successful collaboration between the genders.

Franck must have met Lise Meitner at the colloquium. A friendship soon developed between them. Lise would visit the Franck couple at no. 38 Wielandstraße in Charlottenburg, a suburb of Berlin. Coming from a musical family,

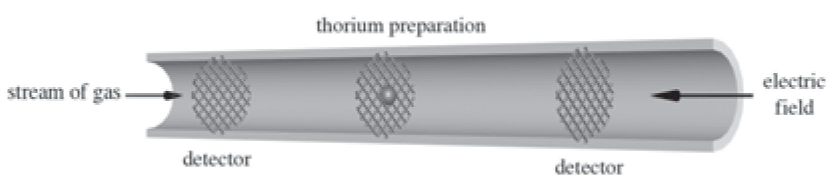


Figure 19 Schematic arrangement of the experiment by Franck and Meitner.

Figure 20 Lise Meitner. By courtesy of the Master of the Fellows of Churchill College, Cambridge. Churchill Archives Centre, Lise Meitner Papers, MTNR 8/4/17.

she occasionally brought along sheet music and introduced them to songs by Brahms. Although Franck had long since abandoned playing the violin himself, he still loved to go to concerts. On one of these occasions he had met a young Swedish lady, a trained pianist of his own age, with whom he became very close. His wedding with Ingrid Josephson took place in Göteborg on 23 December 1907.[22]

The Josephsson family had been living in Sweden for generations. Ingrid had three sisters and two brothers. Her mother's family, the Delmontes, originated in Portugal. The Josephssons were practicing Jews. Rabbi Dr. Vlogh conducted the Francks' marriage ceremony according to Swedish law. A small, unadorned handwritten sheet of paper was their marriage certificate. Contrary to Jewish custom, the pair went away on a honeymoon.[23] Franck's wedding gift for his bride was a Steinway grand piano. Their parents still had to provide for their livelihood, but there was no doubt that Franck would receive an academic post within the foreseeable future.

In 1909 the first child was born, a daughter, Dagmar—Daggie for short. In 1912 the second girl, Elisabeth, arrived and came to be called Lisa. Franck's father, Jacob, had given up his banking business and moved to Berlin with his wife. They resided at no. 19 Berliner Straße in Charlottenburg. James's sister, Paula (called Lotte), had come to the capital when she married the engineer Martin Kallmann, who was responsible for the municipal electrical system; but she became a widow soon afterward. The couple had a son called Heinz. Franck's brother, Robert, had studied law and was living in Munich but was having difficulty establishing himself in his profession.

Figure 21 James Franck with his wife. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Figure 22 Mrs. Franck with Daggie as a baby. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

The year 1911, the centenary of Friedrich-Wilhelms-Universität, gave an opportunity for pomp and ceremony in true *Kaiserreich* style.[24] Guests came from abroad to laud the university and German science. It culminated in a ceremony in the main auditorium with a speech by the kaiser, Wilhelm II. This speech had been written in close consultation with Adolf von Harnack and the minister of culture, Friedrich Schmidt-Ott. The press differed in its appraisal of the events. *Der Deutsche Reichs- und Staatsanzeiger* reported on October 12:

> Before the [university] building stood an Alexandrian guard of honor. In the spacious vestibule banner-bearing emissaries of the student associations formed a lane in full regalia.
>
> [. . .] Around 10 o'clock the professors of the university progressed by the tune of a march. The beadles foremost with the scepters. Soon thereafter the fanfares sounded, drifting off into the old student melody "Sing in festive jubilation" and ending with "Gaudeamus igitur" [Let us rejoice]. The court entered. Received and guided by the rector Privy Government Councillor Professor Dr. Erich Schmidt, Their Imperial Highnesses and Royal Majesties neared.

The kaiser began his address with a greeting and his congratulations to the university, continuing:

> Since the days of her foundation, her fate has been intimately linked with that of our Prusso-German Fatherland. When my ancestor King Friedrich Wilhelm III, God rest

his soul, called her to life a hundred years ago, it was done to return to the State the powers of intellect in exchange for what it had physically lost.

Der Börsencourier had a more critical view of the proceedings but then praised the kaiser's speech:

There has been no lack of critical voices directed against an overly courtly and overly professional, officious character for the jubilee of the University of Berlin.

Yesterday's address by the Kaiser has put this pessimism to shame. The high intellectual plane on which it stood kept it aloof from all partisan bickering.

About the development of science in the future, the kaiser stated:

Meanwhile Humboldt's plan, reaching beyond the university to encompass the totality of all scientific endeavors, has not yet become reality and this solemn hour seems to me especially suited to initiating the completion of what he had envisioned as the final goal.

In addition to the Academy of Sciences and the University, his grand plan for science called for independent research institutes as integral members of the whole scientific organism. Founding such institutes in Prussia has not kept pace with the development of universities; and this lacuna, specifically in our scientific facilities, is becoming ever more perceptible as a result of the mighty progress in science. We need establishments bound to vital research extending beyond the sphere of higher education and unhampered by the purposes of instruction, yet in close touch with the Academy and the University. Calling to life such research sites as soon as possible seems to me a holy obligation of the present day and I deem it my patriotic duty to raise general interest in these enterprises.

The research sites alluded to were granted the right to bear the kaiser's name. German industrialists in the chemical sector had frequently pointed to obstacles barring long-term research at universities. In order to be able to devote more time to research, some full professors were asking to be relieved of their lecturing and time-consuming examination duties. (At that time all examinations were conducted orally and individually.) Friedrich Althoff at the Prussian Ministry of Culture already had been devising plans in 1900 to found independent research institutes (to become elements of the Kaiser Wilhelm Society for the Advancement of Science, officially founded as a registered association) and Althoff had solicited proposals. The physicist Philipp Lenard was among those approached. The university jubilee was seen as a good opportunity to raise funds in the kaiser's name for such off-campus research institutions. Donations of more than 8.6 million reichsmarks (RM) were raised. Two institutes were erected in the middle of meadows in the Domain of Dahlem near Berlin. The Kaiser Wilhelm Institute of Chemistry, in which Otto Hahn obtained a department for radioactive research and in which Lise Meitner started to work as a guest researcher without pay, was one. The other was the Kaiser Wilhelm

Institute of Physical Chemistry and Electrochemistry directed by Fritz Haber. Haber was a physical chemist who had done fundamental research together with Robert Le Rossignol in Karlsruhe on synthesizing ammonia from nitrogen and hydrogen. Their success opened the way to the production not only of artificial fertilizers but also of explosives.

Nothing changed for the university itself following its centenary celebration. Its institutes suffered from a chronic shortage of space in the built-up center of town. There was no room left for new buildings. In any case there was no money for new construction. Highly esteemed though a professor's position was, especially a full-time *Ordinarius*, his assistants could barely earn enough to rent a furnished room. A private lecturer without an assistant's wage or other income usually could not survive on the attendance fees he gathered from his handful of students.

Important Experiments on Quantum Theory

Until 1900 physicists always took for granted that all physical quantities varied continuously. This even applied to thermodynamics, the focus of physics in the second half of the nineteenth century. Measurements of the energy distribution of radiation from a glowing body as a function of wavelength, as Heinrich Rubens was doing at the PTR, yielded curves that indicated a maximum. Some theoretical physicists tried to find a mathematical expression, a formula for these curves, but for some puzzling reason it never completely worked. Willy Wien devised an equation in 1896 that described the curve quite well except for the long-wavelength section of the spectrum.[25] Max Planck was also working on this problem. The solution that he presented in December 1900 at a meeting of the Physikalische Gesellschaft yielded a perfect fit to the experimental curve—but at a price. Planck had to let the radiation be emitted in very tiny packets of energy instead of having it dissipate evenly in continuous amounts. It was "chopped up" or "quantized." Planck referred to an "atom of action [*Wirkungsatom*] $E = h \cdot \nu$," where ν is the frequency of the light. The new quantity h became known as "Planck's constant."

Planck's quanta of energy were a break with the conceptions held by physicists up to that point about the laws of nature. Most of his colleagues were extremely hesitant to accept his conclusion. One major open question was this: Is the quantization only connected with radiative processes? Does it affect atoms at all? Many physicists still did not believe that atoms really existed. A paper by the Austrian Arthur Erich Haas in 1910 providing a first quantum interpretation of the atom was dismissed as an "April fool's joke." Planck's discovery of this natural constant h, however, soon led to other fundamental insights, to which Franck also contributed.

Analyzing atomic behavior is fundamentally different from other research in classical physics. Nothing that happens to the atom is actually "seen." The behavior of atoms can be inferred only indirectly, through deflections of a needle and other measurement data. Franck had already accustomed himself to this kind of research while working on his dissertation. So his published results do not even pose the question "What precisely did I measure?" Other physicists also did not ask this question. It was only much later that this became a fundamental problem in arriving at a proper understanding of atomic physics.

Heinrich Rubens allowed his assistants enough free rein to choose their own special topics. He was convinced that scientific research formed a part of their official duties. That was why few of his assistants participated in his very specialized research projects. Rubens was experimentally exploring the gap between Heinrich Hertz's radio waves and thermal radiation. Gustav Hertz,[26] Heinrich Hertz's nephew, probably felt obliged to contribute to this field and chose it for his thesis. Gustav had originally wanted to study mathematics, but his classmate Westphal had thought he really ought to study physics and had recommended the University of Berlin.

After another joint project with Westphal, Franck had to look around for a new collaborator because Westphal wanted to start some research on his own. Franck approached Hertz about whether he was interested in working on ionization in gases. The subsequent collaboration between the two young physicists quickly developed into a lasting friendship.

Figure 23 Gustav Hertz at his desk in the physics institute. Wilhelm Westphal collection. By courtesy of Wilhelm Westphal.

The interactions between electrons and atoms were not yet sorted out, and the physicists in Berlin were discussing many hypotheses. New experimental results suggested reinterpretations. Pohl and Pringsheim were working together on the photoelectric effect on a metal surface.[27] They discovered a resonance effect upon polarization by light orthogonally incident on the surface. Was an electron oscillating in resonance with the incident radiation? Friedrich Lindemann took up this question and speculated about electron motion.[28] "The assumption is surely more probable that electrons can be excited by light oscillations to rotate around positively charged ions along elliptic paths." He formulated an expression for the resonance frequency that contained Planck's quantum of action.

For the previous five years Franck had gathered enough arguments to risk the step of postulating new ideas about the process of ionization. Gustav Hertz's talent for mathematics would prove important in later abstract formulations, but their individual contributions to their joint papers are not easily isolated. The coauthors indicated their theoretical goal immediately in their first paper, received by the publisher on 31 October 1911 and presented at the meeting of the Physikalische Gesellschaft on November 3. The topic of Franck's talk was a link between the quantum hypothesis and the ionization potential.[29] By way of introduction he noted that for the most part, only indirect determinations of ionization had been offered that were "based on not always secure hypotheses and simplifications." Likewise, in many experiments, the energy of electrons ionizing atoms is much larger than necessary. Direct measurements by other physicists differed quite widely. Franck and Hertz took up Lindemann's idea but applied the data from a selective absorption of radiation by the gases. They calculated the minimum energy needed to separate an electron from an atom or molecule. They believed there must be a connection between the radius of the atom and this ionization potential but had to confess that this was purely hypothetical.

Subsequent to publication, they noticed that Johannes Stark had already performed a similar calculation in 1908–09. He had assumed that in a collision between electrons and an ion or atom, the resonators located on it are excited to oscillate. He had correlated the energy of the colliding electrons, Planck's quantum of action, and the spectral-line frequency.[30] Franck wrote Stark to apologize for having omitted to cite him and informed him that a correction would appear. Stark recognized the quality of Franck's research and invited him to write a report about ion mobility for the *Jahrbuch der Radioaktivität und Elektronik* he was editing. This article eventually appeared in 1912. It was a comprehensive survey of ninety publications by other authors.[31]

Figure 24 Gustav Hertz in the laboratory. Wilhelm Westphal collection. By courtesy of Wilhelm Westphal.

The first experimental research that Franck and Hertz worked on together concerned a direct determination of the mean free path of gas molecules. The example they chose was hydrogen ions as a function of pressure. The free path interested Franck and Hertz for their considerations about collisions of free electrons and gas molecules. They used an incandescent spiral of platinum to generate the ions.[32] Their results agreed well with known values. The publication closed with the desideratum: "Furthermore, we would like to find out the energy loss upon collision, which would appear to be of importance for the theory of collision ionization."

On the basis of this experience, they set out to determine as exactly as possible the ionization potential with slow electrons. An incandescent platinum wire was chosen as the electron source. Otto von Baeyer had used an arrangement of three concentric electrodes. Franck and Hertz decided to use the same setup. Why they did not conduct these experiments together with von Baeyer can only be guessed. It is possible that von Baeyer was already engaged in research with Lise Meitner and Otto Hahn on the energy spectra of β-particles.

Franck and Hertz had a narrow room at the institute within which they performed their experiments with only a few pieces of equipment: three storage batteries, a few adjustable resistors, and a few voltage and current meters. There was barely enough counter space; the mercury manometer for measuring the gas pressure stood on the floor. They placed the rotating mercury vacuum pump somewhere underneath the counter. Every conceivable precaution was taken to avoid sources of error. Von Baeyer had used electrodes made of brass; Franck and Hertz chose the precious metal platinum. Instead of using the standard wax seals, they fused all the electrodes directly into the glass inside the vessel with metallic safety rings for grounding.[33]

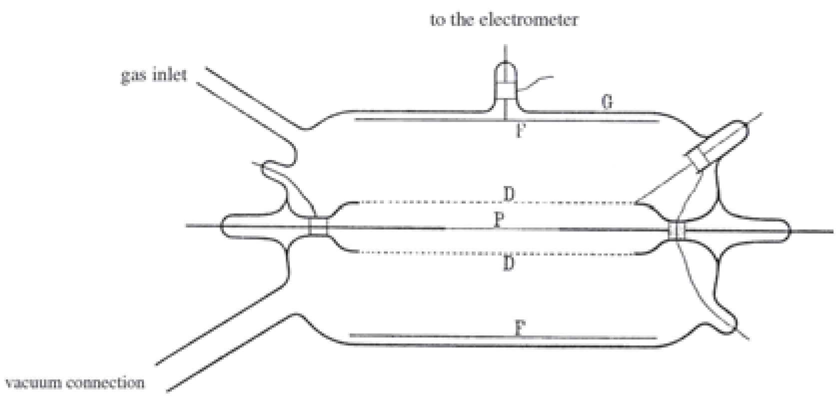


Figure 25 Diagram of the fused tube. P platinum wire; D wire gauze electrode; F cylindrical electrode; G tube. The accelerating tension for the electrons lies between P and D, the countervoltage between D and F. From: J. Franck & G. Hertz: Messung der Ionisierungsspannung in verschiedenen Gasen. *Verh. Dt. Phys. Ges.* 15 (1913), pp. 34–44.

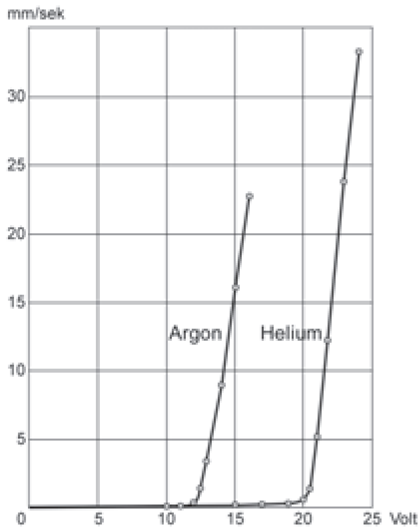


Figure 26 Graph of the current as a function of the acceleration potential for argon and helium. From: J. Franck & G. Hertz: Messung der Ionisierungsspannung in verschiedenen Gasen. *Verh. Dt. Phys. Ges.* 15 (1913), pp. 34–44.

The outside of the vessel was shielded by a metal screen that was likewise grounded. Sometimes the entries written in the laboratory notebook were by Hertz, sometimes, less comprehensively and carefully, by Franck. Hertz enjoyed drawing humorous sketches, and a buxom beauty made an appearance among the data. In one instance, their discussion about how fast their measurements were progressing was duly recorded.[34]

Their publication on measurements of the ionization potential in various gases specified that:

> [f]or the measurement the glow wire was kept at a constant potential of +10 volts. In this way it was possible for the electrons emitted from the glow wire to first be accelerated through a potential difference of V and then to enter a retarding field through the wire gauze. As this field was always 10 volts higher than the accelerating one, the electrons never could hit the receiving cylinder. On the contrary, a charging of the electrometer was required, and specifically a positive charge, for the electrons to produce positive ions in the space between wire gauze and receptor cylinder.

The ionization potentials they obtained were:

helium: 20.5 volts
neon: 16 volts
argon: 12 volts
hydrogen: 11 volts
oxygen: 9 volts
nitrogen: 7.5 volts

More details were given about the correlated ionization potential obtained using Lindemann's formula, but later experimental results would indicate the formula was not correct. Then the authors looked into the future:

"Above all, monatomic vapors of mercury and the alkali group should be examined."

But the time was not yet ripe for an analysis of vaporized mercury. The next experiment first concentrated on clarifying what takes place when a gas molecule collides with a slow electron.[35] An apparatus similar to that used before was required, but the distance to the outer electrode had to be adjustable in order to be able to change the length of the path an electron had to traverse. Their measurements had to be extremely precise in order to be able to say anything about the exchange of energy during a collision.

Physicists still differed about electron structure. The kinetic theory of gases, designed primarily by Ludwig Boltzmann, assumed that gas molecules act in a similar way to billiard balls. Upon collision with a larger mass, like a solid wall, they rebound according to the laws of mechanics and lose practically no kinetic energy. Collisions with a smaller mass, like another molecule, lead to energy loss because of the recoil of the struck molecule. Atomic structure, too, was still unclear. Ernest Rutherford decided to dedicate himself to the study of radioactivity. From measurement data obtained by his coworkers Hans Geiger and Ernest Marsden on the scattering of α-rays off gold foil, he computed the diameter of a positively charged atomic core. But the arrangements of the electrons around or inside this core were unknown.

The Englishman John S. Townsend postulated a theory of impact ionization in which he assumed that all collisions between electrons and gaseous atoms are inelastic. In order to ionize, electrons have to gather the necessary energy as they traverse an electric field without losing it along the way in collisions with gas molecules. In ionization, an electron is dislodged from an atom. The liberated electron is likewise accelerated in the field and capable of ionizing in turn. Thus an avalanche of electrons is formed in a gas discharge.

Earlier experiments had already led Franck to doubt Townsend's first assumption. But he had not questioned Townsend's second posit about the avalanche formation and his calculation of the total current for the gas discharge. Using apparatus with a repositionable electrode that otherwise left the direction of the accelerated electrons essentially unchanged, however, Franck and Hertz found that every collision between helium and slow electrons led to reflection of the electrons. The energy loss suffered by the electrons could not be determined very precisely, but it lay under 0.3 volts at an acceleration potential of 10 volts. The collisions were therefore somewhat elastic. It clearly demonstrated that Townsend's first assumption was wrong.

They were at the point of completing their experiments when Lenard published a theoretical paper about electron conduction; but they could not concur with his conclusions. Barely three months later they submitted a second paper in which they were able to develop and strengthen their own hypothesis with measurements taken of hydrogen and oxygen.[36] They agreed that if a gas has a strong affinity for electrons, then energy loss occurs upon collision, i.e., the collisions are inelastic. But they emphasized that an electron can reach ionization energy in an electric field despite a series of *elastic* collisions.

Scrupulous avoidance of all sources of error had been necessary for them to drive their measurement accuracy high enough to be able to make solid estimates of the energy loss in a collision. This their predecessors had not managed to do.

Franck and Hertz decided to give a presentation during the 85th Convention of German Scientists and Physicians scheduled to take place in Vienna in September 1913. The number of physicists in German-speaking countries was still too low to permit a conference devoted solely to physics. For the Vienna meeting, aside from the plenary lectures, separate sessions were planned for each branch of science. The main speakers scheduled for the joint meetings for divisions 1, 2, and 3 were Albert Einstein on the current state of the problem of gravitation; Walter von Dyck on manuscripts by Kepler in the Viennese court library; Arthur Korn on telegraphic transmission of motion pictures; and Hans Lehmann on cinematographic cameras with optical compensation for image drifting, and motion pictures as a demonstration tool in science. Korn returned to speak about international standardization of important concepts and terms in the theories of potentials and electricity.

Many of the participants came from Germany. The Viennese Lise Meitner was, of course, also present. Heinrich Rubens and Wilhelm Westphal attended, and Max von Laue brought his young wife along, who delighted everyone with her charms. Max Born was also there from Göttingen. The highlight was Einstein's talk about relativity theory. Franck and Hertz had both wanted to speak in the "physics division," but the amount of time allotted to them sufficed for only one presentation and so Franck spoke about the relation between impact ionization and electron affinity. First he reviewed Townsend's theory and the results of their last two studies. New measurements of the current as a function of the potential in which the electrons were accelerated yielded in the case of helium and neon a stepped curve. They interpreted this result as ionization in stages. The current mounts up to a particular saturation point and as soon as the ionization potential has been reached there is a slight nick in the slope. Then the current mounts again. The second stage is reached at double the ionization potential, and so on for a third time. That meant that the atoms are not just ionized when the electrons reach their maximum acceleration. Ionization can already occur in the inelastic collision right near the cathode, the glow wire.

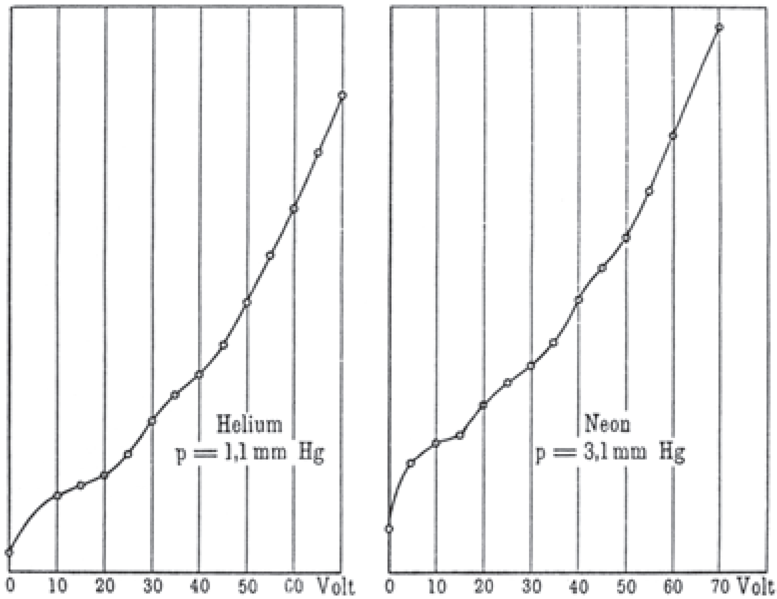


Figure 27 Graphs for helium and neon. Today we know that Franck and Hertz were measuring not the ionization potential but the excitation potential of the examined gases. From: J. Franck & G. Hertz: Über einen Zusammenhang zwischen Stoßionisation und Elektronenaffinität. *Verh. Dt. Phys. Ges.* 15 (1913), pp. 929–934.

An important step had been reached toward understanding the interaction between electrons and atoms and molecules. Both talks, the one Franck delivered and Hertz's contribution about the underlying theory of their experiments, were published under joint authorship in the German Physical Society's proceedings.[37]

Eva von Bahr, a friend of Lise Meitner's from Sweden, joined Franck on the staff in Berlin. She had taken her doctorate in Uppsala and was working with Rubens on the absorption spectra of various gases in the infrared range. She collaborated with Franck on experiments examining gas ionization by positive ions. They were able to use the existing apparatus by von Baeyer, merely switching the polarities of the voltages on the electrodes. The glow wire also had to be specially treated to emit positive ions. Their results did not agree with their initial assumptions. They found that the positive ions ionized to a much lesser degree than electrons.[38]

Then two papers by Franck and Hertz about measurements on vaporized mercury that were to enter their names on the rolls of the history of physics appeared in quick succession.[39] The first paper was presented by Gustav Hertz at the German Physical Society's meeting on 24 April 1914, the second by James Franck on May 22.

They had already speculated about a connection between the quantum hypothesis and the ionization potential in a publication three years earlier. Now they were able to offer proof with what they assumed was a quite clear-cut experiment. Their laboratory notebook reveals, however, that there were a number of false starts before reliable results could be obtained. Again they used the modified rotationally symmetric apparatus from von Baeyer. This time it had been significantly improved to permit measurements at higher temperatures. They chose a smaller gap between the electrodes. Instead of filling the carefully evacuated tube with a gas, they added a little liquid mercury. Then the tube was heated up in a liquid bath just enough to vaporize the mercury to a pressure of about 1 torr. Franck and Hertz had decided to use vaporized mercury for this experiment because Warburg and Kundt had demonstrated that it was monatomic. As this vapor very likely had a lower ionization potential than all other gases known to them, residual impurities were sure to affect the measurements less. So they anticipated obtaining clear and definitive results.

The glow wire was somewhat thinner at the middle so that at that point it would reach a slightly higher temperature and emit more electrons. The platinum gauze electrode surrounding the glow wire was set at a distance of 4 cm and the platinum foil was positioned just 1 to 2 mm away from the gauze.

In preliminary trials they found that up to a potential of V_1, at slightly under 5 volts electrons emitted from the glow wire arrived at the cylindrical platinum electrode with the full energy from the accelerating electrical field despite undergoing many collisions with mercury atoms along the way. Therefore, the collisions the electrons had experienced with the mercury atoms had been elastic. At a voltage higher than 4.9 volts, however, the measured current rose less steeply before falling off again. Energy had been lost to inelastic collisions with the atoms. As a result, they did not have enough energy to overcome the repulsive field and reach the cylinder electrode. The energy released by the electrons, Franck and Hertz concluded, was the ionization energy of the mercury atom.

Then they changed the circuitry to demonstrate the effect better. The countervoltage was held constant and the acceleration potential was increased steadily. The resulting curve showed equidistant maximums at 4.9 volts, the ionization potential, then at 9.8 volts, doubling, and then tripling it. This meant that at voltages higher than 4.9 volts the ionization in the gap between the glow wire and the platinum gauze proceeded in the same manner as had been observed with gas molecules in the earlier joint paper.

These results allowed them to verify Einstein's formula $E = h \cdot \nu$. Stark and other physicists had already speculated about some relation between ionization and quantized energy. In his analysis of the fluorescence of mercury vapor Wood had discovered an intense resonance line at 2536 Å. When Franck and

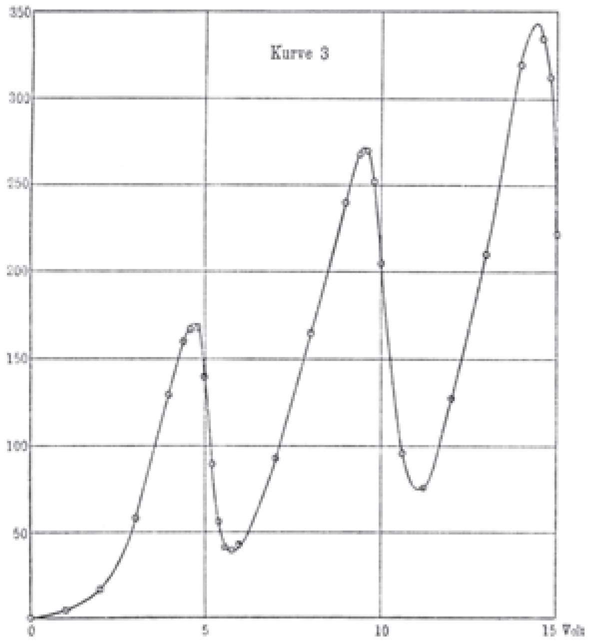


Figure 28 Current plotted as a function of the acceleration potential for mercury vapor. From: J. Franck & G. Hertz: Über Zusammenstöße zwischen Elektronen und den Molekülen des Quecksilberdampfes und der Ionisierungsspannung desselben. *Verh. Dt. Phys. Ges.* 16 (1914), pp. 457–467, curve 3.

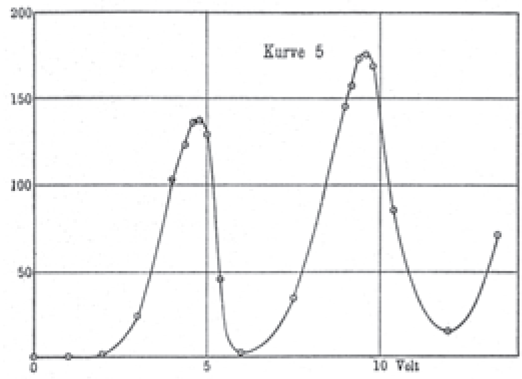


Figure 29 Current plotted as a function of the acceleration potential for mercury vapor. Franck and Hertz recorded the ionization potential at 4.9 V. From: J. Franck & G. Hertz: Über Zusammenstöße zwischen Elektronen und den Molekülen des Quecksilberdampfes und der Ionisierungsspannung desselben. *Verh. Dt. Phys. Ges.* 16 (1914), pp. 457–467, curve 5.

Hertz inserted the frequency ν associated with this wavelength into Einstein's equation and compared the resulting energy E with that corresponding to their measurement of the voltage V of 4.84 volts in the equation $E = e \cdot V$, where e is the charge of the electron, it fit.

They decided to check whether the mercury vapor in their tube would emit radiation of this line in the ultraviolet range at this voltage. They had to procure for the purpose a vessel made from quartz because glass is opaque to such short wavelengths. The spectral observation also required a spectrograph with quartz optics and quartz prisms. The private scholar Professor Eugen Goldstein lent them one built by the Fuess firm in Berlin.

Because the spectrum line that Franck and Hertz were seeking to detect lay in the ultraviolet, a photograph had to be taken of the spectrum. To identify the specific wavelength they exposed the spectrum of a mercury-arc lamp onto the same photographic plate as a reference. This spectrum has many lines. Interpreting the series of lines and their origins was still largely unresolved. Franck and Hertz expected to obtain many lines, but they still hoped that just one would appear. A single line did indeed appear on the exposure, and it was at 2536 Å! So they were able to calculate h and obtained: $h = 6.59 \cdot 10^{-27}$ erg-seconds with a margin of error of 2 percent. The values for h from recent measurements of black-body radiation were considerably less accurate. More importantly, the emission of a spectrum was clearly a quantum process.

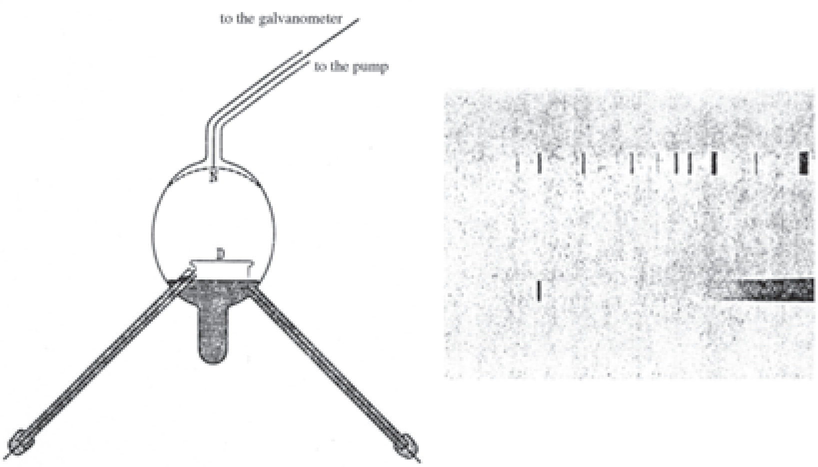


Figure 30 Left: Diagram of the experiment vessel; right: Excerpts from the spectra obtained. Above: mercury arc. Below: Spectrum of excited mercury vapor with electrons at a beam potential of 4.9 V. The visible spectrum of the platinum glow wire is visible on the right. Both from: J. Franck & G. Hertz: Über Erregung der Quecksilberresonanzlinie 253,6 nm durch Elektronenstöße. *Verh. Dt. Phys. Ges.* 16 (1914), pp. 512–517.

Franck and Hertz presented these results at a German Physical Society meeting.[40] No written accounts exist on how the audience reacted at either of the two presentations. Einstein was probably present, since he had moved to Berlin on March 29.

Max Planck must surely have been pleased. As early as 19 April 1888 he had written in a letter with reference to his spectroscopist friend Carl Runge:[41]

> Aren't we going to be hearing something soon about Carl's studies in spectral analysis? A field I have unfortunately not touched yet, but one in which a whole world of discoveries are still locked away. One thing I can't understand is why monatomic mercury vapor has such a complicated spectrum—at least as long as one upholds the immutability of the atom, which I'm not keen on, by the way.

Twenty years later, on 23 February 1908, Planck remarked to Runge:

> Besides, I am firmly convinced that the problem of spectrum lines is intimately related to the issue of the essence of the action atom [i.e., action quantum *h*], as indeed are all problems connected with processes involving the generation of rapid electromagnetic oscillations.

This relation had now been irrefutably confirmed by experiment.

Strangely enough, Franck and Hertz did not refer to a paper by Niels Bohr, On the Constitution of Atoms and Molecules, that had appeared on pages 1 to 25 of the July 1913 issue of *The Philosophical Magazine*. Nor were they willing to do so after the appearance of Emil Warburg's explanation of the Stark effect on the basis of Bohr's new model of the hydrogen atom.[42] Bohr's conceptions[43] were unable to stand up to Franck's and Hertz's critique. (They later justified this conclusion by noting Bohr's inability to explain how a mercury-arc lamp can incandesce at such high pressures and low voltages.[44]) That September Bohr presented another theoretical article on the configuration of the atom. Again the importance of these ideas for their own research escaped Franck and Hertz, even though Bohr specifically cited earlier work by them. His calculated excitation values for hydrogen and helium on the basis of his conceptual model agreed well with the data that Franck and Hertz had generated in their experiments. Bohr's work constituted a break with the idea that predictions by classical mechanics were applicable to atomic events. The current dynamic models of the atom had a positively charged atomic core and negatively charged electrons arranged somehow around this nucleus, perhaps with the ability to orbit around it. According to classical theory, such electrons must lose energy and eventually fall into the center. J. J. Thomson and other physicists had already been debating such arguments. In 1906, Johannes Stark advocated his own very speculative ideas about an atomic model with expanding elliptic orbits for the electrons. As their orbits widen, they emit radiation as a function of their acceleration, which Stark interpreted as spectrum lines. He tried to relate these ideas to energy quanta, but the outcome led to contradictions.

Bohr postulated stable orbits for the electrons.[45] He assumed that electrons do not give off energy as they move along their orbits. A jump, a discontinuous transition by an electron from one orbital path to another, was linked to the absorption or emission of energy according to the relation $E_2 - E_1 = h \cdot \nu$. Applying the known values for the electron, charge e, and mass m, as well as h, Bohr was able to calculate the diameter of the atom. He also was able to supply the correct line positions for the hydrogen spectrum, which had the character of a series.

Bohr's atomic model is a kind of planetary system; it is very straightforward and its mathematical treatment extremely simple. Nevertheless, many older physicists rejected it more or less categorically because they could not accept Bohr's postulates. This was the initial reaction of Arnold Sommerfeld in Munich, who later worked intensely on perfecting this very model. Perhaps it was Bohr's youth (he was born in 1885) and the clumsy style of his publications that made it so difficult to accept these ideas at first, particularly for theorists. Niels Bohr had studied at the University of Copenhagen and written his thesis on the theory of electrons in metals. It was in Danish, so it scarcely received notice abroad. Half a year after taking his degree, in September 1911, he worked in Cambridge under J. J. Thomson and then later in Manchester under Rutherford. That July he was back in Copenhagen, where he had received an assistantship and began to teach as a private lecturer.

Figure 31 Niels Bohr. Niels Bohr Archive, Copenhagen.

In the summer of 1914, Niels Bohr and his mathematician brother, Harald, traveled to Germany. At Göttingen Bohr made the acquaintance of the Dutch physicist Peter Debye. Another stop along the way was Würzburg, where he visited Willy Wien. Munich was the southernmost point of their trip, where Bohr met Arnold Sommerfeld. Berlin was not on their agenda, however. Niels Bohr described his impressions in a letter. Alluding to research by H. Rau in Vienna on the relation $E_2 - E_1 = h \cdot \nu$, he continued:

"I think that the wonderful experiment by Franck and Hertz about the ionization of mercury vapor can be interpreted in the same direction."

World War I

Science students and their young professors were absorbed in their work. Peace had been reigning in Central Europe for almost fifty years. The possibility of war arose from time to time with much "saber rattling," only to disappear again. Few were interested in politics. The general public was unaware of the tensions created when Austria-Hungary received the mandate at the Berlin conference of 1878 to occupy and administer the former Turkish provinces of Bosnia and Herzegovina, despite Serbia's demand that both be added to its territory. On 28 June 1914, a Serbian holiday, a Serbian freedom fighter assassinated the Austrian successor to the throne and his wife during their visit in Sarajevo. The Austrian government issued an ultimatum that Serbia investigate the incident together with Austrian officials and put a stop to the propaganda by the Greater Serbia Party against Austria-Hungary. When this was rejected, on July 28, Austria declared war on Serbia. The system of interlinked alliances that had been hammered out in secret diplomacy between England, France, and Russia, on the one hand, and Germany and Austria-Hungary, on the other, was activated. Despite many warning voices predicting a major European war, it was impossible—or deemed impossible—to prevent an outbreak of violence. Bertha von Suttner's passionate appeal: "Lay down your arms!" faded away unheard.

In Germany, the kaiser issued the command to mobilize on 1 August 1914. An inexplicable wave of enthusiasm gripped the nation. Soldiers in Germany, Austria, England, and France set out to war, encouraged by cheers and showers of flowers from onlooking crowds. Men left their families, their wives, and their loved ones. Human ties were weaker than the wish and will to serve the fatherland even at the risk of their lives.

Members of the Berlin faculty considered it their patriotic duty to give speeches in favor of the war: Ulrich Baron von Wilamowitz-Moellendorff, Gustav Roethe, Otto von Gierke, Hans Delbrück, Adolf Lasson, Adolf von Harnack, Wilhelm Kahl, Alois Riehl, Theodor Kipp, Max Sering, Adolf Deißmann, and Eduard von Liszt.[46] Even scholars who were apolitical cast aside rational judgment and rejected friendships with fellow professionals across the borders. Professor von Wilamowitz-Moellendorff was the first to speak on August 27, calling out to his audience:

> Holy is war, when it is fought for a fair cause. Indeed, war is something grand, just because it moves hearts; it draws into the light of day what lies inside each heart, by rending away all veils of convention. This we do see. How much higher have our hearts been raised by it, by all that is already unveiled in our nation, by all that has been revealed: Unity, one and all; not the slightest difference between King and every last party . . . These are the same intellectual and civic powers that make our superiority in peace and now guarantee our Army's victorious advance. . . . Yes, happy, so lucky are all that bear arms into battle.

The historian Hans Delbrück praised the superiority of the German nation:

> This nation is invincible, and it is invincible not just against yon enemies in the East who cannot acknowledge it as equal before the higher claims of humanity, but also invincible in comparison against yon island folk [the British].

The jurist Otto von Gierke quoted from a verse by Emanuel Geibel:

> "And may the world find convalescence in the German essence."[47]

The theologian Adolf Deißmann chose the theme "[t]he war and religion," and the general enthusiasm moved him to draw bold comparisons:

> Thus another saying from Evangelical Scripture breaks beyond the bounds of its most ancient historical meaning and takes wing in the tempests of the world war, a saying that may inspire us like a consecration to our German calling: Ye are the salt of the earth! Ye are the light of the world!

Max Planck had been serving as rector of the university since 1913 and was now expected to deliver an address on August 3 during a memorial ceremony in honor of the university's founder. Following an exposition on dynamic and static regularities he, too, turned to the current situation.[48]

> We do not know today what the morrow will bring; we merely sense that very shortly something grand, something enormous lies in store for our nation, that it will touch land and life, honor and perhaps the sheer existence of our fatherland. But we see and also feel, for all the terrible urgency of the situation, what the nation may claim her own of physical and civic powers, gathered in a flash into a single fiery flame of holy wrath held up to the heavens, while much of what is otherwise deemed important and worth striving for drops unheeded to the ground as useless tinsel.
>
> Yet, only if all, whether old or young, whether high or low, stand loyally and trustily by the posts fate has assigned to them, may we hope that this new leaf in the history of the world will one day bear good testimony of us for generations to come.

At the end of this speech Planck reminded his audience of a similar celebration held a hundred years before in honor of the victorious freedom fighters against Napoleon. He continued:

> Today our eye may but fleetingly glance at this illustrious image. Today we are not in a mood for festivity and commemoration. For today we must once again look onwards, onwards into chillingly serious reality, and God willing, onwards to battle and victory. God save our Kaiser and his own! God bless and shield our dear, our ardently beloved Fatherland!

Franck may well have heard Planck's address before his departure. He had voluntarily enlisted himself in order to escape the possibility of being called up again by his old battalion where he had been forced to "study physics" their way.[49] So Franck had to leave his wife and two little daughters behind. From August 5 he was stationed for a quarter of a year in the district of Königsberg and received training as a *Pionier*. Then in December he was sent out to the front line in the Picardy in northern France. For a long time, the army postal service was the only link he had to his wife, and a military postcard would occasionally also go out to his children. That April Franck was promoted to deputy officer. When it became a matter of promoting him to officer, one of his superiors asked him why he did not get baptized. Franck later remembered having replied by asking whether he would be a better officer if he were to be baptized against his convictions. His superior had to concede that Franck had a point. But he thought Franck would then become one of them. Franck said that either way he felt like he belonged. Anyway, it had not been his idea to become an officer. The colonel still wanted to send him to an officers' academy, but Franck replied that he could do without such training during wartime, also declining to do so in peacetime. His superior understood, and Franck became lieutenant of land forces in 1915—without standard training for the post. In April he was distinguished with the Iron Cross Second Class; later Franck also received the Iron Cross First Class.[50]

Lise Meitner had registered herself as X-ray assistant and was posted at the eastern front. Mrs. Franck helped her friend maintain correspondence with friends in Berlin and sent out on her behalf little packages of treats to those stationed on the front line.

Figure 32 Franck in the dugout. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

A few days before the war broke out, Franck's friend Max Born received a letter from Max Planck informing him that an *Extraordinariat* for theoretical physics had been approved by Friedrich-Wilhelms-Universität. Planck was to be relieved of some of his lecturing duties and Born was designated for the new position. The onset of fighting delayed implementation of this plan by a few months. Born announced a number of courses, but he was unable to teach them because he was drafted. His asthma prevented him from being sent to the battlefield, so he was relegated to the artillery testing unit. With a group of other physicists, he was assigned the task of developing an acoustical method for finding the positions of enemy fire.[51]

The German advance came to a standstill after the battle on the Marne in September 1914. Positional warfare began. The soldiers on both sides ducked into the relative safety of trenches and dugouts. The German economy was not prepared for a protracted war, and its few reserves quickly began to run out. The officers discussed how best to set the offensive in motion again. One suggestion for forcing the enemy out of his trenches was poison gas, but the Hague Convention on land warfare banned its use.

It can no longer be reconstructed who exactly in Germany first suggested that chlorine gas be deployed. Chlorine acts as a severe irritant to respiratory tissue, causing suffocation. At higher concentrations, exposure can cause death. Fritz Haber, the director of the Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry, threw all his energy and the resources of his institute into supplying chlorine gas and the technical know-how toward its military deployment.[52] Chlorine gas is relatively easily made by the electrolysis of common salt; it can be liquefied under pressure, and the liquid is storable in steel flasks. The chemical industry could produce it out of domestic resources, and limited amounts of it could be made available almost immediately. Haber proposed that large quantities of the gas be released directly from the steel flasks. After trial releases of chlorine were made on some troop training grounds, military observers were convinced of its potential on the battlefield.

On the orders of General von Falkenhayn a section on the front line near Ypern was chosen for the first deployment, and 1,600 large and 4,130 small flasks of gas were installed over a 6-kilometer stretch of front-line trenches. A favorable wind was nervously awaited so that the gas could be blown into the enemy positions, but no winds came from east-southeast. So a second location was chosen. It lay opposite Langemarck. The English stationed there noticed the activity in this section and undermined it at many points. On 16 April 1915, blasts of dynamite in the undermining tunnels produced many casualties on the German side. General Deimling ordered a counterattack in which James Franck took part.[53] Finally, on the afternoon of

Figure 33 Fritz Haber. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

24 May 1915, the chlorine gas was released. The enemy soldiers ran from their protective trenches in panic, but the German troops did not advance far and there was no decisive turn in the fighting as a result. Franck's fellows noticed he was missing. They found him in a shell crater dutifully collecting air samples. More chlorine gas attacks followed. The tragedy of gas warfare could no longer be stopped. All belligerents constantly sought to force their opponents to surrender, with both sides developing and using new, increasingly lethal gases and new gas masks to protect against them. In Germany, these developments were directed by Fritz Haber. The kaiser took the very unusual step of promoting him to the rank of captain. Haber became director of the Headquarters for Research and Testing in Gas Warfare and Poison-Gas Protection at the Ministry of War.

Although some of Haber's coworkers had doubts about this effort because of the Hague Convention on land warfare banning the use of poison gas, Haber knew how to dispel their reservations. He did so out of conviction and patriotism. The death of his wife, Clara née Immerwahr, who shot herself with his military revolver, did not alter his attitude.[54]

Franck was deployed in Champagne and in Flanders. In the fall of 1915 he came down with a serious bout of pleurisy.[55] His recovery from this painful lung disease was slow, but he continued scientific work in the field hospital. Together with Hertz he published a paper on the relative intensities of gas spectra

Figure 34 Franck carrying his daughter Daggie. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Figure 35 James Franck with his wife. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

in the glow discharge of mixed gases.[56] The publisher's date of receipt was 24 March 1916 and the authors' locations were indicated as Wiesbaden and Hamburg. On the basis of earlier measurements Franck and Hertz were able to explain why in a gas mixture the spectrum of the most easily ionizable gas is excited first.

Better again in April 1916, Franck first returned to his unit. For his service, his hometown bestowed on him the Hanseatic Cross. There was still enough time in July for him and Hertz to compile a detailed list of their analyses on the kinetics of electrons and ions in gases.[57] This time the authors' address was indicated as the physics institute in Berlin. Hertz had been discharged as unfit for service and had returned from Russia a sick man. He was being treated in a military hospital. Franck and Hertz's first reference to Niels Bohr's work appears in this joint publication. After a discussion of F. H. Newman's measurements of the ionization potential of mercury, they argue:

> Nor is it permissible, as Bohr has recently attempted, to make do with the assumption that in helium the 20.5-volt [electron] beams and in mercury the 4.9-volt beams first elicit secondary ionization whereby the short light-waves forming on the electrodes or in impurities in the gas would generate a photoelectric effect in the gas. As the steep maxima prove, new electrons form wherever an inelastic collision takes place.

More experimental data were needed before Franck and Hertz were conceptually more amenable to Bohr's theory. Arnold Sommerfeld and other theoreticians had less difficulty overcoming their prejudices against the Bohrian model. Their approaches in their analyses of the model were more mathematical. The publication by Franck and Hertz appeared in a number of parts, interspersed among other scientific contributions or death notices for fellow physicists along with the occasional obituary. The obituary by Albert Wigand on one casualty born in 1887 begins with these lines:

> Georg Lutze's life contains the full tragedy, but also the full glamor of this far too young deceased: A happy childhood, merry student years, a short period of scientific research replete with success and experiences, an enthusiastic departure to war, and in elated, victorious storming advances, a fine soldier's death. With his life, he had brought his fatherland a sacrifice of true value.

When the war was into its second year and hundreds of thousands of people had already met with their deaths, many yearned for peace, but the few pacifist voices still went unheeded. Albert Einstein was one of these voices. He had accepted an appointment by the Prussian Academy of Sciences in Berlin in the spring of 1914. Exercising his right to hold lectures, he was otherwise grappling with generalizing his theory of relativity. Unabashed about his repudiation of militarism and patriotism, Einstein distinguished himself by refusing to sign the notorious “manifesto by the ninety-three.” When German troops had marched into neutral Belgium at the beginning of the war, there had been incidents of looting and attacks on the civilian population. Germans vehemently denied foreign press reports about such atrocities. Without first finding out what in fact had taken place, German scholars and poets felt obliged to respond by signing this lengthy “Appeal to the Civilized World.”[58] Each statement in the appeal opens with the refrain “It is not true . . .” Ninety-three signatures were collected, including those of Emil Fischer and Max Planck, albeit many of the signers had not even seen the text when they agreed to have their names appear on the appeal. Some subsequently apologized to their foreign colleagues. But the damage had been done. The reaction in Holland was particularly severe, and that only poured more oil onto the flames. A few months later another statement of similar content appeared, signed by 4,400 German university teachers. The accusations and insults about cultural achievements developed into an all-out “war of the intellects” (*Krieg der Geister*) that left deep and lasting animosity. One petty jab at the other side was to deliberately omit citing foreign publications. Franck and Hertz never took part in such campaigns.

Franck was then sent to battle in Russia. There he fell seriously ill with dysentery, and inappropriate treatment weakened him further.[59] Totally sapped of his strength, he made his way back to Berlin, barely managing to climb the stairs to his apartment on his last legs. It took a long time for him to recuperate. Food shortages hit the Franck family particularly hard. Dagmar was then seven years old and Lisa was not yet five. Unlike some other families, they had no relatives in the countryside to occasionally send them some staples or to take them in. But some good news did arrive. Franck was appointed professor at Friedrich-Wilhelms-Universität as of 19 September 1916.[60] Heinrich Rubens sent his congratulations. Jacob Franck was surely very proud of his elder son’s success. He, too, had offered his services to the government and helped wherever he could. He donated substantial sums to the Red Cross.[61]

Lethal chemicals and gas masks were being developed at Haber’s Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry. At its field stations the filling of shells with the toxins had to be monitored. The technique of firing the poisons in projectiles was soon mastered. Haber even organized animal experiments to test the toxicity of new substances. Many of these tasks required personnel with scientific training. Chemists and physicists were recalled from the battlefield to work in his institute in Berlin. Barracks were built around the institute, and rooms were requisitioned in the neighboring Kaiser Wilhelm Institute of Chemistry. It was only with some effort that Lise Meitner

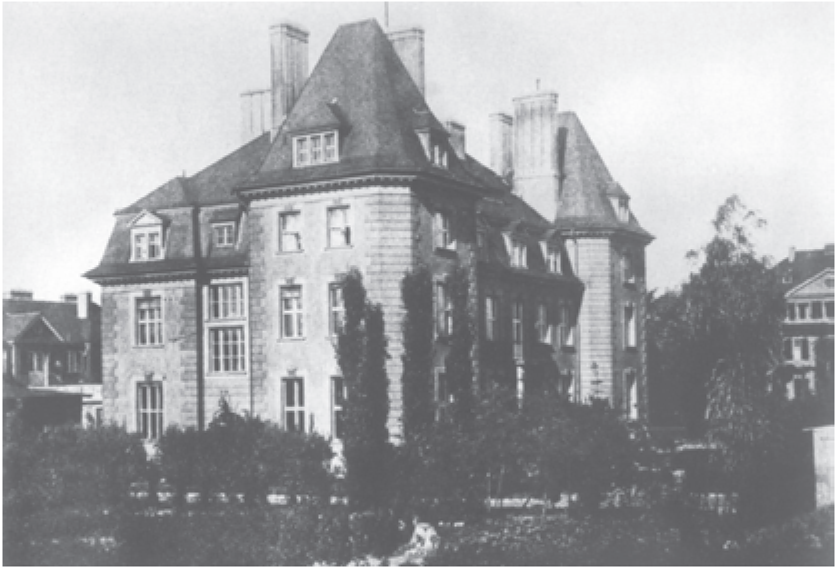


Figure 36 The Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry around 1917. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

managed to protect Hahn's laboratory from being taken over.[62] Among those detached for special duty were James Franck, Otto Hahn, Gustav Hertz, Hans Geiger, and Wilhelm Westphal. Their task was to test gas masks and filter fittings. They had to stay in a room filled with gas until they noticed that the filters they were wearing were becoming ineffective. It was a life-threatening mission because they did not know how long it took for a person to breath in a fatal dose. Franck's friendships with Hertz and Hahn grew firmer during this period. In addition to gas-mask testing, Franck also worked on techniques for producing very fine mists.

News from the front line was worrying. The lengthy war was eating away at Germany's reserves, and despite the use of ever new types of noxious gas, the entrenched positions changed little. When unlimited submarine warfare was re-declared in February 1917, the United States responded by entering into the conflict on April 6, giving a substantial boost to the armaments potential of the Great Entente. The collapse of the Russian military and state and the October Revolution with the peace treaty signed at Brest-Litovsk in March 1918 brought no turn in Germany's favor. Even so, in March it looked as if German troops had succeeded in regaining the offensive. The strongest bombardment ever with grenades and gas grenades broke through a few British and French positions on the western front. German troops advanced to within 60 km of

Paris. But then their reserves were exhausted. The British and French drove the German troops slowly back again in August. A short time later the first American troops reached the front line.

The Entente forces had not yet reached the borders of the German reich when Erich Ludendorff, the general of the Army High Command who had largely determined Germany's military actions, approached the reich leadership on September 28 with the suggestion that an immediate truce be imposed. The military situation was hopeless. Ludendorff together with Field Marshal Paul von Hindenburg called for a new government. Prince Max von Baden became reich chancellor and offered an armistice to the Allies. This news crushed the last hopes of large segments of the population for a dignified peace with territorial gains. Ludendorff was dismissed at the end of October. Soon afterwards there was a mutiny by sailors in Kiel, Lübeck, Bremen, and Hamburg. In Berlin and elsewhere rebellious soldiers ran rampant, stripping the epaulettes off their superiors' uniforms, shouting abuse, and manhandling them. In Munich the government and the royal family were thrown out and a free state was declared. On November 9, giving way to the pressure, Max von Baden announced the abdication of the kaiser, who fled the next day to Holland, although his abdication only became official on November 28.

Figure 37 James Franck (left) and Otto Hahn (center) in front of the gas-mask testing station. By courtesy of Dietrich Hahn.

War's End—A New Start in Scientific Research

Franck was discharged three days before the abdication. Like many war veterans, he never spoke about his experiences nor about how his fellows on the field lost their lives. There are not even general statements by him about the horrors of war. But he came home a changed man. His whole approach to life was marked by this experience. All his actions were guided by earnestness, an impulse to help others, and a strong sense of duty.

The uncertainty about Germany's political and economic future was oppressive. Public and private opinion fluctuated. Lise Meitner wrote to her friend Elisabeth Schiemann about her experiences with Franck and Hahn:[63] "We, naturally, have very many political debates, in which we are almost always of a different opinion, but that does not harm our friendship at all."

Franck was certainly free to think about continuing the academic career path he had started down, but it seemed unrealistic. Students—now of both genders—were soon coming back in such droves to finish their higher education that by 1920 roughly 83,000 were enrolled at universities and 23,000 at the polytechnics. However, budgetary constraints prevented a corresponding growth of the teaching staffs. Reichschancellor Philipp Scheidemann's declared republic with its government headed by Friedrich Ebert tried everything to set up a democratic state, but unrest soon developed in downtown Berlin. On December 24, there were street battles with leftist radicals not far from the palace and the university. In early January 1919 the Independent Social Democratic Party of Germany (USDP) organized the Spartacus revolt in the capital. There was more street fighting in the inner city, and a general strike crippled the gas and electricity works for days. The violence culminated in the assassinations of the Spartacist leaders Karl Liebknecht and Rosa Luxemburg by Free Corps officers.

To relieve the suffering imposed on the innocent, on women, children, and the elderly, by the utility outages, a Technical Emergency Relief service was founded in 1919. Its members did not consider themselves scabs. Franck and Hahn and some of their friends joined this organization, and at one point Franck was stationed as a furnaceman at the gas works.[64]

Despite the turmoil, Franck was busy conducting research again. He had grasped the importance of Niels Bohr's model of the atom and with Hertz had reworked and checked their earlier data against this theoretical framework.[65] They immersed themselves in the foreign articles now accessible to them again and familiarized themselves with the terminology used by spectroscopists. They had not been able to conduct their own research during the war, but the importance of their work was being recognized abroad, primarily in America, and a number of physicists had started to elaborate on their results. They examined ionization phenomena in metal vapors, which Franck and Hertz had also planned to do. Arnold Sommerfeld was applying Bohr's theory to special cases and training many highly gifted physicists. Those among them who got to meet Franck were impressed by his personality and his way of thinking.

In their last joint paper, Franck and Hertz had not yet been able to eliminate all the differences between their measurements and Bohr's theory.[66] Also, the time development of atomic excitation and ionization was not clear, nor were the molecular processes—even for diatomic molecules as simple as the hydrogen molecule H_2. Many questions remained unanswered: When does the molecule dissociate into two atoms? Is first one atom excited or both at once? How do the electrons revolve around the two nuclei? In their publication Franck and Hertz cited 39 particularly important studies by others, including Lenard and Stark. Despite the many remaining open questions, their conclusions revealed a rich harvest of understanding from their years of work:

1. Each jump corresponding to one optical absorption and emission line, therefore each jump of an electron belonging to the atom's outer quantum orbits from one quantum orbit to another, can be effectuated by collision with a free electron, by which the same suffers a loss in kinetic energy by the amount of $h\nu$.
2. Which jumps occur depends on the excitation states of the atom concerned.
3. For a normal, unexcited atom, the possible jumps are identical to those yielding the absorption series of the unexcited atom.
4. The ultraviolet limiting frequencies of the series multiplied by the quantum of action h yield the ionization work of the atoms; the ionization work of the unexcited atom comes from the limiting frequency of the absorption series of the unexcited atom.
5. Analysis of inelastic collisions and the light emission produced by them affords a new means to assign lines to series and to ascertain their pairings. The series limits become accessible to direct observation.
6. The broad analogy between optical absorption and the quantum-like transfer of energy from colliding electrons speaks for the first Planckian hypothesis of quantum-like absorption.

Their manuscript was completed in December 1918, shortly before Franck—at long last—received his first adequately paid position. But it was not a professorship. During the republic, universities were undergoing restructuring.[67] Haber offered Franck a post at the Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry. There had been discussions about it earlier, but Franck had been hesitant to say yes. He wanted to work on his own ideas and was afraid that Haber would propose other, perhaps entirely different experiments. But agreement was soon reached between them.

The Treaty of Versailles prohibited further research on weapons development, and the Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry was obliged to return to pure scientific research. Haber decided to reorganize the institute completely, forming a number of specialized divisions. One of them was placed under James Franck's directorship with the assigned task of continuing his investigations on atomic and molecular ionization and excitation. The contract with the Kaiser Wilhelm Society, dated 10 January 1919, had a term of five years. The annual salary totaled 7,000 reichsmarks with a cost-of-living supplement of 40 percent. The currency devaluation was already making itself felt. Article 5 explicitly pointed out that pension, widow, and orphan benefits were not being granted.[68]

Despite an age difference of fourteen years, Franck's relationship with Haber was amicable. Haber was the first *Geheimrat*, or expert advisor to the government, to treat Franck as an equal and not interfere with his work as a scientist.[69] Franck resumed teaching, but again offered only one lecture per week on a specialized topic. He was now able to broaden his research capacity by engaging doctoral candidates.[70] A well-equipped workshop was available to him at the institute, and the apparatus was of good quality as well. The relations between the different directors were unproblematic and marked by mutual respect for their individual scientific expertise.

The physical chemist Michael Polányi was working on catalysis. In a letter forty years later he told Franck how impressed he had been with the way Franck had once advised him about a particular problem. The focus of Herbert Freundlich's research was colloidal chemistry, including fibrous materials. The physicist Hartmut Kallmann, a former Haber collaborator who had had to endure the director's occasional short-tempered outbursts, now had his own research program besides. The funding for all these projects was precarious. The banker Leopold Koppel, who had generously endowed the institute in 1911, was now himself struggling with financial problems. The Kaiser Wilhelm Society retained its imperial name, but its patron was henceforth the state, which had difficulty granting the necessary budgets. During this period, as later on, the diplomatic skills of the Kaiser Wilhelm Society's president, Adolf von Harnack, were crucial in preventing this officially registered association from being dissolved altogether.

Throughout the war years, Franck had often waited impatiently for a chance to conduct the many experiments his studies had suggested. In the two years he spent working almost exclusively in the Kaiser Wilhelm Institute, he and his collaborators produced ten publications, almost all of which made an important contribution to understanding the atom and its excitation. These contributions made clear that the successful outcome of the Franck-Hertz experiment had not been just a fluke. It had grown out of a profound grasp of an experimental approach to exploring atoms, even if some interpretations may ultimately have been flawed. In order to outline the general direction of Franck's research, the following discussion of his publications will proceed thematically rather than chronologically.

In 1919, a new publication appeared on the ionization of the hydrogen molecule. It was coauthored by Paul Knipping and Franck's advisee Thea Krüger.[71] Her dissertation concerned the energy of dissociation of H_2 into what was believed to be a positive ion and a hydrogen atom H. Two different results had previously been obtained.[72] The outcome was confirmation of the result obtained by the American physicist Irving Langmuir.

Franck revisited the subject a few years later. Miss Krüger was not his sole collaborator in this second effort because Miss Hertha Sponer had joined his research group.[73] Sponer, born in 1895 in Neisse, Saxony, had earned her degree in the subject of spectroscopy at Göttingen under Peter Debye. After a late academic start, thanks to the obstacles women had to contend with at the time, Sponer had transferred to Göttingen after spending the academic year 1917–18 at Tübingen. She joined Franck to research electron collisions with mercury atoms to determine the frequency of inelastic events. Sponer was also employed at the university as an assistant to supervise the laboratory course for beginners.

Franck continued to publish primarily in the promptly issued proceedings of the German Physical Society. Occasionally he sent his manuscripts to the *Physikalische Zeitschrift*. Only once did he publish in the oldest German-language journal of chemistry and physics, *Annalen der Physik*, because its editors took such a very long time. After World War I, however, the German Physical Society could no longer afford to publish as much, and its issues were being consigned out to Vieweg publishers for printing. By the beginning of the 1920s, the pace of research had quickened, and German physicists were painfully aware of the sluggish publication rate of the society's proceedings.[74] In 1920, to redress the problem, it was decided—over the opposition of a few conservative physicists—to found a new journal: *Zeitschrift für Physik*. The new journal was initially published by the same Vieweg company in Braunschweig that had been publishing the society's proceedings. But financial difficulties necessitated a merger with Ferdinand Springer's press, which adopted the new periodical in 1921.

This periodical reflected a division of the discipline into opposing camps. No physicists of the older, more conservative schools of thought figured as authors in the new journal's early issues. Franck was represented with two important contributions and his friend Born with three articles. Other authors included Kasimir Fajans, Alfred Landé, Walther Kossel, Heinrich Rubens, Erwin Schrödinger, and Arnold Sommerfeld.

The first issue of the new journal opens with a paper by "J. Franck," "Remarks about the intensity distribution in series spectra."[75] These "remarks" discuss a number of German, American, and English publications and some findings of his own on the excitation of spectrum lines. He criticized the theoretically computed geometrical dimensions for highly excited atoms. Assuming Bohr's model, at the applied gas pressures (affecting the mean distances between the atoms), the electron orbits of the highly excited atoms would have to impinge on the orbits of the unexcited atoms. Because these unexcited atoms are electrically neutral, however, Franck thought such conditions in the gas nonetheless possible. (This was an early indication that there was a problem with Bohr's model.)

He pointed out furthermore that in electrical excitation of gases and vapors the series of spectrum lines are stimulated only very incompletely, since the higher terms of the series are weak in intensity. On the basis of his 1916 research with Hertz, Franck realized that this difficulty could be circumvented if a gas with a low excitation potential was added to one with a high excitation potential. Then very sharply defined lines of a sufficient intensity are easily obtained for the higher series of the gas of low excitation potential. Thus with an admixture of helium, hydrogen could be analyzed well. Such experiments became an important tool for verifying the different theories.

The next three papers brought Franck step by step closer to an experimental proof of a new behavior of electrons in the excited state inside an atom. Many decades later, these results would prove useful in the development of the laser.

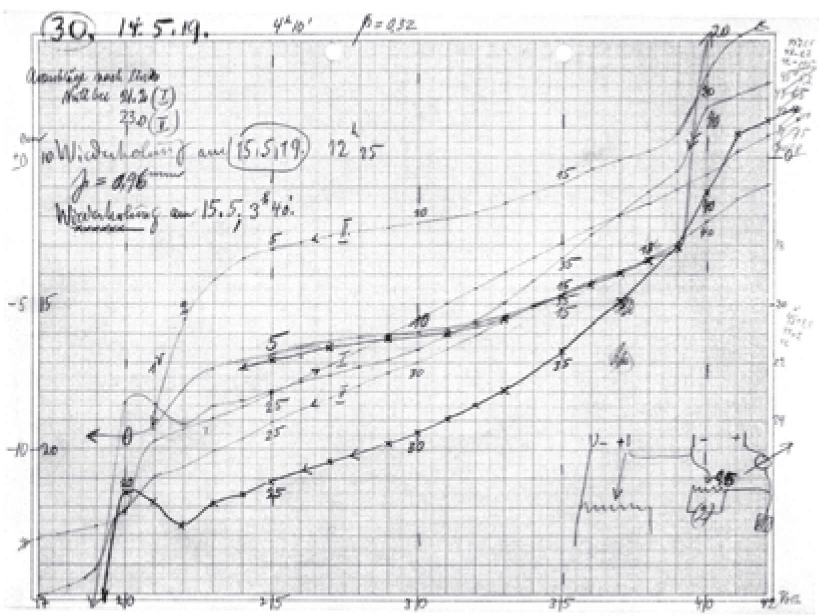


Figure 38 Graphs from data gathered in May 1919. Franck papers, Special Collections Research Center, University of Chicago Library.

Bohr had once suggested that the emission of electrons—photoelectrons—from an electrode by means of short-wave radiation might influence the result of the Franck-Hertz experiment. Other authors had later demonstrated this. Franck now wanted to take up this issue together with his new coworker, Paul Knipping.[76] Knipping had studied physics in Munich under Röntgen and Sommerfeld. He had been involved, together with Walter Friedrich, in the experimental realization of Max von Laue's idea of diffracting X-rays in a crystal. He now joined Haber and Franck to work toward his habilitation degree. He collaborated with Franck on three research papers. The aim of the first paper was a precise measurement of the ionization potential of helium, taking into account photoelectrons. It basically employed the same apparatus as the Franck-Hertz experiment with an additional pipe-shaped electrode concentrically encasing the other three. This allowed additional control of the electron beam.

The spectrum of helium exhibits two series of lines. This seems reasonable because two electrons rotate around that atom's nucleus. Theoreticians like Bohr and Alfred Landé could not agree, however, on what these orbits ought to look like. Were they coplanar, for instance, or did they cross each other? Each configuration produced different calculated ionization values. Experiments would therefore have to be used to pin down the correct model. The records indicate Franck's close attention to the apparatus and the actual trials. Franck and Knipping found for the energy of the first helium excitation 20.5 ± 0.25 volts and for the ionization potential 25.3 ± 0.25 volts. These values agreed well with results by other physicists but confirmed neither Bohr's nor Landé's model for helium. A footnote contained a premonition of the future discovery of the laser:

> [O]n the whole, the interesting fact that according to Paschen excited helium, that is, helium in an alkali-like state, exhibits a resonance emission, seems to us to offer a hint that the alkali-like state of helium is somewhat metastable. An electron raised out of this orbit into the next one always returns to this biquantum orbit and never jumps directly into the monoquantum stable orbit.

Franck was clearly on the way to discovering the metastable state of helium. The issue of the *Physikalische Zeitschrift* containing this paper appeared on November 1. Landé responded quickly with a published letter, and Franck thanked him in the December 21 issue and then presented his own understanding in a bit more detail.[77]

> For, the smallest quantum-like amount of energy transferable by electron collision is 20.5 ± 0.25 volts; there's no changing that, in any case. Otherwise, I do not understand why there should have to be 2 ionization potentials of such differing magnitudes; helium and parahelium ought to differ in their 2-quantum orbits by only 0.8 volts and on the outermost quantum orbit, i.e., at infinity, it really ought to be completely the same,

whichever of the two electrons had originally been taken away. The remaining electron always does have the same defined hydrogen-like quantum orbit. The spectrum of the helium ion resembles the one for hydrogen, the lines are just shifted toward shorter wavelengths.

Franck has left no allusion to the economic conditions oppressing Germany at the time. But some written testimony by Haber does exist. As Franck was about to travel to Stockholm to attend a funeral in the Josephson family, Haber gave him a letter to take along. It was addressed to Svante Arrhenius and introduced its messenger, Franck, as a personal friend. Its purpose was to express Haber's gratitude for the exceptional honor of having been chosen for the Nobel Prize. But Haber was worrying about the possibility of being brought before a war crimes tribunal by the victor powers to answer for his involvement in the deployment of poison gas:[78]

What is to become of us as a nation and as individuals cannot be foretold. The plummeting currency devaluation is causing a tenth part of German industry to lose its ability to continue to do business on its own operating capital; and loans from abroad, if they are not in our currency, must necessarily place us in the position of Portugal toward its foreign creditors. The institutions of science here look like the impoverished man who is trying to keep what remains of his wardrobe from better days in as acceptable a condition as ever possible but is persistently worried about not being able to purchase new things once they are threadbare for lack of sufficient income. We do not know what political difficulties the winter holds for us. The refusal by our French neighbors to grant legitimacy to German or neutral courts to try punishable deeds, and their insistence on extradition to enemy war tribunals is being perceived as vengeance, which is completely at odds with the spirit of genuine peace. Order inside the country is deteriorating in that the government, inharmonious and bereft of the means to help, is exhausting itself on disputes about responsibility, and there is a general deep yearning for a better-functioning regulated state, without people in any way in agreement on which political direction such a better-functioning state should take.

The ferocious struggle for power between the leftists and rightists went virtually unnoticed in Dahlem where Haber's institute was located. The neighborhood of Steglitz, where the Franck family was now living, on Rothenburgstraße, also was quiet. But along his daily route to the university Franck could not avoid witnessing clashes. On March 13 the Pan-German Wolfgang Kapp attempted to take over the government by force with the assistance of General Walter von Lüttwitz and a marine brigade. The flight of the government, a general strike, and passive resistance by officials prevented the success of this putsch. Unrest reemerged soon afterwards in Saxony, however, and in the French-occupied Ruhr region. Too few citizens supported the young democratic state. Since the end of the war, a persistent rumor attributed the defeat to sabotage from within the homeland. This "stab-in-the-back myth" was clearly false and was merely intended to veil the mistakes by the chiefs of the General Staff, the kaiser, Hindenburg, and Ludendorff. But "conniving" Jews were blamed by anti-Semitic elements for the betrayal of the fatherland. Rightists deliberately ignored the high proportion of Jewish patriots who had so recently risked their lives as soldiers and officers on the battlefield. Within science, Einstein became the target of such anti-Semitic attacks, and his special and general theories of relativity were maligned as Jewish constructs.

In early January 1920, as the repatriation of prisoners of war began and Germans were coming home from the former colonies, Franck was able to report to Landé in Tübingen about the progress made in interpreting his experiments.[79]

> In the interim, the business has improved through Sommerfeld's book [*Atomic Structure and Spectral Lines*] and through Reiche's favor. Now Reiche and I have drawn all sorts of conclusions from the occurrence of the resonance line 1.08 μ [found by Friedrich Paschen] that had only vaguely suggested themselves to me while collaborating with Knipping.

The letters again demonstrate Franck's ability to see possible atomic behavior in measurement data and curves. The new recruit Fritz Reiche was a theoretical physicist and one of the small group of Max Planck's graduates. He had acquired the nickname "the little oracle" because, like "the big oracle," Bohr, he had a knack for developing ideas about how atoms behave. He wrote one of the early works on quantum physics. Reiche discussed with Franck models of the helium atom. They developed the speculation quoted above into a prediction that a metastable state of helium can be excited when an electron collides inelastically with a helium atom.[80] From this state there is no direct jump by the electron back to the ground state. The metastable energy level cannot be observed as a spectrum line in emission because the electromagnetic transition between the metastable state and the ground state is "forbidden" by conservation laws. In a manuscript received by the publisher on January 10, the coauthors drew a diagram of their concept of the transitions in helium and parahelium.

On March 22, the editors received the next manuscript from Franck, this time in joint authorship with Knipping.[81] They had remeasured the excitation potential of helium, but this time with the constraint that no ultraviolet light be emitted. They determined a strong change in current as a function of the electron beam energy. They managed to demonstrate that a metastable level occurs at 20.45 volts as well as a clear change in the current at 21.25 volts. Then they computed the positions of the first and last terms of the known spectroscopic series formula. A comparison against the observed values yielded a very good agreement. The publication closes with some speculations—probably by Franck—about the consequences for the reaction kinetics of chemical

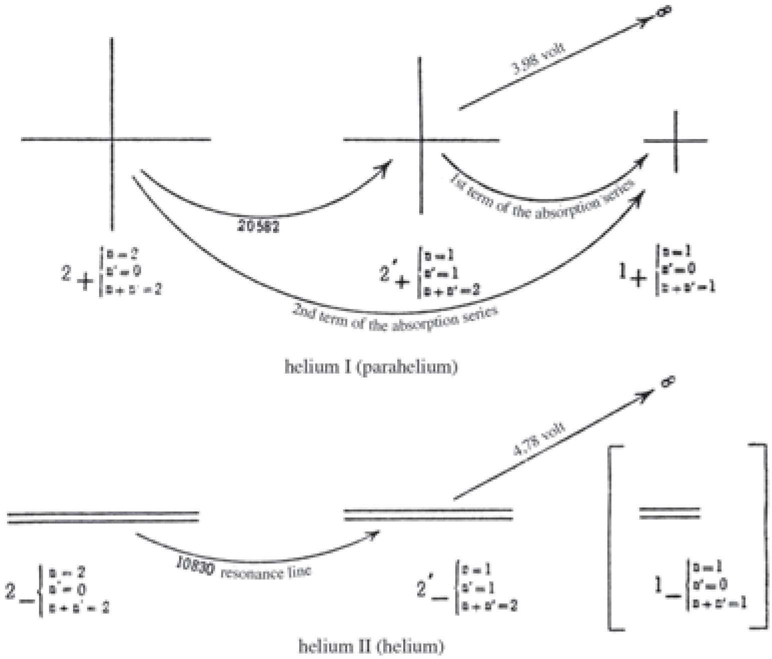


Figure 39 Diagrams of parahelium (above) and helium (below). From: James Franck & Fritz Reiche: Über Helium und Parhelium. *Z. Phys.* 1 (1920), pp. 18–29.

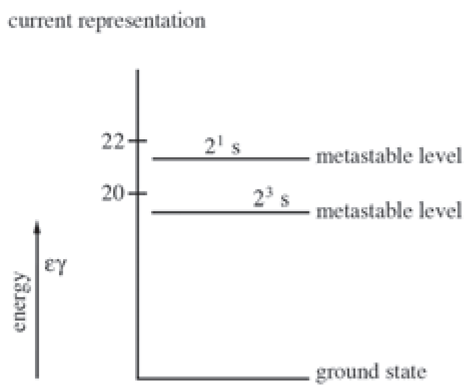


Figure 40 Modern-day term diagram.

processes. His interest in chemistry and its special problems since his student days had evidently not waned.

Soon after this paper appeared Franck received a four-page letter from Friedrich Paschen, who had been holding the physics chair at Tübingen since 1901. Paschen had slowly but surely assembled at his institute the best collection of spectroscopy apparatus.[82] His verdict on research in this field bore much weight and he had the reputation of being a very tough critic.[83]

Highly esteemed Colleague,

Your newest analysis conducted together with P. Knipping on the excitation potential of helium, *Zeitsch. f. Phys.* I, p. 320, 1920, interested me so extraordinarily much that I would like to express my warmest congratulations on this fine discovery and at the same time my utmost admiration for your new electrical method of spectral analysis.

There followed a discussion of various specific findings before ending the first part of his letter with words of praise:

There are more hitherto incomprehensible facts to me that can surely be understood by your interpretation, about which I shall perhaps write at a later time.

Paschen then came to the second part:

Your remarks about the intensity distribution in line spectra, *Zeitsch. f. Phys.* I, p. 2, 1920, gave me an explanation for the generation of new spectra for known elements, which I had chanced upon a long time ago without knowing how it could possibly be that materials like aluminium or chlorine produce entirely new spectra if one gets them to glow from electron collisions in a helium atmosphere.

Figure 41 Friedrich Paschen. Deutsches Museum, Picture Archives, Munich.

At the end of his letter Paschen suggested that Franck analyze neon.

Such letters in the scientific world were not always so supportive. As a rule, however, tolerance and mutual respect governed. When Kasimir Fajans published a paper on electron affinity, Franck could not agree with his conceptions but wrote him diplomatically on 8 February 1920:[84]

Despite the differing opinion I have, I consider your arguments interesting and important, because if I should be right, they serve to clarify the concepts and if you should be right, then naturally much more can be gained by them.

So we are now going to have to tussle it out a little, but thereby "no hard feelings"!

In the spring of 1920, German scientists, particularly the Berliners, proudly welcomed back from Sweden Fritz Haber and Max Planck, who had each just been awarded the Nobel Prize in Stockholm. Haber received it for his research on the synthesis of ammonia and Planck for his discovery of the quantum of action. That December, news would arrive about the nomination of Walther Nernst for the following year's award.

In April, Niels Bohr visited Berlin. This was his opportunity to get to know Einstein and Planck better. At his talks before the ranking professors, younger physicists had little chance to pose their own questions. Bohr was so soft-spoken and his Danish accent so strong that his German was barely comprehensible in a large auditorium. Lise Meitner and Franck had the idea of inviting him the following day to the Kaiser Wilhelm Institute of Chemistry to let the younger, untenured teaching staff speak up, undisturbed by the "bigwig" professors. So even Pohl, who had just become a "bigwig," had to be excluded, friend though

Figure 42 From left to right: Otto Stern, Wilhelm Lenz, James Franck, Rudolf Ladenburg, Paul Knipping, Niels Bohr, E. Wagner, Otto von Baeyer, Otto Hahn, Lise Meitner, Georg von Hevesy, Wilhelm Westphal, Hans Geiger, Gustav Hertz, Peter Pringsheim. Wilhelm Westphal collection. By courtesy of Wilhelm Westphal.

he was. Another problem that had to be overcome was the fact that there was no suitable restaurant in Dahlem for lunch.[85] Haber had set up a canteen at his institute, however, and it was therefore a matter of asking him for permission for all the participants to eat there. This was immediately granted. But shortly afterward Haber thought better of it and invited them all to come to his director's villa as his guests, with the added enticement that Einstein would also join them.

Bohr and Franck immediately saw eye to eye. It was the beginning of their lifelong friendship. Franck was not disturbed by Bohr's way of expressing himself quite vaguely, obscurely, and unclearly about some problems with his theory; and Bohr knew that Franck was capable of conducting decisive experiments for his theories.

Another scientific paper, signed by Franck and his doctoral candidate Erich Einsporn, was completed while Bohr was in Berlin.[86] Einsporn made a very precise determination of the excitation potential of mercury. Previous electron-collision experiments had found only the first excitation level. According to Bohr's atomic model, it involved an electron jumping from the outermost occupied shell of the atom to the next unoccupied one. The experiment employed the Franck-Hertz method, but instead of measuring the current to the external electrode, it sought the rate of the generated photoelectrons. Excited mercury atoms emit ultraviolet radiation as the electron jumps back to its ground state. This radiation, in turn, dislodges photoelectrons from the electrode metal, which are measurable. The wavelengths of the emitted radiation were calculable from the relationship $E = h\nu$, and could be compared against the spectroscopically determined values. The agreement was very good: "Bohr's theory can be confirmed to great precision."

At the same time, some anticipated lines in the spectrum did not occur. They were detectable only through a loss of energy in electron-atom collisions. Franck and Einsporn contended that these were the metastable states of the mercury atom.

In the summer, preparations began for the convention of the Society of German Scientists and Physicians, which this time was supposed to take place in the Hessian spa town of Bad Nauheim. It was to become a memorable meeting because the opponents of the special and general theories of relativity were intent on a public showdown. The convention would be preceded in August by an anti-relativity event in Berlin at which an engineer, Paul Weyland, presented unscientific arguments against the theories. Einstein's response was heavy-handed. He published a scathing newspaper article in the *Berliner Tageblatt*, in which he attacked the renowned experimental physicist Philipp Lenard, accusing him of superficiality in his assessment of the general theory of relativity. Lenard had not always been an opponent of Einstein but included anti-Semitic assertions in his subsequent unprofessional criticisms—especially of the general theory of relativity.

At the Bad Nauheim convention, Planck was assigned the difficult task of guiding the discussion. But the remaining program for the other talks also had to be planned. Franck received an inquiry about a talk by his colleague Walther Kossel. He therefore contacted Peter Debye on July 20 to work out a sensible division of the topics. Originally from the Netherlands, Debye had just left his full professorship of physics at Göttingen for a position in Zurich:[87]

I assume that you have been racking your brains as little as I have about what you would like to speak about. But as I fear you will later perhaps be away and not locatable, I ask you now already what you are roughly thinking of presenting. I, for my part, hope that I will have an easy time of it, since you as the introducer into the field will probably provide all the fundamentals.

Franck intended to report on electron-collision experiments. The medical members wanted the talks to be comprehensible to a general audience. "In this situation," Franck continued,

do you feel like submitting a manuscript for publication? I am hoping we can evade writing but I would appreciate knowing your view on this. I hope you found everything to your liking in Zurich and have come up with some nice new things again. We unfortunately have nothing substantial to dish out here at the moment that hasn't already been published.

During the convention, Einstein stayed with the Borns in nearby Frankfurt am Main. In Berlin, Einstein had advised Max Born to go ahead and swap places with Max von Laue, who had been the professor of theoretical physics at the newly founded University of Frankfurt. Laue wanted to return to Berlin to be able to work with Planck. The Ministry of Culture had approved this highly unusual exchange of jobs, and Born had taken his new position on 4 January 1919.

At the convention in Nauheim, held 19–25 September 1920,[88] Planck managed to avoid a public scandal. Lenard did not come away feeling victorious, however, and the dispute continued. Lenard was not the only physicist opposed to Einstein. Anti-Semitism after the lost war was becoming more apparent even among scientists. After Born received his appointment to Göttingen, his nominee for his successor at Frankfurt, Otto Stern,[89] did not obtain the professorship, partly because he was Jewish.

In the fall Franck received a long letter from Bohr addressing him cordially as "Lieber Professor":[90]

My unfortunately so short stay in Berlin was a quite especially fine and stimulating experience; and one of the greatest pleasures I had there was meeting with you and getting to know you.

Then followed detailed observations on Franck's helium paper and the metastable state:

In connection with my interest in the field of experimental physics you have introduced, I often thought about the possibility of whether you might be able to come to Copenhagen sometime in order to support our research here for a time at the new Institute for Theoretical Physics that is being established here and is being equipped especially for experimental analyses on spectral issues and related problems. I would particularly like to have the opportunity to discuss with you personally the various theoretical problems connected with the area of your investigations and to receive your valuable advice on the installations for experimental investigations. I now hear that you are soon going to Göttingen, but I do not know whether you will perhaps be going there only at the beginning of the summer term and whether you might not therefore possibly be free in the first months of 1921. I dare to write you about this because a sum of money has just been placed at my disposal by some friends interested in the new institute in order to make feasible an invitation to an important foreign physicist for a short time whose presence at the institute could promote the initiation of the scientific researches. So I hasten to ask you whether you have the inclination and occasion to do us the honor and favor of coming here to Copenhagen for a few months at the start of the new year. The sum of money I can offer you totals 3,000 Danish kroner, which I hope can compensate you for your travel and accommodation costs.

The appointment to Göttingen became reality, and Franck gratefully replied to Bohr, with the same familiarity, on October 24.

I found your letter from October 18th, which delighted me inordinately, upon my return from Göttingen; and I would first like to thank you heartily for your so honorable offer that I come to spend some time with you in Copenhagen. I am going to Göttingen at the beginning of March but wanted to move over there in December already in order to be able to attend to all sorts of arrangements in peace. Your invitation is so immensely valuable to me, however, that I shall be glad to come anyway if it should suit you that I be able to be there from the beginning of January until the end of February.

Franck mentioned that during his stay he might have to go to Stockholm for a few days in order to decline a professorship there, as he would be accepting the position at Göttingen. He likewise declined another appointment in Prague that he had received earlier. He was not yet able to answer Bohr's question about the excitation of helium at 21.9 volts. Knipping was still building an automatic measuring device from which they anticipated even better precision measurements. From a paper by Frank Horton and Ann Catherine Davies, Franck gathered that there might have been a neon impurity in the helium in the experiment yielding their inexplicable result. He told Bohr about a paper on excited atoms that would not be completed until December because his negotiations with Göttingen were leaving him no time for it.

Another new collaborator for Franck at his institute was Walter Grotrian, who had developed a simple diagram for the energy transitions of electrons upon excitation that came into general usage. He would later be employed in Potsdam as an astrophysicist. From earlier analyses on the metastable states of helium, they drew conclusions about the formation of molecules from monatomic vapors like mercury and sodium, here also assuming a metastable state as an intermediary stage. Proof was produced using experimental results on mercury vapor by Stark, from F. S. Phillips in Britain as well as their own experimental data. This was the first time that Franck took a close look at molecules.[91]

His reputation among fellow physicists was growing rapidly and with it came his first honor. The mathematician and spectroscopist Carl Runge and the geophysicist Emil Wiechert nominated him on 23 January 1921 to be a corresponding member of the Göttingen Academy of Science:[92]

> Franck has made a notable name for himself among younger physicists through his experimental analyses.

On February 4, Franck expressed his gratitude for the great honor of this election, promising to do his best to participate in the academy's endeavors. Barely a year later, after resettling in Göttingen, Franck became a regular member.

CHAPTER 4

The Göttingen Period

Appointment to the Georgia Augusta

The usual appointment procedure for a professorship in Germany was that a short list of three applicants would be drawn up by the faculty, followed by negotiations with the candidates, starting with the first on the list. Franck's appointment to the University of Göttingen took another route. In spring 1920, Franck's friend Born was offered the chair for theoretical physics there that had become vacant with Debye's move to Zurich. Unsure about whether to accept, Born wrote to Einstein for his advice. Einstein's reply on March 3 was more than a little ambiguous:[1]

> It is difficult to know what advice to give. Theoretical physics will flourish wherever *you* happen to be; there is no other Born to be found in Germany today. Therefore the question is really: where do you find it more pleasant? Now when I put myself in your position, I think I would rather remain in Frankfurt. For I would find it intolerable to be assigned to a small circle of self-important and, for the most part, unfeeling (and narrow-minded) academics (no other social intercourse available). Just remember what Hilbert had to endure with these people. Something else must be taken into consideration. If Max should be faced with the necessity of earning something on the side, a possibility one cannot altogether rule out under the present unstable economic conditions, it would be incomparably better to live in Frankfurt than Göttingen. On the other hand, life in Göttingen may well be more pleasant for the housewife than in Frankfurt, and better for the children; but this I cannot judge, as I do not know enough about the conditions in Frankfurt.

Born was familiar with the situation at Göttingen from his days there as a lecturer. At that time, Eduard Riecke occupied a chair for experimental physics and Woldemar Voigt one for theoretical physics. During the World War a lower-ranking *Extraordinariat* had been created for Debye. Riecke's successor, Robert Pohl, completely redesigned the "great lecture" on experimental physics. His demonstration experiments were impressive. The apparatus was mounted on trolleys permitting a sharp silhouette projection of it to be thrown onto a wall of the auditorium. The students were therefore able to follow the swings of the meter needle with their own eyes. Pohl purchased the necessary projection equipment out of his own pocket. One had to be a very early riser to attend his course because it started at seven o'clock during the summer term and at eight in the winter. If one wanted a seat, arriving late was not an option. Pohl wrote one physics textbook after another for the revamped course. The position Born was interested in filling included supervision of the physics laboratory sessions. Born did not want this task, however, and sought an alternative solution. What about the extraordinary professorship that Debye had held there before he was promoted to Voigt's chair? Calling Born to his office, Ministerial Advisor Erich J. Wende explained to him that the budget for the coming year was already fixed, so there would be no approval for reviving the extraordinary professorship.[2] He let Born review the relevant files, however, and Born discovered that one of the two main physics chairs was supposed to expire only upon the death of its occupant. The error happened to link this stipulation to Pohl's chair for experimental physics—but Professor Pohl was still alive and well! Consequently, neither of the two full chairs had expired and, on the books, a vacancy existed for Franck after all. The Minister of Culture, Carl Heinrich Becker, was called on to decide and he chose to follow the letter and asked Born to propose a candidate for the third post.

Figure 43 Max Born. Voit Collection, M. Born, No. 4. Staats- und Universitätsbibliothek Göttingen, Sammlung Voit.

Born proposed Franck. In this case, therefore, there was no short list of three. The Göttingers had previously already proposed Willy Wien and Wolfgang Gaede, however. After deciding to accept the chair for theoretical physics, Born began his negotiations with the Göttingen faculty, making the appointment of Franck one of his conditions. He could rely on Pohl's support. The other members of the selection committee were for it as well[3]—except for one. The mathematician Felix Klein had reservations about choosing a pure physicist. He feared that applied physics at Göttingen would be overshadowed. Born tried to rebuff Klein's arguments, but his relations with this privy councillor had always been quite strained, ever since his student days. In the end Klein gave way. In a long letter to the ministry, Born set forth the agreements he had reached and his proposals for organizing physics at Göttingen. Franck may have known Einstein's arguments against choosing Göttingen, but for him the argument about home life for his wife and children actually worked in its favor.

Göttingen was a typical university town of almost 40,000 inhabitants that had been spared the political unrest of 1918. The Protestant faith predominated. It was set in the countryside, surrounded by beautiful woodlands. Produce and other fresh foods were much more readily available than in Berlin during the early 1920s. Its industry consisted of small and mid-sized firms, some of which developed and supplied specialized apparatus for the university's medical and scientific departments. Government agencies played an important role in the town and were a major employer. The University of Göttingen had a long tradition of doing science. Founded in 1737, during the Enlightenment, it placed its focus less on its faculty of theology than on law and political science. During its early period, the humanist Georg Lichtenberg was also its leading physicist. The university's luminaries in the nineteenth century included the brothers Grimm, Carl Friedrich Gauss, Wilhelm Weber, and Friedrich Wöhler. Toward the end of the century, the powerful director at the Prussian Ministry of Culture, Friedrich Althoff, arranged with the mathematician Felix Klein to develop a school focused on mathematical research. Klein recruited highly talented mathematicians, including David Hilbert, Hermann Minkowski, and Carl Runge, to the university. Klein also recognized the importance of mathematics and physics for modern technology. With the support of industrial magnates, in 1889 he founded the Göttingen Association for Applied Physics and Mathematics. Woldemar Voigt, the local physicist at that time, pioneered the physics of crystals. Born became interested in this subject as well and made his own valuable contributions to it. Carl Runge had worked intensely for a time in the area of spectroscopy at the polytechnic in Hannover, and Franck found him an interesting person to exchange ideas with.

Before everything had been finalized, Franck participated in the Scientists Convention in Jena that September. Paul Ehrenfest reported to Bohr in one of his regular letters:[4]

> Among the hundreds of physicists there, whose abrasive bustling about entirely depressed me, a handful were a relief to be with. I mean people like J. Franck, Planck, and especially some of the younger people whom you presumably don't know. I felt the aggressive agitation of the younger ones and the blown up self-importance of the older ones the more so, since I had just been spending a full week with Einstein.

Franck's negotiations for employment at Göttingen made good progress. The contract he signed with the Prussian Ministry of Culture on 6 October 1920 stated:[5]

> Conditional on the Minister's approval, the Undersigned agree to the following:
>
> 1. Professor Dr. Franck, Berlin, assumes as of 1 April 1921 the *Ordinariat* for physics available since the death of Professor Voigt at the University of Göttingen. His teaching assignment is experimental physics.
>
> 2. It is agreed with Professor Pohl and Professor Born, the appointed successor to Professor Debye, that the Physics Institute henceforth be divided into Experimental Department I (Pohl), Experimental Department II (Franck), and the Mathematical Department (Born).

Point 3 involved a budgetary issue. The fourth point shows that Franck was well enough acquainted with endless bureaucracy to steer clear of it.

> 4. Professor Franck states that he sets no store by being involved in the general administration of the Institute as a whole. The daily business of his department shall be his responsibility.

Other individual duties listed included:

> the practicals for mathematicians and physicists and the one for medical students in collaboration with the private lecturer, [Heinrich] Rausch von Traubenberg, and the two assistants of the Mathematical Department.
>
> The apparatus hitherto used for these practicals are placed at Mr. Franck's disposal for his department.
>
> Furthermore, Mr. Franck will give a two-hour lecture on specialized topics from his discipline.

Two assistants were granted Franck. Miss Sponer, who came with him from Berlin, received one of the positions. He was also allocated 60,000 reichsmarks to purchase new apparatus. Franck placed "substantial importance" on approval of his demand for acquisitions and additions to the library. His list of demands included a new air-liquefaction system, restoration of the building's large accumulator batteries (most of them up to 500 volts), the purchase of furnaces, and new water piping.[6]

Franck's investiture took place on 15 November 1920, at which time he was also designated director of Experimental Department II of the Physics Institute. As fully tenured *Ordinarius* he received an annual salary of 15,300 RM plus local and compensatory supplements and a children's allowance. If his income from lecture fees exceeded 4,000 RM up to a maximum of 10,000 RM, he was obliged to pay 50 percent to the state treasury. Above 10,000 RM, the state's share increased to 80 percent. If his supplemental income totaled less than 2,000 RM per year, however, the state treasury committed itself to paying him the difference. The number of students attending Franck's courses never was large enough for him to reach the total of 4,000 RM.

Franck had to leave his parents and his sister behind in Berlin, but he would soon have regular business there again as a member of a scientific board, so he could still see them quite frequently. Before his departure from Berlin, the Kaiser Wilhelm Institute hosted a farewell party at which Gustav Hertz and Lise Meitner presented a humorous poem with cartoons. Franck had long been publishing papers jointly with others whose surnames happened to be later in the alphabetical sequence than his. So in the first drawing he is represented standing first in line, looking back at W. Westphal and Wood. Lise Meitner is in the middle of the row, distinguished by an enormous hat.[7] In the second drawing, Brend and Einsporn stand ahead of Franck. The poem poked fun at Franck and his departure. A photo of the members of Haber's institute was taken as a memento.

Max Planck does not appear in this photo. Yet his contributions to thermodynamics and his discovery of the quantum of action, having opened the way for modern physics, made him a central figure among the Berlin physicists—and his personality predestined him to becoming their acknowledged

Figure 44 From left to right, seated: Hertha Sponer, Albert Einstein, Ingrid Franck, James Franck, Lise Meitner, Fritz Haber, Otto Hahn; standing: Walter Grotrian, Wilhelm Westphal, Otto von Baeyer, Peter Pringsheim, Gustav Hertz. Wilhelm Westphal collection. By courtesy of Wilhelm Westphal.

leader. His hospitable home on Wangenheimstraße welcomed many important physicists. Albert Einstein and Max von Laue were foremost among them, as a shared interest in science augmented their personal friendships with Planck. Other guests came to socialize or form a part of the chorus under Planck's strict baton: Lise Meitner, Otto Hahn, and Wilhelm Westphal were among them, as well as the violinist Gertrud Schiemann, her botanist sister Elisabeth, and Agnes von Harnack. Peculiarly enough, Franck was not one of Planck's closer friends. But Planck thought highly of this fellow physicist who was 24 years his junior, and Planck later put much effort into arranging for Franck's nomination for an appointment to Berlin.

When exactly Franck and Einstein exchanged thoughts extending beyond pure science into the personal realm is unclear. When Einstein was planning a series of lectures in 1920 for immigrant students who were denied the right to register officially at the university, he singled out Franck for the lectures on experimental physics. It was probably around then that they began to address each other with the familiar "du." Einstein was always ready to praise Franck's merits whenever his name was mentioned in the context of a professorship vacancy.

Family Life in Göttingen

At the end of 1921, twelve days before Christmas, the Franck family arrived in Göttingen. Their new residence was an apartment at no. 19 Baurat-Gerber-Straße.[8] It was cold and the heating didn't work; the pipes had frozen solid. As if that wasn't enough, one carriage containing their household effects could not be located at the freight station, so they were forced to live out of their suitcases. At Christmas there was still no trace of their furniture. At last, many days later, the carriage was discovered parked on a siding. It had simply been misplaced. The family set up house and their maid reconnoitered the shopping possibilities. Daggie and Lisa started attending their new school in the new year. Both were already old enough to go to the girls' preparatory school, the *Lyceum*.

Franck was getting ready for his trip to Copenhagen. Before the move, in a letter to Bohr dated November 22, he had gone into some detail about what he was planning to work on there.[9] He wanted to conduct absorption experiments on vaporized metals and perhaps also analyze the ionization and dissociation of iodine vapor, as they had discussed during Bohr's visit to Berlin. Franck mentioned the equipment he would need: three meters, a few adjustable resistors, and two storage batteries, as well as perhaps some platinum electrodes. Except for the last, these were all things that twenty years later would be a part of every physics teacher's instrument collection. Franck was committed to reconstructing the apparatus he and Hertz had used and putting it in working order in the Copenhagen institute.

When Bohr had originally accepted his chair for theoretical physics at the University of Copenhagen in 1916, he had put forward the idea of founding a research institution[10] that would allow scientists from various countries to work together for a period of time. Such an institution was much easier to establish in a neutral country than in a state still embroiled in the "war of the intellects." The Danish government supported the proposal, and much time in the foregoing year had been spent on devising these plans. Bohr's institute was destined to become a world center for atomic physics. The Carlsberg and Rask Oersted Foundations supplied funds for the researcher stipends. Hendrik Kramers, from the Netherlands, was its first guest scientist. He worked closely with Bohr on developing the theory underlying atomic structure. Research by a few other young collaborators was also already under way. One of them was the Swedish theoretician Oskar Klein, son of a rabbi. Another theoretician, Sven Rosseland, had arrived from Norway. The chemist Georg von Hevesy came from Hungary and Adalbert Rubinowicz from Poland. Franck postponed his sojourn until the following year, however, because Bohr had overworked himself and needed time to recuperate.

At Göttingen Franck had considerably more responsibilities besides teaching than he had had in Berlin. The institute first had to be equipped with

Figure 45 View of Göttingen. Old postcard.

new instruments. An inventory revealed how little of the existing collection was still usable. As institute director he had to negotiate the wages for his assistants and purchase the new instrumentation. The state allocations did not suffice, so Franck had to try to raise funds from other sources. The mathematician Richard Courant already had one important contact, with an industrialist. To avoid the stigma of being an "in-house" candidate as a former student of Hilbert, Courant could not simply become his immediate successor at Göttingen. So an appointment to Münster had first been arranged for him. While Courant was at Münster, Carl Still, the proprietor of a profitable machine building firm, came to see him about a mathematical problem.[11] The initial consultation turned quickly into long-term friendly relations between Still and Göttingen mathematicians and physicists. Franck soon also received an invitation to meet the industrialist at the beginning of January 1921. Carl Still was able to assuage Franck's fears about what the future held for the German economy, and his financial support of the institute relieved Franck of much worry.[12]

The majority of Göttingen's population held quite strongly conservative views, and the members of its university were no exception. On 18 January 1921 Göttingen, like many other German towns, celebrated the fiftieth anniversary of the founding of the German reich at Versailles in 1871. Despite the inclement weather, the student delegates filed by in procession in full dress, with banners flying, up to the Church of St. John. The standard-bearers arranged themselves around the altar and the delegates lined the central aisle with their rapiers drawn. The university's rector, Consistory Councillor Prof. Carl Mirbt, gave the speech. The Hochschulring deutscher Art had already commemorated the occasion in its own way the night before. This local affiliate of the ultranationalist and anti-republican student union had sung a variant of the famous song "A stately frame had we built" (Wir hatten gebaut ein stattliches Haus), a protest against the banning of fraternities in 1819:

Severed is the bond	Das Band ist zerschnitten,
Of black, white, and red;	War Schwarz, Weiß und Rot,
Fighters for the Reich	Wer für das Reich gestritten,
Stay true until death!	Bleibt treu ihm bis in den Tod!

This altered verse swaps the colors of the kaiserreich—and Nazi groups—for the flag of the Weimar Republic. The original wording is:

Severed is the bond	Das Band ist zerschnitten,
Of black, red, and gold;	War Schwarz, Rot und Gold
Yet God is forbearant,	Doch Gott hat es gelitten,
Mysterious are His ways!	Wer weiß, was er gewollt!

The *Göttinger Zeitung* published a critical report on these proceedings. Theodor Heuss, the future first president of the Federal Republic, wrote in its supplement to the January 18 issue about the anniversary of the German empire:

> France celebrated the half century of its republican existence a couple months ago with much fanfare—in victory it could nonchalantly remember its erstwhile defeat. And we? No one yearns for jubilation. The State, founded fifty years ago fell apart; and it is agony to look back on this great historical moment from the somberness of our day.

The article ends:

> The Republic did not inherit the power of the monarchy but its ruins; and it stands before the unspeakably difficult task of building the stately frame of the nation anew and then stretching its wings forth beyond the domestic boundaries of power.

In the same issue of this local Göttingen paper, the chairman of the Provincial Cartel of the League of German Civil Servants reported the dire situation of his constituents, still waiting to receive a cost-of-living supplement, despite price increases of well over 100 percent. The budgetary troubles of the Weimar Republic also infected university finances. In his search for external funding for extra assistantships, Franck was able to build on his good relations with Fritz Haber and the jurist Friedrich Schmidt-Ott, the last minister of culture under the kaiser. Both had a powerful say in how the funds of the Notgemeinschaft were dispensed.[13] This Emergency Association for German Science had been founded in 1920 by Haber, Nernst, and Schmidt-Ott with funds from commercial industry. The association purchased costly instrumentation and lent it out to applicant scientists for their research. In 1923, for instance, Max Born received a mechanical calculating machine for use by his institute. Two years later the Japanese industrialist Hajime Hoshi donated a large sum to endow the founding of a "Japan Committee." General Electric, in conjunction with AEG and the Siemens firm, later also granted $15,000 for research in Germany in the field of electrophysics. These funds were managed by an Electrophysical Committee headed by Max Planck. Franck was another of its members. Franck's fund-raising efforts were a success. Projects under way at his institute were clearly attractive enough to the decision makers to assure that his petitions were never rejected.

He also acquired apparatus with outside assistance. Albert Einstein was director of the Kaiser Wilhelm Institute of Physics, an institution that in fact existed only on paper. But he had control over its budget and used it to provide support for research by other scientists, including Franck.

As a full professor at Göttingen, Franck was a member of its philosophy faculty. In addition to a strong representation from historical and philological subjects, 24 scientists were included in this large faculty. This administrative unit was too cumbersome to reach decisions specific to the scientists' concerns, so at Hilbert's initiative, they petitioned to secede and create an independent faculty. While waiting for approval by the ministry, they held separate meetings on issues of interest only to members of the mathematical and natural sciences, sometimes convening in one of their private apartments. The most important issues were, of course, staff appointments and habilitation and doctoral degrees. Examination regulations were discussed as well. Franck had no difficulty in integrating into this circle, where, as elsewhere, human weakness was occasionally inclined to reign over reason. But Franck would not let himself become involved in such quibbling, and he never sought the esteemed position of dean. Contrary to the situation with many full professors, his relationship with the *Universitätskurator* was always very good. This official, responsible for reporting decisions reached by the faculty to the Ministry of Culture, was the legal expert Theodor Valentiner.[14]

Although Franck rarely used mathematical aids for his research or publications at Göttingen, he still had a very high opinion of his much older mathematician colleagues Hilbert and Runge. Courant and Franck were almost the same age and it was not long before the Francks began socializing with the Courants.[15] Mrs. Courant was one of Runge's highly musical daughters and an excellent violinist. Nina Courant regularly played duets with Ingrid Franck, and she was soon giving music lessons to the Franck girls. With two other students of hers a "baby quartet" was born.

Figure 46 Carl Runge. © bpk-Bildagentur für Kunst, Kultur und Geschichte, Berlin.

Figure 47 Richard Courant. Staats- und Universitätsbibliothek Göttingen, Sammlung Voit: R. Courant, no. 1.

At Easter, Lise Meitner came to visit from Berlin, and the Franck family took her on an excursion in the finest spring weather, amidst blossoming anemones and liverworts.[16] James Franck was glad that his children were free to enjoy nature by going out for walks in the woods or into the countryside on their own. Miss Meitner needed a little fattening up because she had become even thinner under the hard economic conditions of living in the metropolis.

Franck's research stay with Bohr took place before the summer term started. He left on his trip with a good conscience because his wife was comfortably settled in Göttingen. The visit strengthened Franck's bond of friendship with Bohr and an intense collaboration ensued. At the invitation of the Danish Naturviddenskabelige Samfund, Franck held a talk on February 24 about his electron-collision experiments. Returned home, he described his trip to Carl and Hanna Still in an April 2 letter:[17]

> It was really nice in Copenhagen. I was glad to notice how much importance the local scientists clearly laid on maintaining close ties with us in Germany.

He mentioned that Bohr would be coming to Göttingen to speak about his results and asked whether the Still couple would be able to join them.

> Personal contact with Bohr reveals almost more than his papers that among living physicists he is the greatest beside Einstein and Rutherford.

The progress made in equipping the laboratory and his visits with Bohr had let Franck almost forget his worries.

> Here in G[öttingen] it is so unshatterably peaceful that one sometimes doesn't understand how it is at all possible nowadays. Depending on one's mood, one either rejoices about it or at times is annoyed about the deafness of people toward our great troubles. But complaining doesn't help either.

Franck had mentioned how interested Danish physicists were in exchanging ideas with their German colleagues. In other countries, however, the wounds of the "war of the intellects" had not yet healed. In 1911, with the support of

Walther Nernst, the wealthy, philanthropically-minded Belgian chemist Ernst Solvay had invited renowned scientists to attend a conference about radiation theory and quanta. Einstein, Nernst, Planck, Rubens, Sommerfeld, Warburg, and Willy Wien had come from Germany.[18] The second Solvay conference had taken place in 1913. Now another conference was planned to take place in Brussels in the spring of 1922 on the topic of atoms and electrons. The findings by Franck and Hertz could have contributed importantly, but as Germans they received no invitations. Einstein did get one, but decided not to appear. For some mysterious reason, in subsequent years, even when the conference theme touched on Franck's area of research, he was not among those invited.

The students attending Franck's courses were different from his own classmates at Heidelberg or Berlin. Many were soldiers, some even officers. They were older and had experienced war. The worry about how to finance their studies was much greater than before, and few students chose to study physics and mathematics. In the summer semester 1921, the number of auditors for Franck's two-hour Friday-afternoon lecture about the physics of the atom rarely exceeded a dozen.[19] He did not continue the old Göttinger custom of having one of the students take notes and then rework them into a textbook, as was common among mathematicians and was also adopted by Born.

Figure 48 Max Reich, Max Born, James Franck, Robert Pohl. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Pohl's situation was entirely different. Scientists were not the only audience for his general physics lecture. Students of medicine also attended. Pohl included many illustrative demonstration experiments and held ninety-minute lectures Mondays through Thursdays on mechanics, acoustics, and heat. On Tuesdays Pohl also offered a public lecture on light and color. Born gave his course on the theory of electricity and magnetism four days a week from eleven to twelve o'clock. On Saturdays from nine to ten, he lectured about the kinetics of solid bodies. More-advanced physics students were attracted to the pure mathematics courses by Courant, Hilbert, Edmund Landau, and Runge, as well as to Hilbert's more specialized lectures. On Wednesdays and Thursdays, Hilbert treated Einstein's theory of gravitation from nine to eleven, and on Saturdays from noon to one he discussed the basic ideas of relativity theory. There was also a seminar led by Born and Hilbert on Monday evenings about the structure of matter, as well as the physics *Proseminar* by Born and Franck on Wednesday mornings that registered over eighty participants. In the evening, the very important physics colloquium took place, organized by Born, Franck, Pohl, and the more technically oriented professor for electricity, Max Reich.

Their students jokingly referred to themselves as "die Bornierten, die Franckierten, die Pohlierten," which roughly translates as "the limited, the stamped, and the polished." Niels Bohr's students were added to this class as "die Verbohrten"—"the obstinate."

Research at Experimental Physics Institute II

As agreed at the time of his appointment, Franck had to direct the *physikalisches Praktikum* for students of medicine, chemistry, physics, and mathematics together with Heinrich Rausch von Traubenberg.[20] On average, about 150 students took the course each semester. Starting with quite simple experiments, they had to complete a number of practical exercises, make observations, take measurements, and perform calculations before being tested at the end about what they had learned.

Rausch von Traubenberg, originally from Estonia, had studied physics in Freiburg near Breisgau. His dissertation had analyzed the radioactivity of the spring waters of Freiburg and the Black Forest. At Göttingen, he offered a course on radioactivity. A highly gifted experimental physicist, he knew how to design experiments and develop measurement apparatus from simple means. In 1922 he was offered and accepted a professorship at Prague. Otto Oldenberg therefore took over his duties for the practicals that fall.[21]

Oldenberg, a Berliner, was six years younger than Franck. He had commenced his studies at Heidelberg and completed them with a doctorate at

Göttingen in 1913. He had served in the German army during World War I and afterwards spent two semesters with Willy Wien at Würzburg, where he worked on the physics of the atom. Accompanying Wien to Munich, Oldenberg then transferred to Rostock for a single semester before acquiring his *Habilitation* degree and joining Franck.

Franck's second regularly budgeted assistantship was taken by Hans Falkenhagen, but he left for Danzig before the semester was even over.[22] So Franck wrote to the academic official at the ministry to request that the position be given to Hertha Sponer: "As ministerial approval must generally exist for the hiring of a lady, I take the liberty to inquire whether in this case the Ministry must be applied to again once Miss Sponer has the supernumerary position." The approval was apparently granted without a hitch.

Following the example of his own teacher, Warburg, Franck went on regular rounds through the practicals laboratory to check the abilities and knowledge of his students. He was thus able to gain additional information about how suitable a student might be as a future doctoral candidate. Since the beginning of World War I, female students were matriculating in rising numbers. Professors were responsible for testing each student personally, and Franck soon developed his own examination procedure for majors and minors in physics. According to Wilhelm von Humboldt's conception of a university, professors ought to be not only able teachers but also active researchers. Franck was able to put this ideal union of research and teaching into practice. His lecturing and guidance were augmented by very intense personal attention to his advisees. They became full-fledged collaborators in his experimental and theoretical considerations.

Figure 49 Hertha Sponer and Otto Oldenberg. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

During the 1920s the types and scope of scientific research grew much more rapidly than before World War I. Increasing numbers of students prompted the creation of new professorships. More graduate students contributed to research—as did industrial researchers. In some scientific fields competition mounted correspondingly at universities and polytechnics. Thomas Edison's example served as a model in the founding of industrial laboratories, especially in the electrical sector. The applied and basic research conducted in these laboratories expanded the range of fields examined. After 1918 Gustav Hertz had not managed to obtain a chair in Germany, so he accepted an offer from the Dutch company Philips in the company's research laboratory in Eindhoven, where the working conditions turned out to be very good. The research there involved finding a more efficient source of electric light than the metal filament lamp, which dissipates most of its power in heat. One possible solution was developing a gas discharge lamp. Hertz was able to apply his expertise in electron-collision excitation to this project and also used it to advantage in other related work. When Franck came to visit him from Göttingen, he got an opportunity to establish close ties with other Dutch physicists. To these people the chauvinistic sentiments of World War I, the "war of the intellects," were meaningless.

Research was becoming increasingly international. Göttingen soon began to attract mathematics and physics students from abroad. Born, Franck, and Pohl were intensely involved in this development, but they were also active in reviving scientific life in Göttingen and the former Kingdom of Hanover. In Berlin, Born and Franck had frequently attended the meetings of the German Physical Society and presented reports on their research. Now, with the support of Pohl and Reich, they worked toward founding a regional branch of the society in Lower Saxony. Everything was carefully discussed with Wilhelm Westphal in Berlin to prevent any friction developing with the Berliners.[23] One example of Franck's moderating influence was the invitation extended to Karl Scheel, the society's longtime managing director, to come to their founding meeting, despite some recent quarrels with him.

In spring 1921, Bohr's coworkers Oskar Klein and Sven Rosseland published a theory of energy transfer in collisions between excited atoms and electrons. They were called "collisions of the second kind." This idea inspired Franck to think about the consequences on the fluorescence of a gas.[24] He had already worked on such collision processes with Hertz in 1916 in their paper on the relative intensities of gas spectra in the glow discharge of mixed gases, but the theoretical implications had not yet been completely explored. On August 24 Franck wrote to Einstein asking for his opinion on the equivalence between radiation and the translational energy of atoms. Could the collision of an electron traveling at an energy less than is necessary to excite an atom bring an already excited atom back into the ground state without there being any emitted radiation? In this reaction the energy would be converted into translational energy. Franck thought that this could be the explanation for the extinction of resonance fluorescence at higher gas pressures.

Franck's first Göttingen graduate student was Victor von Keußler, who was researching the excitation of the atomic and molecular hydrogen spectrum by electron collisions. Keußler's analysis was related to an earlier publication by Thea Krüger. Other physicists had subsequently corrected to lower values her result for the ionization energy of hydrogen. Keußler was able to show that the dissociation of hydrogen proceeds in two stages. Franck's second doctoral student in Göttingen, Günther Cario, started experiments based on Franck's conceptions of energy transfer in collisions and proved to be a very skillful experimenter. He had been born in Göttingen in 1897,[25] the son of a physician with a private home practice. In 1914 Günther Cario was drafted into the army, but he was released owing to a heart defect. As a beginning student of physics, Cario worked under Professor Ludwig Prandtl in the Aerodynamic Testing Station in Göttingen from 1917 to 1919.

Franck had already advised a few graduate students in Berlin but now, as an *Ordinarius*, he had to guide more students through to their doctorates. With their help he was able to develop a longer-term scientific program. The scope of each dissertation had to be carefully defined, because the papers had to be successful and contain some new science. It was not just a matter of giving the candidate the feeling of having contributed something to science. He or she was supposed to learn how to conduct scientific research. So there was a reason behind the course listing in the catalog called "Introduction to Scientific Research" and taught by the full professor personally. To start with, an estimate for the apparatus needed was required because the dissertation could not be allowed to tax the institute's budget too much. While they were busy experimenting, he had to make sure that they did not go off on a tangent or tinker about too long with the apparatus. There were a limited number of places, and experiments that took too long blocked the laboratory bench for succeeding doctoral students.

Franck continued to correspond with Bohr about his planned experiments on the problem of collisions of the second kind. As dissertations were supposed to produce something genuinely new, such consultations were important. Moreover, he wanted to avoid any rivalry or misunderstandings with the Copenhageners. Cario, he wrote, was supposed to examine whether the addition of a noble gas would lead to an observable broadening of the spectrum line in resonance fluorescence;

> e.g., it should be possible to excite the [sodium-]D lines in an Hg and Na-vapor mixture by irradiation with 2537 [the Hg fluorescence line], and other analogous experiments, resp. One might thereby perhaps be able to understand the effect of sensitizers.

Franck was expanding on Klein's and Rosseland's conceptions. This research eventually became a success, occupying him and his graduate students as well as a few assistants for a number of years.

Bohr likewise did not want his collaborators to interfere with research under way at Franck's institute. His letter on 16 September 1921 reflects this concern:[26]

> I would like to use this opportunity to ask you whether experiments are under way in your laboratory on deciding the question discussed in our earlier letters about the occurrence of radiationless transitions (from the metastable levels) upon collisions between atoms or whether you have perhaps been planning such an examination.

Another letter written by Franck that November disconcerted Bohr. A paper by two Americans, Frank Horton and Ann Catherine Davies, mentioning electron emissions from electrodes by the photoelectric effect, seemed to put into doubt the conclusions that Franck and Hertz had drawn from their own experiments. Franck had to reconsider the problem but concluded the contrary and drafted a rebuttal. The following exchange of correspondence ended with both sides in agreement that no physicist with an adequate understanding of experiments could doubt the results that Franck and Hertz had originally obtained.

On 22 February 1922 Franck published a paper on some conclusions about fluorescence, photochemical processes, and the electron emission of glowing bodies, based on the theory by Klein and Rosseland.[27] Soon afterwards, on March 1, Bohr wrote to tell him how very interested Klein and Rosseland had been in his "fine paper." This must have been gratifying for him. Bohr's opinion was always very important to Franck, to the point of slight annoyance for Born, although it never rattled their friendship.

Max Born pictured the activity at the institute at the end of a long letter of April 30 to Einstein:[28] "Franck has his whole Institute teeming with doctoral students, all doing nice research, feeding off his ideas." During this period, Franck may have read an article in the *Vossische Zeitung* on 25 April 1922 by Erich Everth about "political professors":[29]

> The charge about "political professors," who in reality mostly remain apolitical, is an old tune in Germany. It has been sung for hundreds of years, since the demagogue persecution, through the Bismarck period, until now. Once upon a time, the political right picked up the refrain, now it's the left. [. . .]
>
> Once upon a time, the ministers assembly in Carlsbad 1819 resolved that professors be dismissable from a university for exerting "questionable influence" and not be reengaged by any other inside Germany; and a special seven-headed investigative committee was established in Mainz. Today—thank God—there is no such thing, the Republic does not defile itself with such methods.

Then, after some historical commentary:

> Nowadays certain professors do, of course, exist who—if it were up to them—would lead Germany to ruin. But it is not up to them, and the havoc that they really do wreak can be combated and is being combated even from among their own ranks.

The columnist examined how many professors could be counted as generally leftist. Only one from Göttingen was named: the philosopher Leonard Nelson. Carl Runge and Richard Courant, who were politically engaged social democrats, escaped his notice.

> The situation among professors regarding democracy and the Republic is probably no worse than in other equivalent segments of the population. But we do not know for sure, and that is a pity.

Another article by Everth appearing just three days later discussed the subject of universities and the new state. An introductory passage was followed by the explanation:

> In fact, it is out of the question that proponents of the three currently governing parties could claim most German rostrums. On the other hand, neither is it the case that their opponents, or indeed the enemies of the Republic, are in the majority. The great majority of German university teachers is certainly politically indifferent. The essence of scholarship is the reason for it.

After a report about the conduct of individual professors from the rightist camp came the general remark:

> There still does remain a group of radical rightists at German lecterns who constantly give the public new occasion to concern itself with them. Always the same names attract such ruffles, whether through articles in the extreme-right press or through incidents in the auditorium making news off campus.

Franck would not have been able to gauge against personal experience the closing commentary about the posturing and behavior of radical rightists in academic committees nor about the way it was being tolerated. Members of the faculty of the sciences at Göttingen may not have all shared the same political views, but polarization among the different camps did not exist.

These professors found other events much more important. In June 1922, right in the middle of the semester, Niels Bohr decided to make good on his promised visit.[30] His brother Harald, the mathematician, had already been to the town and had told him about the professors at Göttingen. Franck looked around for accommodations for the Bohrs and found two furnished rooms in a widow's villa. A stenographer was also procured for the talks: Rudolf L. B. Minkowski, a nephew of the deceased mathematician. To this important meeting with Niels Bohr, who took Oskar Klein along as his "travel attendant," came Wilhelm Lenz from Hamburg and Sommerfeld from Munich, accompanied by the 21-year-old Werner Heisenberg. Alfred Landé made his way there from Tübingen. Wolfgang Pauli, a student of Sommerfeld's and a critical whiz among the younger generation of physicists, was at that time Born's assistant. The mathematician Carl Wilhelm Oseen from Sweden revisited Göttingen, where he had studied under Hilbert. Paul Scherrer also attended from Zurich, and likewise Paul Ehrenfest. The publisher Ferdinand Springer, who had also received an invitation, was deeply impressed by the atmosphere.[31] On six successive evenings, Bohr reported about extensions of his model of the atom. Starting with the hydrogen atom with just one orbiting electron, he was able to indicate on the basis of considerations on energy and symmetry the arrangements of the electron orbits and the number of electrons per orbit in each element of the periodic table. It was possible to deduce the chemical behavior of the elements. Inertness of the noble gases, for instance, was explicable by their each having full electron shells. The reactiveness of the alkaline metals lithium, sodium, potassium, rubidium, and cesium he explained by just one electron occupying the outer orbit. Of course, some questions remained open and unresolved.[32]

Figure 50 Carl Wilhelm Oseen, Niels Bohr, James Franck, Oskar Klein; seated: Max Born. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

The older participants complained about a lack of sleep, blaming it on over-indulgence in the coffee beans Bohr had brought with him. Friedrich Hund thought, though, that the mood excited by Bohr's talks was the more likely cause. It was during this visit that Bohr first met Heisenberg. Sommerfeld introduced him to Bohr as a young man with a serious objection to raise. Bohr loved a good discussion and disappeared with Heisenberg on a long walk. Neither suspected that just three years later Heisenberg would develop a new theory of the atom that would lead further than Bohr's model. At the end of the series of lectures, on June 22, David Hilbert thanked his guest speaker:[33]

> There only remains for me to thank you for the inexhaustibly rich, highly important lessons that you have allowed us to share by your lectures—especially the frankness with which you granted us insight into the inner sanctum of your scientific personality. We appreciate this favor to us very highly. Despite the many problematic and open points of the theory, the general impression is nonetheless characterizable as elating: again and again we experience anew how advantaged a physicist is today when he works with theory. I should like to say: No one else—and humans, as multifaceted as are their occupations, are indeed in a position to estimate the degree of admiration for the human intellect—has succeeded in penetrating so profoundly into the secrets of nature. Your lectures will remain in our memories and have a lasting effect.
>
> If we are permitted to express one more wish, then it is that into the remotest future every link in the long chain of our guest professors will prove themselves worthy of these commencing elements.

James Franck then spent three peaceful days with Bohr in Karlshafen on the river Weser.

The harmonious reverberations from the scientific meeting were abruptly interrupted by confrontation with political reality. While traveling in an open vehicle from his villa to his office, Foreign Minister Walther Rathenau was assassinated by young pan-German activists of the politically extreme right. The headlines of the *Vossische Zeitung*'s evening edition for June 24 read:

> Reichsminister Rathenau murdered
>
> Organized conspiracy against the State
>
> Who is safeguarding the Republic?

The Sunday edition ran the story:

> Call for security of the Republic
>
> The Reich Chancellor's appeal to reason
>
> The enemy is on the right

For many people, honoring the funeral of the murdered foreign minister symbolized a profession of loyalty to the republic. June 27 was declared a national

Figure 51 David Hilbert. Staats- und Universitätsbibliothek Göttingen, Sammlung Voit: D. Hilbert, no. 11.

day of mourning and an order was issued to lower all flags on public buildings to half-mast. Back in August 1921, Philipp Lenard, the director of the physics institute at the University of Heidelberg, had wired his congratulations to the murderers of Matthias Erzberger, that prominent Centrist politician assassinated by ultranationalists for having signed the Armistice. He was not about to obey the government's orders this time. He provocatively insisted on holding his regularly scheduled practicals. The activist Carlo Mierendorff noticed what was going on and reported it to the rector. But nothing happened. So Mierendorff's students and the union tried in vain to negotiate with Lenard, who barricaded the entrances to his institute and turned the fire hydrants on the gathered crowd outside. They called out to him to open up the building, but he resisted and the situation began to get violent. The police therefore moved in and took the professor into safe custody. The university leadership issued a reprimand to Lenard, but no punishment was meted out.[34] A report appeared about the incident in the *Vossische Zeitung*, but it was surely not altogether surprising to Franck. He probably already knew about Lenard's surreptitious harassment of Knipping from Lise Meitner. Wilhelm Hanle, who had been working on his dissertation at Franck's institute for some time, also had a few other sorry tales to tell about Professor Lenard.

Hanle had studied under Lenard at Heidelberg. At one of his seminars, for instance, Hanle had presented a report about Einstein's equation relating mass and energy, $E = mc^2$. Lenard was so furious about it that Hanle thought it preferable to work toward his doctorate elsewhere and subsequently joined Franck's institute. The topic he was assigned at Göttingen was very fruitful: analyzing the influence of a weak magnetic field on the resonance fluorescence of vaporized sodium. Other scientists, notably Wood, had already worked in this area, but Hanle's skill at precision measurement helped him find something new. His results became the subject of discussion in Franck's correspondence with Bohr and Kramers in Copenhagen, but Hanle's attempt at a theoretical interpretation was less of a success. Bohr's model could not provide quantitative predictions about the influence of magnetic fields on atoms.

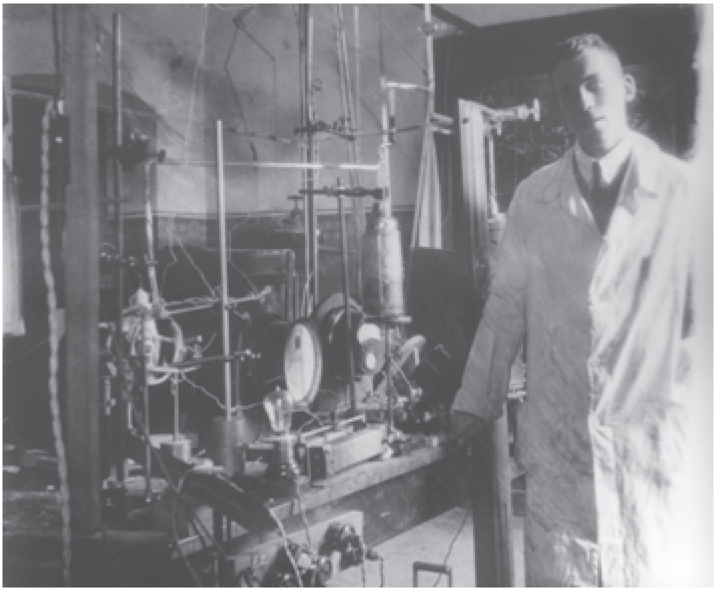


Figure 52 Wilhelm Hanle. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

In the aftermath of Bohr's lecture series, Sommerfeld and Born decided to set their assistants to work on perfecting his theory and subjecting it to mathematical scrutiny. Sommerfeld's highly gifted student Wolfgang Pauli had joined Max Born's institute.[35] Together they tried to calculate the extended Bohrian model by introducing quantization to a disturbed mechanical system. The French mathematician Henri Poincaré had attempted this, based on classical mechanics, for planetary orbits and their mutual influence. Quantization leads to some irresolvable problems, however.

When Born was confined to bed by one of his asthma attacks, the 22-year-old Pauli had to give Born's lectures. There were some strained moments between Born and this quite impetuous assistant, and Franck evidently acted as a levelheaded mediator. Thirty years later, Pauli sent him a letter, expressing his gratitude to Franck for[36]

> patching up the damage that my youthful aggressiveness had caused among those around me. I would like to take this occasion to thank you sincerely, for once, for your quite extraordinary patience with me.

In less than a year Pauli moved on to Hamburg, to work with Lenz. He was succeeded by Werner Heisenberg, even though the latter had not yet completed his doctoral degree in Munich. Max Born and Heisenberg tried to compute the energy levels of a helium atom in the excited state. The results they obtained for the spectra did not agree with observations, however. The model had failed mathematically. Meanwhile Heisenberg had to defend his doctorate at Munich. His examination on experimental physics by Willy Wien was a disaster. Heisenberg was unable to answer a few simple questions from that field, and Sommerfeld's intercession was needed to convince Wien to let Heisenberg pass anyway. Heisenberg returned to Göttingen depressed, but Born and Franck did not regard the affair so seriously. Their solution was that Heisenberg should complete an experimental course with Franck.[37] Heisenberg followed this advice, of course, but Franck very quickly noticed how little the theoretician enjoyed conducting experiments. So Franck had second thoughts. What was the purpose of having Heisenberg go through such an ordeal? If he ever needed the skills, he reasoned, he could easily learn how to go about it from a book. So they agreed to have him "thrown out" of the practicals. Whenever Franck couldn't find Born to ask him about some current theoretical problem, he was able to turn to Heisenberg. That was how he became acquainted with Franck's straightforward way of thinking.

The experimental research under way at Franck's institute still concerned collisions and energy transfer. Franck discussed with Cario how to plan new analyses to verify Franck's conceptions about the transfer of energy in those collisions. The results of the experiments, published in September, vindicated

Figure 53 Wolfgang Pauli. Friedrich Hund collection. By courtesy of Friedrich Hund.

Figure 54 Werner Heisenberg. Friedrich Hund collection. By courtesy of Friedrich Hund.

them. Molecular hydrogen H_2 cannot be decomposed into monatomic hydrogen by, for example, irradiation by the mercury line 2536.7 Å. The energy $h\nu$ of the photons is not sufficient to break the molecular bond. Much higher-energy radiation with a shorter wavelength of roughly 1200 Å would be necessary. Franck supposed, however, that such a decomposition would be possible through a collision between an excited mercury atom and a hydrogen molecule. This was sensitization by means of a different element that does not otherwise react chemically with its collision partner, in this case mercury with hydrogen. To detect the monatomic hydrogen, a chemical reaction was used that the American physicist Langmuir had suggested. Monatomic hydrogen is a powerful reduction agent. If it reacts with a metal oxide, the surface color change clearly indicates the reduction to the metal.

Cario and Franck used different procedures to test the result.

When radiation at a wavelength of 2536.7 Å in the furnace hit the mixture of vaporized mercury and molecular hydrogen, a steady drop in pressure was observable on their pressure gauge. The monatomic hydrogen that formed reacted with the metal oxide and reduced it. The resulting water was then frozen out in the condensation trap. If this cooling stage was eliminated, the pressure rose as the water turned into steam. Opening the tap directed the water to the drying agent, phosphorous pentoxide, converting it into phosphoric acid and causing the pressure to drop again. Switching off the cooling mechanism of the mercury lamp caused self-reversal of the Hg line to increase and the decomposition of the hydrogen to stop. As an additional check, experiments were performed without mercury or without hydrogen in the vessel. At the end of their publication, Cario and Franck estimated the dissociation energy of the hydrogen molecule at 120 kcal, a value approximately 20 percent greater than the current value.[38]

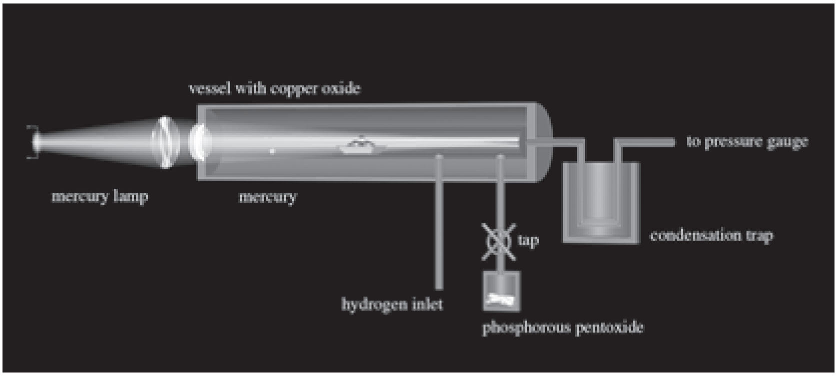


Figure 55 Schematic arrangement of Cario's and Franck's experiment.

Lise Meitner wrote Franck enthusiastically on 16 November 1922 about how the Berliners had reacted to the paper:[39]

> First I have to say that your last paper (atomic H) is one of the most enthralling papers I have read in the last few years. If I weren't afraid you'd become completely bloated up with conceit (or aren't already so in the end?) I would confess to you that as I was reading it I thought it a genuine show-case piece, such as Rutherford's best papers are. Miss Laski reported on it yesterday (nice and clearly) at the colloquium and everyone was very delighted and inspired by it.

Cario meanwhile had to defend his thesis. It examined the development of true absorption and apparent coupling in quantum jumps. Before being appointed to Göttingen, Franck had had little opportunity to gain experience as an examiner. Now he was forced to navigate his way through this professionally and personally challenging realm. As his lecture course covered only a specialized area, whereas the examinations were supposed to cover the entire field of physics, Franck was not bound to specific wordings introduced in a particular course as, for example, Born was.[40] This gave him more leeway during the testing. Cario was examined on 24 May 1922, but for unknown reasons the examination was cut short and resumed on July 12. The very succinct minutes were written by Franck, who tested him altogether for an hour in the absence of another assistant on:[41]

> Kinetic gas theory, mech. pendulum, reversion pendulum, d'Alembert's principle, dispersion—comprehensively, resolving power of optical instruments, diffraction, alternating-current measurements, magnetic measurements, theory of dia/paramagnetism, internal friction, X-ray spectroscopy

How deeply Franck delved into these concepts in follow-up questions is not indicated. He would later be known to pose a few of the same basic questions at his examinations. A description of the resolving power of a microscope was one such topic, as well as the foundations of the kinetic theory of gases. If the examinee was only minoring in physics, topics like resistance and alternating-current measurements, magnetism, and geometric optics figured in the half-hour examination. Rarely was the grade "very good" meted out, and just as infrequently "not satisfactory." Franck was a pleasant examiner who did not feel such a need to demonstrate his authority to his subordinates. Franck also was involved in the admissions tests for physics students at Göttingen.

After Cario's dissertation had appeared in print, Franck received a letter from Bohr about it. Bohr began with cordial thanks for the reception he had been given at Göttingen:[42] "In particular, I cannot even tell you how closely attached I feel to you and how grateful I am for all your help and attention to all things great and small."

But a longer sentence further down contained some critical remarks about Cario's dissertation. Franck was conciliatory. About the error that Bohr had singled out he wrote on 29 July 1922:

> That was, of course, entirely clear to us. I had unfortunately completely overlooked it while reading through Cario's thesis. That otherwise the calculation is somewhat clumsy you must attribute to our experimental theorizing.

No allusion was made in this letter to the worries and want in Germany. The economic situation was deteriorating dramatically. That March, Born and Franck had informed the ministerial *Kurator* that they had exceeded the budget for supplies by 115,000 RM. In August the shortfall had jumped to 240,000 RM. In October Pohl reported a budgetary overdraft for his institute of 977,000 RM.[43] At the beginning of 1923 the weekly wage of the mechanic employed by Pohl had bloated to 669,419 RM. Even so, it was virtually worthless. The effects of runaway inflation hit private individuals much harder than institutions or the state. Trust in the currency system gave way. The government had financed World War I largely with war bonds that had been signed over to sizable segments of the population in exchange for their life savings and retirement capital. When the kaiserreich collapsed, these bonds could be redeemed only at a sharply reduced value. Inflation devoured what was left. Entire families found themselves in the greatest financial difficulties. Advice from his father probably helped James Franck through this situation better than most others in his position.

Most students had found themselves in financial straits already during the First World War, so a university league had been founded in Göttingen that Franck decided to join. Article 3 of its statutes indicates its purpose as: "a collection of funds for the benefit of students, lecturers, and assistants of the Georgia Augusta, for assistance to individuals and institutes in the exercise of scholarly work." These efforts were insufficient, however, and an association called Studentenhaus Göttingen was established in October 1922 to open a low-cost dormitory and canteen. Other social facilities were improvised. There was an alterations and repairs shop, a free-meals agency, social services for female students, a typing office, and a loan bank. Talented students could apply for a study grant from the Studienstiftung des Deutschen Volkes.

An Offer by the University of Berlin Is Declined

In the middle of 1922, Franck was faced with a decision that would have far-reaching consequence. Heinrich Rubens died on July 17. Franck attended his funeral in Berlin and spoke at the side of his grave. Having heard how deeply moving his speech had been, Max Planck wrote him on December 2. His letter mentioned that the scientific content had been as profound as its personal warmth and sensitivity. Planck then came to the main point—Rubens's successor.[44] He presumed that Franck had already heard that he had been chosen for the short list, together with Max Wien and Willy Wien:

> And so I, for my part, would now also like to express the cordial and sincere request that in case an inquiry should arrive from the government that would set before you the necessity of considering the thought of moving over here, that you base your considerations above all on the confidence that behind this nomination by the faculty there lies a sincere wish by our colleagues to win you over to the institute here. I myself know of no better hands among the younger physicists in which I would prefer to see Rubens's heritage entrusted.

Planck then mentioned Franck's "relative youthfulness" for the position, with the reassurance that this, too, time would heal, even though he did see some advantage in it. The extent of Nernst's support at the faculty meetings for Franck's nomination is unknown; this information remained safely hidden behind closed doors. It is probable, though, that refusals by both Wiens as well as the soaring inflation led to a delay in the negotiations for the appointment. The Ministry of Culture did not contact Franck before the end of August 1923:[45]

> I have the pleasure of being able to inform you that the Minister has decided to offer to you the chair for physics that Professor Rubens had held at the University of Berlin.

So Franck traveled to the capital to negotiate at the ministry. He was already familiar with the Physikalisches Institut on Wilhelmstraße. It was almost fifty years old, and much of its equipment no longer met the higher standards of current research. Franck thought it imperative that extensions and renovations be completed. The ministry's letter to him from September 1 pointed out, however, that such demands had led to the appointment of Willy Wien being abandoned. For Franck, though, this was less of a pivotal issue. On 15 October 1923 he wrote to the ministry:

> I am extremely sorry that, after causing you so much trouble, I must now relay to you the decision of declining the appointment to the Berlin chair. I have been constantly wrestling with this decision since my return from Berlin to Göttingen, and day and night it left me no peace. On one hand, I recognized the great honor extended to me, the huge welcome I encountered among you and our colleagues, and felt emotionally obliged to accept the office. On the other hand, day by day I saw the problems mounting that would affect the institute as much as my family in particular. Finally, I earnestly examined whether I had the faculties within me to manage this important position as it deserves, despite all the problems, which have only now become fully clear to me.
>
> I thus arrived at the conclusion that I cannot with a good conscience encumber either the Ministry, or the faculty, or myself with this risk.

Individual temperament defined the reactions of each of Franck's friends in Berlin to his decision. "If I have to be quite honest," Lise Meitner wrote on October 20,[46]

> I must admit that the first impression your letter left on us was of deep dismay and painful disappointment. But now that you have decided this way, we must come to terms with it and it is all one whether I consider your specific reasons for it justified or not.

Fritz Haber found out about Franck's step only upon his return to Berlin in the new year. Responding to his letters from October 16 and December 31, he wrote on 15 January 1924:[47] "The decisive thing for me is your revelation that since your refusal you feel a sense of relief." A decade later Franck would receive a second invitation to Friedrich-Wilhelms-Universität in Berlin, but political circumstances and the anti-Semitism of Nazi Germany would make accepting it impossible.

In Göttingen, Franck's decision to stay was joyfully celebrated. At the party, a spoof on the electron-collision experiment was performed in gigantic magnification, and a comical mimicking of Franck's mannerisms as a lecturer was part of the skit. Towards the end of the year, other good news brightened these worry-ridden times: The Swedish Nobel Committee announced the awards of the Nobel Prize for physics to Albert Einstein and Niels Bohr.

The abundance of scientific research published by the Göttingen physicists, their assistants, and graduate students in the 1922–23 term left no hint of the economic troubles the inflationary period was causing. In the wake of Cario's successful experiments, Franck assigned more dissertation topics, expanding on his conceptions of collisions of the second kind in which molecules transfer excitation energy * from one to another.

$h\nu \rightarrow A \rightarrow A^*;\ A^* + B \rightarrow A + B^*.$

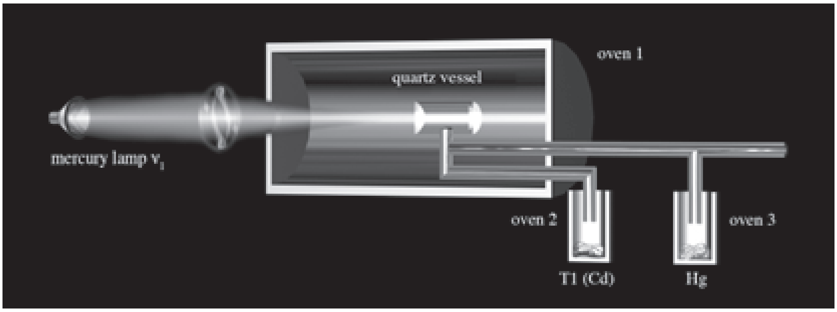


Figure 56 The mercury-vapor lamp irradiates the vessel in the oven. In the second oven, thallium or cadmium can be vaporized into the vessel as well as mercury from the third oven. Redrawn from: G. Cario & J. Franck: Über sensibilisierte Fluoreszenz von Gasen. *Z. Phys.* 17 (1923), p. 202.

Franck and Cario also completed another important project on sensitized fluorescence.[48] Their experiment was able to prove Klein and Rosseland's theory in a new way. If atoms of element A are excited with energy at the long-wave limit of their resonance fluorescence ν, and these excited atoms A* then collide with unexcited atoms of element B, these, in turn, can be excited to emit fluorescent radiation ν_1. Translational energy is transferred as well. The collision accelerates the B atoms; therefore the frequency ν_1 of the resonance fluorescence must exhibit a slight Doppler shift. Cario and Franck observed this with the thallium-line 3776 Å. B is the vaporized mercury and A the vaporized thallium (or cadmium). The mercury-line 2536.7 Å was used for the exciting frequency. As expected, the more oven 2 was heated, the more thallium was vaporized, and the more intensely it fluoresced, and the less mercury fluorescence was observable.

Hans Kopfermann worked on the next dissertation in this area. He was a veteran of the war who had subsequently become a member of the volunteer Freikorps. His experiences from this period weighed him down psychologically, as was true of many others of his generation. As his doctoral advisor, Franck helped him regain a foothold on life. Kopfermann's thesis analyzed sensitized fluorescence of vaporized lead and bismuth. The experiments not only were able to confirm Franck's ideas but also helped map the spectra of these two elements, because energy transfer by atomic collisions excites more spectrum lines than does excitation by light.

Franck and his friend Peter Pringsheim reviewed the results of the previous two years in a paper for an issue celebrating the decennial of the original publication of Niels Bohr's model of the atom.[49] This special issue had been conceived by Arnold Berliner, the editor of the journal *Die Naturwissenschaften*, who also solicited articles from Born and Hertz. The authors of this issue accepted Einstein's light-quantum hypothesis. But not all physicists were yet comfortable with the idea that light was particle-like. The term "photon" came into use only later on. At the end of 1922, the American physicist Arthur Holly Compton had just published the first results of his experiments on the scattering of X-rays by graphite. They indicated a slight shift in frequency of the scattered radiation. Compton himself, as well as Peter Debye, offered a physical interpretation a few months later: this effect involved a collision process between a quantum of light with energy $E = h\nu$ and an electron loosely bound to an atom. Upon impact with the electron, the quantum of light loses a portion of its energy, which results in a change in frequency. The calculations revealed that the classical laws of collisions yielded the observed value for the frequency shift. That meant the quantum of light acts like a particle.[50]

Franck recognized the significance of the Compton effect. Collision processes generally interested him, so he was motivated to formulate an analogous investigation within his own research program. In 1916–17 Einstein had demonstrated that in an energy exchange between radiation and matter, the quantum of light's momentum $h\nu/c$ also has to be taken into account. Franck's doctoral advisee Wilhelm Rump was able to show by calculation that the effect of an electron's collision with a hydrogen atom is far too small to be observable.[51] One could, however, modify the problem to test whether the Doppler effect—on atoms in a vaporized state, hence in irregular motion—is detectable in fluorescence and in reflections. The spectrum lines involved are not infinitely narrow. The motion of the atoms or molecules changes the frequency by a velocity-dependent factor. The process resembles a change in pitch of a moving source of sound. Rump's approach worked for fluorescence, an independent process occurring on individual atoms, but not for reflection, which is a collective process. It was a very good dissertation.

With Franck's recommendation, Rump left even before the year was out to work in Berlin as Emil Warburg's assistant. Franck's former teacher was still active. Franck raised the funds for Rump's wages from the Electrophysical Committee.

Visits with parents and relatives were not the Francks' only tie to the capital. Berlin scholars continued to welcome James Franck to their circle, appointing him to serve on various of their panels. For these appointments, expertise was just one of the requisite qualifications. Also required were efficiency and an appreciation that scientists, too, are human. In the first emotionally charged situation he was confronted with, right at the start, Franck revealed his capacity for reasoned judgment. Einstein was a fellow member on one of these boards but, after the Rathenau assassination, he was keeping out of the public eye as much as possible. Einstein's enemies were still very aggressive.[52]

One test of Einstein's general theory of relativity involved detecting whether a gravitational mass causes light to shift toward the red end of the spectrum. Physicists hoped that this redshift effect could be measured in observations of the Sun. But that required expensive apparatus. Approval was therefore obtained for constructing a special laboratory for the purpose on Telegraph Hill in Potsdam. The design of the new solar observatory by the architect Erich Mendelssohn was very modern. Erwin Freundlich was

Figure 57 Albert Einstein. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

its appointed director, supported by a governing board composed of Einstein and the astronomers Hans Ludendorff and Gustav Müller. Franck joined the board in June 1922.[53] The tower's main structure was already standing by 1921, but the apparatus was still being installed. The physicist Felix Stumpf had the responsibility of adjusting the complicated optics. Tensions arose, however, between Freundlich and Stumpf, and the board was obliged to become involved. Einstein and his wife Elsa were away on a voyage to Japan in October 1922. It was on this trip, while they were still at sea, that Einstein received word about the award of his Nobel Prize.

When Einstein came home, Franck briefed him about the situation in a letter dated 29 March 1923. He also described his own stance as a member of the board. Due to the official nature of this letter, the tenor is rather formal:[54]

> Please do not therefore take this letter as an exaggeration of the importance of my own opinion. As I understand it, Mr. Stumpf is faced with a problem that he could not solve, but that another younger physicist likewise would be unable to solve. For it is clear that the most qualified spectroscopist with many years of experience in the field might be just about good enough to tackle the immense task.

Not even Freundlich could handle the precision fine-tuning of the expensive apparatus, Franck argued. He suggested that the task be assigned to someone else. Touching on Stumpf's career, he pointed out the lack of prospects for a professorship at his age of 39. Franck confessed that he had only recently come to fully appreciate Stumpf's commitment to science.

> I would like to emphasize that before the board meeting and probably even during it, I had thought less favorably of Mr. Stumpf's diligence than I do now, from experiences at the Berlin Institute that lie 10 years back. It is unfair to refer to old experiences that had once become lodged in one's mind. I do not believe that I put weight on them during the meeting. But if I did, I take that judgment back.

Franck was uncomfortable about interfering with another person's destiny. He urged, "I cannot but say that one is obligated to rack one's brains about Stumpf's later fate."

Stumpf had, however, mentioned his intention to apply to the Reich Patent Office. The board would therefore be relieved of this obligation.[55] When Franck visited Einstein that July, this subject may have come up again. On that occasion he corrected his host's considerations on Earth's magnetic field, pointing out an inconsistency with the experimental data, as we gather from a letter Einstein wrote to Born on July 22.

On weekends, the Francks often hosted guests.[56] Otto Hahn occasionally came, as well as Lise Meitner, but Franck was unable to convince Miss Meitner to present a talk at the colloquium in Göttingen.

Figure 58 Ingrid Franck, Lise Meitner, Edith Hahn, James Franck, Otto Hahn. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

When Franck's boyhood friend Philip Elkan visited, he would bring his violin along to play duets with Mrs. Franck. Einstein also once came with violin in hand for a musical soirée, but Nina Courant was very stern whenever he hit a wrong note. Sometimes on a Sunday morning Franck would play chess with Courant. When the weather was nice, the Francks would leave in the early hours either by bicycle for the surrounding countryside or by train for the Weser hills. By then, Hertha Sponer had become virtually a member of the family. It was she who taught Daggie and Lisa how to ride a bicycle. Franck liked to help his daughters discover nature, and he filled other gaps in their school education as well. Understanding things was more important to him than rote memorization. In the wintertime there were ski trips into the Harz Mountains. Summer vacations were spent by the sea, which was especially good for the elder daughter, who was asthmatic. Franck was a good swimming instructor for his daughters. Their vacations were rarely spent in the mountains, as Mrs. Franck was unable to join them on strenuous hikes. She was of fragile health but her doctors were unable to diagnose the cause. The entire family enjoyed visiting the Stills on their estate in Rogätz. One autumn, their generous host organized a hare-hunting party for all the Göttingen physicists and mathematicians. Franck came home with one of the hares in his bag, although he had not shot it himself.

The unusual cooperation at Göttingen among mathematicians, experimental physicists, and theoreticians was harmonious, but the times would not let them concentrate solely on scientific or staffing issues. Their political responsibilities as leaders in society were forced upon their consciences as well. The differences among these intellectuals were striking. Einstein was an unapologetic advocate of the democratic ideal, and his example inspired his friends, strengthening their sense of community. He was disgusted by the attitude of many scholars who sought to advance themselves by publicly applauding the existing order of the kaiserreich with its strong-arm politics.

In the summer of 1923 the members of the German Physical Society were asked to state their political positions. The air was heavy with injured national pride and patriotic sentiment. In 1920 Belgian and French troops had marched into areas of the Rhineland, seizing it as a kind of collateral for outstanding postwar reparations. The behavior by the Entente, particularly on the issue of reparations, made it more difficult for supporters of the young republic to find and stay on the fine line between patriotic sentiment and all-out nationalism. When in March 1923 the entire Rhineland was occupied, the German government appealed to the population to exert passive resistance, but bloody confrontations were the result. Choosing Bonn as the venue for the next annual convention of physicists was therefore a political statement. On August 25 Max Born wrote to Einstein asking his opinion and wondering whether he would be attending.[57]

> Today I should like to ask you something (and would appreciate a *prompt* reply): one is constantly bombarded with official communications from the Helmholtz Society, the German Physical Society, etc., asking one to attend the congress of physicists in Bonn. If this were to be somewhere else, I would not even consider going. But in Bonn, because of the French occupation, great importance seems to be attached to receiving large numbers of visitors, and Franck is of the opinion that we should go for the sake of good form. In my opinion it would have been more sensible not to hold the congress in occupied territory; for it is a mistake to mix up scientific meetings with politics in any way whatever.

Born worried about the problems that traveling would pose and checked to find out whether Planck, Laue, Haber, and Lise Meitner would be going. The conference took place in Bonn that September without incident. Attendance was very good despite the devaluation toward the end of that inflationary period. Einstein, Sommerfeld, Born, and Franck were among the some three hundred participants. The meeting had to be abruptly ended ahead of schedule, however, so that the participants could afford their tickets home, as the Reichsbahn had suddenly raised its fares.[58] Franck's talk concerned the sensitized fluorescence of gases, the topic of the paper he and Cario had submitted that summer to the *Zeitschrift für Physik*.

Franck did not always accept speaking invitations. He regarded his mentoring responsibilities at the institute to be more important. As he put it to the physicist Walther Gerlach, he did not want to be regarded as "a vagrant physicist." That fall the American physicist Robert Andrews Millikan went on a European tour. Afterwards he submitted a report of his impressions to the General Education Board in New York along with a ranking of European physicists and their laboratories.[59] Göttingen, with its professors Franck, Pohl, Born, Runge, and Wiechert, was described as one of the most active centers for progress in physics in the world.

Franck continued his noontime habit of looking through the daily papers, even though the inflation had increased the price of a single issue of the *Vossische Zeitung* to billions of reichsmarks. Two news reports on 7 November 1923 were disturbing. The first came under the heading "Today's plunders in Charlottenburg":

> The looters proceed in a very organized fashion here; mostly 10 to 20 men group together, invade the shop as quick as lightning, sweep up the wares in a matter of minutes, and dash away again in different directions, in order to regroup five minutes later a few blocks down to choose a new store to plunder.

Some of the affected stores were not far away from where Franck's parents were living, on Berliner Straße in Charlottenburg. The second article was at least as worrying. This report from Coburg ran under the headline "Deployment of the Hitler guard":[60]

> The order by the Bavarian government, intending to expel a number of Jews from Coburg as well, found the anti-Semitic resonance among hordes of undisciplined volunteers that insightful people have been fearing. During the night into Monday an unheard-of incident took place in the village Altenhausen about two hours away from Coburg. Twenty to thirty youths, armed and in uniform, came into the village and surrounded two houses in which Jewish families live. The windows and doors were smashed in and the inhabitants dragged out. They proceeded to summarily court-martial them and convicted them to death by hanging. The people did seem to have second thoughts in the end, so they just viciously beat up their unfortunate victims. During this farce of a trial, money and valuables were stolen from the residences. It has not been possible until now to identify any of these rowdies.

At Göttingen, Franck was not exposed to such overt anti-Semitic animosity; but one of his daughters did complain that a girl at school was finger-pointing Jews as murderers of Christ. Franck visited the girl's parents and was able to clear the matter up. The mathematician Edmund Landau was never bothered on his way to and from synagogue.

The morning edition of *Vossische Zeitung* on November 9, now costing 30 billion RM, had more devastating news from Bavaria: "Hitler coup in Munich." Southern Germany had been a focus of political foment for some time.

> Hitler declares himself head of the Reich and proclaims Kahr as Bavarian regent. Knilling and Schweyer are arrested. Ludendorff takes over leadership of the German Army.

The lead article, "Off with the masks!" was written by Georg Bernhard:

> The tension is gone. The blow has fallen. The shrouds of mist have parted. And now one can see the theater and its actors in full sharpness.
>
> For weeks it has been known that an attempt would be made in Bavaria to proclaim a "Reich government." It was thought insane. But any insanity is apparently possible in the witches' cauldron Bavaria. Yesterday's event in the Munich Bürger Brewery has even instructed the skeptics.

Hitler was arrested, tried, and sentenced to prison. It looked as if the republic was out of danger again. In November the government finally managed to halt the inflation. The rentenmark was introduced at a rate of one to one billion reichsmarks of the old currency. Slowly but surely the economy began to recover. Scientific publishers began to take an interest again in new books and new authors.

In 1907, Ferdinand Springer and his brother Julius had taken over the family publishing business founded by their grandfather in 1842. Ferdinand Springer was in charge of the categories of medicine and science.[61] Ever in search of new projects, Springer had established the professional journal *Zeitschrift für Physik*, but offered nothing similar for mathematics. Their rival firm Teubner was publishing a periodical for this field, but financial difficulties limited its issuance. The concentration of prominent mathematicians at Göttingen and Richard Courant's pressure convinced Springer to take over the struggling periodical in 1920. Courant had already persuaded Springer to take on another project, a series of monographs (*Einzeldarstellungen*) in the field of mathematics. Nicknamed the "yellow series" from the color of its bindings, this series gained world fame. A parallel scientific series was entitled *Ergebnisse der exakten Naturwissenschaften*.

Ferdinand Springer, observing the success of Born's and Franck's research, decided to plan a similar series for physics. Negotiations began during early 1924. The proposed title of this series, "Structure of matter in monographs," allowed for coverage of a broad range of fields. Born, who had already published a successful book on Einstein's theory of relativity with Springer, and Franck were to serve as editors. Both would receive honoraria. As Franck had taken ill, Born approached Ferdinand Springer with an unusual concern. His letter from 18 February 1924 includes the statement: "Franck requests that in the contracts and on the title pages of the books our first names only appear abbreviated in initials, as he does not like his given name."

In the ensuing months Born and Franck proposed a number of topics and authors for the project. Franck wanted to write one volume on the excitation of spectrum lines by collisions. He committed himself to submitting the manuscript by May 1925. The agreed honorarium was 1,900 rentenmarks. Born offered the title *Atommechanik*. From among their friends, Lise Meitner would report on nuclear physics and Otto Hahn on products of radioactive transformations. The physicist Rudolf Ladenburg, Grotrian, and many others also agreed to submit manuscripts.

Franck could not get started on his book. There were too many other highly interesting problems in physics to consider and discuss with an assistant, or if none happened to have time in the mornings, with an advisee or one of his students.[62] Franck loved best to talk about his conceptions on a walk, climbing the path to the Hainberg; at times such conversations were virtual monologues. The almost daily coffee breaks were another occasion for hypothetical discussions as he smoked through a number of cigars. It happened that when Bohr was accompanying him on one of his weekly rounds through the graduates' rooms, Franck completely forgot about the experimental setup they were just examining and was already thinking ahead to its sequel. But he was always receptive to ideas by his juniors. In hot summer weather, the open-air municipal pool was the preferred venue for continuations of their discussions about atoms and molecules. A skillful dive by Franck headfirst into the pool was part of it.

After such careful forethought, dictating the finished text for publication was often just a matter of a day. Franck's graduate students were not expected to submit masterpieces in style.

At the end of the summer term of 1924, Werner Heisenberg delivered his trial lecture on the historical and logical development of quantum theory, part of the process of earning his habilitation degree. Franck was in the audience.

Earlier, in June, Born, Franck, and Pohl had received an important letter from the Rockefeller Foundation, to which they had applied in response to a request for proposals issued in March. They received a grant not only for an extension to the institute but also for the hiring of an additional assistant as well as a postgraduate researcher.[63] This was the start of a fruitful collaboration between the University of Göttingen and the Rockefeller Foundation. In a joint letter, the three professors wrote Wickliffe Rose, president of the International Education Board:

> We most obligingly thank you for your letter of the 18th of June 1924 and the extremely valuable support you are granting Göttingen physics.
>
> Furthermore, we acknowledge with gratitude receipt of the check for 612 dollars, which we shall use according to its prescription. The assistantship has initially been assigned to Dr. Hanle, a student of Franck.

Soon afterwards, applications were submitted for travel grants to America for Oldenberg and Miss Sponer. Franck himself would not travel to the United States until years later.

In the middle of the year, Franck sent to the editors of the *Zeitschrift für Physik* a manuscript on the ionization potential of positive ions.[64] In it he returned to the incompletely solved problem treated ten years earlier with Miss von Bahr. Hans Scharf's dissertation, three years before, had not led to its clarification either. Unlike the case for ionization by electron collisions, no definite figure could be found for atomic ionization potentials when the projectiles were positive ions. Franck showed that the reason was that collisions between mercury ions and atoms rarely took place. This elementary point had apparently "not been taken into account yet anywhere." He continued: "We have to decide between ionizations that take place in a single act of collision between ion and atom and those in which more than two collision partners are involved in sequence."

He set up an equation for the energies:

initial kinetic energy of the ion, $\frac{1}{2}mv^2 = 2$ (ionization work and the estimated potential energy of the two masses).[65]

For details about the calculation he referred to a recent publication by Born and Heisenberg on the influence of the deformability of ions on optical and chemical constants. He stated, however, that "[t]he assumption underlying the equation is that the ionizing electron-jump of the impacted atom takes place so quickly that the heavy masses of the ions do not change their positions during the [electron's] jumping time."

This was the first time that Franck expressed the far-reaching principle that later came to be known as the "Franck-Condon principle." His fellow physicists soon recognized its significance in explaining chemical reactions and it became a permanent fixture of theoretical chemistry.

An American, E. M. Dymond, came to Göttingen to conduct research at Franck's institute on a grant from the International Education Board of the Rockefeller Foundation, and Franck assigned him a project on molecular spectra. At low temperatures vaporized iodine is composed of diatomic molecules. When the absorption spectrum is spectrally resolved, band structures—very closely lying lines—are visible. A molecule incorporates, in addition to rotation, oscillations of its component atoms against each other. This changes the line spectrum into a band spectrum. Franck asked Dymond to examine what happens when iodine's fluorescence spectrum is excited by light of very short wavelength. He found that the fluorescence disappeared when exposed to 4995 Å light. This was precisely where the continuous absorption spectrum ended. The iodine molecule had dissociated into an excited atom and an unexcited atom. Franck discussed the process in detail in a later paper.

Franck was very careful to ensure that his regular assistants, Hertha Sponer and Otto Oldenberg, in addition to monitoring the laboratory course for some two to three hundred students of physics, mathematics, and medicine, had opportunities to conduct independent research in a field of their own preference.

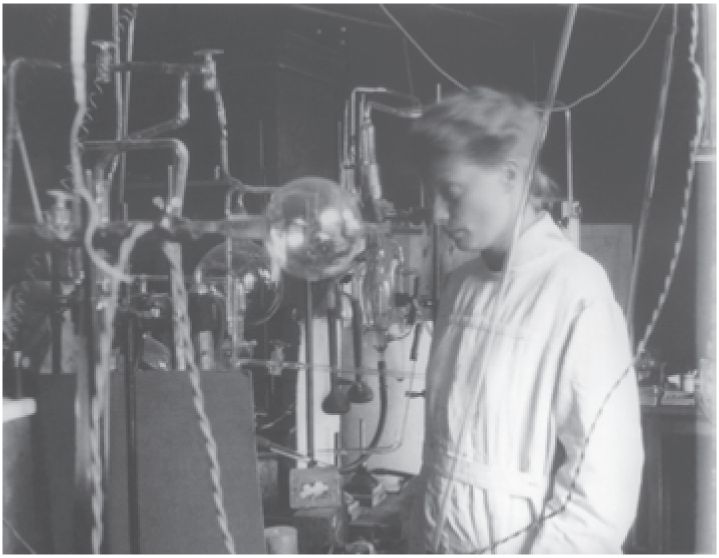


Figure 59 Hertha Sponer. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Hertha Sponer was interested in a peculiar effect that Carl Wilhelm Ramsauer had presented in 1919 during the physicists' convention in Jena.[66] Electrons traveling very slowly through a noble gas were thought to interact very rarely with the gas atoms. It appeared as if the gas had become "transparent." The experiments were tricky, however. It was difficult to eliminate all the disturbing side effects. Miss Sponer sometimes worked on her own, sometimes together with Rudolf Minkowski, the nephew of the deceased Göttingen mathematician. Franck offered advice for the experiments and contributed his theoretical ideas about the electronic and atomic processes involved. Born and Bohr naturally also contributed to the discussions. All this happened without producing a publication signed by Franck on the subject.[67] The results confirmed the Ramsauer effect, but that was not properly understood until a few years later.

Hertha Sponer was also in charge of the institute's valuable electrical measuring instruments and the mercury-vapor vacuum pumps used by the various doctoral candidates for their experiments. This gave her a kind of authority that she used very rigorously. Although she was a close friend of Franck's, she avoided being the institute director's eyes and ears. The private physics colloquium that she hosted in her apartment encouraged candid criticism. Members of Franck's staff were invited to it, along with some of his, Pohl's, and Born's students and graduates, Heisenberg among them—the "stamped, polished, and limited" generation.

A second area of research that Sponer devoted herself to was the analysis of molecular spectra. Oldenberg worked a bit in this field as well. Franck discussed the institute's affairs freely with Oldenberg, who became a close friend.

Other relationships with subordinates did not work out as well. Dr. Ludwig Sommer, an assistant of Professor Sommerfeld in Munich, applied for a position under Franck in 1924.[68] Franck did not urge him to come because the pay level at Göttingen was so low. When Sommer came, Franck went out of his way to secure and add to his paycheck. The new assistant refused to cooperate, however, and Franck became so annoyed that, quite exceptionally, he could not hold back some bitter words about him at home.[69] A few years later the issue had escalated to a point where the academic mediation board had to intervene.

In early October 1924 Franck traveled to Cambridge to present a talk. Despite his worries that his English might be incomprehensible, the visit was successful, and a highly talented young Englishman was inspired to come to Göttingen to conduct research at Franck's institute.

In 1925, the Franck family moved into larger quarters. Their new apartment was in the Levin villa on Merkelstraße. This three-story building had a distinctive shape, as it had formerly also served as a water tower. A retired geography professor lived on the ground floor, the *Universitätskurator* Valentiner and his family lived on the first floor, and the Francks above them. A large room at the top of the tower with a gallery and a commanding view of the surrounding countryside became Franck's home office. He liked to conduct meteorological observations from there. The latest edition of Arnold Berliner's *Lehrbuch der Physik*, with the following very personal dedication, probably stood on a bookshelf in that room:

Face the man of knowledge	Vor den Wissenden sich stellen
That's safest in any case!	Sicher ist's in allen Fällen!
Long may you have labored	Wenn du lange dich gequält,
But at once he sees the gap;	Weiss er gleich, wo dir es fehlt;
For applause you may even hope,	Auch auf Beifall darfst du hoffen
He knows where you've struck home.	Denn er weiss, wo du's getroffen
To my fatherly friend James Franck	[d.] väterlichen Freunde James Franck
for your kind verdict.	zur nachsichtigen Beurteilung.

Mrs. Franck had a fine, large music room, where the grand piano could resonate to good effect and there was space enough for a quartet besides. At first, the two girls shared a room; later Daggie moved into the guest room. There was enough space for one of the two maids to live in. The large garden was shared equally with the two other units in the building, but Daggie and Lisa were allowed free rein over the entire area for their games with their friends. On weekdays Franck left the apartment around nine o'clock in the morning,

Figure 60 "Grandee Castle" (*Die Protzenburg*). Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Figure 61 Ludwig Sommer, Werner Heisenberg, James Franck, and Günther Cario. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

after having read the morning mail. The maid was sent out to meet the postman in order to spare Franck a few minutes' wait. The professor would return home at noon for lunch, after which he would lie on the sofa to study the *Vossische Zeitung*. Afternoons would be spent at the institute again. He usually rode there on his bike, as did Born and the assistants. There were times when the four of them would be cycling down the street together in deep discussion of physics.

Franck was still occupied with the important problem of what actually happens when a molecule is excited and dissociates. The experimental findings and the theory often matched well, but important details still remained unexplained. The motions, oscillations of diatomic molecules, can be classically calculated using the model of two weights connected by a spring. In the ideal case, the two masses swing against each other like a harmonic oscillator. The turning points of the various swing breadths, plotted on a graph, form a parabola.

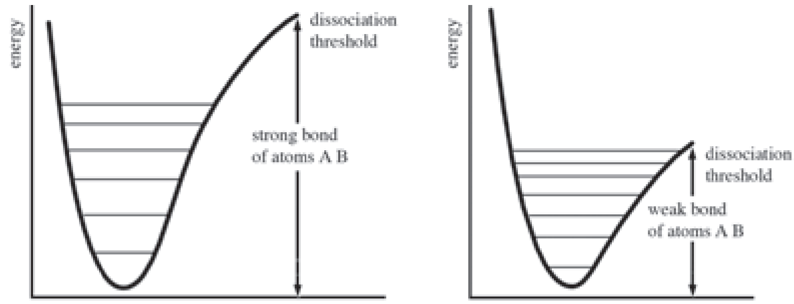


Figure 62

In a real diatomic molecule, the two atomic masses cannot stretch apart indefinitely without exceeding the intermolecular forces binding the atoms together: the molecule would dissociate. Nor is it possible for the atoms to come too closely together, as, at short distances, they repel each other. This situation can be represented by another curve:

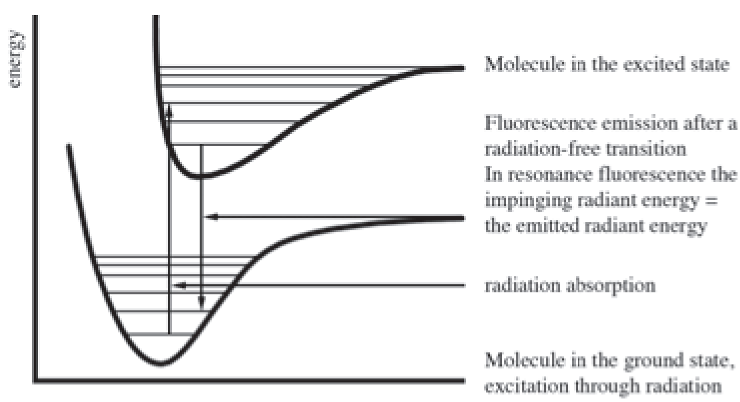


Figure 63

Franck found it important to understand what the curves look like for different types of bonds and what happens at dissociation. Discussions and more discussions with Born and the other members of the staff followed. Potential curves were drawn.

In 1924, Franck published in the *Naturwissenschaften* the text of a talk summarizing the current knowledge about atoms and molecular collisions and their chemical importance.[70] The article immediately preceding it was about the quantum rules of photochemistry. It presented Emil Warburg's analyses of Einstein's photochemical law of equivalence. Franck's article, like his earlier one about ionization, had something fundamental to report. Again no emphasis was placed on its novel character. After establishing that the transfer of energy found in binary collisions cannot lead to molecule formation because the extra energy cannot be transferred into the molecule's translational energy, Franck wrote:

> But this energy reservoir for collecting residual quanta must fail for collisions of two atoms that are not supposed to separate after impact because, according to the principle of the conservation of momentum, the centroidal motion of the two-atom system must be constant before and after the collision; i.e., the translational energy should not change. There only remains diverting the surpluses by collision with a third atom or molecule that does not otherwise participate in the reaction; as it separates again from the freshly formed molecule, the residual amounts can now be transferred into translational energy in observance of the principle of linear motion. This is the reason for the necessity of threefold collisions for a reaction to take place, which Boltzmann had already called for (albeit for reasons that we now no longer regard as convincing) and which are in fact necessary, as recent analyses on reaction rates have shown.

Franck's insight became the subject of Born's intense theoretical elaborations.[71] Their first paper on quantum theory and molecule formation was submitted for publication on December 15. It opens with an elementary introduction to the problem. How does molecule A react with molecule B, they ask, when energy released in the reaction is exothermal? What happens when the released energy is so large that it really ought to immediately dissociate the formed molecule again? This energy would have to be conveyed to a third party. Ergo a threefold collision. They then differentiated this assertion from exchange reactions of the type:

$$AB + C = AC + B$$

Just like catalytic gas reactions, these reactions do not need a third party when, for instance, a metal surface picks up the excess energy. The potential curves of the various kinds of bonds were then thoroughly discussed and the calculations performed. Many of Franck's notions reappear in the conclusions. This text reflects the intense discussions between two scientists with very different ways of thinking. They sought to relate their statements to experimental findings

Figure 64 James Franck carrying Gustav Born on his shoulders, Max Born. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

wherever possible. In considering the electron transitions, they assumed, as Franck had previously proposed, that all electron motions were so much faster than the motions of the atomic nuclei that it would be permissible to regard the nuclei as at rest. Franck had already advanced this postulate before. Much effort was spent on reducing the speculativeness of their theoretical considerations. From this view of atomic processes they defined a "quasi-molecule"[72] that upon collision acts like a pair of atoms with regard to the absorption and emission of light. They believed such "quasi-molecules" could be deduced from the spectra of strongly dissociated molecules. A possible predissociation was also considered.

A second, shorter paper commenting on the dissipation of the heat of reaction appeared in the following year in the *Annalen der Physik* under the same title. In it they referred to ideas by Michael Polányi from the Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry. In a reaction between two molecules:

A + B = C + heat of reaction,

Polányi assumed that at collision the heat of reaction was transferred onto a third atom not actively involved in the reaction. William Lewis, from England, suggested that instead the energy was released in the form of radiation. Both interpretations assume that the formed molecule C cannot absorb more energy than is needed to split it apart, that is, to dissociate. Born and Franck questioned this and set forth their reasons.

Franck had already demonstrated by experiment in 1921 that an electron collision can be used to excite a hydrogen molecule more strongly than its work of dissociation. So some of the energy could be transferred into rotational energy, for example. Threefold collisions such as in sensitized fluorescence presumably account for the excess energy in recombinations in the absence of an electric moment, therefore, of a dipole moment. In the case of polar molecules, however, Born and Franck could not exclude an emission of radiation. In their opinion, such an emission would be possible only when two of the three colliding molecules dissociate again. Bonding between two oppositely charged ions can generate radiation. This phenomenon, called chemiluminescence, was a special focus of research at Haber's Kaiser Wilhelm Institute. On July 3 Franck wrote to his former coworker Polányi to compliment him on his fine paper on reactive glowing. Denying having been the inventor of ternary interactions,[73] he pointed out that the Viennese physicists Boltzmann and Karl F. Herzfeld, and "if I am not mistaken, also a certain Mr. Polanyi, has always defended threefold collisions."

Another of his correspondents was the physical chemist Karl Friedrich Bonhoeffer, who was working under Nernst in Berlin. Their topic was new experimental methods to test dissociation. Franck hoped to combine a visit with his parents with a personal interview:[74]

> I find it important to speak to you sometime about your fine researches or to become acquainted with your views on whether you think like I do on the question of nitrogen [dissociation]. You have presumably already had a look at the nitrogen thing; in any event, it is clear to me that the idea only occurred to me because [the Russian physicist Aleksander N.] Frumkin informed me of your results with hydrogen, so you do not need to eye me as some scoundrel wanting to snatch something away from you.

Figure 65 David Hilbert and James Franck. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

The research conducted by Born and Franck is a rare example of an equal collaborative effort between an experimental physicist and a theoretician.

To this was added the active support of mathematicians, above all Hilbert and Courant. That is why Göttingen at this time had a particular attraction for aspiring physicists as well as active researchers. The occasional contact with students from other universities confronted Franck with the fact that collaboration between physicists and mathematicians was much poorer elsewhere.

It also revealed that anti-Semitism was more prevalent among other faculties and student bodies. Walter M. Elsasser had been studying under Willy Wien and Arnold Sommerfeld at Munich. Born in 1904 in Mannheim, he had only become conscious of his family's Jewish origins during the World War.[75] Surely ignorant of Philipp Lenard's political attitude, he had commenced his study of physics in Heidelberg but was advised not to stay after having completed two semesters. So he had transferred to Munich, only to be told three semesters later that all members of Wien's institute, with the exception of Willy Wien himself, were members of the Nazi party. Again he could not stay. Sommerfeld wrote a letter of recommendation for him to Franck, and in the spring of the following year he was finally able to work in peace on his dissertation on electron diffraction. But the experimental difficulties proved too much for him and he had to abandon his experiments.[76] It was only with a theoretical thesis under Born's mentorship that he finally met with success.

Problems with the apparatus were just one reason for Elsasser's failure under Franck's guidance. Another was the growing complexity of such research. Indeed, large industrial research laboratories were beginning to gain the advantage. The equipment at Franck's institute still afforded the means to perform all the experiments needed, even though the electrical and physical measurement apparatus still lacked electronic amplification. The demands of signal engineering during the World War had encouraged the development of tube amplifiers in the electronics industry, but it was still too early for them to meet the rigorous requirements of precision measurement by physicists at university laboratories. Amplification of direct current was unsatisfactory at Franck's institute, yet precisely such types of measurements were often inevitable. A mirror galvanometer was used for this purpose.

Considerable impetus for the development of electronic measuring instruments came from the rapid rise of radio broadcasting for entertainment purposes. Despite the often catastrophic state of the economy in the early 1920s, the German electronics sector involved itself in the development of public radio, which had found its beginnings in the United States after the World War. In Berlin, it was possible to receive broadcasts with relatively simple apparatus from the nearby radio transmitter—Germany's first. In Göttingen, however, a multistage tube set was needed to be able to listen in on the programs. These devices were still equipped with 4.5 V DC accumulators for preheating the tube filaments and what are called anode batteries to operate the amplifier source. Tuning to the transmitting frequency and adjusting the amplification required both patience and practice. Franck was an enthusiast and purchased his own radio set.[77]

Friends often stopped by the Francks' to enjoy the classical concerts broadcast on Sunday mornings. A series of Bach cantatas was particularly memorable. The regulars were the Courants, the Hilberts, and the Runges. The last lived just across the street, and whenever they received a dinner invitation from the Francks, Carl Runge enjoyed giving the fresh arrivals a thorough scrutiny through his telescope to guide his own choice of attire. As the evening progressed, Professor Hilbert would inevitably cut a few of his East Prussian jokes.

A recently appointed astronomer and astrophysicist was a newcomer among their party.[78] Hans Kienle was thirteen years younger than Franck and had taken part in the fighting in Flanders as a volunteer right after he had passed his high school exams. An injury ended his service, so he was able to commence his studies in mathematics and physics at Munich in 1915. His postdoctoral degree (*Habilitation*) was awarded in 1920. At Göttingen he took the position of deputy director, later to become the director of the observatory, a venerable post in the footsteps of Gauss. Kienle was one of the members of the expedition to Sumatra in the winter of 1924–25 to observe the solar eclipse and photograph the Sun's chromosphere. Astronomy was but one of the many topics Franck enjoyed discussing with his new friend.

Nonscientists also were counted among the Francks' group of friends. A notable example was Professor Hermann Nohl, who devoted himself particularly to educational aspects of his field, philosophy. His wife, Bertha, played music with Mrs. Courant, and the Nohl girls, Johanna, Klara, Marie, and Barbara, were friends with Lisa and Daggie.

Göttingen had much to offer concertgoers. The Francks liked to attend the Handel *Festspiele* and hear performances by famous musicians on tour. Concerts conducted by their neighbor Fritz Lehmann were particularly prized.

Not all such gatherings were social. The World War and the unspeakable human suffering it had caused were still fresh in everyone's mind. On November 23, the staff of the Georgia Augusta were summoned to assemble in front of the main auditorium to honor the dead and witness the unveiling of a war memorial.[79] Members of the faculty of the sciences had responded generously to the memorial fund-raising appeal, and many were present at the ceremony. The attendance of Field Marshal von Hindenburg lent political importance to the ceremony. Heroism was not the message that its sculptor, the Dutchman Josef Kemmerich, sought to convey: eight exhausted figures sorrowfully bearing a dead comrade on their shoulders. The rector, Professor Julius Binder, delivered the address.

Two months earlier, in its meeting on September 13, the Provincial Diet of Prussia had expressed the wish that the peace movement be

> sufficiently fostered in accordance with its great importance at universities and polytechnics, within the framework of suitable fields of knowledge (history, politics, international law), e.g., through teaching assignments [. . .]
>
> The peace movement is already receiving extensive treatment in lecture courses primarily in the disciplines of law and the liberal arts, as an inquiry among universities has revealed.[80]

It is not known how Franck personally stood on the issue of pacifism during this period. His statements on the subject originate from a much later time.

Two papers in the final 1924 issues of *Die Naturwissenschaften* document the importance of Franck's research and hypotheses to the efforts of theoretical physicists. Niels Bohr published his ideas on experiments by Wood and Alexander Ellett as well as by Hanle in a paper on the polarization of fluorescent light. A footnote contains an acknowledgment: "Above all, information in a letter by Mr. Franck about an analysis by Mr. Hanle [. . .] drew my attention to the possibility of the proposed interpretation of these phenomena."[81]

But Bohr's arguments extended a little further, leaving many issues somewhat up in the air. Atomic physicists generally respected Bohr's authority, and his discussions with Born and Franck about their work on chemical bonds reveal this esteem. Offense to their friend had to be avoided at all costs. One letter to Bohr by Born from 15 December 1924 contains the following diplomatic passage:

> As regards our scientific discussions, I had the impression that Franck and I fully agree with your views, but according to your letter you seem not to have gathered this from my message. We are entirely of the same opinion that the theory of quanta must take a step forward in the direction that the transition times [from one energy level to another] cannot be regarded anymore as infinitesimal relative to the lifetime of the states themselves.[82]

On December 26 a paper appeared by Max Born on the topic of a talk he had given at the convention of German Scientists and Physicians in Innsbruck about chemical bonding as a problem of dynamics. It was a reworking for this audience of Born's research with Heisenberg on the influence of the deformability of ions. Quantum theory was applied to explain the strength of chemical bonds.[83] On the question of determining the electron affinity of positive ions, Born mentioned an idea of Franck's that Oldenberg had tested with negative results. Again we see the close connection between experiment and theory in Göttingen physics. The theoreticians clearly wanted to find support for their hypotheses in observable, measurable events.[84] Einstein's three famous papers of 1905 exemplified this approach. Each concluded with a suggestion of how his theory might be tested by experiment. This ideal way of doing science was manifest in the daily interaction between theoreticians and experimentalists in Göttingen.

Franck advised up to a dozen graduate students at once and, most of the time, also guided the experiments of three or four more guest researchers from abroad. In the winter semester 1924–25 the 26-year-old Herbert Stuart started to work on his dissertation. Stuart, the son of an Englishman, had been born in Zurich but had returned with his widowed German mother to her native country, where he had acquired German citizenship in 1916. He had completed his studies of physics at Würzburg before joining Franck.

Stuart's assigned topic was to revisit the problem of the extinction of the resonance fluorescence of mercury vapor by an added gas. Franck realized that the earlier results could not satisfactorily clarify the important question: How large is the proportion of excited atoms losing their excitation energy upon collision (impact of the second kind) with unexcited or other added atoms before they can release the energy as radiation? The analyses by Cario and the American Wood had not adequately taken into account all the possible sources of error. Instead of analyzing the direct emission from a mercury lamp, Stuart used it to excite mercury vapor to give off a resonance glow, which became his actual light source. With it Stuart was able to obtain a very narrow excited spectrum line. Other analyses used this method as well.

Nine different added gases were examined for their extinction efficiencies. The noble gases, helium and argon, showed the lowest extinction rates by collisions of the second kind, while hydrogen reduced emissions by more than 90 percent. Stuart attempted to extrapolate the collision radius of an excited mercury atom. The resulting radius was much larger than anticipated. A reasonable estimate then led to a figure three times greater than for an unexcited atom.

But still no light could be shed on the atomic process of depolarization and the influence of collisions against the container walls. The various dissertations under way in parallel under Franck's mentorship reveal how dense his research agenda was and the extent to which he was interacting with the Göttingen theoreticians. The complexity of the experiments also grew perceptibly, which required even more supervision of the graduate students. Before letting them get started, Franck gave them a thorough rundown of the physics behind their individual projects.

Reinhold Mannkopff examined the extinction of resonance fluorescence from sodium. As in Stuart's experiments, fluorescence was used as the excitation source. Again, a considerably larger radius resulted for an excited sodium atom. There was a third dissertation devoted specifically to this problem of identifying the collision radius. Goverdhan La Datta from Lahore investigated the degree of polarization of the resonance glow of sodium vapor. Only one of the wavelengths of the two sodium D-lines (D_2) was used for the excitation, and the influence of a magnetic field on the effect was also investigated. Heisenberg had already analyzed this topic theoretically (before working on the new quantum mechanics). His analysis took into account the influence of a magnetic field on the atom. Datta also was able to draw on preliminary research by Wood, who had developed an optical arrangement with polarizers capable of separating the two sodium D-lines in 1914. D_2 was the line Datta used for the excitation. His experiments also yielded a quite large value for the collision radius. Franck would later conduct further experiments with Cario to obtain greater precision.

At the beginning of 1925 the 27-year-old Patrick Maynard Blackett arrived at Franck's institute from Cambridge.[85] He had previously been working with good success on developing the Wilson cloud chamber. With automatic trigger control he had managed to obtain from among more than twenty thousand cloud-chamber exposures clear proof of a transformation of nitrogen into an oxygen isotope through bombardment of α-rays. Rutherford was able to conclude this indirectly from another experiment. Blackett wanted to learn more about the ionization processes that produce the cloud tracks in a Wilson cloud chamber. As Franck's research was particularly pertinent to this problem, his institute was a good place to work on it. Blackett's young Italian wife, Constanza, accompanied him to Göttingen, where they lived at no. 28 Weender Landstraße.

With Blackett, Franck could confidently tackle a tricky experiment that also required careful interpretation. Another attempt was to be made on clarifying what happens when an electron collides with a hydrogen molecule. Four different conceptions of this process already existed from the work of a number of scientists, including Franck together with Knipping and Thea Krüger. But as is so often the case in science, decisive proof was lacking. Guided by tips from Franck, Blackett surveyed the copious literature on the problem. The most interesting physical process—and for Franck surely the most probable one—was the decomposition of the hydrogen molecule upon collision with an electron into an excited hydrogen atom and an unexcited one.

Figure 66 Patrick Maynard Blackett in the laboratory. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

At first, Franck and Blackett worked together using an arrangement that Gustav Hertz had tried out for generating electron beams.[86] Through a careful choice of experimental parameters and apparatus design they were able to eliminate collisions of the second kind, in which an excited atom loses its energy in a collision, as well as the excitation of free atoms by electron collisions.

First they observed the glow of two spectrum lines from hydrogen gas bombarded by a narrow beam of electrons and compared it with the intensities of the multiline spectrum. The outcome was then checked by another method. The experiments lasted into the summer, occasionally even filling weekends. The Doppler broadening of one line of the hydrogen spectrum was examined. They used apparatus that Wood had already specified for the purpose.

Doppler broadening of spectrum lines is ordinarily dependent on temperature. If the two atoms of the hydrogen molecules separate, however, they fly apart at such a high velocity that an additional broadening of the line must necessarily result. Franck and Blackett were able to observe this effect clearly. Franck then continued to speculate about the process—probably on his own—critically applying the predictions of other physicists. In the molecule the two hydrogen nuclei share the two electrons. After dissociation each nucleus has to have its own electron. Franck noted as before that nuclei move much more slowly than electrons. But, as he had previously discussed with Born, the quantum transition of the electrons cannot take place infinitely fast.[87] So he incorporated Ehrenfest's adiabatic hypothesis (i.e., no emission of energy as the two electrons simultaneously assume new orbits adiabatically) into his considerations on dissociation: repulsion motivates the separation of the two nuclei. Both processes require energy that has to be supplied by the colliding electron.

In September the publication coauthored with Blackett was sent to the editors of the *Zeitschrift für Physik*[88] and Blackett returned to Cambridge.

Franck could not afford to concentrate solely on the scientific problems related to his research with Blackett. He was obliged to stay abreast of the ideas and results of other scientists working in his large area of research, as well as incorporating the occasional insight from further afield. When Hans Georg Grimm wrote to Born from Würzburg, Franck decided to relieve busy Born of the task of replying, as the topic was the disintegration of molecules into ions and the concept of electron affinity.

Franck's notions were quite unconventional, but his letter from May 8 also reveals a healthy dose of self-criticism. Toward the end he wrote:[89]

> Considering that I have to travel to the Bunsen Society, as I have been assigned a talk, I hope to see you there and to be able to converse with you more about this subject. I just ask of you one thing: Please do not add to the literature about the spectral proof of electron affinity, unless you are declaring that it is nonsense; I would like to kill off that changeling that I had put into this world as thoroughly as possible.

Franck was perfectly aware of how formidable a task it was to understand atomic processes. The observational data could suggest hypotheses but could not provide solid proof. This is clear in his letter to Bohr from April 20:[90]

> I am, at the moment, so nervous and unsure of myself that I would not be surprised if you would simply laugh at me about the content of the enclosed manuscript. Please do so very pointedly, if you think I have made a whopping mistake.

Franck spoke at the main convention of the Deutsche Bunsengesellschaft in Darmstadt at the end of May within the series of talks categorized under the topic of inelastic atomic and molecular collisions. His report, "Quantum-mechanical problems of chemical reactions," was an elaboration on his joint publication with Born in the *Annalen der Physik*.

He did not need to go into Wolfgang Pauli's idea that the two electrons orbiting around the atomic nucleus may never have the same combination of four quantum numbers. The paper introducing Pauli's exclusion principle as an important improvement of the rules of quantum theory had appeared in January. Up to then only conceptual models existed about "imaginary" orbits or "imaginary" shells that electrons could legitimately occupy along their courses around the atomic nucleus. Pauli demonstrated that advances could be made toward explaining spectra by assuming that each quantum state within an atom could only be occupied by a single electron.[91] In the case of helium this means that the two orbiting electrons have to have different quantum states—later found to be different spin orientations. Electron spin had not yet been discovered.

At that time, the government was compelled to make cuts to its university budget, so most faculty members were concerned about finding ways to improve working conditions at their institutes. Besides Mr. Still's aid, the Rockefeller Foundation was the most important source of financing. In July 1926 the influential gentlemen from the American foundation paid another visit.[92]

Courant and Franck were among the party viewing the site for the planned mathematics institute. They came properly prepared to answer all of their fellow colleague Edmund Landau's objections, which—as rumor had it—were primarily motivated by personal ambition.[93] Göttingen mathematicians and scientists had their own share of internecine rivalry. The midday meal took place at the Courants' home, and Runge and the *Universitätskurator* Valentiner were also there. One of the visitors later gave his assessment of the Göttingen academics Born, Hilbert, Franck, Pohl, and Prandtl for the foundation. All were evaluated as being highly competent. Franck was reportedly one of the most important leaders the world over and, like Courant, was persuasive—tactful, not argumentative.

The year yielded further fundamental discoveries in quantum physics. As Franck and Blackett were working during the summer break, there was a decisive turn of events. Initially, Sommerfeld's mathematical approach to the problems was the main influence on Werner Heisenberg's notions about the atom. At Göttingen, Born's new views were added to this influence, along with Franck's experimentally grounded input. Bohr then made a convert of Heisenberg to his way of thinking during his visit to Göttingen, and Heisenberg's own visits and lengthier sojourns in Copenhagen reinforced this new conviction.

In Copenhagen, Heisenberg made the acquaintance of Hendrik Kramers, someone closer to his own age than Bohr.[94] Both young researchers were occupied during the winter of 1924 with the theory of dispersion, which Kramers had taken up the preceding summer. They attempted to formulate the interaction between light and matter on the basis of quantum theory. This subject had already long since been explored experimentally and Kramers's first paper pointed out that his theory contained only observable optical quantities. Heisenberg returned to Göttingen just as the fields were beginning to flower and immediately had a serious attack of hay fever. So he decamped to Heligoland, an island on the coast of the North Sea, to recuperate. No longer under the direct influence of Bohr or Born, Heisenberg continued to ruminate about the contradictions in Bohr's model of the atom. It was strikingly similar to the planetary system with its orbits determined by a central attractive force and counteracting centrifugal forces. Those planetary orbits are clearly observable and can be calculated by the classical methods of mechanics. In contrast, the "orbits" of electrons around an atomic nucleus are basically unobservable. The frequencies of spectrum lines are the observables and measurables, along with their intensities and splittings caused by electric and magnetic fields exerting an influence on the atoms. Heisenberg felt he had to drop Bohr's visual model and distance himself completely from it. The "electron's location" Heisenberg now replaced by the set of all observable radiation quantities that can be "entered" on a chart. He also drew up a "chart" for the concepts of electron momentum and energy. In this way it was possible to draw mathematical associations in which Planck's quantum of action figured fundamentally. After developing this idea further he sent it to Born in Göttingen to look at and submit for publication.

In a detailed letter to Einstein from 15 July 1925 about the research under way at Göttingen, Born devoted a single line in passing to Heisenberg's manuscript:[95] "Heisenberg's latest paper, soon to be published, appears rather mystifying but is certainly true and profound."[96]

After his letter to Einstein had already been sealed, Born realized that Heisenberg's computational scheme matched an existing mathematical operation that he had learned about as a student—matrix calculus. Born set a highly gifted graduate student, who already had been in Göttingen for a few years, to the task of helping him check this idea. On closer examination it proved to be right. The mathematical apparatus needed to solve Heisenberg's ideas could be borrowed from linear algebra. The proof yielded a brilliant verification of Heisenberg's concept. The difficulties and contradictions emerging from explanations of the Zeeman and Stark effects by Bohr's theory disappeared when the new theory was substituted.[97] When Heisenberg returned to Göttingen, Born, Heisenberg, and another of Born's students, Pascual Jordan, worked on a detailed account of the new quantum mechanics. It was only ready in the late fall, after Born had already left for the United States. This publication gained lasting fame as the "three-man paper" (*Dreimännerarbeit*).[98]

Two other mathematical theories of quantum mechanics were developed independently. Inspired by Heisenberg's first publication, the English physicist Paul Adrien Dirac found an additional algebraic solution that in many cases is much easier to handle mathematically. This achievement guided Dirac to physics despite his original career plans of becoming a civil engineer. Unable to find employment after his graduation, he had been attending mathematics courses at Cambridge on a stipend.

An Austrian found an entirely different approach to the problem.[99] Starting out from analogies in optics and applying differential equations, Erwin Schrödinger found a simpler way to calculate the intensities of spectrum lines. Many physicists were already accustomed to working with differential equations, so the introduction of "Schrödinger's equation" was rapid and it was soon in wide use. The crucial question was: Could all three of these mathematically very different approaches be transformed into each other without contradictions arising? In Göttingen, David Hilbert, the Hungarians John von Neumann and Eugene Paul Wigner, Richard Courant, and Pascual Jordan set out to solve this question. The answer turned out to be "yes."

These were momentous events for many theoretical physicists. Nevertheless, they did not directly affect Franck's research. The energy terms he obtained by experiment were unchanged.

The year 1925 had another surprise in store for physics, however. After a number of false starts—and caustic rebuffs by Pauli—Samuel Goudsmit and George Uhlenbeck managed to demonstrate that the electron must be spinning around itself, in either a leftward rotation or a rightward one. It consequently has a magnetic moment.[100] Accordingly, the two electrons of a helium atom can have differing spins. This made it possible to understand the behavior of excited atoms in a magnetic field. Franck was very interested in this, as he had already worked on the subject in the past, and Hanle had conducted experiments in this line under his supervision. The theory behind the helium spectrum was clarified without Franck's having to retract anything in his earlier publications. To navigate better in the increasingly complicated mathematics of this area, Franck consulted the book *Methoden der mathematischen Physik*, coauthored by Hilbert and Courant but mainly reflecting Courant's style. Franck was in the fortunate position to be able to discuss the contents of the book with Courant, and he recommended it to his students.

For his presentation at Oxford before the Faraday Society, Franck drew on results from his research program. He incorporated work by Dymond, Heinrich Gerhard Kuhn, Oldenberg, Sponer, and his own experiments with Blackett. His report was published under the title Elementary Processes of Photochemical Reactions.[101] By combining curves of potential energy with these measurement results, he was able to show how dissociation and chemical bonding work. From research conducted by Dymond at his institute on radiative excitation of iodine vapor, iodine molecules, and observations of the band spectrum—particularly the transition from the individual bands to a continuous spectrum known as the place of convergence—Franck was able to make a prediction about the energy of dissociation. Upon electric excitation of atoms, a continuous spectrum appears when ionization occurs, that is, when an electron separates itself from an atom. Franck recognized an analogous case with molecular spectra. The results calculated in this way coincided well with values for the work of dissociation obtained by entirely different methods. Franck's contribution was another important illumination of the theory behind chemistry.

Dymond translated the article into English for publication in the *Transactions of the Faraday Society*, which received the text on 21 August 1925. Franck then expanded the manuscript in German and submitted it to the *Zeitschrift für physikalische Chemie*, which recorded its receipt on 22 January 1926. In England he had opened his talk with Einstein's photochemical notions of $E = h\nu$ and the experimental verifications by Emil Warburg. In the German article this introduction was omitted. Another omission was perhaps related to considerations about Heisenberg's quantum mechanics, because the English version mentions the states of electrons in diatomic molecules of identical atoms:

> In this class the electron of the atom is not distributed but quite new orbits of the electron appear which belong to totally different types of motion from those of the free atoms. As an example, let us take the assumption frequently made that two or more electrons are common to both atoms of a diatomic molecule; the orbits cross in some way and encircle both nuclei.

This statement about "orbits" that Heisenberg had declared to be "unobservable" constructs was deleted in the subsequent version.

A sensational, apparently well-founded scientific discovery illustrates how little was known about the atom and its nucleus at the time, despite the many recent advances made in atomic physics. Professor Adolf Miethe from Berlin reported about a conversion of the element mercury to gold by electric discharge. Gold was demonstrably detectable after a mercury-vapor lamp had been in operation for a long period.[102] The process was reproducible and successfully repeated in various other laboratories. Though the amounts of gold involved were tiny, they were nevertheless detectable. How this transformation from one element to another could occur was hotly debated. Finally, scrupulous analyses revealed that the gold originated from trace amounts in the copper-wire leads. The gold diffused out into the mercury. Therefore no conversion between the elements had taken place.

Before the Francks could leave for their summer vacation in Wenningstedt on the North Frisian island of Sylt, something had to be done about Hertha Sponer so that she could become a private lecturer in time for the winter term. Franck had to use his utmost skill in the art of persuasion to obtain Pohl's permission to have Miss Sponer qualify for the *Habilitation* degree. Pohl's counterargument was her lack of scientific expertise. His disinclination to tolerate women in science may perhaps also have played a part. This discussion took a toll on their old friendship, and Franck's relations with Pohl were still not completely mended many years later.

Under the circumstances, it was advisable for Sponer to be able to put forward a published book as proof of her independent scientific work. As editors of the series on the structure of matter, Franck and Born were always looking for potential authors. Many of their colleagues who had initially promised to submit manuscripts had not delivered, despite reminders. In a letter of 29 July 1925 Franck suggested to Ferdinand Springer that Miss Sponer write a book about vacuum spectroscopy for the series. She could produce it during a research year abroad in Berkeley on a Rockefeller grant, during which she would be working specifically in this field.[103] Vacuum spectroscopy was at that time still largely undeveloped in Germany because of a lack of suitable instrumentation. Two weeks later Hertha Sponer received Springer's offer and she committed herself to submitting the finished manuscript by the end of 1927. Springer granted her request for an advance payment of forty dollars.

Figure 67 Hertha Sponer. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Sponer left for the United States at the end of October, and Franck's daughters and Carl Runge organized a cheerful farewell party.[104] A brand-new bus delivered the voyager and her crowd of friends to the train station, where they saw her off with fine speeches and singing. The local paper, the *Göttinger Zeitung*, reported about the event—not without a prod at Pohl that was obvious only to insiders. Hertha Sponer's stay in America was very successful, and she received invitations to Japan and the Soviet Union. Franck applied to the Rockefeller Foundation[105] for the necessary funding and she was able to make new contacts. After her return it was possible to install a high-resolution vacuum spectrograph at Göttingen under her direction to address the issue of the excitation of nitrogen.

The frequently changing governments of the Weimar Republic were unable to provide the necessary funding for universities and scientific institutions, however, even in subsequent years. The rising numbers of young people taking up academic studies only caused the situation to worsen. At Göttingen, for instance, 2,494 students of both sexes were registered for the summer term of 1925, and the very next year the enrollment rose to 3,014.[106] The faculty of sciences was issuing eighty to a hundred doctoral degrees per year. The associated operating costs and capital expenses worried the professors in charge. The Rockefeller Foundation again came to the aid of Göttingen science, commissioning Dr. Wilbur Tisdale to travel to Göttingen. He arrived there with his wife at the beginning of October,[107] and Courant and Franck met them at the train station and accompanied them to the Francks' home for a meal with Born and Pohl. The conversation in German was relaxed, and whenever the right word would escape Tisdale, he felt free to switch to English. Afterwards, when the women had retired, the intense discussions began about grant candidates for the International Education Board; the conference continued on the following day. Construction plans for a nearby new institute building for physics and mathematics were also broached. Tisdale was aware of how productive the close ties between these two fields were, particularly at Göttingen, so the preliminaries were set for an important decision for the coming years.

Soon after the Tisdales' visit, the Borns had to prepare themselves for their trip to America. Max had been invited to give a lecture series at the Massachusetts Institute of Technology in Cambridge. He acquainted the American physicists with quantum mechanics and worked intensely with Norbert Wiener on its development. The existing version could only calculate periodic processes of the atom. Born and Wiener found an important extension to nonperiodic processes. Their article was published in an American journal, after which it appeared in the *Zeitschrift für Physik*. Having completed his series of lectures, Born and his wife, Hedwig, were free to continue on a tour of the United States. Unfortunately Mrs. Born took ill and decided to return to Germany ahead of schedule, leaving her husband to finish the tour on his own.

Soon after his return to Göttingen in early spring, Born submitted for publication two manuscripts in quick succession. The first employed the new quantum mechanics to address collision processes, a problem that Franck had been examining experimentally for a long time. That fall another paper followed, on the adiabatic principle in quantum mechanics. After a close study of Schrödinger's wave mechanics, Born looked for a possible interpretation.[108] Schrödinger believed he could dispense with particulate characteristics. Everything was, he thought, waves or wave packets. Born's first paper already reveals his basic ideas about atomic collisions. He wrote:

> Schrödinger's quantum mechanics thus offers a very definite answer to the question of the effect of a collision; but a causal relation is not involved. No answer is given to the question: "What is the state like after the collision?" Rather only to the question: "How probable is a prescribed effect of the collision?"
>
> Here the whole problematic issue of determinism looms large. From the point of view of our quantum mechanics there are no such quantities causally defining the effect of a collision in an individual case; but neither has observation offered us any clue to the existence of inner qualities of atoms determining a particular collision outcome.

Born then became more specific:

> I personally am inclined to give up determinism in the atomic world. But this is a philosophical question for which physical arguments alone are not decisive.
>
> Practically speaking, indeterminism is in any event valid both for the experimental physicist as well as for the theoretician.

His paper about the adiabatic principle contains this note:

> It may remain an open question whether corpuscles like electrons, protons, and light quanta really exist; but we are certain that with the aid of these concepts numerous phenomena may be simply explained and we are now trying to bring this into harmony with wave mechanics.

Born emphasized Franck's involvement and research on collision processes in his theoretical considerations. Franck's theoretical models of reactions always assume individual atoms or molecules, although his measurements are the result of the effect of very many atoms or molecules at once. The statistical nature therefore cannot be easily ascertained. Wave mechanics interested Franck enough to motivate him to join Oldenberg in attending some of the lectures Born's assistant Friedrich Hund was offering on the subject.[109]

Professor Franck had little time to spare for leisure and relaxation. Business at the institute continued throughout the year. Graduate students used the summer break to conduct their experiments without interruption. Vacationing for a longer period of time was not done that year. Between Christmas and New Year's the work did slow down a little, but as the dates of some of his letters reveal, Franck still continued to deal with his paperwork.

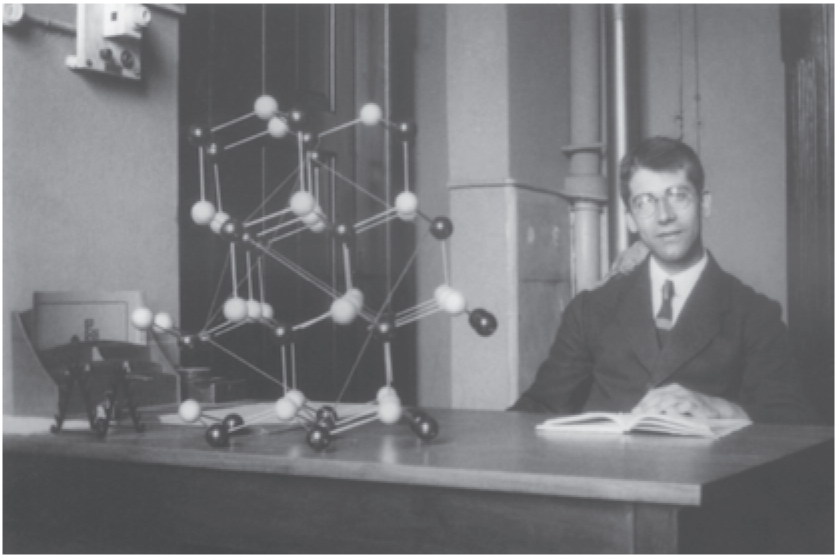


Figure 68 Friedrich Hund. Friedrich Hund collection. By courtesy of Friedrich Hund.

The Franck household celebrated Christmas with a decorated tree, but only with due reservations and as a concession to the two girls as well as out of consideration for the cook and the maid, who were Protestants.[110] Franck's parents in Berlin did not honor such Christian rites, nor did they visit their son's family in Göttingen on those religious occasions.

In science notable dates did receive due acknowledgment, however. Arnold Berliner thought it important to promote historical awareness among younger physicists. So on important birthdays he published articles in his journal *Die Naturwissenschaften* honoring members of the older generation in the profession.

The ninth of March 1926 was one of those important dates. Emil Warburg would be eighty years old. A member of the national bureau of standards (the PTR), Eduard Grüneisen, drew up a biographical sketch, and Franck offered a contribution on the activation cross-section for atomic processes of collision, so that he could refer to Warburg's earlier research on the viscosity of gases and its relationship to the diameter of the molecules.[111] With regard to the diameter of an excited atom, Franck pointed to Heisenberg's new quantum mechanics:

According to the conceptions of quantum mechanics, one cannot expect that the collision cross-section will really coincide with the orbital diameter of the luminous electron [i.e., for sodium, the single electron on the outer shell of Bohr's atomic model] obtained on the basis of normal mechanics; but a similarity will continue qualitatively to exist.

He summarized the various findings from other institutes and the latest dissertations from his own institute on activation cross-sections. The result for the main issue still did not seem satisfactory, though:

> Let us hope that by this method [of measuring the resonance fluorescence and its polarization and depolarization under the influence of a magnetic field], precise knowledge can be obtained about the force field surrounding the atoms; hitherto it was only possible to say that its existence is detectable with certainty up to a distance of 10^{-4} cm from the atomic nucleus.

The paper was finished in February 1926—but that was not the only manuscript he was working on.

Since April 1925, Ferdinand Springer had been sending Franck 100 marks per month as advance payment for working on a book on atomic excitation by electron collisions. Yet progress on his manuscript was slow. Starting in August, Jordan began to receive the 100 marks, because Franck decided to let him help with the book. Franck dictated the text to him, relying largely on his own memory. After he had completed the section on photochemistry, he wanted to know whether his account of Karl Friedrich Bonhoeffer's results was accurate and sent it to him for his review. If Haber had time, he added, he was also welcome to read the draft. On March 29 the complete manuscript was sent out to Springer with a cover letter.[112] "I hope that the result is acceptable," he wrote. "As Dr. Jordan has collaborated so much on it, I would like to publish it jointly with him. I assume that this does not cause any difficulties."

Franck also mentioned the textbook edited by Hans Geiger and Karl Scheel, *Handbuch der Physik*. It, too, was being published by Springer. Franck had written a very similar essay for the textbook about the excitation of quantum jumps by collisions.

> The account offered here is substantially longer than in the *Handbuch*, because of the addition of many more general aspects not belonging in the textbook; but the main parts of 2–3 chapters are entirely the same, for it seemed too stupid and unproductive a task for us to restyle the account.

There is an added note in Franck's hand:

> Many times I wanted to thank you for the forbearance with which you issued the monthly installments of 100 marks to Dr. Jordan in advance. Please be so kind as to make the prepayment for the month of April as well. I just read in the contract that I have unfortunately exceeded the agreed period of 11 months. But the book has profited by it, as much of importance has meanwhile appeared that should be a part of it.

Franck also approached Bohr on Jordan's behalf, seeking a financial contribution to allow Jordan to undergo speech therapy at a special school to help him overcome his speech impediment.

The book was ready at the beginning of July. Franck dedicated it to his father and thanked Dr. Hans Fesefeld and Dr. Heinrich Kuhn in the foreword. To Bohr he wrote:[113]

I long considered whether I should take the liberty of dedicating it to you but, on one hand, I would then not have been able to give my father that pleasure and, on the other hand, I think you do not need any superficial dedication, as the book's content is entirely based on your conceptions and your trains of thought.

The chapter headings reveal the breadth of the subject matter:

Kinetics of very slow electrons in gases and vapors

Methods for determining the critical potentials by electron collision

Critical potentials and spectral terms of atoms

Quantum-jump gains in electron collisions

Conversion of kinetic energy and thermal energy of atomic structures into excitation energy

Conversion of excitation energy

Kinetic potentials of molecules

Connection between quantum jumps and chemical reactions

Franck asked Springer to send out complimentary copies to 27 fellow scientists. His list begins with Planck, Einstein, Haber, and Meitner. Of course, Bohr and the others in Copenhagen were included, along with Hertz, Reiche, and Sommerfeld. Even Pauli, Heisenberg, Ehrenfest, and Arnold Berliner received a copy. Springer was also asked to send one to his father. The Göttingers received their copies from Franck personally. The first eight hundred copies were soon sold, then the demand subsided. The entire series was unfortunately not profitable for Springer.

Heisenberg's book had to be forwarded to him in Leipzig, as he was busy negotiating there about an impending appointment to the local chair for theoretical physics. On 29 May 1926 he wrote to Franck:[114]

Before I leave here to embark on my new career, I would like to thank you and your esteemed wife warmly for all the kindness that you have shown toward me throughout the years of my Göttingen stay. The spirit perceptible at our institute Christmas parties and the "Franck festivities" and permeating all the collaborative work and sense of community did, of course, largely come from you. And because it is mainly due to this spirit that one immediately feels at home in Göttingen, I'd like to thank you especially for it. I could not imagine anything finer than working in Göttingen again one day under the reign of this spirit.

I have already written to Born about the outcome of the Leipzig and Dresden negotiations. Now I have a very special favor to ask of you: Since you so kindly congratulated me at the time on the appointment to Leipzig, I would appreciate hearing your ultimate advice.

Heisenberg first visited Bohr before he finally accepted the chair at Leipzig.

The departure of Heisenberg meant that Born had to look for a new assistant. Born's group of physics students, from a variety of national backgrounds, was also constantly growing. His carefully prepared lectures did much to make the otherwise unpopular subject attract interest, and he was able to assign dissertation and research topics on a grand scale. Robert Oppenheimer, Edward U. Condon, and Joe Mayer came from the United States, Edward Teller came from Hungary. Paul Dirac also visited Göttingen from England for a longer period in the spring of 1927, staying until early summer. Like Oppenheimer, he lived with the Carios. Likewise Karl Taylor Compton with his family from Princeton, who also took up quarters in their home. This helped the Cario family out financially, but the arrangement did not lead to any closer exchanges of ideas or scientific collaborations between landlord Günther Cario and his roomers. Born's other students—some of them future assistants of his—came from various regions of Germany. They included Walter Heitler, Friedrich Hund, Fritz London, and Lothar Nordheim. Only Maria Göppert was a local Göttinger.

Not everyone shared Heisenberg's opinion of the special academic atmosphere at Göttingen. Oppenheimer mocked the way in which Göttingen physics was being carried out.[115] Although conceding that these physicists were hardworking, he described their approach as "combining a fantastically impregnable metaphysical disingenuousness with the go-getting habits of a wallpaper manufacturer." The Rockefeller Foundation had an entirely different impression of the situation, as the report about Georg David Birkhoff's and Wilbur Tisdale's visit on July 2 indicates. An after-dinner gathering of all the full professors of mathematics and physics at the Francks' home led again to an exceedingly positive verdict by the foreign guests. Born and Franck, indeed the entire group, were ranked highly on the Rockefeller list. The site of the future mathematics institute was viewed on the following day. The Rockefeller Foundation decided to provide the large sums for its construction as well as for a new extension to the physics institute.

Franck's ability to warm people to a scientific project and to direct them was highly appreciated. Friedrich Paschen, the new president of the bureau of standards in Berlin, decided he would be a good addition to the board of trustees. On June 14 the reich minister of the interior wrote to the Prussian minister of science, the arts, and cultural affairs:[116]

The President of the Physikalisch-Technische Reichsanstalt has suggested the tenured professor at the University of Göttingen Dr. James Franck for nomination as member of the board of trustees of the Physikalisch-Technische Reichsanstalt. The above-named declared his acquiescence to an appointment.

Please kindly state to me whether any objections to a nomination of Prof. Dr. Franck exist.

On 30 August 1926 Reich Interior Minister Külz was able to inform Franck: "The Reich President has appointed you by decree of 11 August 1926 as member of the board of trustees of the Physikalisch-Technische Reichsanstalt."

Franck attended the board meetings as often as he could. The minutes reveal that, unlike Nernst, he kept himself very much in the background. There is, of course, no record of whether he discussed some of the business with President Paschen in advance of the meetings.

In the previous year, Franck had forcefully pushed through Hertha Sponer's certification for the postdoctoral academic degree. He now sought professional acknowledgment of another woman scientist and personal friend. With his active support, Lise Meitner was elected corresponding member of the Göttingen Academy of Science, thereby becoming the academy's first female physicist member.

C H A P T E R 5

The Nobel Laureate

On 12 November 1926, at 25 minutes past noon, the Göttingen post office received a telegram from Stockholm:

> Professor Franck.
> Nobel prize in physics awarded to you and Hertz. Please inform by telegraph whether you can attend the festive plenary meeting, Stockholm 10th December.

Figure 69 James Franck. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

It was the delayed award for 1925.[1] Bohr had been proposing Franck for the prize since 1921, and he and Einstein had nominated him again in 1924. Max von Laue had put his name forward the year before. Finally, in 1926, Bohr, the German physicists Alfred Byk, Grüneisen, Edgar Meyer, Nernst, and Westphal suggested to the election committee that he share the award with Gustav Hertz. The task of choosing the prizewinner from among the nominees and submitting the name to the Royal Swedish Academy of Sciences fell to the mathematical physicist Carl Wilhelm Oseen from Uppsala. His justification alludes to scrupulous experiments and the importance of the results for Bohr's theory.

Max Planck sent his congratulations by postcard on November 12.[2]

My dear Colleague,

I hope the report in the papers about the Nobel prize is correct. In any case, I am extremely pleased and send you my heartfelt congratulations. This instance, too, was a fortunate and deserving choice. My wife also sends you and yours warm regards. If possible, do have your wife accompany you to Stockholm. It is a fine, memorable experience for life. I hope all is otherwise well with you.

Looking forward to seeing you soon!

Haber chose a more stately tone for his best wishes.[3]

It is an honor for us generally in Germany and there is something exalting about it because this choice reached by the Nobel Committee was the right one; and everyone throughout the world who knows anything about the matter will approve of the choice. It is doubly exalting because it shows that there is a higher court of human justice above the prejudice and malice in one's own country that evaluates merit by the facts . . .

As an afterthought came the more personal wisdom: "Success makes all of us healthier and more efficient."

Arnold Sommerfeld sent his applause on 13 November 1926.[4]

To the everywhere most renowned Franck and Hertz Company

With pleasure did I hear that your famous business has been en-Nobeled. As you have always served your numerous customers with sound trade and have furthermore seen to the founding of many affiliates abroad as well as at home for the continuation of operations along the same guidelines, this recognition bestowed on you will be regarded everywhere as well justified.

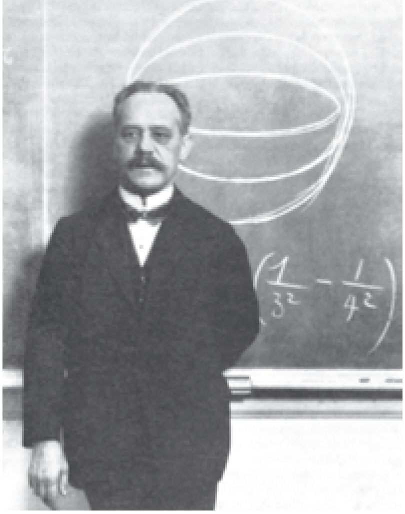


Figure 70 Arnold Sommerfeld. Deutsches Museum, Picture Archives, Munich.

Willy Wien likewise sent word to Franck and Hertz. J.J.'s son George Paget Thomson wrote from England on November 14:[5]

May I be permitted to offer you my most sincere congratulations on the Nobel award? It will be a source of great pleasure to all physicists that it has been given one whose brilliant discoveries have done so much to give sure experimental basis to the quantum theory. As you said at Oxford, physics reveals its strength [with] its feet in nature earth: experiments; [none] has done more to give a firm foothold than yours.

I shall remember with pleasure our meeting at Oxford and hope for another soon.

On the same day the *Vossische Zeitung* published an interview with Gustav Hertz in Halle. Two days later an article from Göttingen appeared about James Franck and Richard Zsigmondy. The latter had been awarded the Nobel Prize in chemistry:

The Göttingers, who with their university and relatively numerous research institutions feel a little lost in the thicket, are proud that the Nobel prize this year has been awarded to no less than two professors at their university. The names Franck and Zsigmondy have become popular overnight. The waiter at the hotel does not need to check in the directory to tell me the telephone number and apartment of Professor James Franck.

Franck's interview was brief because he had to leave to give a presentation. "Your harvest with me is a little meager," his interviewer quoted him as saying, "especially when one considers that you came specially from Berlin to Göttingen. But Professor Zsigmondy will surely compensate you abundantly for it." With these words Professor Franck dismissed the journalist. The report about Zsigmondy's research in the area of colloidal chemistry was indeed lengthier.

It was not long before the official letter arrived from Stockholm with the invitation to come personally on December 10 to receive the prize sum, the certificate, and the gold medal. There was the additional request that he deliver a public speech about the prizewinning research a day or two after the award. Franck conferred with Hertz before writing to Stockholm with his acceptance. Might his brother-in-law, Martin Kallmann, also be permitted to attend, he asked?

Next came his application on December 1 to the university *Kurator* for a leave of absence:[6]

I humbly petition Your Honor for a leave of absence for the period of the 6th to the 29th of December, as I have to travel to Sweden and thereafter to Russia. Please entrust Prof. Oldenberg with my substitution until the 24th of December and thereafter Prof. Born until the 29th of December.

His daughter Daggie provided a detailed report about the great event that took place in Göttingen on 27 November 1926. In a letter to her grandparents, Rebecca and Jacob Franck, she pleaded:[7]

Tell me, someone, where to start and with what first! Well, with the finest thing, and that was the torch procession. The preparations for it on our part mainly consisted in finding and carrying out chairs and tables. In the evening around 9 [o'clock] Papa's friends and colleagues, who also wanted to have a look, arrived first. Outside, 4–5 guards had posted themselves in front of the garden to keep order, and Göttingen's inhabitants pushed themselves forward to the fence and stared at the brightly lit house, where for the time being there was nothing more interesting to see than a back with apron strings (belonging to our Henny).

All this, Lisa, a friend of ours, and I noticed as we were keeping watch for the torch procession. The watch was worthwhile; the procession could be seen and heard approaching with a big brass band. So we ran upstairs and told everyone that the company please assemble on the house terrace. Of course, all the ladies did not have their coats on anymore and the gentlemen were very politely trying to help them into the wrong ones. But everything was settled despite the mix-up. Papa stood with the gentlemen on a huge terrace down by the house. Above it the ladies (among whom I naturally count myself), distributed among two upper terraces. Then it came.

A train of lights with absolutely no end in sight filed into the garden, which could hardly hold them all. After they had all positioned themselves in very fine formation, one of them delivered a speech from the open stairs about the Nobel prize, the Nobel prize, and more Nobel prize—and physics besides. Then Papa held a speech that I liked very much. Papa pointed out the relationship between teachers + students that was so nice here, etc. Then another student gave a speech and said among other things that since 1901 "28 Nobel prizes" had gone to Germany. The 1st student gave three cheers to Papa, which was done with great fanfare and percussive flourish. Papa gave three cheers to the university, and the student to something else.

The silly policemen were meanwhile standing at the gate and not letting any of the people in, so the good Göttingers saw the necessity to climb in over the railing. Then the procession retreated to the beat of the band, after everyone had sung the German anthem together. As they departed the band was playing: "Imagine that, imagine that, you Berlin bud!"

There were about 1,000 students in the train, 400 among them bearing torches. The sight was the finest thing I had ever seen in my whole life. If only you had seen it. Afterwards we had another merry gathering with about 40 people here. It was very nice.

Figure 71 James Franck, Ingrid Franck, Ellen Hertz, and Gustav Hertz. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Franck took his wife, Ingrid, along to Stockholm and the physical chemist Richard Zsigmondy also attended. Hertz, having just accepted a professorship at Halle, traveled from there to Sweden with his wife, Ellen. According to the December 10 issue of the *Vossische Zeitung*, George Bernard Shaw was among the expected guests as recipient of the prize in literature for 1925, but he unfortunately declined at the last minute. The awards for 1926 were to be made on the same occasion, so the laureate in physics, Jean Perrin, and in chemistry, The Svedberg, were also there for the ceremony.

Oseen delivered the *laudatio* for the physics prize,[8] closing with the words:

> Through clear thinking and painstaking experimental work in a field which is continuously being flooded by different hypotheses, you have provided a firm footing for future research. In gratitude for your work and with sincere good wishes I request you to receive the Physics Nobel Prize for 1925 from the hands of our King.

At the banquet held in the Grand Hotel across from the royal palace, Svedberg delivered the first speech. Then James Franck stood up. Speaking also on behalf of Gustav Hertz, he offered a personal glimpse into what the pursuit of science meant to him.

> Your Royal Highnesses!
>
> Highly esteemed ladies and gentlemen,
>
> I ask for permission also in the name of my friend Hertz to thank Mr. Oseen and Mr. Cassel for the so kind words they dedicated to us. I wish I had the ability to express the sense of deep gratitude that fills us. But really, the extent of the honor you have awarded us is too great; the magical hospitality and friendliness with which you are surrounding our wives and us acts too strongly for me to be able to say what moves our hearts.
>
> In the last few weeks we have been able to accustom ourselves to the thought that your verdict has drawn us among that number whom Alfred Nobel wanted to distinguish in his generous will; nevertheless the inner sense of amazement remains that we are being rewarded for doing what we enjoyed doing: The pleasure we feel as every scientist does when he may help work on problems within his discipline and double pleasure when here and there he manages to make some new finding. Have we thus made ourselves worthy of so very much recognition and praise?
>
> Is it not rather we, who must have every reason to be thankful?—thankful for the opportunity to work, thankful also to destiny for permitting us to collaborate in an epoch so rich and vibrant in our science and to carry building blocks of that magnificent frame of quantum and atomic theory which particularly men like Planck and Niels Bohr have erected?
>
> Hertz and I have experienced many fine things together and have stood side by side through many a difficult hour. So I know that I may say also on his behalf that we always considered it the greatest privilege to have Nature's timelessly beautiful meadows at our disposal, a refuge for her disciples to revisit at will at least in their thoughts.
>
> Alfred Nobel wanted to smooth the path into Nature's realm for scientists honored and rewarded in his name; he surely did not want them to travel down it alone but to

Figure 72 Franck's framed prize certificates. Franck papers, Special Collections Research Center, University of Chicago Library.

take along as many companions who seek it as their faculties allow. We feel this duty and will definitely always strive to devote ourselves to it.

I would not like to close without emphasizing how many fine and good things I have experienced in my life that have origins in your country. Sweden is the homeland of my wife; many friends have I found in Sweden, and now we receive the honor I consider to be the greatest that may be bestowed upon a scientist. You will surely not think it a mere platitude if I say that, next to my own fatherland, my love and admiration lies most with the Swedish lands, and that it comes from my heart when I invite you to join me in raising the cheer: Long live the land of Sweden!

As was customary, the prizewinners delivered their scientific lectures on the following day at the polytechnic. Franck and Hertz divided the subject between themselves. Franck gave a historical account of their experiments and how they related to Bohr's theory of the atom, and Hertz covered the more theoretical part.

The Francks then continued on their planned trip to the Soviet Union. Franck's father's advice was probably very useful when it came to investing the prize money for their future. Franck received roughly two hundred congratulatory letters and over 450 telegrams. Many of these letters had to wait until his return for a reply. On New Year's Day he thanked Fritz Reiche, who had in the interim followed a call to Breslau from Berlin, in a very personal letter:[9]

You can hardly believe how much the kind way in which our colleagues and friends are acknowledging the award of the prize to Hertz and me means to me. You, dear

Mr. Reiche, who have stood by me so much in word and deed in Dahlem, should know that this recognition dropped into our laps, in that happy chance linked our line of research with those magnificent ideas by Bohr and Planck.

But you perhaps do not know so well what it meant to me, who was always suffering from unrequited love for theory, to have such a selfless and knowledgeable advisor by my side, particularly during those critical years after the war when one had to refortify oneself emotionally again. Truly, those hours in your little haven away from [Hartmut] Kallmann's battle cries are a lifelong memory for me.

These many friends were now intent on inviting the Nobel laureates to give talks at their universities, but Franck and Hertz were hesitant to comply. Walther Gerlach at Tübingen would not be turned down, however. Their excuse had been that they could offer only old hash—"Blech und Kohl," as they put it. So the welcoming party at the provincial station in Tübingen came suitably prepared with a large baking tin and a head of cabbage!

Before he could leave for Stockholm, Franck first had to finish a paper for *Die Naturwissenschaften*. In March 1927 Carl Runge would be celebrating his seventieth birthday and Berliner wanted to publish something special for the occasion. Franck decided to treat an astronomical problem that he was discussing with Kienle. His article considered a redshift in resonance fluorescence from multiply repeated scattering. This was one more piece of evidence of the

Figure 73 James Franck and Gustav Hertz by the train in Tübingen. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

broad scope of Franck's interests in physics. It reached well beyond his already quite extensive area of expertise. The paper starts with the assertion:[10]

> C. Runge's research, devoted to spectroscopy and its application to astrophysical questions, is so fundamentally important for this field that I would like to draw my small contribution to the Runge commemorative issue from specifically this area of problems.

Franck essentially expanded on Rump's dissertation, without actually referring to it, for he first treated Einstein's theory of emission and absorption from 1916–17 and the transfer of a light quantum's momentum in absorption $h \cdot \nu/c$ and $h \cdot \nu'/c$ in reemission, as well as the magnitude of the change in wavelength in the interaction between light and matter. It is far too small to be observable, possible only with X-rays and matter, as Compton had demonstrated. If, however, the acts of emission and absorption occur frequently enough, Franck contended, this change in wavelength ought to be detectable. Such conditions could not be reproduced in the laboratory because it would not be possible to create a sufficiently large rarified cloud of sodium vapor, for instance. But certain stars do exhibit such effects visible in sodium D-line observations. Emission lines originating from the change in wavelength are visible along the long-wave edge of the absorption line. At the end of the paper Franck mentioned that Jacov I. Frenkel was busy conducting a quantitative analysis of the problem in St. Petersburg.

Figure 74 Carl Runge and Ingrid Franck 1926. © bpk-Bildagentur für Kunst, Kultur und Geschichte, Berlin.

A glamorous birthday celebration was organized for Runge in Göttingen—another expression of the close friendships and mutual trust among the academic staff. Four months later a heart attack put an end to Runge's life. At his funeral Franck first praised his accomplishments in the so different fields of mathematics, physics, and astronomy. He then continued on a very personal note:[11]

> What a pure joy it was, particularly for the physicists among us Göttingers, when more than two years ago, after retiring, Runge decided to turn his attention to physical problems again . . . when he returned to experiments with the enthusiasm and agility of a youngster and allowed not just his loyal collaborators but all of us at the institute to learn from his great skill as an experimenter. How fine and enriching the physics walks and hikes were, which I

was often permitted to accompany him on as a trusted friend. Although very much his junior, one really could—and indeed had no alternative to feeling like a trusted friend.

Sudden death snatched him away from all this, from the finest productive creativity and activity. Are we now allowed to succumb to despondence and numb grief? No, we aren't; we should be glad that such a person lived among us; we should be doubly glad if we had the good luck to know him more intimately. Sudden death, which spared him from old age and weakness—taking him from among our number as a 70-year-old youngster . . .

Not all institutes had the benefit of such a trusting relationship between the young and old professors. Michael Polányi's letter from Fritz Haber's Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry shows this clearly enough. Polányi held a part-time position as private lecturer at Charlottenburg Polytechnic in Berlin in addition to his post at Haber's institute, but he was unable to find a permanent salaried position. He wrote to Franck on 23 April 1927:[12]

It would be embarrassing for me if my friends had the feeling that I was making demands that I am not justified to make. Therefore let me stress that I do not deserve a position different from the one I currently hold. The situations of others better than I (Miss Meitner and others) are no different. [. . .]

Are you coming to Berlin before your America voyage? If so, may I speak with you then for a half hour about this matter? Not that I have anything of essence to add to what is mentioned in this letter. But you will understand that a conversation with you about these things, which occasionally do trouble me, would be of great value to me, even if you then only reiterated your kind disposition toward me—for which I warmly thank you.

Yours, M. Polanyi.

The mentioned trip to America took place the following year. Franck probably spoke with Polányi in Berlin that summer when he was visiting his parents with his daughter Lisa, since Polányi stayed under Haber's employ at the institute and became a member scientist of the Kaiser Wilhelm Society.

Franck's advice was sought not only on personal matters. His sense of responsibility extended well beyond his own professional specialty, to issues of peace and mutual understanding. Eight years after the World War, the world of science was still divided by Germany's breach of trust. The issue of welcoming Germany into the International Union was hotly debated. The Göttingen Academy's stiff reaction was not constructive, Franck thought, and he felt obliged to express his reservations in a letter to the secretary on 4 May 1927:[13]

I am, to be honest, unhappy that the option remains open to the opposing side to exploit a tactic taken by us that in my opinion is wrong and use it the more potently against us. Our position was as strong as it could have been, if only we had joined on the grounds of the American and Norwegian letters.

Thus again it will be said that we had been the ones to boycott the possibility of peaceful cooperation.

We really ought to have learned how important public opinion is in the world. As cooperation with the others dominates in the press, the question won't even be raised about whether or not real reasons exist for us to mistrust the advances. Moreover, I think the letters were meant as genuinely as they ever could have been and our dilational [hesitant] response will therefore only offend our friends and strengthen our enemies.

A strong spirit of internationality prevailed at the University of Göttingen. Its many foreign guests, supported particularly by the faculty of the sciences, were firm proof of it. William Meggers came during the summer of 1927 from the U.S. National Bureau of Standards, along with his fellow Americans Richard Tolman, professor of physical chemistry and mathematical physics at Caltech, and Robert Wood. Meggers usually made an annual appearance at Born's and Franck's institutes.[14] Christian Moeller from Bohr's institute represented Denmark and the Americans Wheeler Loomis and Louis Alexander Turner later followed as Guggenheim Fellows. The ingenious native of Odessa, George A. Gamow, arrived from Leningrad and enlivened the discussions at Göttingen in many ways. He befriended one of Franck's graduate students, Friedrich Houtermans, who was working on photoelectric ionization of mercury vapor. Fritz, as he always called himself, wrote his dissertation on the strength of countless cups of coffee at a local café; it had to be published in two parts, because it was too long for a single issue of the *Zeitschrift für Physik*.[15] In it Houtermans succeeded in attributing various excitation states of the mercury molecule to specific sections of its fluorescence spectrum.

The Student Body Turns Political

Issues of science policy repeatedly interrupted the research routine. As the student body was simply a reflection of the political mood in Germany, there was no ivory tower for scientists to retreat into. Right-wing radicalism and anti-Semitic tendencies could no longer be ignored. Members of the German nationalist Volkspartei attempted to block a reform in the Prussian parliament that would have limited the political rights of militant students at Prussian universities. After this major bill (number 233) was voted down in November 1927, Minister of Culture Carl Heinrich Becker gave a long speech explaining the political motivations behind the defeated measure.[16] It had been prompted by a consolidation of German and Austrian student associations; more moderate student groups had failed to suppress a particularly virulent strain of anti-Semitism imported from Austria. Becker explained:

It was not the welfare of the student body that dictated the slogans [against the bill] but a political struggle for power. Nothing proves better than the outcome of this vote how political our student organization is and how necessary the new regulation by the

State Ministry was, which set before the organization the choice either to return to self-governance within the education sector or to dispense with it altogether. What remains is pure politics. This may very well have its reasons but it is now at least undisguised politics and can no longer deceive the public in the dress of objective or indeed educationally motivated self-governance.

[. . .] [N]ow those pulling the political strings come along and exploit this mental mood. "You're a pan-German, aren't you?" Certainly. "You're for academic freedom?" Naturally. "The government is threatening it, so you should vote no." But then our self-governance will be lost. "Our Austrian brothers would regard that as a betrayal of the pan-German cause." Then, I have to vote no. This was the very simple way in which the voting proceeded, a usurping of the general ignorance about the issues. Thousands of flyers prove it.

But who were these political string-pullers? Some of them unfortunately sat in the leading organizations of the major student corporations. These are ruled not by students but by senior academicians. Much resentment against the new State is nestled there; this is where some of the reactionaries are nestled, not at universities, not among professors, but many former academicians outside in the provinces. It should be known that most of the large unions explicitly or inexplicitly follow anti-Semitic principles. The Austrian Aryan groups exploited this situation to influence the mood in favor of their partisan tinted campaign of anti-Semitism; and they found a more than willing audience here. Anti-Semitism in Austria is fanatical to the point that in the negotiations Austria's Aryan student groups have declared it as their mission to incite Germany to anti-Semitism. [. . .] Anti-Semitism and political discontent mingle strangely with true idealism and partisan ambition for power and that is how the slogan emerged leading to the rejection of the student bill.

A strengthening national socialism influenced political life. Hitler was released early from jail and the party reorganized. In 1926 Hitler initiated the Nazi Student League, and just one year later a group of five members was organized at Göttingen University, under the leadership of Walter Gross, that began to arouse more interest among students. In 1925 a chemistry student called Achim Gercke had already begun compiling a kind of directory of all Jews in German universities.[17] Handwritten copies of it were disseminated under the title The Jewish influence in German higher education (*Der jüdische Einfluß auf den Deutschen hohen Schulen*). Its first issue also examined the teaching staff at the University of Göttingen. Born, Courant, and Franck are entered there as "of the Mosaic faith," as they are in other reference works. But the issue's subtitle—A genealogical record of Jewish and Jewified university and college teachers—points to its political purpose. There was not a trace of such political radicalization or anti-Semitism among Born's students or among Franck's or Pohl's. Many of the foreign visitors remarked about the open-minded harmony in their institutes, both on the personal level and scientifically. The result was even more visitors coming from abroad to study physics at Göttingen. Some even came just to experience the stimulating atmosphere. A native Welshman from Rhagadar, Robert D'Escourt Atkinson, who had studied at Oxford and was assistant to Frederick Lindemann, joined Franck's institute to work toward his doctorate.

In his playful congratulations on the Nobel Prize Sommerfeld had praised the sound "service" to science by Franck and Hertz. It was typical of Franck's way of working to rarely be satisfied with the first results obtained. After a period of rethinking, he would tackle the problem again from another angle, usually by a new experimental approach. No experiments in atomic physics yield completely straightforward conclusions. Experimental conditions, often parameters of an entirely unfamiliar nature, always inconspicuously influence the outcome. With Blackett, Franck had investigated what happens to excess energy in a process of molecular dissociation. They had concluded that it goes into the kinetic energy expended in the high-speed separation of the coreactants. Franck decided to check this result together with Thorfin Rusten Hogness, a fellow from the University of California supported by the International Education Board. They confirmed a second finding, that the place of convergence in the absorption spectrum is associated with the process of dissociation. As in the project with Blackett, the variation in the Doppler broadening in photochemical dissociation was used, this time for sodium iodide. The energy in excess of the work of dissociation generated by the beam forces the coreactants to separate at increased velocity. So in the subsequent experiments successively shorter wavelengths were chosen for the beam. Less fluorescence was stimulated as a result, but the Doppler shifts got larger. Toward the end of the 1920s no reliable sources of intense monochromatic ultraviolet light had yet been developed. Instead powerful electric sparks were generated between metal electrodes. Hogness and Franck used silver, cadmium, and zinc electrodes and found their anticipated results qualitatively fully confirmed.[18] This verified that the velocity with which the reactants separate rises as the energy of the photons driving the dissociation is increased (the term "photon" was not yet in use at the time).

Some dissertation topics that Franck suggested dealt with apparently trivial problems that would otherwise be regarded as "largely solved." Walter Lochte-Holtgreven was assigned such a topic. The sodium spectrum contains two closely lying intense lines: D_1 and D_2. Their intensities are in a ratio of 1 : 2. The question was: How do various stimuli affect this intensity ratio? Lochte-Holtgreven was able to show how to change the known intensity ratio and to explain it as well. He continued to work on this interesting problem and related issues when he later received his professorship at Kiel.

In joint publications coauthors are generally listed in alphabetical order. Franck's paper with Blackett is one example. Toward the end of it there is a reference to a thesis by Heinrich Kuhn about the absorption spectra of chlorine. By the summer of 1927 two articles appeared coauthored by Franck and Kuhn as well as a third together with another collaborator, Günter Rollefson, on interpreting the continuous absorption spectra of alkali halides such as NaCl. They opened a new field of research.

Heinrich Kuhn and his classmates at university were no longer members of a generation that had actively participated in the World War. The age gap with Franck and other professors had widened significantly. Respect for senior authority was taken as a matter of course by those who had started school during the kaiserreich. Franck never regarded his position as *Ordinarius* as a sign of such superiority, so his many younger students and graduates continued to sense his willingness to introduce them to physics as easily as they did his kindly concern for his fellow man. Twice a year the institute organized spirited parties. In the summertime they took place on a nearby hilltop, the Hainberg or the Nikolausberg, where Franck was able to show off his bartending skills. In the wintertime, everyone was invited to a big social event at which Franck's foibles as a teacher were likely to figure in some comical skit. Young talent thrived in such a welcoming and inspiring environment. Many of Franck's students received appointments to professorships in experimental physics at a relatively young age, without personal connections having to be brought into play. Heinrich Kuhn spent nine happy years at Göttingen with Franck, becoming his closest coworker.[19]

Kuhn's father was a lawyer and notary public in the small Silesian town of Lueben. His second son, Heinrich Gerhard, nicknamed Heini, was born in 1904. The lawyer's interests extended beyond the usual classical education to include the natural sciences, and Heini found them very stimulating. As a schoolboy he was already conducting his own chemistry experiments and building all kinds of physical gadgets. In 1922, just like his teacher James Franck twenty years before him, he started studying chemistry at Greifswald. A lecture about Bohr's and Sommerfeld's theories of the atom attracted him to physics and he went to Göttingen in 1924. Franck recognized Kuhn's talent early on and allowed him to speak at the seminar, with its grueling question-and-answer session afterwards. During a private interview Franck sounded out whether Kuhn would be suitable as a doctoral candidate and also consulted with his assistants about him. This was the normal route to obtaining a position at the Experimental Physics Institute II. Despite the many extensions added to the institute, the number of those interested in a position was far higher than space would allow.

The problem of what exactly was going on in dissociation continued to enthrall Franck, and so the topic of Kuhn's research was a foregone conclusion.[20] His experiments on an optical determination of the heat of dissociation of halogens produced such interesting results that he was allowed to submit a brief notice to *Naturwissenschaften* before his thesis had even been completed. Franck granted his graduate students leeway in writing their theses. There was no "institute style" to abide by. It was still customary that the examinee pay a visit to the professors before taking the doctoral examination. As Kuhn was to be tested in chemistry, he still had to see Professor Windaus. Franck invited Kuhn to accompany him to the public pool. That was where he would meet Windaus; so the introductions took place in swimming trunks.

Kuhn's dissertation, "Absorptionsspektren und Dissoziationswärme von Halogenen," appeared, as did many theses issuing from Franck's institute, in the *Zeitschrift für Physik*. On 2 April 1927 its editors received the article by Franck and Kuhn, on the absorption and fluorescence spectra of silver iodide molecules and their chemical bond, along with the one in coauthorship with Rollefson. This paper cites Condon's publication in the *Physical Review*, in which he performs the quantum mechanical calculation of Franck's principle (the Franck-Condon principle). But Franck first had to come back to the "changeling" he had told Grimm he would so much have liked to stamp out. A correction needed to be made to a paper by two other physicists, Ernst Angerer and Gustav Müller, who had concluded that the spectrum of alkali halides could be interpreted as the anion's electron affinity spectrum. The analyses at Göttingen yielded that photochemical dissociation can separate heteropolar alkali halides either into two normal atoms or into one normal atom and one excited one. The second joint effort by Franck and Kuhn examined the same problem in the case of silver iodide in the vaporized state. They demonstrated that a homopolar bond was involved.[21] As the molecule dissociates, it falls apart into a normal atom and an excited atom. The question that arises is: What kind of bond figures in the solid state, as AgI is electrically conductive both in the solid and melted states? One could only speculate at that point. Experiments had to be performed with related compounds to test whether they could solve the problem. At the end of July the draft paper on experiments with the related bonds AgBr and AgCl was finished. Both bonds are homopolar in the gaseous state, therefore they are atomic bonds. The measurements were complicated because Kuhn had to heat the substances to 850–900°C in order to increase the vapor pressure sufficiently.

Franck never did return to the problem of the bond of AgI in the solid state.

Not even the Nobel Prize could guarantee sufficient state funding for Franck's research program. Nor was his the only institute in economic stringency. In May 1927 Pohl, Born, and Franck applied to the university *Kurator* for additional staff.[22] Born and Franck each needed another regular assistant, and Franck wanted one supernumerary post in addition. Their workshops were also short of hands, and so three new posts along with another secretary each were included on Born's and Franck's lists of essential additions. In September Franck even took out money from his account for Pohl because Pohl was donating instruments to the new auditorium from his own collection. But their application was rejected. In an effort to retain his master mechanic, Wilhelm Sperber, Pohl tried to obtain approval for a position in the civil service for him. In the interim he paid him bonuses out of his own pocket.

The International Congress of Physicists was planning to celebrate the hundredth anniversary of Alessandro Volta's death in Como in September 1927. The invitations had already been sent out at the end of the preceding year. In reply to Willy Wien's congratulations on his Nobel award, Franck wrote on 1 January 1927 about his concern that the conference would become too political.[23] The oppressive measures by the fascist regime in Italy against its German-speaking minority worried him.

> May I add a few words about the Volta festivities in Como. I, too, have proper doubts about the actions by the Italians in southern Tyrol. But I have been taking the standpoint that our fellow professionals issuing the invitation certainly do not identify themselves with that impossible conduct. But now I hear that Mussolini will be appearing there in person. If this turns out to be true and if circumstances have not essentially improved by next fall, I will likewise cancel; having already accepted, however, I don't want to do it now but shall wait and see how conditions develop and then decide.

The speakers from Germany who ultimately attended were Born, Franck, Gerlach, Grüneisen, von Laue, Meitner, Paschen, Planck, Sommerfeld, Otto Stern, and E. Wagner. Einstein did not. Heisenberg was listed as among the Danish participants even though he did not arrive from Copenhagen but from Leipzig, where he had in the meantime accepted a professorship. At Como Franck again spoke about his new research in the boundary area between chemistry and physics. As expected, Mussolini hosted a reception. Franck's talk would later appear in the published proceedings. Instead of adding detailed references, he cited Hertha Sponer's article in the *Ergebnisse der exakten Naturwissenschaften*, perhaps motivated by the thought that it would attract his fellow physicists to her research.[24]

The variety of alternate activities scheduled for the participants offered them plenty of opportunity for scientific discussion in a more private setting or relaxing excursions in larger or smaller groups in Como's beautiful environs. Bohr broached the philosophical question: What exactly does a physicist really observe in atomic processes? What is real? Quantum mechanics, and above all Heisenberg's uncertainty relation, made this a live issue. One draft of Bohr's talk bears the English title The Philosophical Foundation of the Quantum Theory. It was only discussed on the sidelines at Como. Not long afterwards, though, at the Solvay Conference in Brussels, Bohr and Einstein battled it out in a controversial and intense debate. Born was present in Brussels, but Franck was not. The highly intellectual altercation about complementarity, in which Pauli and others also intervened, separated theoreticians into two opposing camps.

Born and Franck may have discussed this question between themselves, but there is no indication that any seminar at Göttingen or in Born's series of lectures motivated experimental physicists to reexamine what they viewed as "reality" and "interference" or manipulation by an experimenter.[25]

The problems occupying Franck were entirely different. He was yet again trying to make sense of experiments performed by other physicists and to reinterpret their results without the intention of generating his own data or delegating out such work. The love for theory he once confessed to Fritz Reiche reemerged. This time the issue was the recombination of positive ions and electrons in gases. Franck and Jordan had made a claim that he now had to qualify a little. Franck's hypothesis was made on the assumption that their electric field causes positive ions to recapture the emitted electrons very rapidly, yielding excitation luminescence.[26]

In December an article by Clinton Joseph Davisson and Lester H. Germer appeared in the *Physical Review*: Diffraction of Electrons by a Crystal of Nickel. It offered clear experimental confirmation that matter diffracts electrons.[27] After many failed attempts, these authors had succeeded, in the excellently equipped Bell Laboratories, in doing what Elsasser had failed to achieve at Franck's institute: the experimental proof that electrons behave like waves of light and that their wavelength depends on their velocity, that is, on their beam potential. Two years later an electrical engineer studying at Charlottenburg Polytechnic near Berlin, Ernst Ruska, would design the first electron microscope with magnetic lenses for his *Diplom* thesis, without ever having heard about Davisson and Germer's results.

Their publication was certainly mentioned in Franck's lectures. Franck always tried to share recent advances in physics with his students.[28]

The busy year terminated with the institute's Christmas party. Mannkopff made an appearance as Mr. Rockefeller doling out generous grants, while Hertha Sponer and Heinrich Kuhn conducted a dialogue in verse. Then Miss Sponer proved her talent as a dramatic street-ballad singer with incidents from the institute routine.[29]

First Trip to America

In the past Franck had received and declined many invitations to the United States. Now it seemed he could refuse such speaking engagements no longer. On 5 September 1927 he asked for official leave from the first of the new year until May 5:[30]

> As justification for my application I permit myself to point out that I have been postponing accepting such invitations to America for years, to wait for a point in time when

> such a trip was possible without major detriment to my institute. I now believe that my institute duties and course obligations can be substituted by the private lecturers Prof. Oldenberg and Dr. Sponer, especially if all the necessary preparations are made in the first part of the winter semester 1927/28.

Shortly before Christmas Franck answered Professor Edwin C. Kemble's letter from the Jefferson Physics Laboratory in Cambridge, Massachusetts, to let him know what he would be speaking about. One lecture series was titled Connections Between Spectroscopy and Chemical Reactions. The other was Optical and Electrical Phenomena Connected with Recombination of Ions and Electrons. So they covered just recently completed research.[31]

Mrs. Franck did not want to accompany him on this trip. Her health was not stable enough. Neither did she want to leave her daughters on their own for such a long time,[32] though they were already quite independent. Besides their musical activities, they were also playing tennis and learning horseback riding. Franck suggested that Dagmar come with him. At eighteen she was certainly old enough, but she was about to take her school leaving examinations and hesitated to be away for so many months. So he traveled by himself.

Franck visited Edwin C. Kemble in Washington, D.C., as well as William Meggers in his excellently equipped laboratory at the National Bureau of Standards. The bond of friendship between the Meggerses and the Francks dated back to the Meggerses' visit to Göttingen. Classical music was their shared love. Meetings of the American Physical Society and of the U.S. National Academy of Arts and Sciences offered Franck the opportunity to renew acquaintances made with past visitors to Germany and to make new ones as well.[33]

He brought back some Native American souvenirs for his daughters, a skirt for Dagmar and a Navajo rug for Lisa. All in all, it was a profitable trip for Franck, and not just scientifically. The lectures were well paid. It was decided to use the money to buy a Fiat, which they dubbed the "lion."[34] It carried them on many fine excursions outside Göttingen. Once they delighted Franck's mother with a drive into the Göttingen woodlands; she and her husband never went on such outings, whether in Hamburg or in Berlin. The girls took driving lessons and obtained their licenses as soon as they were old enough.

Franck's parents fully appreciated their son's scientific accomplishments and distinctions and enjoyed taking part in his happy family life. Not long after Jacob celebrated his seventieth birthday his health failed him, and he died on 5 November 1928. He was buried, as he had wished, in Hamburg in the cemetery Vor dem Dammtor. Rabbi Duckes from Altona delivered the funeral sermon, duly acknowledging the many ways Jacob Franck had helped others and praising his civic concern.

His son James had a similarly strong civic conscience. He was a member of the Israelitische Union, a charitable organization that Einstein had also joined.

Research and Science Policy

On 9 December 1928, Fritz Haber would be sixty years old. Franck felt particularly attached to Haber and usually went to see him when he was in Berlin. Science was not always the reason for these visits; Franck also came to help out when Haber was suffering from one of his terrifying heart attacks—angina pectoris. The *Zeitschrift für Physikalische Chemie* issued a birthday volume in Haber's honor, with his portrait as the frontispiece.

Franck's contribution to the volume discussed the absorption spectra of negative halide ions in solution. It was coauthored by the spectroscopist Gerhard Scheibe, a guest researcher at Franck's institute.[35] They measured the spectra of NaI, NaBr, and KCl in aqueous solution. The aim was to see if there was any detectable indication of electron affinity. The vapor experiments usually conducted at the institute appeared unsuitable, and Franck and Scheibe also thought an analysis of the solids unpromising. Born's theory of lattices had already provided important clues to the problem. Optical absorption curves showed two maximums attributable to the two values for electron affinity, assuming two optical excitation states. A figure for electron affinity had to be determined out of the information from Born's calculations and other molecular data, including water, obtained by experiment. The result was satisfactory within the confines of their assumptions. The publication is written in a style that strongly suggests Franck was the main author.

Figure 75 Fritz Haber. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

Franck also had to compose a piece for Berliner's *Naturwissenschaften*. He chose to write about Haber's research on excitation and ionization by chemical reactions:[36]

> In this issue in celebration of Haber's sixtieth birthday, designed to offer an overview of his multifaceted areas of research and personal interests, one should not fail to point out that Haber was one of the first to see the deeper connection between quantum theory and spectroscopy, on one hand, and heat tones [heats of reaction], on the other.

Franck continued to say that Haber had been the first to realize that chemiluminescence—that is, radiation emissions in chemical reactions—can be regarded as a reversal of photochemical reactions. The reaction between sodium and chlorine was given as an example:

$$Cl + Na + Na \rightarrow NaCl + Na^{excited}$$

$$Na^{excited} \rightarrow Na + h\nu.$$

Recent measurements by Polányi and his collaborators had shown that the reaction was more complex, Franck explained.

$$Cl_2 + Na \rightarrow NaCl + Cl$$

is the primary process, which takes place without chemiluminescence. Then follows:

$$Cl + 2\ Na \rightarrow NaCl^{excited} + Na$$

$$NaCl^{excited} + Na \rightarrow NaCl + Na^{excited}$$

$$Na^{excited} \rightarrow Na + h\nu$$

Franck may have chosen this particular example to bolster Polányi's work. His conclusion was:

> Many important problems are still awaiting resolution in this area. But Haber cleared the approach and pointed out the way for further research. May this field produce many more beautiful blossoms of success for him and the other members of his institute.

Hertha Sponer had returned from her voyage to America in September 1926, and a paper cosigned with Raymond T. Birge on the dissociation of nonpolar molecules had appeared in the *Physical Review*. But there was no prospect of her obtaining a permanent position either in Göttingen or elsewhere. The book she had promised to write for Springer about vacuum spectroscopy was never written. The reason was that a similar book authored by someone else already existed and had even appeared in second edition, so it was pointless to produce yet another volume on this limited topic. A survey of molecular spectra did not exist yet, however. Sponer had already published a few things on the subject in volume VI of the general science series *Ergebnisse der exakten Naturwissenschaften* that appeared in 1926. Even so, when it was proposed to Springer as a new project, he agreed. The material had a tempting abundance of aspects to pick from in exploring the question: What happens when molecules dissociate? This book appeared quite late, in 1935, as volume XVI of the series *Struktur und Eigenschaften der Materie*. It serves as a good record of the development of Franck's notions on molecular spectra. Although wary about commenting on the publications interpreting the Ramsauer effect, Franck worked together intensely with Hertha Sponer on dissociation and predissociation.

Franck, as a member of the Göttingen Academy of Science, presented their joint contribution on determining the work of dissociation of molecules from band spectra at the meeting on 21 December 1928.[37] (Whether Franck actually read out the full thirteen pages to his colleagues at the meeting is not documented.) The introductory comments—the entire text again strongly reflecting Franck's style of writing—recapitulate the principle Franck had proposed: During dissociation the electron transitions take place so rapidly that the much heavier atomic nuclei practically maintain the same distances between one another inside the molecule. The bonding modifications provide the nuclei with vibrational energy. Condon was able to confirm this in his quantum mechanical description of the band structure. A recent paper of his was able to provide the reason for the indeterminancy of the amount of transferred vibrational energy. But the detailed structures of some band spectra are blurred. The French physicist Victor Henri saw in this effect a predissociation of the molecule (defined p. 179). Born and Franck had already published some thoughts about this in their paper of 1925. Franck revisited the incompletely answered question: Why does predissociation occur so rarely? The coauthors provided the answer:

> We are only going to be able to expect predissociation in cases where a molecular state of dissociation exists in which the nucleus distance does not differ substantially from the molecular distance from which the spontaneous dissociation proceeds.

Figure 76 Willy Wien. Deutsches Museum, Picture Archives, Munich.

This was then backed by a detailed discussion of potential curves. The data obtained by the Swede Lamek Hulthén and his coworkers from experiments on metal hydrides were incorporated as examples. For these analyses Franck had sought funding from the Göttingen Academy in the amount of 4,000 marks; an additional 2,000 marks were collected from the Notgemeinschaft (the Emergency Association for German Science).

The University of Munich was surprised by the death of their full professor of experimental physics, Willy Wien, who had not even reached retirement age. So the science faculty had to look for a suitable person to fill his chair and direct the large institute.

As successor to Conrad Röntgen, Wien had been able to equip the institute very generously for his own research purposes. It was an eminent post.[38]

One influential member of the faculty, Arnold Sommerfeld, was away on a trip to India, so the faculty had to ask him to send them his nominations as soon as possible by telegram. Lenard tried to intervene on behalf of his friend Johannes Stark and contacted the Bavarian minister of culture directly. The senate of Section II of the faculty of philosophy (scientists at Munich had not yet attained the status of an independent faculty) reconvened on October 23. Stark's candidacy was unanimously rejected, the minutes record; likewise two other finalists—Ernst Back, who was a physics assistant at Tübingen, and Professor Jonathan Zenneck at Munich.

> Debye, Gerlach, and Hertz are provisionally proposed in that order, following most intense debate. Further inquiries should be made about Franck before a final decision is reached.

The issue was whether Franck would be willing to hold the "major experimental lecture course." A former member of the Göttingen staff, the mathematician Constantin Carathéodory, was commissioned to find out. The next meeting put to record:

> Discussion of the candidacy of J. Franck, after announcement that Franck would be willing to deliver the experimental physics lect[ure]. Fr[anck] should preferably appear in first place with Debye.
>
> The list should read:
>
> 1st *æquo loco* Debye & Franck, but the Min[istry] should be asked to appoint Debye first.

Sommerfeld also cabled his approval about the finalists: Debye, Franck, and Gerlach in first place, Hertz coming in second, and Back third. A lengthier justification for the individual candidates was then drawn up for Minister Goldenberger. About Franck it stated:

> His studies on the transfer of energy in a collision between atoms and molecules are as attractive for their simplicity and elegance in the method of inquiry as they are important for understanding the mechanism of chemical reactions. The latest research performed by him and his collaborators on the dissociation of molecules under the influence of light promises to provide deep insights into the state of bonding of atoms and molecules.
>
> As for teaching, Professor Franck, a genteel personality, has been holding the physical practicals and specialized lectures with success.

Debye was not approached first, however, because an exchange of letters between the Bavarian and Saxon ministries of culture revealed that the ministry in Saxony did not want him to leave his position in Leipzig, which he had taken just one year before. Otherwise, it was concerned that it probably could not meet his conditions. So there was nothing in the way of an appointment being issued to Franck. But he only received word from Munich on December 28. Franck immediately informed Valentiner, the official for university affairs at the education ministry, of this fact. Valentiner reacted right away, wanting to keep Franck for Göttingen. He informed the minister of science, the arts, and cultural affairs in Berlin about the situation, specifying that the official call had been issued on the first of April or May 1929.[39]

The extraordinarily large and still growing attractive force that Professor Franck exerts on young students, the great prestige he enjoys in the United States of North America—he is a trusted consultant of most, if not all North American states on questions of physics—the importance that the University of Göttingen attaches to upholding or repairing good relations particularly with North America, and the general esteem that Mr. Franck enjoys in all the faculties, must certainly lead to the expectation that his own faculty will submit a special petition to the Minister to do the utmost possible to keep him at the University of Göttingen. Mr. Franck will temporize for the time being.

Franck traveled to Munich with Ingrid to have a look around, visiting the physics institute on January 14 and 15. The physicists welcomed the couple with great cordiality. Then he spoke with Councillor of State Hauptmann at the Bavarian ministry of culture to tell him what extensions to the institute he thought were necessary.[40] The auditorium could seat only 350. That meant that more than half of the registered students could not attend a given lecture, even though, as Franck saw it, they certainly had every right to expect it. Other urgent necessities were enlarging the laboratory facilities, increasing the number of assistants, and raising the institute budget. Franck's primary concern was not expensive apparatus for his research but necessary upgrading of the teaching and responding to the concerns of his students.

The next stop on their trip was Berlin. Franck had to barter with the authorities about benefits for the institute at Göttingen and safeguards for his own future if he were to decline the appointment to Munich. He wrote to the dean at Munich, the astronomer Alexander Wilkens, on 21 January 1929:

As a general outcome of my consultations with the gentlemen at the Berlin Ministry, I must inform you that my reception there was extraordinarily congenial and obliging. My salary in Göttingen cannot, of course, nearly approach the Munich level. But this is set against a readiness to go a good deal further than the extent reached up to now in budgetary and staffing aspects for my Göttingen institute, with instantaneous effect as well.

But I must again underscore my general attitude that I could only bear the responsibility of assuming the Munich obligations if the wishes I expressed in Munich would be fulfilled in totality: to these conditions belong in particular the construction of an extension to the auditorium and the laboratory space for the reasons I had stated in person.

He was hoping that his demands would benefit the faculty under all circumstances, even if he decided not to go to Munich.

In a letter from January 1929, after he had returned from Munich, Franck told Lise Meitner that he was still determined to stay in Göttingen.[41] The expert at the ministry, Dr. Wolfgang Windelband, negotiated again with Franck about his conditions for staying, evidently with the approval of the minister of culture. The following terms, marking the limit of what the ministry could afford to offer, were hammered out. This agreement was signed by both parties on January 23:[42]

1) Prof. Franck is willing to decline the appointment to Munich issued to him as successor to Prof. Wien under the following conditions.
2) His basic salary shall, on the approval of the Minister of Finance, be raised to 15,600 reichsmarks.
3) Professor Franck shall be guaranteed an annual total of RM 16,000 course attendance fees.
4) Prof. Franck shall receive a teaching assignment in atomic physics with compensation totaling six times his basic salary [i.e., RM 3,300].
5) In addition, a special remuneration shall be approved with the purpose of retaining his employ at the University of Göttingen of RM 2,000 annually.
6) In the financial year 1929, RM 10,000 shall be made available to Prof. Dr. Franck for the purchase of apparatus at the institute. In the financial year 1930, RM 8,000. In the financial year 1931, RM 7,000.
7) Professor Dr. Franck shall receive a laboratory assistant with a monthly wage of RM 200.
8) A yearly amount of up to RM 1,000 shall be placed at Professor Franck's disposal for guest speakers.

Franck decided to decline on February 4. That was before Windelband had heard from the ministry of finance that the contract had been officially approved.

Despite the great attraction that, as you know, this appointment to the so especially honorable post at Munich has held for me, I have had to decide to decline, as you can gather from the enclosed carbon copy to Councillor of State Hauptmann—not in underestimation of the Munich position, rather from the feeling that under the prevailing conditions I cannot trust myself to do justice to my duties there in a manner that the position demands.

It was Windelband's task to convince the minister of finance to grant his approval. His letter pointed out Franck's importance to the University of Göttingen as well as the income that Wien's chair was offering.

Prof. Wien's earnings came to about 60,000 m[arks], and the great increase in the number of auditors specifically in scientific subjects certainly permits the assumption that his successor will rather have an even higher income.

Franck's audience statistics at Göttingen were not nearly as high, because he was not teaching the main lecture course. That was the responsibility of Pohl as the second full professor of experimental physics.

> Precisely because of this fact and because of the excellent cooperation with his closer colleagues, which has proved extraordinarily stimulating and beneficial for Prof. Franck's research, he would be prepared to decline the Munich appointment, at a loss of great material advantage, if he be granted a basic salary of 15,600 m[arks].

The minister of finance granted his approval of the contract between Windelband and Franck on March 3.

In the end, Franck was clearly satisfied with the arrangement. Too many things tied him to Göttingen and the work that was under way at his institute. He wrote to Sommerfeld assuring him how much he would have liked to have worked together with him.[43]

A number of teaching assistants were needed for the practical sessions. Already at the beginning of the 1920s Franck had pointed out to the *Kurator* that for every 25 students, one supervisory assistant was needed to assure success during the laboratory sessions. When Hertha Sponer left for America, a substitute had to be found. It was just at this time that an assistant from Max Wien's institute arrived in Göttingen from Jena: Arthur Robert von Hippel, a former physics student at Göttingen.[44] He was part of the war veterans' generation. His grandfather had been a famous ophthalmologist and a personal friend of Wilhelm Conrad Röntgen's; his father was a professor of jurisprudence at Göttingen. Arthur von Hippel had studied there under Hermann Simon and earned his doctorate in physics in 1924. He found a position as Max Wien's assistant, and he and his wife, Marianne née von Ritter, had moved to Jena. Max Wien was conducting research in applied physics, working on problems connected with high-frequency engineering and electrical conductivity at high electric field strengths. This interested von Hippel, but shortly afterward, his wife died of pneumonia and he returned to Göttingen. Franck granted him free rein in choosing his area of research, so von Hippel started to investigate electrical breakdowns. It was a topic related to research that Franck had once conducted. The result was a joint publication on electrical breakdowns and Townsend's theory.[45] As with many of Franck's articles, it was a revision of experimental data generated by other physicists for their theoretical implications. It was the only paper in this area bearing Franck's signature. Von Hippel, on the other hand, continued to concentrate on the problem for a longer period of time.

Franck had managed to obtain a travel grant to the United States for Otto Oldenberg. This trip was soon followed by an offer by Harvard University. Oldenberg accepted the position, and so Arthur von Hippel received Oldenberg's regular post.

In the midst of his negotiations with the university official, *Kurator* Valentiner, and the ministry, Franck was compelled to answer an agitated letter from Lise Meitner. Reporting that Haber had told her about the possibility of a position being created for Miss Sponer at the Kaiser Wilhelm Institute of Chemistry—therefore in the institute at which she and Otto Hahn were working—she wrote in exasperation:[46]

I don't know whether you, who do unfortunately have a very hard time uniting objectivity with friendship, share Haber's opinion that Miss Sponer's achievements would justify her taking such a position over here. For the time being, I'm convinced that you surely didn't suggest this proposition to him.

But it doesn't seem quite fair to me to help even one's best friend to the detriment of another, even if the other is a complete stranger.

The reply is an example of Franck's levelheaded ability to gently stave off such kinds of insinuations:[47]

Dear Lise Meitner,

I'd like to answer you briefly right away. Haber's opinion that Miss Sponer should direct a division at your institute I do not share, but rather consider it nonsense. As concerns the accommodation of Miss Sponer as Haber's assistant at your institute, I told him many times that I consider it neither in your interest nor in Sponer's, nor in that of the K.W.I. of Ph. Ch. as a possibility. A person who is situated away from his institute in an exclave does not have enough contact with his institute. As regards all of you, I can imagine that you do not appreciate such an exclave.—That you had an interest in Miss Sponer's destiny I said to you once only, at the beginning, in the connection that I reported to you, namely: You had likewise told me that it would not be good for Miss Sponer's prospects if she constantly stayed with me here, above all because of the intellectual dependence.—There, I think that suffices.

That I, in your opinion, had a hard time uniting objectivity with friendship, has perhaps the advantage in the present case that I do not assess your distrust of me as objectively as I would have to assess it of a person with whom I do not feel so bound by friendship. Besides, I understand your agitation about Haber's completely impractical suggestion.

Nonetheless, I do believe I may expect from you a letter that speaks a little more reflectively, because I simply cannot understand how you can think me capable of such intriguist dealings. Even if I did deem H. Sponer a genius, I really could not, after the conversations with you and Hahn, suggest her for the post, which according to your wishes ought to be filled entirely differently.

I also heartily hope that any discord between us cannot last.

Hertha Sponer remained in Göttingen, and Lise Meitner's friendship with Franck was unaffected and continued without further disruption.

The experimental training that young physicists obtained under Franck's guidance was many-sided because when assigned a topic for their theses they did not automatically receive a finished apparatus with which to carry out a series of measurements. The obstacles posed by designing the proper setup for the experiments first had to be overcome. Werner Kroebel, for his dissertation, was given the task of identifying the source of a spectrum line in mercury vapor in the very-long-wavelength range. Franck and Grotrian had already thought about this problem in 1921. Kroebel was able to confirm the earlier interpretation with his findings, involving emission from a metastable excited state of Hg_2 molecules. The conclusion was that the Hg_2 molecules must have a dipole moment. It was this phenomenon that Kroebel wanted to investigate further.

In March 1929 Einstein, Haber, von Laue, Nernst, Paschen, Planck, and Emil Warburg sent to the president of the Kaiser Wilhelm Society for the Advancement of Science, His Excellency Privy Councillor von Harnack, a multipage petition to build an institute for theoretical physics as an extension of the Kaiser Wilhelm Institute of Physics.[48] All but von Laue, who had been managing Einstein's "institute" of this name for years, were members of the board of directors. But the institute still had no actual facilities. Einstein—and then his proxy, von Laue—were only able to distribute its funds as grants, usually dealing with the paperwork and administrative affairs personally at home. The authors of the petition first pointed out that theoretical physics had gone through such an "unparalleled" and "so mighty and successful" a development in recent years that they were "almost at a loss to name its equal in the entire history of science."

This was followed by references to the institute's previous business and its drawbacks as well as to the diverse funding activities that the Notgemeinschaft was currently assuming to an increasing degree.

> For this reason an institute not just limited to distributing resources but also to joining excellently qualified people in a common effort is probably on the best road to major success.
>
> This applies increasingly, and the more keenly so, as no pure research institute for theoretical physics exists in the German Reich and this creative and fruitful branch of the "exact" sciences has no place at which the atmosphere of the discipline can condense and breathe vitality into the common cause of a cooperating group of suitable individuals.

The physics of X-rays and molecular beams, as well as structure theory, were mentioned as potential areas of research.

> Theoretical physics cannot have facilities that preclude experimental activity. All come to a point where one's theoretical considerations cannot move on, if some consequence of these reflections is not initially tested and a decision reached that designates from among the manifold of conceivable possibilities one as the only one of importance [. . . .]
>
> Whereas an experimental physicist regards an experiment as a tool, a theoretician sees it as a signpost at a crossroads indicating the right way to go. Times when theoreti-

cal physicists could dispense with doing experiments signify ones in which trial has overtaken comprehension, experience has outdone theory.

In our times, the contrary is valid.

The signatories petitioned for an institute building with a working floor space of about 2,400 square meters. No staffing figures were provided.

The aim was to re-create what Born and Franck had already achieved in Göttingen: a decentralized institute operating on mutual trust and cooperation with subordinates and collaborations between the assistants and younger staff members. The Kaiser Wilhelm Society was seeking something similar for its new Institute of Physics. But almost a decade passed before this plan could materialize. By then the conducive circumstances, the underlying trust in German reliability, was thoroughly obliterated by National Socialist ideology.

It is questionable whether Franck or Haber ever saw the text of this application, especially considering how unrelated the fields of research envisioned for the new institute were.

At Göttingen Arnold Eucken, a pupil of Nernst, filled Professor Gustav Tammann's vacant chair for physical chemistry in the fall. So Franck had one more person to talk to about his ideas in the field. The faculty's consultations that year went smoothly except for one major difference of opinion about an honorary degree. Hilbert had submitted a petition that the publisher Ferdinand Springer be distinguished with a doctorate for his active promotion of scholarly publications.[49] Hilbert was so upset when the faculty rejected the proposal that he threatened in no uncertain terms that another rejection would jeopardize the existing ties of confidence within the faculty. A reversal by a vote of eleven to ten then allowed Hilbert's wishes to become reality. Valentiner, the official for university affairs at the ministry, approved it without further ado.

Another impending anniversary date obliged Franck to take up his pen again. In the upcoming spring Friedrich Schmidt-Ott would be seventy. After lengthy deliberations it had been decided to dedicate to the former minister of culture and president of the Notgemeinschaft a volume on developments in German academia within the individual disciplines over the past half century, that is, since 1880.[50] The range of topics was sweeping: theology and philosophy, jurisprudence and art history, subjects in philology as well as all the disciplines of the exact sciences. This was not an easy task for its contributors. They had to identify the main developmental trends in their field and duly acknowledge all the essential priorities without offending the sensibilities of any of their professional colleagues. Max Planck wrote the chapter on theoretical physics, Franck authored the one on experimental physics, and Jonathan Zenneck covered applied physics. The voluminous work of five hundred pages in octavo format opens with a whimsical introduction by Adolf von Harnack.

This volume, edited by Gustav Abb, bore the title "Out of fifty years of German science—Individual portraits of the development of its disciplines" (*Aus fünfzig Jahren Deutscher Wissenschaft. Die Entwicklung ihrer Fachgebiete in Einzeldarstellungen*). Franck's dozen-page contribution begins with basic statements that coincide with thoughts expressed in the application for the new building for the Kaiser Wilhelm Institute of Physics:

> The science of physics has experienced fundamental changes and extensions in the last 50 years as never before in its history. The fact that this jubilee volume subdivides advances in physics proper into three reports: theoretical physics, experimental physics, and applied physics, is indicative. These chapters and—if one takes physics in a somewhat wider sense—also astrophysics, geophysics, and physical chemistry, evolved into separate disciplines in recent years for purely practical reasons; for the sphere of physics has become too large for individual persons to survey. In fact, the science of physics only emerges from an interaction between its theoretical and experimental findings.
>
> Determining the facts is the business of experiment, their systematic classification, the task of theory, while applied physics recompenses its two sister disciplines by borrowing their results for its own purposes by supplying increasingly precise apparatus and experimental methods, which make new advances feasible. The tight mesh of experimental and theoretical strands consequently constrains the most important experimental data to consistent ordering principles of theory; and allusion to results stemming from the field of applied physics will likewise be necessary.

Franck mentioned that many major advances in high-precision physics contributed to fundamental adjustments in accepted theory. He was referring to the radiation measurements performed at the Physikalisch-Technische Reichsanstalt that had led to Planck's quantum hypothesis.

There is cursory allusion to the "Franck-Hertz experiment" in the last section on experimental foundations of quantum theory. Due mention is also made of the many other physicists involved in the development of experimental physics. His summary:

> Theory and experiment have, as mentioned at the outset, most radically changed the physical world-view during the past 50 years. Just like at the beginning of the epoch under examination when the main principles of physics seemed to have been settled, now again a calm in the stormy development of physics seems to have set in, which will serve urgently needed consolidation and further experimental verification of our view of the world. But even now observations already exist that cannot automatically be brought into accord with established conceptions, particularly in the area of nuclear physics. Whether it involves momentary problems to be overcome without any change to the general assumptions of physics, or whether it is a new stage in the evolution of physics to be reached, only the future can tell.

Franck surely discussed problems of nuclear physics and current issues regarding the way an atom's nucleus is structured whenever he met Lise Meitner and

Hahn in Göttingen or Berlin. He advised his students to work in this field. Nuclear physics would figure importantly in the future, he told them.[51]

It was not possible to expand the course curriculum to new fields, however, for financial reasons, despite the rising statistics of registered students. The state was unable to increase its university allocations. For 1929 the ministry had assured the *Kurator* 10,000 reichsmarks for Franck's institute and 8,000 and 7,000 for the subsequent two years. But in actual fact only 6,870 reichsmarks were approved that year. The full repercussions of October 29—"Black Friday" on Wall Street, signifying an end to the prosperity—had not even been felt yet. The reich government was still locked in difficult negotiations about reparations payments, and parliament was hotly debating whether to accept the Young Plan. The *Vossische Zeitung* reported about the various parties' reasons "for and against" the plan. The rightist *Göttinger Tageblatt* granted column space to more radically inclined elements. Its semimonthly supplements included the *Junge Front*, the "voice of nationally conscious youth" (*Stimme der volksbewußten Jugend*) promoted by the veterans' organization Stahlhelm, as well as the *Jung-Akademische Zeitstimme*. These two inserts openly promoted authoritarian *Führer*-ism, the martial arts and combat, with aggressive scenes to illustrate their texts. Some serious violent clashes even took place between Communists and National Socialists downtown. How does the quadricentennial celebration of the Reformation at Göttingen in remembrance of October 1529 fit into this picture? Academic life clearly continued to be virtually untouched by political events or trends of the day.

For the two friends Born and Franck, the last day of October was a particularly special day. The Academy of Science in Berlin elected them as corresponding members.[52] Erwin Schrödinger had written the nomination for Born, and Friedrich Paschen had signed the proposal for Franck's election. After explaining the importance of the Franck-Hertz experiment at length, Paschen discussed Franck's research on metastable states and on collisions of the second kind. He also described Franck's way of working:

> One has to marvel at the simple, sensible experimental methods in all the research by Franck and his pupils. They quickly became common knowledge for the whole of experimental science. But what is perhaps more marvelous is the clear picture of the world of atoms that Franck has worked out for himself and for science and from which he succeeds, mostly instinctively, to set further progress in motion.

The *Göttinger Tageblatt* waited until the end of November to give due notice to this distinction. At the beginning of that month, after a long period of preparations and much trouble in raising the funds, the Mathematics Institute had been completed on the site of the former *Realschule*.[53] It is a T-shaped structure of austere exterior decor with inviting but practical interior furnishings for lecture halls, the reading room, the library, and most notably the conference room for the Mathematical Society. It became the model for many other buildings devoted to mathematics. The true instigator of this project, Felix Klein, had died four years earlier. A portrait of him by the painter Max Liebermann was hung in the conference room in remembrance. The inauguration on December 2 was attended by the Prussian minister of culture, Becker, and the American ambassador Jakob Schurmann and representatives of the Rockefeller Foundation. Hermann Weyl and Theodor von Kármán were the speakers for the occasion, introduced by the indefatigable Courant as host.

The spacious extension to the Physics Institute funded by the Rockefeller Foundation and the Prussian state was also ready for occupation. The large Rowland concave grating for essential high-resolution analyses of all kinds of spectra was set up in the basement. The equipment for intensity determinations was supplemented by a new photometer to measure the degree of blackness of spectrum lines. It had been designed by the Hamburg physicist Paul Peter Koch.[54] The new building also offered considerably more room for the beginning and advanced laboratory courses. Almost three hundred male and female students received their training there each semester.

Franck was not feeling well and probably had gallstones. He was plagued by biliary colic attacks. Then he had serious appendicitis that required surgery. His recovery was slow, and it was a long while before he could devote himself fully to science again.[55] When Paul Ehrenfest came to visit from Holland at the be-

Figure 77 Paul and Galinka Ehrenfest with Franck and Runge (Sponer and Lisa obscured). Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

ginning of the new year in 1930, Franck was still suffering from the aftereffects of his operation. Ehrenfest was one of the invited speakers on the budgeted program. This highly respected theoretician loved to pose "simple" questions during a scientific discussion that would often lay bare the weakness of a given argument.[56] But unlike Pauli, he did not resort to sarcasm or cutting wit. Ehrenfest and his friends Born and Franck were in regular contact with one another, and he had spent a longer period of time at Göttingen in 1928–29 as a substitute while Max Born was on sick leave.[57] Ehrenfest was the successor to the Dutch Nobel laureate Hendrik Antoon Lorentz at Leyden.

A new member of Franck's staff arrived at the beginning of October. Eugene Rabinowitch, born in 1896 in St. Petersburg, had started studying physics in his native city in 1916, but the political situation had prevented him from graduating. So he went to Berlin in 1920 and took his doctorate there on a thesis in chemistry under Professor Friedrich Paneth's guidance, living off a grant from the Notgemeinschaft. He also worked in the Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry for a short time before coming to Göttingen. Franck welcomed Rabinowitch at his institute to conduct a theoretical analysis on the heat of activation in gaseous reactions. This thesis and the topic of the conference of the Bunsen Society in Berlin in May 1929 on heterogeneous catalysis got Franck and Born thinking about the problem of adsorption catalysis.

Both Born and Franck had to travel to Paris in March. Born was scheduled to give a talk, and Lauder William Jones wanted to meet Franck at his office in the Parisian branch of the International Education Board. He wanted to discuss the situation of physics at German universities and at the Kaiser Wilhelm Society. The low pay levels in academia compared to those at the Kaiser Wilhelm Society were discussed, as well as the scientific qualifications of a few fellow physicists. Franck explained to Jones how much easier it was to plan and conduct longer-term research without interruption in a Kaiser Wilhelm Institute than at a university, where research on a thesis generally only took two years to complete.[58] Franck's list of universities producing quality physics placed Leipzig and Munich at the top. Toward the end of the sojourn, Jones invited Franck to come to Princeton as a visiting professor, succeeding Karl Taylor Compton, who had just accepted the presidency at the Massachusetts Institute of Technology. In his record of the meeting, Jones noted that he believed Franck would accept the position but with the proviso that he stay for only one year. Franck had insisted that he could not be away from Göttingen for longer than nine months. Jones characterized Franck in his report to New York as the most helpful advisor of the fellowship program.

In the same month as the trip to France, Born and Franck presented their views on adsorption catalysis to their fellow academicians at Göttingen.[59] A talk

Figure 78 James Franck and Max Born in front of the Physics Institute in Göttingen. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

about catalytic acceleration of gas reactions through adsorption on a surface had already taken place at the previous annual convention of the German Bunsen Society. Haber had been the speaker, and in his introduction he had pointed out the important role that catalysis could play in economic development. Born and Franck revisited the problem on a purely theoretical level. Citing Fritz London's contribution to "the Sommerfeld Festschrift of 1929," they discussed, among other postulates, how to account for the required heat of activation for such reactions. Born and Franck also called attention to an idea advanced by George Gamow. This Russian physicist had shown that there was a certain quantum mechanical probability that α-particles could tunnel out through the potential barrier surrounding some heavy nuclei. The resulting spontaneously emitted particles were already being used to cause other nuclear reactions.

They then introduced a new factor in heterogeneous catalysis: the residence time of the gaseous reactant as a result of adsorption on a solid catalytic surface. On the basis of certain assumptions, they calculated for a given example the separating distances between the resultant nuclei at a residence time of one second. Their result showed the feasibility of a reaction without heat of activation.

On 26 May 1930 the surgeon released Franck from treatment, and he hoped to have the remaining bandages removed two days later—in time for his planned trip to Heidelberg for the Bunsen meeting.[60] Renowned physical chemists from England and France attended this broadly conceived convention. Franck delivered the first survey talk. It was a report about spectroscopy and molecular structure—determining thermodynamic quantities from spectroscopic data. Before broaching scientific issues, Franck made a few general remarks that revealed his concern about furthering mutual understanding between chemists and physicists.[61]

> The charge made against current scientific development is that it leads to extremely narrow specialization. The mass of information is, indeed, growing so enormously that an individual can only handle a very narrowly delimited field of knowledge. Scientific progress is erecting dividing walls, yet it is also tearing them down again. As soon as research about a specialty grants sufficient overview, the comparison can start with its neighboring fields, and with it an attempt to arrive at a general ordering principle. Individual analysis must again test its validity, to confirm or refute it. At the present time we are experiencing this process on a large scale between the sister sciences physics and chemistry. Chemists and physicists have to grapple in the same way, for instance, with Bohr's established theory of atoms grounded in quantum theory. Nomenclature poses the main difficulty. The jargon used on either side complicates communications. It is here, I think, that physical chemists are called upon to mediate.

The scientific part of Franck's speech was composed in a very instructive way. He slowly introduced the audience to the basic facts about spectroscopy and the possibility of determining energies of activation and dissociation from observable quantities. Then he explained complicated processes like predissociation, as well as giving recent results that he and Born had developed. He conscientiously named all contributors to this research, excepting only his own, so his own part in this major development can only be surmised from this modest account.

During the course of the convention Eugene Rabinowitch also presented his research with Franck on the heat of activation in bimolecular gas reactions and the chlorine detonating gas reaction.[62] The resulting publication contains many detailed footnotes to individual passages. Fritz London's theory was appropriately acknowledged and the Sommerfeld *Festschrift* properly cited. The examples chosen for the analysis, such as the chlorine hydrogen reaction effectuated by short-wave light, are actually all quite simple and had been the subject of many articles in the past. Franck's findings on collisions of the second kind, threefold collisions, and the absorption of radiation by molecules in the colliding state, when combined with Rabinowitch's work, drew a more complete picture of how activation and reaction proceed. Franck's special interest in physical chemistry was becoming increasingly evident.

With very few exceptions, Franck's assistants were good choices. They soon developed into independent researchers and able supervisors for graduate students. Nevertheless, Franck continued to do his weekly rounds through the institute, with his assistants in his train. Werner Kroebel was now one of them.[63] Whenever someone was not ready to make an on-the-spot progress report, Franck considerately accepted the usual excuse, "I'm rearranging the apparatus setup." But most of the time the boss's advice was very much welcomed and closely followed.

Arthur von Hippel adjusted well to the routine at the institute. He became such a trusted coworker that he eventually plucked up the courage to apply for the hand of Franck's elder daughter, Dagmar. They were engaged in the summer of 1930 and married soon afterwards.[64]

Franck's happy family life and successful research did not delude him about the state of politics and the economy, however, which was constantly deteriorating. A few of his closer assistants, notably Heinrich Kuhn, remembered him mentioning these concerns during one of their walks.[65] An April 16 article in the *Vossische Zeitung* reported that there were numerous Nazi cells in industry. Its long list of affected employers included the electronics firm Siemens, the electricity combine AEG, the radio-set manufacturer Ludwig Loewe, the Deutsche Bank, the Discountgesellschaft, and the publishers Scherl. Cells were even being set up in schools. The situation at the University of Berlin was menacing. Nazi policies were also being advocated underground at the University of Göttingen. Dr. Wilhelm Dames joined Franck's staff from Würzburg as an assistant in 1931 but did not mingle with the other assistants. Only later, in 1933, did it become clear why he remained such an outsider.[66]

The National Socialist press controlled fifty weekly papers and magazines and four daily papers. The firm of the politician and former industrialist Alfred Hugenberg played an important role. A reporter for the *Vossische Zeitung* complained under the subheading "The threat from the right" that the police were doing nothing to combat this threat whereas they were acting rigorously against Communists. Göttingen physicists heard news about the goings-on in the Soviet Union directly from their Russian visitors and émigrés, such as Pavel A. Cerenkov, Victor Fock, Igor I. Tamm, and Sasha Rumer. In early May the press reported that there were three million unemployed job seekers in Germany. The expected springtime relief to the job market was sluggish. A textile factory in Göttingen had to close down, and unemployment continued to rise in the rural outskirts as well. On June 7 the university celebrated its anniversary in its main auditorium. Members of the local government, the mayor, representatives of affiliated universities, churches, and the Göttingen officers' corps took part. The composition of the academic senate reflected the growth in the faculty for the mathematical and natural sciences: the faculty of theology had 9 members, that of the juridical and political sciences 10, the medical faculty 15, and the philosophers 19, while the mathematicians and scientists held 27 seats. The number of students rose from 3,962 in 1929 to 4,672 in 1931, with women making up less than 10 percent.[67] Over 10 percent of the city's population were students.

Three graduates started working on their theses under Franck's mentorship: Dietrich Schmidt-Ott, who was the son of the president of the Notgemeinschaft,[68] Hans Ramien, and Kurt Freudenberg.[69] Degrees earned under Born's guidance went to Maria Göppert and Victor Weisskopf, whom Ehrenfest was also advising. Weisskopf learned much from Franck's method of understanding atomic physics without recourse to mathematics.

Despite many constraints dictated by the failing economy, scientific and social life among the younger generation at the institute was intense. Born and Franck occasionally invited their assistants and graduates home.[70] When Born's asthma was troubling him too much to appear at work, his students would meet at his apartment for their discussion course. Debates at the physics colloquium were often continued over drinks or a meal at a restaurant. These evenings offered an opportunity for more informal conversation with the speaker. Sometimes these conversations went deep into the night—becoming, as it were, "eine kleine Nachtphysik."[71] Some of the participants, such as Fritz Houtermans, later continued this custom when they received their own chairs.

When Franck and Born had been reunited at Göttingen, they and Pohl had founded a regional branch of the German Physical Society, the Gauverein Niedersachsen der Deutschen Physikalischen Gesellschaft. As its initiators they felt obliged to contribute talks to its semiannual conventions from time to time. In 1930 the Gauverein Niedersachsen convened on July 12 and 13. Born and Franck chose to speak about their research on adsorption catalysis, and Franck again allowed Rabinowitch to present their copublication.

It was during this period that Franck submitted Kuhn's name for the habilitation degree. He liked the way Kuhn worked and advised students. In August the Francks drove by car to Italy to Lake Garda. Franck's health had improved enough for him to be able to go swimming again. In a letter from Göttingen, Kuhn worriedly reported about his application for the habilitation degree, which was not proceeding without some minor mishaps. Franck's reply shows his easy manner in backing Kuhn.[72] "You obviously don't have a knack for privy councillorship," he wrote reassuringly, adding the advice: "I suspect that your sins can be somewhat compensated for if you invite the Ministry's staff advisor, the Kurator, and me to some generous wine tasting."

Franck decided not to accept an invitation to attend a congress in Leningrad but let Kuhn go in his stead. He advised Kuhn, though, not to give away too much information about their physics to the people in Russia. After returning home from Italy, Franck could read in the *Vossische Zeitung* about the collapse of the Brüning government. Responding to a bid by the Social Democrats, it was unable to find a majority in favor of the laws that were urgently needed to impose a state of emergency to rescue the government from bankruptcy. The parliament was dissolved and new elections were scheduled for 14 September 1930. The fringe parties at both ends of the political spectrum fought bitterly against each other. There were some violent fights even in Göttingen. Seventeen parties and numerous smaller alliances were applying for seats in the *Reichstag*. The day after the election was held, the *Göttinger Tageblatt* published the epigram:

Naming the Truth — is easy	Die Wahrheit zu nennen — ist Spiel
Seeing the Truth — is much	Die Wahrheit zu erkennen — ist viel
Saying the Truth — is hard	Die Wahrheit zu sagen — ist schwer
Bearing the Truth — is more.	Die Wahrheit zu ertragen — ist mehr.

With an election turnout of 91.6 percent in Göttingen, the National Socialists became the strongest party, with 37.8 percent of the electorate, followed by the Social Democrats, with 23.6 percent. The rightist press—the *Göttinger Tageblatt*, for instance—was triumphant. The Social Democrats managed to retain their lead in the reich as a whole, although they lost some ground. The National Socialists were not far behind them. The *bürgerliche* parties supported by property owners lost some mandates.

Research continued without disruption, however. Franck received an invitation to give the Wills Memorial Lecture at a convention in Bristol, England, on October 25. At the beginning of his address about the relationship between spectroscopy and chemistry,[73] Franck apologized that the sheer size of the field prevented him from offering a complete survey and said that he would limit his discussion to research conducted in his institute. But there were plenty of experiments and theories by other researchers to choose from. From band spectra and the principle that he and Condon had identified—giving a very clear description of Condon's quantum mechanical calculation—he showed the audience how to interpret the behavior of molecules and their dissociation from the potential curve showing their binding energy as a function of the distance separating the nuclei. He explained possible misinterpretations, presenting examples of a false convergence in the band spectrum or intensity fluctuations. He referred in this regard to Heinrich Kuhn's experiments and measurements. The German version of the talk appeared in March 1931 in the *Naturwissenschaften*.

The winter term had already started when Franck returned to Göttingen. The university's situation still seemed to be stable. Its draft budget for the financial year of 1931 totaled five million marks. The income was the sum of graduation fees totaling 12,500 marks, attendance fees coming to 80,000 marks, and matriculation fees of 11,700, to which were added the receipts from the medical clinics of 916,000 marks. The salaries for the 67 tenured and 23 extraordinary professors totalling 1,123,000 were the largest debit entries. The wages for staff members not in the civil service, the majority of whom were assistants, totaled 482,000 marks. Funds were available only for new buildings and extensions in the clinic complex. So Franck had to draw the funds for a new air liquefaction system for his institute from the Rockefeller Foundation. The subsidy for the university from the Prussian state was 3.5 million marks. The salary reduction for civil servants of 6 percent as of 1 February 1931 was probably already taken into account.

Carl Heinrich Becker had been replaced as Prussian minister of culture at the end of January 1930 by Adolf Grimme. Like his predecessor, Grimme could only grit his teeth at the government's policy of ever deeper cuts. The financial situations of other universities in the Weimar Republic were similarly difficult. According to the official surveys in the winter term of 1929, there were 122,304 registered students. As in the past, half of the student body came from families in the mid-level civil service and in commerce and trade, while 15 percent came from the smaller groups of higher-level civil servants, teachers, and professors. Only three percent of the students were children of common laborers. Career prospects for all aspiring scholars in their chosen fields were generally bad. Up to 25 percent of the graduates could not find a job in their profession. At the end of 1932, sixty thousand graduates were seeking employment.

Franck had a realistic and farsighted view of the political situation and the economy. He told his American contact at the Rockefeller Foundation that the population was at the end of its patience.[74] If radical changes for the better did not happen soon, chaos would have to be anticipated and either national socialism or Bolshevism would take over the government. Which one depended on whom the army chose to side with. Franck was aware that the Nazis were gathering strength. A Nazi student league, the Nationalsozialistische Deutsche Studenten Bund, had existed at Göttingen since 1927. It gained the majority in the student council in 1931.

Göttingen's citizens were confronted directly by the major social and political issues of the day. They were asked to do more than simply cast their votes on election day. One issue was whether or not to cede to Poland large areas of the former German territory in Upper Silesia. So-called *Ostmarkwochen*, nationalistic rallies in support of the East Mark territories, were held throughout the reich, with the University of Göttingen among the participating organizers.[75] Their purpose was to maintain ties with the German inhabitants there and encourage other Germans to resettle there. The Göttingen historian Karl Brandi made the opening speech at the East Mark rally in February 1931. Numerous members of the faculty of the mathematical sciences were also in attendance, including Hans Kienle, Victor Moritz Goldschmidt, Walter Heitler, Richard Courant, Lothar Nordheim, Gustav Angenheister, Arnold Eucken, Hertha Sponer, Max Born, Arthur von Hippel, and Emmy Noether. James Franck, Edmund Landau, Robert W. Pohl, and Otto Heckmann also attended with their spouses. At the end of the event, members of a Communist student group distributed leaflets lambasting the government and German landowners who preferred to employ cheap Polish labor instead of German agricultural workers. This incident shows that German academics did occasionally take part in political demonstrations and become politically active, if only rarely.

A small group of Berlin physicists conferred together about a delicate problem that Franck was informed about only later. Walther Nernst was nearing the age limit as director of the Physical Institute. He had held that office since Rubens's death. Who should be his successor when he retired?

There was still no sign that the initiative of March 1929 for a Kaiser Wilhelm Institute of Physics had borne fruit. In 1927 the Austrian Erwin Schrödinger was recruited as successor to Max Planck. The high prestige of Planck's chair for theoretical physics was maintained. Experimental physics at the University of Berlin, on the other hand, had clearly been losing its luster. It could no longer compete with the Göttingers Franck and Pohl or against Gustav Hertz at Charlottenburg Polytechnic on the outskirts of Berlin. The rooms on the riverbank by parliament were more than half a century old, and they looked run-down in comparison to the polytechnic's new physics building on Hardenbergstraße, which was spacious and excellently equipped.[76] The physics facilities were only one sign of the university's backwardness next to the polytechnic. Hertz's choice of research fields was pioneering. He was successfully working on isotope separation by diffusion.

In March, Fritz Haber revealed to Lauder Jones of the Rockefeller Foundation the Berliners' plan to appoint Franck as Nernst's successor. Franck should have the dual function of professor and director of the Kaiser Wilhelm Institute of Physics.[77] Nernst was still in office, of course, so it was important not to offend his sensibilities. Haber may have sent out a careful feeler in this matter during one of Franck's visits to Berlin. They were collaborating on an article about the theory of catalysis for ions of heavy metals in dilute sulphuric acid. The paper was essentially a reinterpretation of results by the American Hans L. Baeckstroem. Frustration spills over into Haber's letter to his "dear friend" Franck from January 2:[78]

> Thanks to you, misery and premature last gasps! On this green carpet lie [the papers by] Count Schweinitz and Dr. Goldfinger among a heap of thermochemical data that were known already during your nice visit here but had not been mixed together in the same way by the mechanical shaker and now upon fervent compilation of the results have contracted into the tough shoe sole that is upsetting my belly most disagreeably.

There followed, with handwritten additions and cross-outs, Haber's interpretation of the chemical transformation of the SO_3 ion into SO_3. His closing:

> That's it for today, in greeting, despair, and attendant feelings. Maybe you'll phone us a consoling or contradictory word, as circumstances allow. In the name of the fellow-crestfallen,
>
> yours truly, Fritz Haber.

The despair passed and the paper was finished. Referring to Fritz London's ideas about homopolar bonding, the coauthors argued that a threefold collision was also involved. Franck's publication with Gerhard Scheibe on electron affinity was equally important in explaining how a water molecule in the proximity of a sulfite ion is decomposed by incident ultraviolet light into H^+ and OH^-. Haber presented these results on April 23 at the meeting of the physical and mathematical section of the Berlin academy.[79] The report differs in style from Franck's earlier collaborative publications, reflecting an equal involvement of both researchers in its composition.

While they were still writing the script for the talk, Haber sent Franck a "strictly confidential" letter on a different matter.[80] The *Ordinariat* at the University of Kiel needed to be filled. The finalists were Professors Walther Bothe, Ladenburg, Pringsheim, and Rausch von Traubenberg. But Haber thought it boiled down to a choice between Ladenburg and Rausch von Traubenberg because the other two held positions that they were unlikely to leave. The authorities wanted to know what Rausch von Traubenberg's political leanings were, to make sure that his appointment would not lead to trouble at the university. Haber also discussed Ladenburg's situation. He would be accepting an invitation in the United States, but Planck had no doubt that Ladenburg could receive the lifetime position with full pension benefits at the Kaiser Wilhelm Institute of Physics.

> There is no question of building the institute for the time being. It will certainly not be settled before you have been consulted and you will be appointed on the institute's board of trustees for the purpose. Even after this has happened, the financial conditions, on one hand, and the imminent business of the succession to Nernst in the summer of next year, on the other hand, will constitute an obstacle. One cannot foretell the course of such things precisely but I do feel very confident that you will be offered the succession to Nernst together with directorship of the new Kaiser Wilhelm institute and be relieved of all lecturing obligations. You would then become director of the Kaiser Wilhelm institute and LAUE would remain in his position as deputy director and EINSTEIN, who has no inclination for it, would leave his position as director. Then you would get LADENBURG as member of the institute and otherwise rule in the city and at the institute as you see fit.
>
> If your inclinations rather lead you to withdraw completely from the [university] post in the city after a while, then my resignation would afford the opportunity, in that after 5 years you would have the option that rather than directing the Kaiser Wilhelm Institute of Physics, you could take over mine.

More than a year elapsed before this affair was official.

In Göttingen Franck and his assistants, mainly Kroebel, were busy making preparations for a special summer course in physics at the end of June. It involved planning many quite complicated demonstration experiments. As they were nearing the end phase, Franck wrote to Lise Meitner to apologize for not having attended the talk she had given during the meeting of the Kaiser Wilhelm Society.[81] He entrusted this letter to his graduate student Hans Ramien, who had earned his doctorate summa cum laude in May. Franck had taken Ramien very much under his wing and sensitively advised him about how to overcome his terror of the final examinations. Ramien delivered the letter to Miss Meitner, who had been informed about his situation. Franck wanted Ramien to learn about Geiger counters. The reason behind these trials was Franck's friendship with Kienle and his interest in astrophysics. An extremely sensitive photon counter was supposed to be designed based on Geiger's counting-tube principle for Kienle to use in his astronomical research.

The second part of Franck's letter to Meitner bore news of the family. The Franck couple had become grandparents.

> Now a few more words about us at home. Everything is going very well for us right now. Albeit I can't declare that Ingrid has relaxed very much. She was in Sweden visiting relatives for a couple of weeks and that's straining. Daggie has to endure all sorts of aches and pains, breast inflammation, etc., but now things are fine over there. The von Hippels now live very nearby and we are very glad to have them living in a nice apartment so close to us. The boy is developing very well. Lisa is likely to be going to Berlin next semester. With some probability she will be starting studies to become an upper-school music teacher.

At the end of June Franck delivered his publicly announced experimental course. Its structure was carefully conceived, progressing gradually from visualizable concepts to non-intuitive ones.[82] The first section dealt with the makeup of matter: molecules and atoms. Franck mentioned the various ways of determining the dimensions of a molecule. Then he discussed diffusion phenomena. Two experiments were performed, one presenting Brownian molecular motion. Three different methods of obtaining the Loschmidt number were discussed as well as experiments on the gas laws and atomic beams.

The second section dealt with ions and electrons, beginning with electrolysis. Then followed the generation of ions in a flame, by UV light, as well as X-rays and radioactivity. Demonstration experiments of these were also done. With a few experiments Franck explained the beginnings of quantum theory with the black-body radiation law and the photoelectric effect.

The third section introduced the audience to notions by physicists about the building blocks of atoms: protons and electrons. An experiment was done to determine the ratio of charge to mass for an electron as well as Millikan's experiment to determine the electron charge. Examples from radioactivity, α- and β-rays, measurements with a Geiger counter-tube, and demonstrations of the Wilson cloud chamber illustrate this section. Crystal structure is discussed using Laue X-ray patterns, referencing the character of Roentgen rays (X-rays). Having explained X-ray diffraction, Franck could illustrate the duality between waves and corpuscles by diffracting cathode rays (electrons). Electron-collision experiments, along with their consequences for the structure of the atom, were the finale.

At the end of the semester, Dietrich Schmidt-Ott sat his doctoral examinations. His assigned thesis related to Heinrich Kuhn's dissertation on the process of dissociation of alkali halides. Schmidt-Ott went to the United States for a year, and after returning he continued Ramien's experiments on developing a highly sensitive photon counter.[83] At the beginning of the 1930s the technical and scientific means for developing such a sensitive meter were lacking. Sometimes Schmidt-Ott's counter worked well, sometimes nothing worked at all, and finally the project had to be abandoned. That would have been a bitter end for a student as his dissertation thesis, but such is the misfortune that regularly occurs in research. The idea was a good one and a solution seemed possible, but unanticipated and insurmountable difficulties arose in its execution. In assigning dissertation topics, Franck almost always chose a good middle road; his topics were not always easy to achieve, but they were generally soluble. Cases like Ramien's, where a topic had to be aborted, were rare.

Many news reports of the previous few months in the *Vossische Zeitung* and on radio broadcasts dealt with the state's rapidly decaying finances. In May the Brüning government had to make salary cuts in the civil service. Pensions were reduced and indirect taxes were raised. In Göttingen every fifth inhabitant lived off the public budget. The situation was particularly critical in the construction sector. On June 13 and 14 the stock exchanges in Germany were closed down, and a few banks shut their counters. A new state of emergency was supposed to stave off the worst, but France insisted on continuing to receive its reparations payments. To stop the flight of capital abroad, a special tax was imposed, the *Reichsfluchtsteuer*, and traveling outside the country became more expensive. In September the Prussian state had to take draconian steps to save its budget. State salaries were slashed yet again. The repercussions of this dire economic situation were not yet visible in the university's course catalog, however.

In the winter semester of 1931–32 Franck and Born held no lecture courses, but otherwise Franck continued to be listed as usual, as supervisor of the physics practicals, research advisor, and organizer of a seminar and the colloquium. Private lecturers delivered the course lectures. Günther Cario chose the subject of experimental foundations of thermodynamics. Franck was a little disappointed that Cario did not develop any interest in theoretical considerations. Arthur von Hippel offered a course on gas discharges.[84] It was more than a purely academic topic for him, since he was working with another member of the staff on developing an improved mercury-vapor lamp. Many investigations conducted at

Franck's institute required this light source, but it was not yet optimized for physical applications. The new lamp was much better suited and later found its way onto the lighting market. Heinrich Kuhn chose a very modern topic for his lecture, announcing a course on the experimental foundations of wave mechanics. The *Sponerin*, or "Sponeress," as Hertha Sponer was nicknamed, gave a course on boundary areas between physics and chemistry. The course catalog also listed under course no. 467: "English language course for students of physics, time by arrangement, free." It was offered "on commission of Prof. Born and Prof. Franck."

In late fall Franck was in Berlin again and went to see Haber. There is no record of what they discussed, whether science, politics, or perhaps entirely personal issues. But there were many problems to choose from. Max Planck had become president of the Kaiser Wilhelm Society in June 1930, as successor to the deceased Adolf von Harnack. The concern was that the society should be prevented from falling too strongly under state leadership and control. Haber had harbored the hope of taking the position himself, but the majority of the society's senators did not want him. Haber was not satisfied with Friedrich Schmidt-Ott's leadership of the Notgemeinschaft.[85] What could be done about it? Haber had to consider who could take his place and lead his large institute with its many different ongoing research programs in the individual divisions.

The Göttingen physicists had the pleasure of seeing Ernest Rutherford at the beginning of December when he came to accept an honorary doctorate. The award ceremony included many speeches, of which Pohl secretly made wax phonograph recordings.[86] Pohl had hidden a microphone in the lectern and installed the recording apparatus in the adjoining room. The result was satisfactory and it was later released on shellac records under the label His Master's Voice. Franck mentioned this visit briefly in a letter to Lise Meitner on December 20.[87]

> You take me for more easily offended than I am. I didn't notice a thing in the letters from all of you and, besides, already completely forgot about my new distinction as science advisor of your institute, so I have difficulty feeling liberated from it again. I can imagine how entirely senseless an enterprise establishing such a board really was. We heartily wish you and the Hahns nice Christmas holidays and plenty of relaxation and all the best for the new year. We had Rutherford over here on a visit, who was completely charming. He said so many good things about you that your ears really ought to be tingling. He started in such an off-hand spontaneous way about it that he could not know how very pleased we should be that even he finally had noticed what we have known about you since ages.

The original idea of forming boards for the institutes of the Kaiser Wilhelm Society had come from Haber.[88]

The year ended with news that caused more consternation. The minister of finance ordered another salary cut for civil servants of 9 percent as of 1 January 1932.[89]

Quite different news excited physicists, though. Franck rarely brought prepared notes with him to his lecture, so it occasionally happened that a topic at the forefront of physical research would be mentioned in class. In February Franck appeared in the small auditorium with a letter in hand. James Chadwick from Rutherford's laboratory at Cambridge had written him that he had just found the neutral component of the nucleus that Rutherford had postulated with approximately the same mass as a proton. Franck was skeptical at first, though he assured the students that Chadwick really was a serious, good physicist.[90] But the news turned out to be true. Lise Meitner also started examining the finding and her Italian guest researcher, Franco Rasetti, conducted related experiments.[91] The Hungarian Edward Teller, who had just recently turned 24 years old, may have been among the students listening to Franck. He, like many of his compatriots, had left his country for political reasons and come to Göttingen. He was talented both in theoretical physics and in experimentation. He assisted Born in writing the work on optics and instructed Miss Sponer about the theory of band spectra. Officially, he was under Eucken's employ. He wrote a paper together with Franck and Sponer for the *Zeitschrift für physikalische Chemie* on predissociation of molecules composed of three atoms. Victor Henri had coined the term "predissociation." When radiation of longer wavelength, hence of weaker energy, than that of the continuous dissociation spectrum is used, then structures indicating predissociation become observable in the bands. This was well understood in the case of diatomic molecules. These three authors demonstrated how much more complex the conditions are for triatomic and polyatomic molecules.[92] Citations in scientific periodicals indicate that growing numbers of researchers were beginning to take the Franck-Condon principle as the point of departure for their own analyses.

The budgetary situation worsened despite economy measures, and the university was forced to shed assistantships. As dean of the faculty of the sciences, Max Born conferred with his colleagues about what to do. Eliminating the assistantships would take away what little income their holders were earning and make them jobless. The university operations would suffer substantially as well.[93] Born probably first discussed with Franck the option of reallocating a small portion of the budget reserved for the faculty's tenured professors' salaries in order to keep the assistants on. The figures showed that it would work, and the faculty as a whole agreed, with one dissenting vote. When Born went to see the university official about it, Valentiner was moved by the generosity of the proposal and gladly accepted.

Franck was struggling with certifying Rabinowitch for university teaching. Born and Goldschmidt supported the idea, but it encountered problems at Göttingen. Franck wrote to Karl Friedrich Bonhoeffer in Berlin for help on 29 February 1932.[94]

> Why we can't do it is based on the following, which I would like to tell you completely frankly but confidentially: I cannot certify him in physics because I have 4 habilitated people over here and Pohl, who is thinking of certifying at least a fifth, will legitimately give me the biggest trouble if I wanted to present yet another of mine for habilitation. I wouldn't shrink from battle if I didn't have to concede to my friend Pohl that he was entirely justified, especially in view of the fact that I cannot be sure to stay in Göttingen indefinitely and must not leave a building full of private lecturers to an ev[entual] successor. A habilitation in physical chemistry would in principle be possible, of course, but Eucken, with whom I spoke about it, does not want any habilitation for a man who is not employed at his institute. Yet he does not want to hire Rabinowitch under any condition. He has his own people; and besides, Rabinowitch's religion doesn't suit him either.

Franck did not manage to arrange for Rabinowitch's certification, and after 1932 conditions changed totally.

Göttingen's treasurer complained about major shortfalls in the tax receipts, and very substantial slices had to be cut out of the budget. The salaries of local government employees suffered, along with the school budget and the subsidy for the city's theater. The Deutsche Studentenschaft canceled a strike against university fees. The majority of the students did not care either way, but two

Figure 79 From the left: Arthur von Hippel, Dagmar von Hippel, Lisa Franck, James Franck. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

small associations, the leftist Rote Studentengruppe and the rightist Eidgenossen, persisted.

Radical polarization had long since become part of everyday politics. The economic crisis spread to America. Edward Condon wrote to Arnold Sommerfeld on 4 May 1932 about how much the situation over there had changed since they had last seen each other in 1927. In those earlier days any young man could get an assistant professorship, but those times were long gone.[95]

Professor Nernst's retirement in Berlin was drawing dangerously near. The Rockefeller Foundation had already asked Planck and Haber for information in January.[96] Haber was himself approaching the age and state of health necessitating imminent retirement. Planck and Haber wanted Franck to assume the dual post in Berlin.[97] However, the faculty of philosophy had still not reached a decision on the Nernst succession.

So Franck celebrated his fiftieth birthday without knowing whether he would be going to Berlin or staying in Göttingen. To avoid any parties, he went away with the von Hippels and Lisa to the coastal island of Sylt.

Many birthday wishes arrived in Göttingen. On August 24 Haber chose to open his congratulatory letter with "Dear James." After an introductory uncertainty about whether Franck would be home to receive his letter, he wrote:[98]

> I wish you from my heart luck in entering the most important decade of mature life. All important people need an interlinking of merit and luck throughout their whole lives; but men of your kind are so rich in accomplishments from ages 20–50 that no squandering from handing out intellectual and emotional goods can diminish their wealth. Only after 50 does the time of cautioning to economize start and one has to be lucky to be able to ignore this cautioning and give away as much wealth as you are used to doing. The situation is basically the same for older men as for young women, albeit on another stage and to another degree. What matters is the sunshine they are able to radiate from themselves; young women at home, and older men in the constantly growing sphere of activity in which they are set. You have scattered so many light quanta against the shadows cast by the mass of German prejudice, that all of us who flatter themselves with your friendship have been brightened by it and cannot imagine their lives without you anymore.

The "growing sphere of activity" Haber alluded to was Franck's increasing devotion to research on photochemical processes. In August, Rabinowitch submitted his manuscript analyzing reactions between bromine and benzol in beams of light of different wavelengths for publication in the *Zeitschrift für physikalische Chemie*. In the same volume 19 (1932) another paper appeared by Eugene Paul Wigner on transgressions of the potential threshold in chemical reactions (Über das Überschreiten von Potentialschwellen bei chemischen Reaktionen). It cited Franck's and Born's article from 1930. Like Teller, Wigner came from Hungary but had studied chemistry at the polytechnic in Berlin. His development of group theory would later contribute substantially to quantum mechanics. Teller's and Wigner's paths would recross Franck's in exile.

The institute was about to experience some change. The longtime secretary, Frida Richter, would be leaving on October 10 to get married. Franck put forward Grete Paquin's name to the *Kurator* as her successor. She had already acted as substitute when Miss Richter had been on sick leave. "I regard it as lucky for our operations at the institute to acquire such a lady. To her prior training in science is added her ability to take down letters in short-hand in foreign languages."[99]

Franck requested that Mrs. Paquin be ranked at the same salary level as Miss Richter. The ministry initially disapproved, however, and proposed a former secretary from the Institute of Agriculture. But Grete Paquin ultimately received the position and was able to dispatch the remaining birthday correspondence.[100] She familiarized herself quickly with the routine business at the institute and soon knew where to find the boss late in the afternoon when she needed to get his signature on some finished letters: He was surely explaining some physical problem to a young doctoral student. Overhearing part of their conversations, she had the impression that atomic physics really was quite easy to understand. Franck explained highly complex processes to the young physicists in a most intuitive way.

Arnold Berliner would be celebrating his seventieth birthday toward the end of the year, and this time the publisher himself was supposed to be honored in his journal, *Naturwissenschaften*. The prelude to Einstein's *laudatio* reads:[101]

> I would like to tell my friend Berliner and the readers of this journal why I value him and his work so highly. This has to happen here because one otherwise has no opportunity to say such things. Our upbringing toward objectivity has allowed everything personal to turn into a "taboo" that mortals may only break on very exceptional occasions, such as, for inst., on this one.

He praised Berliner's defense of clear and circumspect expression and said that his attempt to keep existing knowledge stimulating was as important as focusing on the solution to a particular mystery. Born and Franck each wrote a contribution to this birthday issue of thirty essays. Franck coauthored with Kuhn a quite compressed article discussing strengths and kinds of molecular bonds based on examination of continuous absorption spectra. It criticized the exaggerated expectations of other authors when calculating the energy of dissociation from a band spectrum for polyatomic molecules, particularly when polar bonds were involved.[102]

The winter term was in full progress when the negotiations for the appointment in Berlin finally began to make headway.[103] The short list placed Franck first, then Hans Geiger, then Otto Stern. Nernst tried to interject, insisting that the appointee really ought to teach the main lecture course. He took cover behind the dean of the faculty of medicine. On 7 December 1932 Nernst wrote to Franck directly, laying out in a long letter all sorts of doubts and recommendations. Nernst first considered how Franck might work with a current member of the institute: Ludwig Sommer. Then he broached the issue of living in the official residence at the institute. The upcoming replacement of the mechanic was then discussed before he came to what he probably deemed was the main issue: teaching the *Große Vorlesung*.[104]

When I got the second appointment at our university after leaving the Reichsanstalt, I received as I took up my current position a very obliging but resolute letter by the Faculty of Medicine that I should assume the main lecture on physics.

I answered at the time to the effect that I took this quite as a matter of course, since this duty of holding the main lecture traditionally falls to my post.

For me the main question had always been whether it was practicable for the head physicist to assume the major lecture course. I believe I must definitely answer this question in the affirmative; and based on some spot checks I made, all head experimental physicists at other German universities probably share this point of view. It would take a load off my mind and surely off some of my colleagues' if you would deliver the mentioned lectures.

Nernst then mentioned what he construed as problems facing the minister of finance regarding the compensation. He concluded with the assertion that the lecture had given him much pleasure and not very much work. Franck saw through Nernst's tactics, and the appointing committee did not take his objections seriously either. His statement was acknowledged without further discussion. Peter Pringsheim had volunteered by letter to assume the main lecture course.[105]

The official call had not yet been issued, but Haber could not be held back. He started looking around for a suitable home for the Francks. He found a house for rent and possible purchase in the immediate neighborhood of the Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry, and he tried to whet Franck's appetite for it. As he was planning to leave on a trip with his sister, he wrote Franck a letter about these options on November 23.[106]

Three more weeks passed. Then Planck was able to bring Franck some relief:[107]

My dear Colleague,

Yesterday evening the Faculty of Philosophy finally completed its report about the question of Nernst's successor and unanimously decided to propose you in the first place and at a considerable lead, with the explicit request to the Minister that, in case you brought to bear any doubts about assuming the main lecture in experimental physics, that he "abide by your nomination under all circumstances." Thus, as I believe, no problems may be feared from that quarter. I do not doubt that now the invitation will be issued to you.

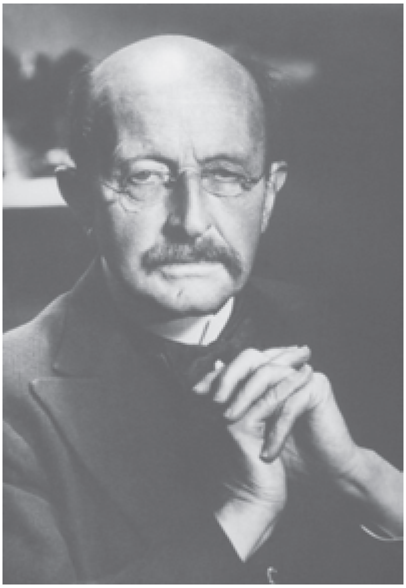


Figure 80 Max Planck. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

Now I have a related favor to request of you, namely, that you be so kind as to inform me if during the course of the appointment negotiations difficulties of any sort arise, irrespective of the angle from which they may emerge, so that I may apply my best powers to contributing toward their removal. Of course, I shall release to you the available funds of the Kaiser Wilhelm Society.

Should occasion lead you to Berlin sometime, I would be particularly pleased if you could give me one evening so that we could discuss the matter in leisure with a few of our colleagues. Good notice in advance would be preferable so that the gentlemen might not already be otherwise engaged. With warm regards between households,

Yours very truly,
M. Planck

Franck had declined an appointment to Berlin after the death of Heinrich Rubens in 1922. Now he was willing to take on the much larger and multilayered task. But no indications exist of the reasons why he wanted to leave the Göttingen institute and collegial relations he had built up. Was he attracted by the thought of broadening the scope of his research, of having a far larger staff? Had Göttingen, or indeed, the group of friends, become too confining for the Franck couple?

Politically, the year came to a stormy end. Brüning's government could not sustain itself and had to resign in the middle of November. Franz von Papen, the appointed managing chancellor of the reich, was forced to slash the budget even further. Agreement seemed to be possible with the National Socialists for the first days of December. But then von Papen's transitional cabinet suddenly resigned and Reich President von Hindenburg named General Kurt von Schleicher chancellor. He retained his authority over the ministry of defense, which he had been heading since 1929. The Nazi party repudiated the new administration, and von Schleicher, for his part, wanted to deny Hitler access to power. A dissolution of parliament was expected, along with a call for new elections at the beginning of 1933.

CHAPTER 6

The Nazis Take Over—Resignation and Emigration

Under the headline "Papen negotiates on," the *Göttinger Tageblatt* reported on January 9:

On the domestic scene nobody is able to find a way out. Everything is in ferment. New fronts seem to be forming. The struggle for power is taking on unusual forms.

It is possible that the talks between Papen, Schleicher, and Hindenburg will scatter a little the mists enveloping the government that make it impossible to gauge the intended course. It is also presumable that the Reich Chancellor would prefer it if he could come to some sort of agreement with the National Socialists.

Speculations about a vote of no confidence then followed.

There is already talk about Hitler coming to Berlin next week and a meeting taking place with Privy Councillor Hugenberg. . . . National Socialist sources in Berlin said on Thursday that the meeting between Hitler and Papen should not be minimized: the ground was being cleared for a front formed by the National Socialists, the Stahlhelms, and Papen's entourage to oppose the Schleicher-Strasser, front.

Routine business was in full swing at Franck's institute. Lise Meitner was looking for a new staff member, and so Franck described the abilities of one possible candidate whom he could not take in at his own institute for lack of space. Five guest speakers had committed themselves to talks at the colloquium within the course of the first two months. Hermann Schuler was scheduled for January 12, and the spectroscopist Rudolf Seeliger five days later.[1]

On January 19 the university celebrated in its great hall, the *Aula*, the founding of the reich in 1871. The armed forces took part, along with the student union's standard-bearers with their banners. Professor Adolf Passow delivered an address on present-day obligations of university education in economics—a very current topic indeed, as the unemployment rate was again extremely high; the Central Federation of the Christian Union of Construction Workers reported a figure of almost 90 percent. No one knew how work could be found for the six million jobless. Political news from Berlin was troubling. On Bülow Square, where the Karl Liebknecht Haus was located, Nazis unveiled a memorial dedicated to the activist Horst Wessel, who had died under dubious circumstances. This demonstration brought together eighteen thousand members of the SA and SS. Hitler spoke, as well as Count Helldorf of the Stahlhelm. The wishful verse published in the liberal satirical magazine *Simplicissimus* after the Nazis' defeat in the fall was not fulfilled:

One thing certainly can be said,	Eines lässt sich sicher sagen,
Which pleases us all round,	Und das freut uns rundherum,
Hitler's neck-deep in trouble,	Hitler geht es an den Kragen
This Führer's time is up.	Dieses Führers Zeit ist um.

A column in the *Göttinger Tageblatt* on January 28 reported that the parties were again engaged in negotiations about forming a government.

> The question: With or without parliament? culminates in whether the Reich's president [Hindenburg] will be prepared to drop Schleicher, and authorize Hitler to form a government in the case that a majority should succeed in being formed in the Reichstag despite the huge, still extant conflicts.

Hitler became chancellor of the reich just two days later.

The *Göttinger Tageblatt* ran the headlines:

> The national consensus.
>
> Minister Frick on the intentions of the Hitler-Hugenberg cabinet.
>
> Thunderous ovations for Hitler.
>
> The new cabinet's first meeting.

A national consensus it certainly was not! The parties representing the propertied middle class were excluded. The *Göttinger Tageblatt* printed a brief résumé of Hitler's life with a portrait, closing with the declaration: "After the cabinets of Brüning, von Papen, and von Schleicher, had resigned, the Reich President satisfied the call by the NSDAP [Nazi party] and named Adolf Hitler Reich Chancellor."

Joseph Goebbels was not yet part of the cabinet; Walther Funk was the first head of propaganda. In Göttingen the National Socialists organized a torchlight procession for Hitler on January 31. A counter-demonstration organized by the Communists failed, not least of all because the police sided conspicuously with the SA. The liberal *Göttinger Zeitung* tried to describe the situation with careful precision, but the *Göttinger Tageblatt* boasted about the demonstration:

Ten thousand, from every political camp, from every profession and social station, lined the streets and felt emotionally tied to the brown soldiers of the Third Reich, who were greeted with stormy cheers of *Heil!* Whoever saw the 3,000 SA and SS people and the Hitler Youth march by, swept up in the wave of enthusiasm and yet contained by iron discipline, with many others tagging along to the beat of Prussian marches, had to feel the historic importance of the hour. It was as in August 1914. Just as then, now too, the partisan spirit sank away and the nation rose, full of faith and loyalty; thus the united front of the German liberation, hankered after for years, was formed here as an almost unbelievable self-evidence.

The Saturday evening/Sunday edition of February 3–4 bore the news that the Nazi inspector of the province of Lower Saxony, Ex-Instructor Bernhard Rust, had been appointed minister of cultural affairs. The winter semester ended that month, but the doctoral students at Franck's institute were still busily experimenting away and Franck's own research continued on without a break. Courant decided to take his family on a ski trip to Arosa, Switzerland. Two of his collaborators went along so that they could work on a book project that had long been postponed, the second volume of the "Courant-Hilbert": *Methoden der Mathematischen Physik*.

The colloquium continued with a talk on February 16 by Reinhard Mecke about his analyses on band spectra, a topic of importance to Franck and Sponer. Jordan arrived from Rostock on the same day, and on the 23rd Wolfgang Pauli gave a presentation, coming from Zurich. Franck's appointment to Berlin was in its final stage. He had already written a letter to Windelband, the expert at the Ministry of Culture. Planck was very pleased about Franck's decision, as his letter of February 5 clearly shows:[2]

With your kind forwarding of a transcription of your letter to Mr. Windelband, you have done me a great favor and performed a valuable service toward the cause that lies so close to my heart, for which I sincerely thank you. I shall now take this as an excuse to contact Mr. Windelband directly and present to him my conception of the interests of the Faculty and the Kaiser Wilhelm Society with respect to the fostering of physics. Let me also thank you again very specially for also having given me & my wife that Sunday evening (and night).

Planck then emphasized again how much he and his colleagues wanted Franck to come. Franck, of course, also visited Lise Meitner in Dahlem and discussed among many other things the addition of another new staff member from his institute. On February 11 he added another point by letter about the proposed collaborator, and continued:[3]

Just a couple of words more about the Berlin affair. I personally cannot imagine that Mr. Rust would have any great desire that I come to Berlin. Nor have I heard anything new from there. After that depraved anti-Semitic agitation, the National Socialists cannot, according to my conception, immediately do the contrary of what they have always been preaching. You will have gathered from the letter that I had written to Windelband and which I sent in carbon copy to Pringsheim with the request that he show it to you, that I, for my part, have done everything I could do. So let's wait and see in complete composure.

Franck was evidently not as optimistic as many academics and members of the general public that Hitler's regime could not last long. It was, after all, the eighteenth government in office since the kaiser's abdication. Franck's colleagues made one final attempt at keeping Franck in Göttingen. On February 10 they wrote to their "Dear Colleague Franck":[4]

For a long time we have all been weighed down by a serious worry of losing you from among us by an appointment to Berlin. We have largely abstained from any attempt to influence your decision until now. But it seemed to us as if ultimately you alone must answer the question whether you act appropriately on your own behalf and on that of science as a whole by accepting the dual post planned for you in Berlin.

They asked him not to misunderstand their silence up to that point but to reconsider his decision one more time.

For our group of scientists and mathematicians, for the Faculty, and for the whole university, your departure would be a disastrous personal and professional blow. . . .

All of us would breathe a sigh of relief for the Faculty and for ourselves, if ultimately the decision could fall on the side of your staying here.

Yours most sincerely,

A. Kühn, D. Hilbert, A. Windaus, E. Landau, A. Kötz, M. Reich, O. Neugebauer, V. M. Goldschmidt, Courant, L. Prandtl, Schermer, Eucken, Pohl, Kienle, Angenheister, Born.

Nazi policies soon determined the ultimate decision.

On February 28 the *Göttinger Tageblatt* headline was: "Parliament burnt down by Communists." This accusation became the basis for brutal measures against Communists. Prior to the March elections, "mighty" Nazi demonstrations had taken place in Göttingen, organized by the district head, Dr. Rudolf Mentzel. He was a chemistry graduate from Göttingen and a member of the SA since 1922. At the elections on March 2 in Göttingen, the National Socialist German Workers' Party (NSDAP) received 58 percent of the votes, the Social Democrats 20.9 percent, the right-wing Black-White-Red 10 percent, with all remaining parties lying under 4 percent. Throughout the entire German empire, the Nazis took 43.9 percent, followed by the Social Democrats with 18.3 percent. The Communists received 12.3 percent, despite intense discrimination and arrests of their leaders. The moderate Center party took 11.2 percent. On March 14, Reich President Hindenburg accepted Joseph Goebbels's oath of office as minister of public information and propaganda. An "enabling act" was already under way to dismiss Communist civil servants from office without a pension.

In this situation, Planck was negotiating as president of the Kaiser Wilhelm Society with the leading officials at the Ministry of Culture. He wrote to Franck on March 2.[5]

> After having recently contacted Messrs. Valentiner, Windelband, and [Erich] Leist about your appointment, I would like to report to you my view of the present situation in this matter. Characteristically, the original obstacles, namely, the holding of the main lecture and the financial aspect, have receded completely into the background; I regard them as basically entirely surmountable and do not fear anything of essence anymore from that quarter.
>
> However, now the political aspect dominates, and to such a degree that it poses a real danger. If one considers that this kind of problem is, as it were, dictated by chance and entirely without substance, it would seem that with a change in the general political situation (which in my opinion will surely not fail to occur) the conditions could easily improve again. But for the moment, absolutely nothing can be done.

Hitler's government declared that since flames had devoured the *Reichstag*, the opening ceremony for the newly elected parliament should take place with a mass in the Garrison Church in Potsdam on March 21. Minister Wilhelm Frick wrote an appeal for this national holiday; so did Goebbels, which ended with the words:

Ne'er will the Reich be destroyed,	Nimmer wird das Reich zerstört,
If ye unite and be true	Wenn Ihr einig seid und treu

Public buildings had to be decorated with black-white-red flags and the swastika. It was the first time that the constitutionally prescribed imperial black-red-gold flag could not be hoisted. Now the flag of a political party was permitted to fly—in violation of the constitution. The general management of the Kaiser Wilhelm Society dutifully bought swastika flags for its institutes. Both flags were raised, even at the Institute of Physical Chemistry and Electrochemistry directed by the Jew Haber.[6] Minister Rust instructed all schools to make it possible for all pupils to listen to radio broadcasts of the speeches. They were to be made aware "that they are here witnessing the beginning of a new epoch in German history under the stamp of the nationalist idea of the state. In the *Göttinger Tageblatt* the text by Rust appeared:

Let them flutter from every house!	Laßt sie wehen von Haus zu Haus!
Hindenburg speaks to Germany	Hindenburg zu Deutschland spricht
By the bier of Frederick the Great,	An des Großen Friedrichs Bahre,
Hitler calls to People's Court	Hitler ruft zum Volksgericht
Over fourteen Red years.	Über vierzehn rote Jahre.
Spring wafts through the German abode.	Frühling weht durchs deutsche Hause.
Hoist your flags!	**Flaggen raus!**

Göttingen's municipal theater was playing the entertaining pieces "Morgen geht's uns gut" (Tomorrow we'll be fine) and "König für einen Tag" (King for a day). The armed forces (*Reichswehr*) organized a demonstration on the marketplace, holy mass, and an SA parade. In the afternoon, the imperial black-red-gold flag was burned in front of a tavern. At eight thirty in the evening a torch procession marched through town, headed by storm troops of the SA, followed by the Hitler Youth, and its juvenile divisions, *Jungvolk* and *Schuljugend*. Then came the various Göttingen associations and at the end "Hitler's black soldiers, the SS."

The next day, the first session of parliament met in the Kroll opera house in Berlin. Hermann Göring was chosen by acclamation to head parliament as *Reichspräsident*. The first bars of the folk song "Üb' immer Treu und Redlichkeit" (Always practice loyalty and integrity), played by the Garrison Church chimes, were declared the national radio broadcasting pause signal.

In Göttingen the town council decided to rename Theater Square as Adolf-Hitler Square, "in grateful memory of the 21st of March 1933."[7] Throughout the reich's entire territory, offenses were perpetrated against German citizens of the Jewish faith, and the police rarely intervened on behalf of the victims. Jewish stores in Göttingen were damaged and there was open harassment. The *Vossische Zeitung* complained that militant Nazi supporters were forcibly expelling Jewish judges and lawyers from a courthouse in Breslau. At Göttingen the Jewish attorney-general, Dr. Fritz Eichelbaum, was placed on leave without justification. On March 24 a two-thirds majority of the deputies in parliament—over the opposition of the Social Democrats—voted in the "enabling act." It secured Hitler's government much more extensive authority than any former chancellor had had under the Weimar Republic. Hitler was able to rule with practically no need for parliamentary approval. The Weimar Republic and democracy were at an end.

Franck received an invitation by Dirk Coster to come to his home in Holland with his family. Franck's reply was:[8]

> I carried your kind letter around with me for 3 days and took it out again and again to reread, that's how much it pleased me. Right now one is doubly receptive and grateful for proof of friends and friendship. I know how cordially and honestly your kind invitation is meant and I would gladly make use of it for myself or my family if I did not take the standpoint that now especially it is one's duty to stay at one's post as long as it is entrusted to one and to calmly continue working. I hope that this will be possible and expect a quiet semester with the usual work.

Courant was still in Arosa, hoping that despite the political situation he would be able to stay away for long enough at least to finish half of the planned book. But he heard unsettling rumors that he was not intending to return to Göttingen anymore.[9] Franck realized how risky the situation was and wrote to his friend, advising that he return to Göttingen to set the rumors to rest.[10]

Jew-baiting continued to gain momentum, and a few Jewish associations abroad reacted to what was going on in the Third German Reich under the banner of the National Socialist German Workers' Party (NSDAP). There were calls to boycott German products. Hitler's government and the rightist papers immediately snapped back with stinging words. "Sharpest rebuff of Jewish slander campaign," "The NSDAP armed to repel," "That's enough now!" are some of the headlines in the *Göttinger Tageblatt* of March 28. Large posters calling for a boycott of Jewish shops appeared on the pillars used to post advertisements, and in Berlin a campaign committee was formed to organize the boycott. The reich representatives of German Jews and the governing board of the Jewish Community directed a letter to the president and chancellor of the reich, the government ministers, and the chief of police. It appeared unabridged in the *Vossische Zeitung* on March 30:

German Jews are deeply shaken by the boycotting call of the National Socialist German Workers' Party.

By the fault of a few, for whom we never have and never will bear responsibility, we German Jews, who feel tied to the German homeland with every fiber of our hearts, are to be brought to economic ruin.

German Jews have dutifully offered bloody sacrifices to the Fatherland in all its wars. In the Great War, among the five hundred thousand German Jews, twelve thousand gave their lives. In the areas of civilian employment, we have done our duties with all our might.

Germany's Jewish organizations have opposed the slandering and boycotting campaign abroad with utmost severity and good success. They did everything that lay within their powers and will continue to do so.

Despite this, German Jews are now supposed to be destroyed as the alleged guilty.

We appeal to the German people, to whom justice always has been its highest virtue:

The accusation of having harmed our nation profoundly injures our honor. For the sake of Truth and for the sake of our honor, we raise protest against this charge. We trust in the President and the Reich Government not to allow our rights and livelihoods in our Fatherland to be taken away from us. We repeat at this time our commitment as part of the German nation, for whom sharing in the toil for its revival and rise is our most sacred duty, our right, and our dearest wish.

The league of Jewish veterans Reichsbund jüdischer Frontsoldaten also protested against the Nazis' planned measures.

The papers reported that Jewish academics in Münster were barred from entering that province's university to teach. Students at some universities disrupted or prevented Jewish professors from holding their lectures. Einstein had already left the year before to give some courses at Princeton as a guest lecturer. Press reports informed him about what was going on in Germany, and he protested savagely against the new government's anti-Semitic campaign. The *New York Times*, the *Morning Post*, *Le Soir*, and other papers published his harsh statement, and the German Foreign Ministry took due note of it. The presiding secretary of the Prussian Academy of Sciences, Professor Heinrich von Ficker, wrote to Einstein, asking whether he had publicly "repudiated the present government in Germany."[11] If this should turn out to be true, the academy would be obliged to state its position. Ficker corresponded with Planck about the Einstein affair and about the possibility of expelling him or having him voluntarily withdraw his membership.

But Einstein was too quick for von Ficker. He and his wife, Elsa, had boarded their return ship from America in March. It landed not in Germany but in Belgium. His letter of resignation, dated March 28, arrived from there:[12]

> The current state of affairs in Germany compels me to resign herewith from my position at the Prussian Academy of Sciences. For 19 years the Academy has given me the opportunity to devote my time to scientific research, free from all professional obligations. I know how very much I am obliged to her. I withdraw reluctantly from this circle, also because of the intellectual stimulation and the fine human relationships which I enjoyed throughout this long period as a member and have always valued highly.
>
> But under the present circumstances I consider my position's inherent dependence upon the Prussian government intolerable.

Courant did not agree with Einstein's way of handling the situation and told Franck he ought to try to help repair the damage he had caused. Then he wrote about the persecution.[13]

> What hurts me particularly is that the renewed wave of anti-Semitism is not just directed against unsavory literature and other subversive elements, which I and you condemn alike—perhaps even more so than many a "völkischer" man. It troubles me that it is directed indiscriminately against every person of Jewish ancestry no matter how truly German he may feel inside, no matter how he and his family have bled during the war, and how much he himself has contributed to the general community. I can't believe that such injustice can prevail for long—at least insofar as it depends on the leaders, especially Hitler, whose last speeches left a quite positive impression on me.

Franck traveled to Berlin to collect his daughter Lisa so that she would be at home with her family in Göttingen on the day of the boycott. She was undergoing training as a physiotherapist in the capital.[14] Franck met the count Georg Vitzthum von Eckstädt, an art historian who had been teaching at the University of Göttingen since 1920, in the train. They had known each other for a long time and their conversation drifted to politics. Franck perceived the anti-Semitic defamation as intolerable, both personally and on behalf of all Jews. He discussed with the count what options remained open for him.[15]

The train back to Göttingen was packed full. Many Jews were getting out of the city.

The *Göttinger Tageblatt* continued to follow the fomenting speeches about the new government's measures. One column, under the heading "The counter-blow—General boycott against German Jews," read:

> The NSDAP has made a reality her announcement that soon it would not be warning anymore but would be raising its arm to strike back. The order for the boycott is out! This coming Saturday the counter-campaign against the slanderous foreign propaganda will suddenly hit in the form of a total avoidance of Jewish stores, wares, doctors, and lawyers.

Numerous violent incidents were associated with the boycott, but it did not lead to a pogrom.

After all opposition by the Communist Party had been crushed by a wave of arrests at the beginning of February, the decisive blow for public employees came on April 7. It was advertised as a law for the "restoration" of the professional civil service. The *Vossische Zeitung* printed a summary of it on April 8.

> The law's purpose is described as "restoring a national professional civil service." The law applies to all civil servants in the direct employ of the Reich, the provinces, the local authorities, etc., furthermore social service agencies. Not excluded are judges and teachers at universities.
>
> Civil servants of non-Aryan descent are to be placed in retirement (§§ 8 ff.); honorary officials are to be dismissed from their offices.
>
> The foregoing section does not apply to officials who have been in the civil service since 1 August 1914 or had fought for the German Reich or its allies in the World War, or whose fathers or sons had fallen in the World War. The Reich Minister of the Interior may approve further exceptions in consultation with the minister in charge or the highest state authorities for officials abroad.
>
> Civil servants who, based upon their previous political activities, cannot guarantee that they have always unreservedly supported the national state, can be dismissed from service.

On the following day the *Vossische Zeitung* printed some initial details about the "law":

> II. The second group comprehends officials of "non-Aryan descent." Aryan descent, according to the statements issued thus far, which ought to be set forth in the implementation ordinances, does not exist if one of the four grandparents is not Aryan.

16 Professors on Leave
On Basis of New Civil Service Law

was the leader of the *Vossische Zeitung*'s April 14 issue. These were members of the university staffs at Berlin, Frankfurt am Main, Cologne, Breslau, Halle, Kiel,

Figure 81 James Franck. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

and Königsberg, as well as the commercial college in Berlin. The newspaper remarked that these instances were based on the racial descent or political views of those affected. The readers were also informed that an opinion by an authorized expert on race research at the Reich Ministry of the Interior could be obtained and used as proof of Aryan origin.

The University of Göttingen was not yet mentioned, but there was no doubt about such leaves being issued to those professors as well. The three friends Born, Courant, and Franck had to reckon with receiving such notification. Courant had the added burden of a past as a political activist for the Social Democrats. Franck spoke with his wife and his son-in-law, von Hippel, about this inevitability, as well as with Hertha Sponer.[16] Franck had never expressed his political views in public. But now he felt compelled to act. Heinrich Kuhn, who was likewise vulnerable, was another person he spoke to about it.[17] As a war veteran, Franck was exempted from the Law for the Restoration of the Professional Civil Service. But his honor had been injured, and his pride did not let him tolerate it in silence. Kurt Martin Hahn happened to visit Göttingen at the time and went to see the Francks on April 16. He was director of the provincial reform school at Salem Castle and a good acquaintance of Professor Hermann Nohl. He discussed with the Francks various steps Franck could possibly take. They drafted letters to the minister and to the university's rector, agonizing over the best wording. But Haber first needed to be notified. On 15 April 1933 Franck wrote him affectionately:[18]

Don't scold me as impetuous or thoughtless. I expressed my wish to the Minister today that I be released from my duties. The reason I gave was "the attitude of the government toward German Jewry."

I also informed the Rector, the Kurator, and the Dean and am now glad it is no longer still in front of me. I simply cannot stand before the students at the beginning of the semester, whose representatives have set up the precepts you know about, and act as if none of all this concerned me. Nor can I gnaw at the bone of clemency that the government holds out to war veterans of Jewish race. I respect and understand the point of view of those who wish to stay in office today; but there have to be people of my type as well. In a K.W.I. the situation is, I think, different. Don't scold your loving J. Franck.

The letter to Prussian Minister of the Arts, Sciences, and Cultural Affairs Rust states:[19]

Mr. Minister,

With these lines I ask you, Mr. Minister, please to release me from my duties as regular professor at the University of Göttingen and director of Physics Institute II of this university.

This decision is an intrinsic necessity for me because of the attitude of the government toward German Jewry.

Most sincerely, Prof. Dr. James Franck.

After informing the rector Siegmund Schermer that he would try to continue to work in science inside Germany, he justified his decision to tender his resignation more clearly:

We Germans of Jewish descent are being treated as foreigners and as enemies of the fatherland. It is expected that our children grow up knowing that they are not permitted ever to prove themselves worthy Germans.

Whoever has been in the war is permitted to continue to serve the state. I decline to take advantage of this privilege, even though I understand the position of those who today see it as their duty to stay resolutely at their posts.

On April 18 the *Göttinger Zeitung* published an article about Franck's resignation:[20]

Voluntary Resignation of Prof. James Franck
Requested Release from His Official Duties—Reasons in a Letter to the Rector of Georgia Augusta

The director of the Second Physical Institute of the University of Göttingen, Prof. James Franck, has requested from the Prussian Minister of Sciences, Arts, and Cultural Affairs immediate release from his official duties.

This news will cause a major sensation not only in Göttingen, but throughout Germany, and one can even justifiably say, throughout the world. Franck is not just any lecturer of local or preeminent national importance. Franck's international reputation and global fame is unsurpassed by virtually any other German scholar today. When he received the Nobel prize a few years ago, the whole of Germany considered it an exceptional honor—because a German had again spread the fame of German scientific research beyond its borders. When such a man, who is only fifty, voluntarily relinquishes his teaching and research activities, the loss to science is beyond estimation. . . .

Prof. Franck's decision must be evaluated essentially, indeed even morally. We would like to hope and wish that this step with which Franck shatters his own life's work and substance has the effect that other scientists who are forced to resign as a result of the legal regulations have recourse to our science here. Otherwise, the resulting losses would be irretrievable or only recoupable after a long time has passed.

The evening edition of the *Vossische Zeitung* of April 18 published Franck's statement with the comment:

Professor Franck's letter could, if it is read as it is intended by all parties without fervor and prejudice, assist our self-appraisal.

The sacrifice he is offering could show where the path leads that we might now want to go down.

The first reactions to Franck's departure from office in the form of a letter came from Lise Meitner and Michael Polányi, written on the day of the press announcement.[21]

Your dear letter naturally first gave me an inner jolt; but upon closer consideration and after I had read the wording of your letter to the rector, I have to concede that you are right. One cannot live contrary to one's convictions; and a person with such a straight, dignified mentality as you certainly cannot do it. For you, your step will surely mean mental liberation, and—as cannot be otherwise expected—that Ingrid and the children approve of it, simply shows again: everything is all right over there.

Polányi wrote:[22]

I learned about your step with astonishment and joy. As long as Jews exist, what you have done to save their honor will not be forgotten.

Peter Paul Ewald from Stuttgart let Franck know on April 19:[23]

Your valiant step inspires many with happiness and admiration. I congratulate you. I myself have resigned my rectorship, "as I cannot share the government's standpoint on the race issue." Just now I hear that my petition has been granted.

In a letter from the same day, the rabbi Dr. Joachim Prinz from Berlin confessed:[24]

I feel it as my duty and a need to thank you for the extraordinary example you have offered in these difficult days for German Jewishness and German persons.

The well-known surgeon Max Neisser wrote directly after Franck's resignation was reported in the papers to give him his full backing. Franck immediately replied on April 20.[25]

[P]lease accept my cordial thanks for your kind letter. It would have been personally more amenable to me to take the step that I took as you are silently doing. My decision for publicity despite this was in order to give many young Jews the feeling that they were not simply being left in the lurch. I do not expect any political effect to come out of this step, of course.

Fritz Haber's hope to see Franck as his successor was dashed. He wrote from Berlin on April 21 that he had informed Planck that his institute would be inaugurated on October 1 bereft of its director and staff scientists falling within the scope of the law.[26]

I cannot immediately do anything for you and your son-in-law at this moment and in this situation as departing institute director to offer you or him a home, as I so fondly wish I could. But no words are needed for you to believe how deeply I wish to achieve this through Mr. Planck. The thought that this institute should not fall into your hands is the bitterest drop in the brew of these weeks. You wish to stay in Germany and I, although not having the wish, do not see the possibility of proceeding otherwise. I would not know how to emigrate honorably and find an existence abroad in my later years.

Hermann Dießelhorst, a close friend of Franck's, wrote from Braunschweig on April 22.[27]

How often have I been thinking of you and the other Göttingen colleagues who, just like you, are subjected to this atrocious national psychosis. But it was only through the step that you took and, above all, the manner in which you took it that I realized how very deeply insulted you must be feeling. And to the same degree must I feel shame for witnessing this in lame speechlessness. I do know how you dedicated your whole life to our science, how fondly you love it, making you untouchable to human weakness, how you are not driven by superficial ambition but by pure love of the fine science for which you have been endowed with so much skill. What kind of fatal madness is this, to sweep everything away in such a wave!

Edith Hahn wrote a furious letter to the Francks, also on April 22. She already saw how heavily guilt would bear down on the future.[28]

I am racking my brains and puzzling over what we could possibly do. If I didn't like you both so much, I could envy you for being Jews—and these are really not just empty words—and thus for having justice completely on your side and we for ever and ever the humiliation and the inextinguishable shame, which never can be made good again. You both did something, this is what is so marvelous; and it has certainly made a big impression. It will please you both to hear perhaps that I have been asked probably 20 × from several quarters: Have you read that thing by Prof. Franck? . . .

On Wednesday I bought up all the remaining issues of the *Voss* at our Ullstein branch and sent them to all the people whom I haven't yet quite given up for lost, because I think your letter should bring them back to their senses; and I hope the whole world will react to it.

Repercussions were felt around the world. American, British, Dutch, and Italian papers published articles about Franck's resignation. But no measures of any kind were taken by foreign governments. No German university, no academy protested openly against the dismissals.

Fear of the terrorizing tactics that the SA was known for some time to be already using drove any activism into anonymity. Franck received a declaration by Göttingen students expressing how highly they esteemed his attitude—

without signatures. Robert Atkinson wrote perspicaciously from America on April 19:[29]

> These are hard times and it is impossible to know what will happen or whether any kind of act can help; but only because there are too few who hold your attitude. I feel very unsure about many very important questions but am already pretty sure that the present powers certainly do have respect for courage and selflessness.

Many other Jews in Germany namelessly expressed their gratitude to Franck.

In Göttingen Rudolf Mentzel incited 42 lecturers to a counteroffensive. In response to his announcement they sent a "declaration" to the *Göttinger Tageblatt* on April 24. It was rumored that the interests of an ominous group lay behind Franck's deed.[30]

> We the undersigned Göttingen university lecturers are of the opinion that this step in general, but also in particular the sentence in the declaration: "We Germans of Jewish descent are being treated as foreigners and as enemies of the fatherland, . . ." can seriously impede the domestic and foreign political activities of our government of the national renewal. We are in agreement that the form of the above tender of resignation is tantamount to an act of sabotage; and we therefore hope that the government will carry out the necessary purging measures expeditiously.

These were Nazis and members of the Deutschnationale Volkspartei, who had perhaps also given their signatures in the hope that they might fill the vacated positions of those "on leave."

One lecturer was not willing to put his name under this appeal. Max Pohlenz justified his refusal to Mentzel with the argument that Franck was still willing to pursue scientific research inside Germany.[31] The zoologist Alfred Kühn wrote to ask Franck about the rumored ulterior motives, and Franck immediately replied:[32]

> You tell me that certain colleagues are assuming that my resignation had resulted from pressure by a group for whom I was posing as a purported exponent. This is not true. The truth is only that I considered the timing and consequences of my step with friends on the day of my resignation, which is clearly my right. As proof that my intention of resigning had been developing for weeks into a firm inner necessity for me, I can list you plenty of witnesses. As examples I name Mr. Thiersch, to whom I had described my views during a walk with him roughly a fortnight before my resignation; and Count Vitz[th]um, whom I met in the train on the Thursday preceding the boycott; as well as Privy Councillor Bosch, whom I had written three or four days prior to my resignation that I would not be postponing my decision for much longer.

Franck went back to the institute for one last time to say good-bye to all the staff. The subsequent correspondence is written on privately addressed sheets, not on letterhead of the Experimental Physics Institute II.[33] Franck wrote recommendations for all the workshop employees. At home he offered private seminars that some of Born's doctoral students also attended. The Sponeress, von Hippel, and Kroebel were the only "Aryan" participants.[34]

On April 25 the Ministry of Culture sent a telegram to its official for university affairs with the instruction:

> Until the final decision is reached on the grounds of the law for civil servants, Professors Honig, Courant, Born, Emmy Noether, Bernstein, and Bond[y] will be released from all university duties but with continued full disbursal of their salaries. The aforementioned are to be notified immediately.

This was just the beginning of the dismissals. Other names followed in the coming weeks, with purely political reasons also being a determining factor. This had already become evident in the case of the mathematician Noether. She was suspected of being a Marxist in mentality. Max Born was deeply mortified about the situation. He could not believe the injustice, but he did not have the stamina to resist like Franck or even to hold his ground.[35] He decided to leave on an early vacation with his wife and son. They had already reserved lodgings in Val Gardena, a valley in one of their favorite vacationing areas among the Dolomites in northern Italy. They were able to take the rooms ahead of schedule. Their two daughters, who were still studying, stayed in Germany for the time being. After these dismissals, the posts were reoccupied by Nazis. Professor Wolfgang Köhler at the University of Berlin reacted with a very unusual step for an academic. He wrote a longer article for the *Deutsche Allgemeine Zeitung* under the title "Conversations in Germany." It appeared on April 28 and was also available as a separate reprint. Its first lines clearly set the tone.[36]

> The powerful men now governing Germany have inquired on more than one occasion about the other Germans, who are now standing on the sidelines and whom it would surely be worth winning over. Anyone wanting to win them over must know why they are distancing themselves. And if they really are worthy, it becomes a patriotic duty to discuss this question in public.

Köhler mentioned the impact of the events designed to lead to a consolidated reich, but he also added oral testimony. An unnamed person was quoted questioning the wisdom behind replacing qualified men with National Socialists:

> We could not understand this; for, it is Germany that is at stake, not a party, even though it may be the most valuable one. It is hard for us to join a party whose policy we do not yet understand on such a fundamental point.

With this aspect in mind he turned to the issue of Jews. He thought Germans had the right to control the composition of their population and to limit through judicious regulation disproportionate numbers of Jews in important affairs of the nation. Remarks by his counterpart about Goethe, Spinoza, Lessing, and Heinrich Hertz led to a mentioning of James Franck's name.

Someone told me as we were going down the street: "The name of the greatest German experimental physicist today is Franck; some believe he is the greatest experimentalist of this science in the world today. This Franck is a Jew, a kind person if ever there was one in Germany. Until a few days ago he was a professor at Göttingen, a celebrity of Germany, and the envy of the scientific world abroad. A German law has affected this good and great man so strongly, not through its wording but doubtlessly through its intent, that he is leaving us. Have you read the words he used in resigning his post? Had another proof been wanting that Jews can be dignified people, then this man has supplied it." He took his hat off, and it seemed to me that I should do so too.

This depiction of Franck's attitude agrees with the impression of Walther Rathenau's brother, Fritz, whose son Gert was one of Franck's advisees. Fritz Rathenau wrote to Franck on April 29:[37]

You, esteemed Professor, who have attained unrivaled and lasting merit for science—and solely for science—have done a service to our community of faith, which will survive this storm as well; for this I can say to you but one thing: my profoundest and inextinguishable thanks!

Following a visit with Franck, Fritz London wrote him a grateful letter.[38]

Dear Professor,

I would not like to return the Köhler article without telling you how happy those hours you gave me made me. It is something so wonderful and consoling to know that in this world, which seems so godless, there are still people who—instead of perhaps circumventing things—have found a stance to take despite all doubts and internal and external onslaughts, that befits their dignity. Although each must seek out his own path as suits his own way, your act has strengthened more than one person in the awareness of what he owes as a German and a Jew.

The government continued to be busy. The third ordinance on the implementation of the Law for the Restoration of the Professional Civil Service specified *in re* Article 4:[39]

1. The membership of an official in a political party—except for the Communist party—does not yet alone justify the assumption of nationalist unreliability. This applies even when the civil servant has been a registered member of the party, has paid membership dues to it, and has attended its meetings.
2. The conditions of § 4 Paragraph 1 are met particularly when a civil servant has presented himself orally, in writing, or otherwise through his conduct as opposed to the nationalist movement, has insulted its leaders, or has abused his official position to persecute, slight, or otherwise harm nationalist-minded officials. . . .

3. A civil servant, who has fought at the front during the World War for the German Reich or for its allies, has proven his national reliability at that time in any case with this deed; a particularly careful examination of his case is thus called for.

Courant was determined to take every possible measure to be able to stay at the university.[40] He built his hopes on the fact that he was a war veteran. Perhaps an implementation ordinance would make it possible for him to stay. His friends submitted an appeal to the minister along with a large number of collected signatures in an effort to have his dismissal reversed. But they soon had to recognize the problems attached to such solidarity. Franck corresponded with Hermann Mark, who had left Haber's institute and was going to the dye consortium IG Farben, about whom he should contact in the company.[41]

Letters acknowledging Franck's resignation were still coming in. For instance, the president's office of the Cartel of Jewish Associations or the Reich League of Jewish War Veterans:[42]

Esteemed fellow-soldier, Professor Dr. Franck,

We have the strong desire to express to you our admiration and our thanks for your wonderful standpoint in your capacity as a front-line soldier and as a Jew. By it you have given German Jews moral support that has no equal. We are proud to be able to count you among our number.

On May 10 Göttingen experienced a sordid book-burning spectacle organized in parallel with similar events in Berlin and other German cities.[43] In April the *Völkischer Beobachter* had already raised the cry against the *undeutscher Geist* (un-German spirit) in libraries. Now the National Socialist Student League was the orchestrator. In preparation, students rifled through bookstores and libraries the day before to take away books that had been published in the German language by Jewish authors. They did not bother about legality. On the day of the event the new rector of the university, Professor Friedrich Neumann, spoke in the overcrowded *Aula* about the battle against the "un-German spirit" and that this was but the beginning of the campaign. A long torchlight procession wove its way through the town amidst the applause of many onlookers to Adolf Hitler Square, where the books had been thrown in a heap. Heinz Wolff, the leader of the student association, delivered a speech full of demagogic comments about the authors and their books. He ended with a call for good breeding and morals within the family and the state. The tall bonfire burned slowly to the ground. The ceremony finished with the national anthem and Horst Wessel's song "Raise High the Flag."

What future lay in store for Franck and his family in such a state? He was still trying to look for an opportunity to conduct research outside the civil service. Otto Oldenberg and his wife, Kathrin, had written him some sympathetic lines on April 23 about his departure. He now had time to respond. He told them about the problems his employees were having finding new jobs. He himself was waiting to see what would happen. Friends believed there must be a reason why the government was dragging its feet with his petition.[44]

This may be true, but for me a retraction would only be possible if the government's attitude toward Judaism changed decisively; of that I detect only very weak signs. That is why I regard my affair as a completely irreversible process.

On June 2 he presented before the Göttingen academy a short paper analyzing the catalytic action of the noble metal palladium.[45] It was an attempt to interpret the results and notions presented by other scientists about the dissolution of hydrogen in the metal—taking the energetic conditions into account. One of his graduate students was also working on hydrogenation catalysis for his thesis.

Pohl was required to inform the university administration about the political persuasions of his subordinate assistants. Besides those in his own institute, he also had to survey Franck's, whom he was stepping in for. Franck wrote on May 20 in reply to this inquiry:[46]

I have a clear view of the political mentalities of Miss Prof. Sponer, the private lecturers Dr. A. von Hippel, and Heinrich Kuhn because of our close personal interactions. I can vouch with my word that on the basis of their past political views all three can count as politically reliable and would never work against a nationalist government.

Franck mentioned in addition that they had all voted for moderate parties. He could not provide any information about the laboratory aides paid on the assistant budget but knew that some of them were right-wing radicals. He had, however, always considered it important not to have any people around him of Communist persuasion.

This statement was evidently not sufficient in the case of Miss Sponer and Kuhn, as soon became apparent.

At the end of May Franck received a postcard from Born in Val Gardena. In his reply from May 27 Franck reported that he had been in Berlin and spoken to Planck, Haber, Pringsheim, Hertz, Meitner, and von Laue.[47]

Haber is not doing well. His resignation is final; the Ministry has already approved it. Pringsheim has now likewise been placed on leave. Wehnelt seems to have had his fingers in Pringsheim's case, albeit this is just a suspicion right now. Planck and Laue, indeed the others also were especially nice; many asked about you and send their warm regards. You know the relatively optimistic view they hold from your own conversations with them.

As for me, I have now received my leave, until the final decision has been reached, in an entirely friendly letter by the Ministry.[48] I told Planck that I would accept any position that was available that would offer me the opportunity to conduct research in

Germany and some income, so long as it did not include any character of state employ. For I do not want to be a civil servant as long as the martial laws against Jews exist.[49] Planck fully understood as well, likewise Laue.

The global economic crisis limited the job options for these professionals "on leave." But Turkey was interested in employing émigrés from Germany in Istanbul. There were also offers to go to Belgrade.[50] Karl Herzfeld invited Franck to come to Johns Hopkins University in Baltimore, Maryland, for three months. He was hopeful about the possibility of raising the funds for a five-year extension of this contract. That Franck could succeed Wood was also conceivable. Franck was undecided. Einstein offered his opinion indirectly in a letter to Born from Oxford on May 30. After reporting about his own activities, he wrote:[51]

I am glad that you have resigned your positions (you and Franck). Thank God there is no risk involved for either of you. But my heart aches at the thought of the young ones. Lindemann has gone to Göttingen and Berlin (for one week). Maybe you could write to him here about Teller. I heard that the establishment of a good Institute of Physics in Palestine (Jerusalem) is at present being considered. There has been a nasty mess there up to now, complete charlatanism. But if I get the impression that this business could be taken seriously, I shall write to you at once with further details.

He then discussed his earlier unsuccessful attempt to convince Rockefeller to redistribute its grants. Einstein had been toying with the idea of forming a university for exiles but had given it up. What he thought of Germans in general comes up in this letter.

You know, I think, that I have never had a particularly favourable opinion of the Germans (morally and politically speaking). But I must confess that the degree of their brutality and cowardice came as something of a surprise to me.

Max Born continued to stay in touch with Franck from his outpost in the southern Tyrol. He sent Franck a copy of a letter Heisenberg had sent him from Leipzig. It was another attempt to persuade him to return:[52]

But I was very shocked by the other subject of your letter: I never reckoned with you not wanting to come back to Göttingen and I still hope that this is not your definitive decision. I recently saw Planck in Berlin and spoke with him about the question of what we could do for physics. Planck has—I think I may safely pass this on to you—spoken with the head of government and received the assurance that the government would do nothing beyond the new civil service law to impede our science. As, on the other hand, the law affects only the smallest minority—you and Franck certainly not; Courant probably neither—the political adjustment could take place without any damage to Göttingen physics. I personally understand very well, of course, if you are adverse to returning to such thankless surroundings; but you do also know how very gratefully those pupils of yours think of you, who were able to experience firsthand the scientific atmosphere emanating from your research. It is not exactly easy for the rest of us to hold out at our posts, either: [Felix] Bloch's departure from my institute has partly destroyed a component of my institute that had cost me much time and effort. A few ugly things have happened in the scientific administration as well.

The main argument in Heisenberg's letter was that the ugliness would precipitate out of the good. Franck did not allude to Heisenberg's letter in his response to Born but insisted again that he was unwilling to reenter the civil service. He then looked toward the future:[53]

On the other hand, I am of the firm opinion that linking the destinies of friends is senseless. In other words: I write you this fact not with the wish of influencing you in any way. With Courant, too, I concur that the coupling forces should only relate to personal issues. What the autumn will bring for those on leave is very doubtful to me. Many think that the processes are reversible; it does not look like it to me, though. Many things have already been set in motion for the younger people so you don't need to worry too much on that score. I recently saw Planck. He is one of those people with a basically optimistic outlook and also, as ever, a magnificent person.

When Frederick Lindemann came to Göttingen in search of young physicists for Oxford,[54] Franck introduced him to Heinrich Kuhn. Lindemann spontaneously offered him a position and Kuhn accepted without hesitation. Nazi students had already acquainted Kuhn with their terror tactics.[55]

In the second half of June Franck traveled with his wife to Leyden to give a talk at the invitation of the physicist Wander Johannes de Haas. Franck's ulterior purpose was to look for employment and research possibilities in Holland for younger people suffering his predicament. Franck approached Dirk Coster about his coworker Gert Rathenau, who later was able to find a position as a result. They returned to Göttingen. Both Franck and Born had received offers to teach in Istanbul or Belgrade, where there were plans to strengthen the physics programs. Born had already declined because he was able to go to Cambridge, at Rutherford's invitation. He was looking forward to the change and hoped that Franck would be able to join him in England. The two friends first had to settle the future of their series. Ferdinand Springer was still in charge of his publishing house, but they could not continue as editors. Franck left his decision about Istanbul up in the air. On one of his trips to Berlin he probed his chances of finding a position at IG Farben. The reply by one of Carl Bosch's secretaries on June 27 was not encouraging:[56]

I just spoke with Priv. Coun. B[osch] and would like to report to you about it. He is of the view, as we all are, that a moderate solution to your state employ [the pension] is the basis of your employment at the K. W. I. in Dahlem and that [at his urging] the initiative for this will *hopefully* come from the Min. of Culture. As soon as you start your work there, 8,000 marks will be immediately at your disposal annually as external member of I.G. [Farben].

G. Hochheim continued to mention that Bosch would be taking steps on Franck's behalf as well as on Miss Meitner's at the Ministry of Culture. But how would Franck's position at the Kaiser Wilhelm Society fare with Philipp Lenard as one of its senators? Lenard's petition on June 28 reads:[57]

> Prevented from traveling, I submit the following three questions to the Senate in writing:
> Will the Senate support that (1) the Jew Fritz Haber, (2) the Jew James Franck, (3) the Jesuit Muckermann be removed immediately, respectively kept completely away from the institutes of the Kaiser Wilhelm Society?
> Any conversions or papal dispensations alter nothing about the quality of the above-named.

When Oldenberg announced that he would soon be getting invitations from Harvard and Caltech, the probability that the Francks would be settling in America became increasingly certain. Oldenberg was enthusiastic. On July 13 Franck gave a talk at the invitation of the Swiss student association of the University of Zurich. He explained how electricity forms in stormy weather. To introduce the speaker, Richard Bär wrote a brief outline of Franck's research for the local paper. Returned from Switzerland, he was compelled to draw for himself a clearer picture of his own future. The president of Johns Hopkins University was expected to visit Göttingen and wanted to know whether Franck would accept their offer of a quarter-year lectureship at the university. Franck was basically amenable but still left the door ajar to other options.[58]

In response to Arnold Berliner's suggestion that he write a review of the new edition of Emil Warburg's physics textbook, Franck wrote:[59]

> I do not have much news to report. I received very many inquiries from abroad, some of which I answered negatively, some dilatorily. But I am beginning to regard the possibility of my staying in Germany very pessimistically, especially since the extension to the civil service law has probably reduced the options for my son-in-law to nil [because of his marriage with Dagmar Franck]. The prospects opened to my friend Born did please me.

His mood comes across more strongly at the end of his letter to Born from July 26. After discussing the employment chances of one of Born's Jewish assistants, Franck continued:

> As concerns me, I have now written a brief paper with Rabinowitch and one recently appeared in the Göttingen Nachrichten. But these are all just reminiscences from before. I do not get to doing any physics at all, I don't even open the envelopes of the journals sent to me.

The paper he alluded to was not insignificant. It concerned the photochemistry of solutions and free radicals, carefully considering the energy relations of dissociation and recombination.[60] Starting from data on photochemical processes in a gas that allowed the coreactants to move over a certain distance without undergoing a collision, it examined the influence of the molecules in the immediate vicinity. Diffusion and the influence of temperature were taken into account.

Conditions inside the country for its ostracized and persecuted citizens worsened by the day. What was still possible today was tomorrow forbidden. It was futile to try to anticipate the government's next measures. It affected Franck's endeavors to stay in Germany. Alfred Kühn tried in vain to procure a research professorship for Franck at one of the academies. Franck wrote to thank him on August 29.[61]

Please allow me just to tell you today how much it pleases me that you and our other kind colleagues are trying every possible means to keep me here. If it were only a question of whether I should like to continue to work in this trusting and kind group, there would be no problem. But you know how many other grave things there are to be weighed and considered.

Franck mentioned that his wife had been treated by the famous Swiss nutritionist Dr. Maximilian Oskar Bircher-Benner with some success after a deterioration of her health in recent years without any identifiable medical cause. The physical chemist Arnold Eucken supported the idea that Franck receive a research professorship at an academy. But Franck wrote to him on August 29 to dissuade him. His handwriting exposes his emotional upset.[62]

Dear Eucken,

Please accept my letter in cord. thanks for your kind note. I, too, regretted having to relay my good-byes, as you were away. I went to Berlin to check the possibility of working as a guest of the KWI (with Bosch's support). This possibility does not exist. There is no plan to hand Haber's institute over to Mr. [Leo] Ubbdelode but to wait through the winter and then appoint a successor. (It appears that your name is being discussed along with Bonhoeffer and [Prof. Max] Volmer; this please treat as confidential.) But as reg[ards] me, the senators of the KW[Society] could not possibly go along with a related solution. Von Laue advised me to drop the plan completely. That matches my impression. It appears that there is no room left for people of my heredity and my temperament in Germany to work with success. I must unfortunately also attach this assessment to your plan. Firstly, I doubt that the Ministry would receive your plan favorably. Secondly, even if this precondition were satisfied, my position would still have the status of an active civil servant and this I will not and cannot accept. The course of events since my decision to resign has strengthened my view daily that it is impossible for me to work here as a public servant.

You know that I feel just as good a German as any other, but that won't help me; I simply have to emigrate, even though I know that my wife and I won't be able to grow roots anywhere else; but perhaps the children will succeed, or at least the grandchildren. I do not want them to have to feel like second-class citizens. So, with a heavy heart I ask you please not to expend more effort on my behalf. I am grateful to you and feel furthermore, as you know, very attached to you. I hope that this will persist even over spatial separation. In the interim I hope to see you again in Göttingen in the fall.

Most cordially yours, J. Franck

If you can manage to save my institute and arrange for a competent man to be my successor, that would please me very much.

Two days later Hitler allowed himself to be celebrated in Nuremberg at the "party convention of victory." It was on this occasion that he first mentioned a purge of the party.

Franck's friends pressured him to slowly make up his mind about where he would like to go. Wilbur Tisdale of the Rockefeller Foundation wanted a final decision about a longer research stay either with Bohr or in America. In the middle of September Franck explained his wishes to Otto Oldenberg.[63]

My dear Oldenberg,

I have been delaying a letter to you for a long while because I did want to be able to report something final about our fate and because the final decisions were constantly postponed. Well, everything is clear enough for me to want to write to you now at least and ask you at the same time to give me your advice and support on some points.

Niels Bohr offered I come to Copenhagen, and you can understand what a great temptation it is for me to do so as well.

Initially that would be for three years, but his earnings would be able to cover only his living expenses. He might go to Istanbul for a quarter of a year, where Harry Dember, a professor at Dresden, was going as a physicist and Arthur von Hippel was going as an "electrician," but Franck still had no contract in hand. He had not given up his American plans yet. He definitely wanted to visit Harvard and Boston, after which he would stay in Baltimore before returning immediately to Copenhagen.

I gradually have to try to get back into physics; and this can only happen if I drop anchor properly somewhere. During the last few months I have been exclusively occupied with human destinies; and such business is apparently suited to robbing one of a bit of joy in life.

One of these worrying destinies was Miss Sponer's. Where could she possibly go? National Socialists expected women to be mothers, not scientists. Added to that, it was certain that Pohl would not back her if a professorship became available. She would have to leave Germany.

Franck's decision was reached at the end of October. It was not Istanbul, not Belgrade, but Copenhagen. Bohr's very kindly worded letter from October 23 was written by his wife, Margarethe, on his behalf:[64]

I can't tell you how very happy your nice letter made me. As you know, I've been hoping for years that we might one day get the opportunity to collaborate closely together; and I feel the prospect that this hope may become reality in the near future is a great chance.

Franck did not dare cross the border before his final departure from Germany, so he met his friend Niels Bohr near the Danish border to discuss the details. The farewells from all their Göttingen friends approached inescapably. A last photo was taken of a group of them drinking coffee in Mrs. Paquin's garden. She had been loyally settling all his correspondence of the past months.

Hate was in the air in Germany. Johannes Stark had pressured the president of the PTR (the German national bureau of standards), Friedrich Paschen, into resigning in order to free up the position for himself. But that clearly was not enough for him. He decided to "purge" the board of trustees with the help of the party's local workers' and employees' cells and section for professionals (the Nationalsozialistische Betriebszellenorganisation and Nationalsozialistische Fachgruppe). This affected Franck. It did not make the slightest difference that Stark had earlier thought quite highly of his research. On December 14 these two Nazi groups wrote to Minister Frick, probably on the basis of information provided by Stark:[65]

The existing board of trustees of the Physikalisch-Technische Reichsanstalt (P.T.R.) still has its old composition from before the rise to might of National Socialism. The

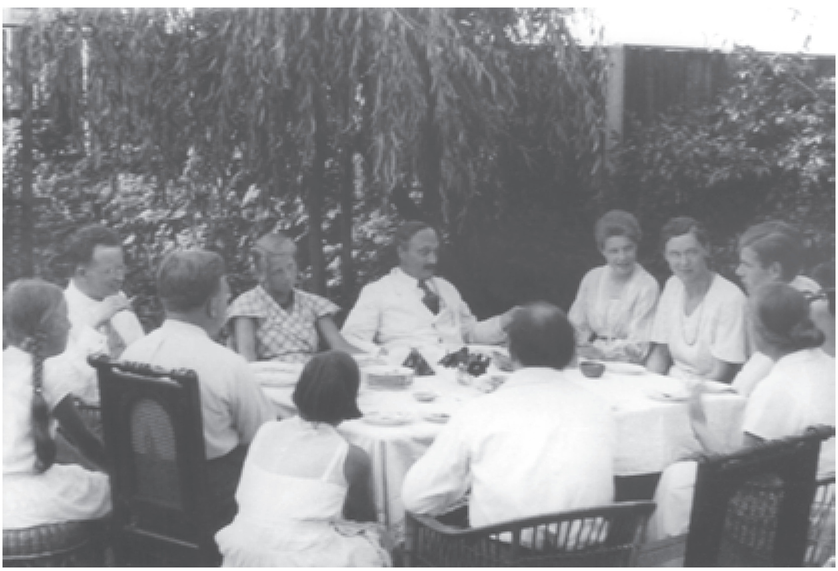


Figure 82 Farewell event in Mrs. Paquin's garden. From left to right, facing: Arthur von Hippel, Mrs. Grete Paquin, James Franck, Hertha Sponer, Frida Richter, Heinrich Kuhn; from behind: Mrs. Paquin's daughter, Eugene Rabinowitch, Dagmar von Hippel, Werner Kroebel, Ingrid Franck. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

traitor Einstein has been excluded but there still are Jews and notables of the old system among the remaining members. The N.S.B.O. and N.S.B.A. of the P.T.R. are convinced that a continuance of the board of trustees as it is presently composed contradicts the restructuring of scientific research in the spirit of National Socialism. The N.S.B.O. and the N.S.B.A. therefore request that the old board of trustees be immediately dissolved. The National Socialists at the P.T.R. would have already organized the dissolution of the board of trustees in April 1933 if the expectation had not been that higher authorities perform the dissolution.

The reasons are specifically the following:

1. On the board today there are people like Professor James Franck (full-blooded Jew); Professor Haber (full-blooded Jew); Professor Hertz (half-Jew); Professor [Heinrich Matthias] Konen against whom criminal proceedings are currently under way; and Professor Nernst, one of the strongest advocates of the liberalist and capitalist world view. As for the rest, a purely democratic structure from before is, in principle, still there.
2. On the question of filling the presidency at the P.T.R. which became available in April this year, men were proposed as president as recently as March 1933 who are Jews or half-Jews, such as Franck, Konen, or Ramsauer; and these nominations were advocated at the Reich Ministry of the Interior.
3. Furthermore, there are representatives on the board whose memberships seem not to be legitimized either by scientific occupation or by influential position in industry.

We would specially welcome having P[arty] C[omrade] Secretary of State [Gottfried] Feder belong to the new board, the appointments to which will surely occur with the involvement of the P.T.R.'s president, P[arty] C[omrade] Prof. Stark.

The Francks left Göttingen on November 25. Their last night was spent in the Krone inn.[66] The *Baltimore* brought them to America.

A Short Visit to America

A strong sense of transition marked the few months' stay in America. Göttingen and Europe were constantly in mind. This was just an intermezzo. At Johns Hopkins University in Baltimore Franck had time to perform a few experiments with Robert Wood in addition to his lecturing. They measured the ultraviolet absorption of heavy water, D_2O.

In response to a letter by Heinrich Kuhn outlining his problematic start at Oxford, Franck wrote sympathetically on 11 February 1934:[67]

I certainly know what the situation you describe feels like. And yet there is no alternative to gradually getting used to it. Where we live is not home and we are permanently guests. We can't complain about a lack of kindness, at all. On the contrary! But that is due to the stamp of approval I have [i.e., the Nobel Prize]. From Arthur I hear that he is really having a damned difficult time at Stanford. Those guys haven't a clue what a scientific enterprise needs.

He was worried about problems his other son-in-law, Hermann Lisco, might be encountering while taking his exams because of his marriage to Lisa.

> Sponer has been fired and I am trying hard to find her something.
>
> I wish I could apportion out the offers being made to me—or rather, to my Nobel Prize—to younger ones. And yet, not a ghost of a chance inside Germany! Well, one just has to grit one's teeth.
>
> I'll be playing the evangelist this weekend and recount in a two-hour lecture here what you have all been doing in recent years, adding my own pinch of salt. Besides that, I am tinkering away with Wood on some little experiments. Maria [Göppert-Mayer], [Robert Henry] Dicke, Herzfeld, etc., are extremely nice. It was fine with Oldenberg too.

Franck's letter does not provide any details about the institute even though it was very probable that he would be accepting a position there. Situated in Maryland, the state founded at the beginning of the seventeenth century by Catholic immigrants and the last to join the original Union, was the seat of the American archbishop. Johns Hopkins, the only university in its harborside capital, Baltimore, had been founded in 1876. The physics department was much more modestly equipped than what had been available to Franck at Göttingen.

On their return to Europe, the Franck couple first paid visits in Hamburg and Berlin and then left for Copenhagen at Bohr's invitation. James Franck's official dismissal from the German civil service was dated 8 February 1934. The certificate contains the routine expression of thanks.

Niels Bohr's Émigré Guest

In Copenhagen the Francks found a nice apartment with a wide view of the sound. The grand piano could be put in place, and Mrs. Franck, who was slowly recuperating from the many disturbances of the last months, was able to start playing it again. On a fine day they would sometimes take a horse-drawn carriage to Dyrehaven, with Professor Franck in his favorite seat up front beside the coachman. The apartment was not far away from Bohr's institute, so Franck was able to take a bicycle to work, as he was used to doing in Göttingen.[68]

He was there at the institute as a visiting professor funded by the Rockefeller Foundation.[69] His task was to set up a department for experimental physics with two or three staff scientists. Bohr was unable to do so himself because he was tirelessly engaged in seeking support for the many people who were applying to him for help. He was also gradually redirecting the focus of research at his institute. As Franck had been starting to devote increasing attention to reaction kinetics and problems in physical chemistry during his final years at Göttingen, Bohr wanted to refurbish his laboratories to be able to conduct his own experimental analyses related to the theory of nuclear physics.

Dr. Hilde Levi was a coworker of Franck's in Copenhagen. Coming from

Frankfurt am Main, she had studied physics in Munich. The anti-Semitic currents at Willy Wien's institute had motivated her to transfer to Haber's Kaiser Wilhelm Institute of Physical Chemistry and Electrochemistry in Berlin. Dr. Hans G. Beutler had supervised her dissertation in the field of spectroscopy, and Peter Pringsheim was her doctoral advisor. She defended her thesis in the spring of 1934. When Max von Laue examined her about theoretical physics, she was unable to answer his questions, however. She had not attended his courses. But her situation must have been clear to von Laue because he simply laughed it off and let her go with a passing grade. He knew full well that she would not find a position in Germany and an academic title would help her find one abroad. Soon afterwards she was hired at Bohr's institute, where she was able to prove her mettle in science.

Figure 83 Hilde Levi. Author's photo. By courtesy of Hilde Levi.

For many physicists Bohr's institute was the first stop in what usually would become a long odyssey before permanent employment. Franck's laboratory was situated in the basement. He shared it with a former graduate student of his, Hans Kopfermann, who was working there as a guest researcher on the hyperfine structure of the spectra of the rare earths. Franck loved the sea and often rode his bicycle along the coast. On fine summer or fall evenings Hilde Levi often joined him. One urgent worry was where else von Hippel could find a job. His teaching post in Istanbul was completely unsatisfactory. Franck asked Born whether he had any recommendations. The general economic crisis was draining the budgets at universities and other funding agencies, so it was difficult to find anything in academia. Lord Beveridge's Academic Assistance Council had exhausted itself, despite Lord Rutherford's efforts as its president to raise more funds and locate positions. Born told Franck about opportunities at the University of Jerusalem, but that was out of the question for von Hippel. He was not a Jew.

Then Born discussed their book series on the structure of matter. He had just received a letter from Friedrich Hund that irritated him. He crossly brushed it aside with the comment about the future of the series in Nazi Germany[70] "Basically I don't care a rap about it all. I'd only be sorry if Hund's condition developed into complete softening of the brain." He was referring to this carefully worded passage in Hund's letter about the coeditor Hermann Mark, who had been forced to leave the country:[71] "I had been very skeptical about the choice of

Figure 84 In the auditorium at Bohr's institute. From left to right, front row: Wolfgang Pauli, Pascual Jordan, Werner Heisenberg, Max Born, Lise Meitner, Otto Stern, James Franck. Second row, fourth from the left: Carl Friedrich von Weizsäcker, Friedrich Hund; second from the right: Otto Robert Frisch. The first seated in the fifth row is Edward Teller. Standing on the left: Niels Bohr, Léon Rosenfeld, Edoardo Amaldi. Niels Bohr archive, Copenhagen.

Mark from the first because—if I am rightly informed—Mark does not satisfy all the requirements that would be made of a university teacher in Germany."

Franck could not have been so entirely indifferent to the fate of their series. Hertha Sponer was still working on her manuscript for the volume on molecular spectra. The finished book would be useful proof of her academic qualifications in her search for a position. Courant, who was still living in Göttingen, traveled to Paris to settle some business of his own with Tisdale at the office of the Rockefeller Foundation. There he met the founder of the Institute for Advanced Study at Princeton, Abraham Flexner, and their conversation had bearings on Franck's destiny. Courant reported to his friend.[72]

Flexner expressly left word for you, likewise stating his willingness to pave the way over there for Hermann Lisco. Tisdale will try to come to Copenhagen in September to speak with you. Both thought you should not take the Danish options for Hippel too seriously, even if Niels managed to push something through temporarily. I cannot sketch for you so quickly the kindheartedness with which Flexner and Tisdale are working for all of your sakes.

Even so, Franck was unable to relax. His memory often failed him, as he complained in a long letter to Otto Hahn and Lise Meitner [about her friend].[73]

I have finally also written to Lotte Grüneisen. It's disgraceful that I'm no longer fit for anything and forget one thing after the next. I can't even say that too intensive work lies behind it; it is probably rather that I'm constantly feeling as if on a voyage and am mentally still waiting for the finality of routine order.

He reported his intention to concentrate on nuclear physics. He had written to Otto Robert Frisch, who was working temporarily with Blackett at Cambridge, to invite him to collaborate in Copenhagen. Frisch accepted and arrived in time to take part in Bohr's annual conference of physicists. Heisenberg arrived from Germany, and the later Nobel laureate Hans Bethe was also there. The topic this time was the theory of the atomic nucleus. Franck learned some new things about the field from the talks and discussions but was distressed to see how quickly he forgot them again.

"The Bohrs are so charming," Franck confided to Meitner and Hahn, "and he is so superhumanly intelligent and wise, that one is constantly amazed about it, despite everything one already knew about him."

Although things were still very much up in the air, Franck believed they would be going to Baltimore. Their futures were financially too insecure in Copenhagen. In reply to a letter from Born in Cambridge, Franck wrote on October 29:[74]

One thing is definitely clear to me—Germany isn't an option for us anymore. I was just in Berlin recently and also spoke with the Plancks and the Laues as well as with Hahn and Lise Meitner. Those people are certainly not enjoying themselves, but they all simply have to keep quiet.

He mentioned two projects about the fluorescence of fluids but was currently busy with nuclear physics.

I am benefiting incredibly much from Bohr. Now Hevesy is also here and I would like to say that—despite the restrictions of space and staffing and despite the at times slow temperament of the latter—I am feeling very comfortable. This is even more applicable to my wife; she is still not completely back to normal but has recuperated visibly here. Nevertheless I realize that there must be an end to this state.

You and Courant, Tisdale, and in some sense also Harald Bohr have advised me to choose America. The decisive point was that I want to live with the children. Flexner will probably have little difficulty finding a position for the young Lisco, who is sitting his exams right now in Berlin. Hippel is much more problematic. During

Figure 85 Niels Bohr and James Franck 1935. Niels Bohr archive, Copenhagen.

the holidays Hippel gave a talk here that the people liked exceedingly. The local electrotechnician [Professor Peder Oluf] Petersen immediately invited him to work with him for half a year. But considering the tight constraints here, this can really only be for half a year.

Georg von Hevesy had felt compelled to resign his position at the University of Freiburg in 1934 and had returned to Copenhagen, where he had formerly held the professorship for theoretical physics. Franck asked Born again if he could think of anything suitable for von Hippel, as he really was a talented fellow. He then went into his own plans.

In this situation, when Tisdale wrote to me that I should reply to Baltimore at last, I did say yes with certain little ancillary conditions and am now waiting for [University President Joseph] Ames's answer. Next July I have to hold summer-school lectures at Cornell University in Ithaca. Whether I will simply stay in America or perhaps only go in the winter I don't yet know. I think that Wood's successorship is a pretty secure option for me. And aside from the issue concerning the children, at my age it really is becoming important to have the possibility of getting my fingers on a little more money—I estimate $6,000—so that I can take out some life insurance.

Photochemical reactions and the processes involved in the fluorescence of fluids and vapors had been part of the agenda of the Experimental Physics Institute II at Göttingen. Now Franck began to take an interest in photosynthesis.[75] Bohr had referred to the applicability of the correspondence principle to biology in a talk titled "Light and life," and his daily contact with Franck may have otherwise kindled Franck's interest in researching photosynthesis.[76] But Otto Heinrich Warburg's biochemical research in Berlin could just as easily have been his inspiration, or the applications of physical methods being developed right then to analyze biological processes. Franck became so intensely preoccupied by these new problems that they became the focus of his energy and creativity for the rest of his life. Papers on purely physical topics appeared only very occasionally from then on.

For a hundred years scientists had been trying to understand the very complex process of photosynthesis, which involves physics, chemistry, and biology. How does a plant use daylight to generate from

carbon dioxide (CO_2) and water (H_2O) $\Rightarrow$ starch, carbohydrate, lignin, and oxygen O_2?

The reversal of this process is the production of energy through combustion at a high temperature or through decomposition at a lower temperature, which releases carbon dioxide and water again. The path that researchers followed in an attempt to understand the chemical reaction was filled with sidetracks and detours. Semi-quantitative measurements were able to determine the gas conversions very early on. But how chlorophyll, which gives the green color to leaves, works remained completely mysterious. Was it a catalyst? Or did it take an active part in the reactions? Being green, chlorophyll absorbs mainly the red range of light. These light quanta have relatively low energy. The fact that two reactions are actually involved was recognized in the nineteenth century. The first happens at the time of exposure and the second follows during the subsequent period in the dark. Richard Willstätter and Arthur Stoll's deciphering of the structure of chlorophyll in 1913 was a major advance for researchers in this field.

Willstätter and Stoll tried in vain to explain the photosynthetic process from the chemical structure of chlorophyll. The next major step forward was made by the chemist Otto Warburg, the son of Emil Warburg, and by his collaborator, the biochemist Erwin Negelein.[77] They not only developed a very accurate and sensitive manometric procedure for determining the quantities of exhausted and produced gas but also designed a reaction vessel that allowed the biological sample to be exposed to a defined intensity of radiation. After retiring from the presidency of the PTR, Emil Warburg had experimentally verified with the assistance of Hans Ramien (one of Franck's doctoral students) Einstein's law of photochemical equivalence on simple inorganic compounds. His son, Otto, had been working in the PTR for some time already, becoming acquainted with the calibration of sources of light, among other things. He and his collaborators tried to determine the number of light quanta needed for photosynthesis. Otto Warburg worked predominantly with technicians or laboratory assistants whom he was currently training. He usually had only one guest academic in his laboratory at a time, and it was not seldom that such collaborations would end rather abruptly.

Many unresolved problems existed in research on photosynthesis. As with the beginning phase of research on ionization around 1910, photosynthesis research lacked a standard nomenclature, adding further opacity to exchanges among the scientists.

Some experiments related to the excitation of chlorophyll by light and analyses of weak fluorescence. Many very basic questions were as yet unresolved. Does the expired oxygen come from the carbon dioxide or from the water? What is the first step in the absorption of light? What bonds lead to the formation of a carbohydrate?

This was the situation when Franck entered the field with his first critical contributions. They were still able to appear in *Die Naturwissenschaften*. The terrorizing against all things Jewish in Germany was not yet total. Arnold Berliner was still the journal's editor and Ferdinand Springer was still able to manage his publishing house. Franck's first article was a solo production on the problem of carbon dioxide assimilation.[78] It was an analysis of recently published experiments by the Heidelberg chemist Hans Kautsky on the fluorescence of chlorophyll. In his discussion of Kautsky's conclusions Franck was able to draw on his knowledge about the energy released by light quanta in fluorescence from the experiments he had conducted in Göttingen. He was able to assess the energetic potentials of reactions postulated by Willstätter and Stoll. He concluded that Kautsky's as well as Willstätter's notions were energetically permissible. The energy required—the number of light quanta necessary for photosynthesis—was a key problem that Franck would struggle with over many decades. It would later be the subject of his most vehement controversy with Otto Warburg.

As he was composing this first article in this field, Franck was quite insecure about his findings. He sent out his manuscript to Berliner with the confession:[79] "I constantly vacillate between the hope that what is written in this paper is something good and the opinion that it is obvious or the fear that it is wrong." Then he announced that he was sending a copy to Willstätter. He wanted to write to Kautsky only after Berliner had accepted the paper. Berliner unfortunately altered the first sentence before it went to press, changing it into what Franck described as "a monstrosity" (*Missgeburt*). The second article, coauthored by Hilde Levi, on the mechanism of oxygen activation by fluorescent dyes,[80] jumped into the debate between the biochemist Hans Gaffron and Kautsky.

These would be the last articles by Franck to appear in a German periodical for more than a decade.

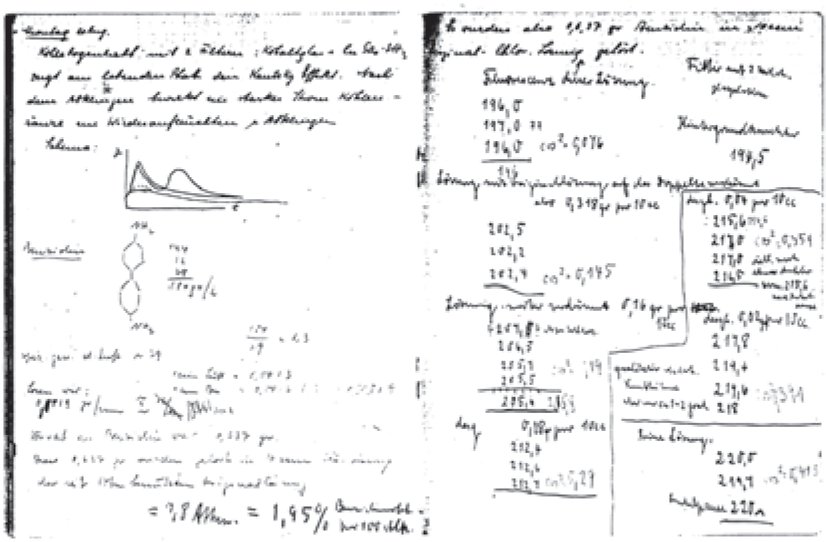


Figure 86 The Copenhagen notebook was written in both James Franck's and Hilde Levi's hands. Franck papers, Special Collections Research Center, University of Chicago Library.

On 11 November 1934, Franck wrote to Kuhn:[81] “It is very nice to do one’s own experiments again, but it does make one realize how pampered one was.” He was struggling with an analysis of chlorophyll fluorescence. The uncertainty about his future comes up again in this letter.

Whether or not we’ll be staying here probably also depends on Hippel’s fate. We’ve lost so much that we would at least like to have the children within reach. Shall we have to go to the USA after all? Let’s wait and see!

On November 20 he wrote to Kuhn again, setting him straight on what was affecting his decision about where to go. “The reason why we would be leaving is truly not that we aren’t quite content here. It is ideal here personally speaking; and Bohr’s mere presence replaces the physics of an entire institute staff.”

He reiterated the crucial reasons: definitely living in the same country as their children and earning enough to secure a pension. The Hippels’ absence in Turkey could not persist. Franck traveled to Istanbul to intercede on behalf of his son-in-law and assess the situation before he wrote two letters to Karl Herzfeld in Baltimore to accept the offer to go to Johns Hopkins University. Herzfeld sent a delighted response on 22 January 1935. He assured Franck that he would settle the formalities with the immigration authorities. He asked Franck to tell him what his one or two courses would cover. If his lectures dealt with nuclear physics, would he perhaps like to discuss the experimental aspects? Gamow was currently teaching the theory of the atomic nucleus.[82]

The other lectures given here will be Wood, Physical Optics; Dicke, probably Quantum Theory; [Joyce Alvin] Bearden, Radioactivity; Mrs. Meyer [probably Maria Mayer-Göppert] has not yet been decided; I will give the advanced Theoretical Electricity course. Our Seminar has not yet been decided on; Nuclear Physics or Structure of Complicated Molecules have been mentioned. I had thought that among other subjects which might be agreeable to you photo chemistry, or something of that kind.

He also proposed a lecture course on experimental electricity but retracted it.

At the turn of the year 1934–35 Franck received mail from Arnold Berliner. He was convinced that Franck would not be happy at Bohr’s institute over the longer term because he must conduct his own Franckian physics.[83] Grete Paquin in Göttingen was boldly helping many victims of the persecution to emigrate. She described her impression of the Third Reich in her New Year’s greetings.[84] “Our country has changed so much and has become so unutterably strange that it cannot be *Heimat*.”

Franck’s contacts with Göttingen were frequent. His last doctoral students were finishing up their experiments one after another. Pohl graded their dissertations and conducted the examinations. The young Rathenau sat his examination in December. The curriculum vitae obligatorily attached to his thesis begins with these lines:[85] "I, Gerhart Wolfgang Rathenau, son of Imperial Government Councillor Dr. Fritz Rathenau, was born on the 25th of June 1911 in Charlottenburg, Berlin, and raised in the Jewish faith." It was an expression of solidarity with Franck.

In the following spring Franck's pupil Heinz Maier-Leibnitz took his examinations with Pohl and reported to his *Doktorvater* Franck:[86]

> Now my studies are finished; I can look back. And thus I have infinitely much to be thankful for, Herr Professor. To you primarily and almost exclusively. I thank you for all you have given me of knowledge and comprehension about physics. But above all I thank you for being permitted to learn from you a love of physics. I think that is the most important and finest thing I could learn. I am happy to have known you and am proud and glad to be called your pupil.

After Franck's personal intervention, the von Hippels were able to leave Istanbul, and his son-in-law started his research work with Petersen at the Polytekniske Læreanstalt in Copenhagen.[87] In the early spring of 1935 there was a proper

Figure 87 The families in Tisvilde. From left to right: Lisa Lisco, Arthur von Hippel, Dagmar von Hippel, Ingrid Franck, Edward Teller, James Franck, and the Hippels' two children, Peter and Arndt. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

reunion of the entire Franck family, when Bohr let them all stay in his summer cottage in Tisvilde. Franck clearly needed the vacation to relax, as his circulatory system was troubling him.

Still no permanent position could be found for von Hippel, and the Liscos had to return to Berlin because Hermann had to acquire his professional license. Lisa was working as a physiotherapist at the Jewish hospital. Franck decided to divide the money from his Nobel Prize between his two daughters so that their families at least could have some financial security; the gold medal he entrusted to Niels Bohr for safekeeping in Copenhagen.[88] His own research was not going well, as he informed Born: "My nuclear physics at the moment is expiring in papers that are finished up just as someone else is publishing the same in *Nature*."[89] Since he had accepted the offer from the university in Baltimore, berths were booked for the Francks' voyage to America on June 20. But before Franck left Europe for good he visited his mother and sister in Berlin. He also said good-bye to Planck, inviting him to join him in Denmark for a few days. Planck's answer deeply moved Franck:[90] "No, I cannot travel abroad. On my previous travels I felt myself to be a representative of German science and was proud of it—now I would have to hide my face in shame."

Franck found it very hard to take leave of his friends and Germany. "I can't muster up all that great an enthusiasm for the voyage to America," he confessed to Heinrich Kuhn in a letter dated 11 June 1935. "[W]e are too well off here for that."[91]

CHAPTER 7

America—A New Home

Mrs. Franck stayed in Copenhagen, as her husband first wanted to find a suitable place to live in Baltimore. When the lease was signed and everything else was settled, she would follow. After Franck found a pretty residence, Ingrid boarded a ship and Franck went to collect her in New York in October. Their household effects and the wedding present, the grand piano, had still not arrived, though. So they bought a set of bedroom furniture and camped out in the empty apartment for a while until life could gradually normalize again.[1] Their maid Mae, of African American origin, proved to be an excellent choice and became a trusted permanent member of their household. With her help the family was able to adjust to life in America, as they were no longer visitors for just a few months at a time. Franck joined a self-help organization for German immigrants. Paul Tillich, the anti-Nazi socialist, was its president and Elsa Brändstroem, Ulrich Stolper, and his brother Toni were among its directors. Its aim was to offer financial aid and advice to recent émigrés to help them adjust to their new surroundings. Franck also subscribed to *Der Aufbau*, a newsletter that the German Jewish Club in New York had been issuing since 1 December 1934. It brought news from Germany and notified its subscribers about important legal requirements affecting immigrants. There were useful tips about life in the new homeland and how it differed from Germany. A longer article discussed the political mood at American universities and among students:

The tone over here [in Chicago] at the Medical School is apolitical. I haven't heard any anti-Semitic remarks yet nor have I heard of any such experiences by other Jewish students. There is no discrimination against Jewish students at the Medical School. However, a whole series of hospitals do not accept any Jewish trainees or only in exceptional cases, even though they do have Jewish doctors among their "staff." One does also occasionally hear views like "Hitler is doing a damn good job over in Germany"; and no unions accept Jewish members. This is simply accepted as natural, without there being any propaganda for or against it; and, on the other hand, purely Jewish "fraternities" exist with activities of zero public impact.

The research work at Johns Hopkins got started. Yet, as Franck wrote to Kuhn,[2] "Actually it is a darned poor and limited institute, but somehow things will work out."

As a member of the university, Franck had to adjust to the American academic system. Unlike in Germany, each university was set up differently and had its own funding mechanisms. The composition of the student body differed as well. Some universities did not admit Jewish students; others were very liberal, like Johns Hopkins with its relatively old tradition. The students took only written examinations. Franck was able to conduct experiments with Wood again, and Wood's talent at improvisation continued to impress him. They exposed sample leaves to pulses of light and measured the intensity of the fluorescence, occasionally checking the temperature dependence. Their paper was finished in May and sent to the editors of the *Journal of Chemical Physics*.[3] It sought to interpret the role of oxygen inside the leaf, to understand the process of light saturation. At the turn of the year 1935–36 Franck reported to Hilde Levi in Copenhagen about the progress they had made in these photosynthesis analyses before responding to her letter.[4]

Do let us hear from you again. Your letter sounded so wonderfully like home. To me Bohr's institute is a sort of home of choice, as one must, for better or for worse, tear the real *Heimat* out of one's heart. Do you ever read [Heinrich] Heine? One understands so well: "I once had a fine homeland—it was a dream." The only thing that really lasts are personal and family relationships.

Isn't it a pleasure to be able to think of people like the Bohrs? We are coming early this spring and look forward to seeing all of you again, as well as our children. If only I knew what to do for them. Life before used to pamper us so much that it is only through introspection that one can reconcile oneself to the new situation. But with Heine's—"when I think of Germany at night," etc. Read Heine, and [Friedrich] Schiller too; I now even understand Schiller's pathos; it is hard not to be emotional where "meanness rules and irrationality and the ravings of mindless fools." Well, in Nature the most magnificent laws still hold, if only we understood them. The most trivial discovery always sends shivers of wonder.

That summer of 1936 the Francks were able to see the Bohrs and their beloved Europe again. One could still dare to travel to Germany. Some émigrés, including Born, took the Olympic Games in Berlin as an opportunity to come back to Germany one more time. It could be presumed that Hitler's regime would not take any anti-Semitic measures during the Games. The government certainly flexed its muscles, but it wanted to put on a good show and impress the foreign visitors with its organizational prowess. Well ahead of time, on 29 January 1936, Hitler's deputy Rudolf Hess instructed regional leaders that all posted signs should "state, without particular viciousness, that Jews are unwelcome." But they should avoid spelling out any punitive measures against them. The headline of the July 1 issue of *Der Aufbau* read: "Anti-Semitism in Hitler's Germany, an international problem."

A member of the French parliament, Salomon Grumbach, remarked:

> When in September 1933 the plenary session of the League of Nations had to concern itself for the first time with the "Jewish problem" in the shape it took during the Third Reich as a consequence of official anti-Semitism by the Hitler government, the world could still think that despite everything this was merely a "domestic German affair" . . .
>
> So, after the victory of the "doctrine of the Nordic race," one really ought to have foreseen that emigration during a period of general peace would inexorably lead to immensely difficult problems for states initially experiencing the influx of emigrants; and that states neighboring the Third Reich would in the first place soon be set before the dilemma: either facing the charge of inhumanity by refusing to take in the Jewish refugees (who make up the largest part of the total emigration); or else, by letting them in, multiplying the economic problems that every state is currently experiencing . . .
>
> In fact, starvation, slow death by denial of the right to work, is threatening hundreds of thousands of German Jews and "Christians of non-Aryan origins." Emigration is the sole means left to those who do not want to die like a baited animal without the least attempt at self-defense. The world now knows that two to three hundred thousand people are affected; women and men, the elderly and children forced to leave a country that they held to be their fatherland, that they had served, and in whose cemeteries their loved ones had been laid to rest, to look elsewhere for their sustenance, the right to live that Adolf Hitler's Germany is denying them.

Franck visited the Liscos in Berlin and met his third grandchild, little Barbara.[5] His mother, Aunt Frieda, and his own sister and brother were still in Germany. They discussed whether they too should emigrate. The Liscos were soon able to leave for America and found an apartment in the same building as the Francks. Lisa and baby Barbara spent the night before their departure at the Hahns' home, and Hermann stayed with Lise Meitner. In America Hermann Lisco found a job as an "instructor" of pathology. His father Eduard lost his position as headmaster in Göttingen for denouncing national socialism. His son's marriage to a Jew was surely as much to blame.

Franck traveled on, to Copenhagen, where the von Hippel family was still living. Bohr's annual informal physics conference was taking place in June and Franck would attend. It was an illustrious gathering of more than sixty physicists. Among the participants only two were women: Lise Meitner and Hilde Levi, who was now working for Hevesy at the local university. Once again nuclear physics was the main theme. Two years before, Lise Meitner had convinced Otto Hahn to join her in looking for the transuranic elements that Enrico Fermi claimed to have found by bombarding uranium with neutrons. She discussed possible models for the atomic nucleus with Heisenberg, as her experiments on α-decay had important bearings on the theory.

Back in Baltimore, Franck worked on a response to a paper by Kurt Wohl. It allowed him to delve a bit into the energy relations of photosynthesis. Wohl had found that four light quanta sufficed for the process. Karl F. Herzfeld, the Viennese now at the Catholic University of America in Washington, collaborated with Franck in taking a closer look at the energy requirements of individual reactions. The article's acknowledgments reveal that they also consulted with Edward Teller.[6] Their results were presented at the symposium on molecular structure at Princeton at the turn of the year. Franck and Herzfeld were already writing a lengthier paper, An Attempted Theory of Photosynthesis.[7] It included recent results published by other scientists and addressed objections to their own theory:

> One might question whether one should try to write specific photochemical reactions in view of our present relatively small knowledge of photosynthesis, but firstly such discussions lead to new experiments, and secondly it seems important to see whether it is possible to account for this biological problem without deviation from the usual laws of physics and chemistry.

They welcomed Hans Gaffron's concept of a "photosynthetic unit": the carbon dioxide is absorbed not by a single molecule but by a large set of chlorophyll molecules. A point made toward the end of the article, that plants need a protective mechanism against the too intense energy of light quanta, was important for future research.[8]

Franck's publications from this period reveal how few coworkers he had and how modest was the apparatus made available to him.[9] The university could not afford to hire more staff. The American economy was still in the depths of a depression, despite efforts by the federal and state governments to come to grips with the mass unemployment.[10] The jobless figures were in the range of twelve and thirteen million, and private charitable organizations and the Red Cross reported more than twenty million aid recipients. The gross national product in 1935 dropped to 66.7 percent of its 1929 level.

Despite this dire state of the economy, the Rockefeller Foundation was willing to support Franck in Baltimore. He received a grant of $10,000 for the purchase of apparatus. But scientific instruments are useful only if the right people are available to operate them. Opportunities for émigrés in the United States had virtually disappeared; not even physicists with an international reputation, like Born's doctoral graduate Lothar Nordheim, could find a position. Franck could not accommodate Rabinowitch either, because he was not allowed to hire a German assistant. So he did not manage to re-create the highly productive working environment that had ensured such enduring success for his research at Göttingen.

To this were added private financial worries. His mother, aunt, and sister could follow him to America only if he could vouch for their livelihoods.[11] Lise Meitner's fate in Berlin was equally uncertain and he wondered how he could arrange for her emigration to the U.S. He did not have much money in the bank, so the only way to get the immigration permits would be to offer his life insurance policies as "collateral." But his own financial security was of first urgency.[12] He negotiated in vain with the university treasurer about a pension. The ability to communicate was apparently undercut in part by the treasurer's anti-Semitic bias. The university president, Isaiah Bowman, tried to settle the issue directly with Franck.[13]

From Baltimore to Chicago

It was in this situation that Franck received an excellent offer from the University of Chicago. In 1939 Samuel S. Fels would be donating $25,000 for research in science, medicine, and related fields.[14] It was not long before Fels's commitment was increased further. A board directed the fund, but Fels took a personal interest in its distribution and evidently found Franck's research on photosynthesis interesting. The fund was prepared to cover Franck's salary at the University of Chicago, along with some apparatus purchases. In May Franck heard from Professor Hogness.[15]

> I want to take this opportunity to tell you how glad I am that you are coming and that the other members of the faculty feel the same way. I am sure that your presence here will add a new note of inspiration to all of us.

Since its founding in 1896, the University of Chicago had attracted such famous scientists to its staff as the zoologist Charles O. Whitman, the astrophysicist George Ellery Hale, and the physicist Albert A. Michelson.[16] Another prominent member of the faculty was the historian William E. Dodd. This South Carolinian born in 1869 had attended history courses at Leipzig in Germany. After a period of teaching in Virginia, he had received his appointment to Chicago. President Woodrow Wilson chose him as an advisor and so did Franklin D. Roosevelt, who sent him to Germany as ambassador in 1933.[17] Dodd left no doubt about what he thought of Hitler. He refused to join the diplomatic corps at the Nazi party convention in Nuremberg. The State Department was not pleased and he was recalled. His opposition to national socialism may have been a motivation for the university board to decide to appoint James Franck. One Swede, Anton J. Carlson, was among the faculty at Chicago, but there was little contact between this physiologist and Franck. The rambling campus, located in a neighborhood of large residences, was very different from German university grounds, with its large sports stadium and neo-Gothic buildings. Even its clinics, built in 1927, resembled the style. Professors could meet for lunch or dinner at the faculty club, the Quadrangle Club.

In Germany academic life was completely dominated by National Socialist ideology. The University of Göttingen celebrated its bicentennial during the summer semester 1937 with much pomp and Nazi fanfare.[18] Friedrich Neumann was its rector, appointed—not elected—as the university's *Führer*, in true Nazi style. His address did not waste a single word on Born, Courant, Franck, or even Hilbert. Only Gauss, Weber, and Felix Klein were granted honorary mention. General Karl Becker, professor of defense technology from Berlin, gave a menacing prescription for what science was expected to do for the Third Reich:

> If science offered us a new weapon, the significance of which is properly recognized, the preparations for which are timely, and the production of which is in sufficient quantities and strict secrecy and is then suddenly and mercilessly deployed when needed, it could be a pivotal factor in a war.

Under the motto "science and belief" Minister Rust broached the race issue:

> For us race is not just the subject matter of a discipline under that label but the fruitful and bearing principle of the humanities as a whole. Biology is older than National Socialism. But even it did not know what treasure trove it had uncovered.

As the years went by, Franck drastically limited his correspondence with friends in Germany. He wanted to avoid getting them in trouble. But he was still very concerned about their fates. He was able to hear from Max von Laue through his son Theodore, who had come to Princeton in 1937 to study history, and immediately sent a package of food to the Laues when he heard about dire shortages in Germany. When Theodore occasionally came to visit, he brought his violin along to play duets with Mrs. Franck. Her husband took pains to impress upon the young man the importance of democracy.

The *Aufbau* brought shattering news from Germany. Its first April issue contained a report by a Jew who had managed to escape from a concentration camp. It outlined the conditions to which Jews were subjected there, besides the debilitating, life-threatening starvation.

> One time, twelve prisoners were condemned to hang for two hours with their hands tied above their heads in such a way that their toes just barely brushed the ground. A number of Jewish prisoners have already committed suicide and others have become crip-

ples for the rest of their lives because they were not physically strong enough to endure the compulsory labor. Last spring there were 2,500 detainees in the camp; during the summer we had to build 36 new barracks because other consignments were expected.

In the May issue Rudolf Brandl wrote under the heading "Menschendämmerung"—the twilight of humankind:

Whoever condemns Hitler as the great ravager of our day—and there are many who do—is turning the facts upside-down: Someone with an eighth part of an education, exhibiting clear traits of a psychopath, who had been loafing around for years on the fringes of the riff-raff proletariate, could only become a destroyer of monumental proportions because his contemporaries' civic substance had become so rarefied that even the professed defenders of humanity have taken to their heels.

Brandl complained that Jewish representatives in the French and British governments were not challenging the Nazi regime. Foreign powers simply tolerated the Third Reich's "annexation"—that is, military occupation—of Austria.

Lise Meitner automatically became a German citizen as a result. The new racist laws suddenly applied to her case as well. Dutch friends came to her rescue. The physicist Dirk Coster helped her flee in July via Holland and Copenhagen to Stockholm. On 23 October 1938 Franck wrote her a long letter to congratulate her for her sixtieth birthday on November 7. About forced emigration he remarked:[19]

I know it is a hard piece of work on one personally to leave one's friends, an institute that one had partly built up oneself and in which one had created a [research] tradition, and the entire closer or more distant environment in which one had become rooted. And yet, dear Lise Meitner, there is basically something good about our being forced to build something up again at our age; and it will at least prevent us from making ourselves too comfortable on the last rung in Haber's ladder of humanity—to be—to doubt.

For egoistic reasons I would have rather seen you settled in the U.S.A. but in your own interest we are glad that it has become Sweden. Scandinavia almost seems to have become the last European nook of refuge for European civilization.

He then reported about their life in Chicago.

The apartment is nice, if not as prettily located as in Baltimore. It is a full floor in the style of a Charlottenburg rental residence on Wielandstrasse. Autumn is almost the finest season and today is the first inclement day at 2–3 degrees. It has been mellow summer until now. We are encountering many nice people but naturally do miss the children. At the institute I have 3 large rooms and we are starting work with a total of 6 people: 2 assistants, 1 colleague who is spending his sabb. year with us, and 2 students. Funds are available for the purchase of apparatus; I just have to accustomize myself to the lack of many little things in a chem. department that one had taken for granted in a physics department.

Ingrid is feeling quite well; she is getting used to the new surroundings. I urged my mother and sister to join us; I don't know if they will do so; the decision will probably be made soon.

Ingrid then added her own birthday greetings.

The letter does not mention the expansionist policy the Third Reich was pursuing as it resorted to increasingly drastic measures at home. Through threats, tolerated by the British and French governments, Hitler succeeded in occupying parts of Czechoslovakia. It was only a matter of time before the rest was annexed.

During the night of the ninth of November 1938, the storm that Goebbels had organized against the Jews broke loose. Ninety-one unpunished murders, many desperate suicides, countless acts of violence and arrests of Jewish citizens, the pillaging of virtually all of Germany's synagogues, and looting of Jewish-owned stores—what a horrific accounting.

Franck received a telegram from his mother urgently requesting an affidavit for herself, and his sister. He sent them out with notarizations together with a letter of recommendation and warrantee by the university to the Danish consul. A cousin also received an affidavit. Fritz Reiche and his wife were still in Germany. Would they be able to escape?

A number of Franck's closer friends were rapidly approaching their sixtieth birthdays. In the coming year Einstein at Princeton reached this milestone, as did Hahn and von Laue in Germany. The letter to Hahn had to be very carefully worded, since Franck knew from reports in the *Aufbau* that there could otherwise be dangerous consequences for him. His birthday greetings were followed by a discussion of the discovery of nuclear fission, the unexpected result of Hahn's research on the transuranic elements.[20] The American papers were writing about it in a relatively reasonable way, Franck told him. "The New York Times," he wrote,

legitimately named your discovery "the greatest event since the discovery of radioactivity." We were naturally also pleased about the contribution that our friend L[ise] has made to it.

It is difficult for us to write to you about all the emotions we feel for you over such a long distance and between men it is not particularly customary either. So just let me say that your friendship and company in war and peace has always been a great pleasure for me; and at the present time, when I am living to a large part off memories, your rare rectitude and staunchness in finding the right way in the chaos of life gives me confidence that mankind ultimately does not have to be so much a *race maudite*."

The fissibility of the uranium nucleus by neutron bombardment announced in Otto Hahn's and Fritz Straßmann's paper, and theoretically interpreted by Lise Meitner and her nephew Otto Robert Frisch, at first seemed to be a purely

Figure 88 Otto Hahn. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

scientific discovery. Just a few weeks later, in March, physicists in France and the United States found out that two or three neutrons are typically released by fission. These neutrons would be capable of splitting further uranium atoms. So a chain reaction with an explosive release of energy seemed feasible. The word *U-Bombe* began to appear. A few of Franck's former colleagues were even experimenting with neutron emission. Edward Teller, Eugene Wigner, and Leo Szilard had been keeping in touch with each other since their Göttingen period. Szilard realized the serious risk posed by bomb development inside Germany. Where would that lead? Teller may have occasionally discussed this problem with Franck in Chicago, even though Franck was not yet involved, either directly or indirectly, in their activism.

Franck's new secretary, Mrs. Norene Man, also had some German skills. She would continue to assist him with his correspondence for years, until 1956. Here in Chicago Franck could redouble his work on his newfound interest. He wrote to the Liscos at the start of 1939:[21] "I'm possessed again with photosynthesis, which is proving to be a cross between a Moloch and a Medusa. The more determined am I to understand it; and I've already come at least a little bit further."

The first paper to be published after his arrival in Chicago was coauthored with Edward Teller, who held a position at George Washington University. A number of physicists had been examining photochemical processes in crystals and on their surfaces for some years already. Notably, the Russians Jacov I. Frenkel and Rudolf Peierls in England had published important results about how a stimulating beam directed at a crystal is transferred inside its lattice. Franck and Teller took this as their starting point for theoretical considerations that became the germ of the later theory of excitons.[22] Franck and Teller were able to verify their notions from the analyses by Gerhard Scheibe and his collaborators of fluorescing crystalline organic substances. The next step was applying these notions to chlorophyll. It was revealed that the molecule had to have the capability to transform incoming blue light to an energetically lower level corresponding to red light. (This process was later confirmed.) Further observations about the conduction of the excitation led to the conclusion that the process of photosynthesis must occur very rapidly, in approximately 10^{-10} seconds. Their theory found application in the sensitization of photographic emulsions.

This concentration on science, however, could not always distract Franck from the impending global conflict.

The *Aufbau* of 1 June 1939 granted front-page space to Edvard Beneš, the president of the Czechoslovakian republic whom Hitler had just ousted. His message was "We must all stand together." In the modern world, dictatorship and democracy could no longer coexist, he declared. One of them had to eventually give way, and he believed that it would be dictatorship. On page 7 of the same issue under the heading The Spirit of Faith, Albert Einstein stated his position on the British government's assurances to the Arabs about limitations on Jewish immigration into Palestine:

> England has, in part, ignored its sacred pledge. She gave her word then in a dire hour and she is acting now, too, in a dire hour. Remember, however, that in the life of people, and especially in times of need, there can be only one source of security, namely: confidence in one's strength and steadfastness. We are justified indeed in this feeling of confidence. For what the Jewish nation has achieved in Palestine through the self-sacrificing efforts of the pioneers and through unselfish voluntary aid by Jews in other lands bears witness to extraordinary productive force.

In this article, written in English, Einstein warned that there could be no greater misfortune than constant quarreling between Jews and Arabs. His conclusion:

> This spirit of faith carried our forefathers through times of greatest distress, so that our productive force—unbroken through millennia—contributed to the enrichment of human culture. Let us be steadfast, so that future generations may be justified in saying the same of us.

The famous writer Thomas Mann was worried about Germany's fate and decided to contact a number of prominent personalities. He sent his brother Heinrich, the well-known novelist, the following appeal. Other recipients were the political activist Hermann Rauschning, the stage director Max Reinhardt, the author Stefan Zweig, the Austrian expressionist writer Franz Werfel, the Christian existentialist philosopher Paul Tillich, the physicist Erwin Schrödinger, and James Franck:[23]

> Esteemed Professor,
>
> In the midst of tumult and uncertainty, in the midst of threats of war and new "appeasement," one thing is taking increasingly definite shape: the decision must and will fall inside Germany. As long as the German people do not free themselves from this

"leadership," there will be no lasting peace in the world. We have known this for a long time and the world is beginning to grasp it. We also know that the Germans basically hate their regime and that war is the only thing they fear more than Hitler.

It is established that within the last half-year a considerable number of Germans to whom neither "political" nor "racial disrepute" could be attached have left their country, simply because the November pogroms or the propaganda campaign against Czechoslovakia had been too much for them.

It is essential for Germans inside and for us representatives of intellectual Germany outside that we open a dialogue.

Our voices will be heard at home if only we make ourselves stridently audible enough.

Thomas Mann wanted to organize the dissemination in Germany of 24 pamphlets authored by émigrés throughout the course of the following twelve months. His letter closed with the lines:

Only if Germans put a stop to Hitler can war be avoided. If it is not forestalled, only if Germans refuse their service to the regime before the defeat can we hope for a peace that does not once again bear the germ of a new war. The Germans have to be brought back to reason; and who else should do so as long as we remain silent?

The Mann family also lived in Chicago, and Franck may very well have discussed this appeal with Thomas Mann in private conversation, explaining to him why he could not offer to contribute to the series. Peter Pringsheim, a former collaborator of his, was Thomas Mann's brother-in-law.

Niels Bohr briefly visited Franck in Chicago during one of his trips to America and was able to appreciate the improved research facilities placed at his disposal.

World War II—Yet Research Unabated

Thomas Mann's suggestion came too late. Hitler invaded Poland on September 1 and two days later Britain and France declared war on Germany. Poland was overrun and capitulated. Under the headline "Chosen—Also in this battle! The fate of Jewry as a whole is at stake," Franck could read in the *Aufbau* of 15 September 1939:

Now the world has its war. The war it wanted to prevent and did nothing to prevent. Egoistic and social interests and an almost incomprehensible stupidity in grasping the situation, on one hand, megalomania, bloodthirsty and manic imperialism, on the other hand, have managed to transform Europe into a battlefield . . .

Amongst these nations we Jews stand. So distant are we from this event that not even a Hitler could coax out of us more than a few bellowing habitual clichés to link us with the gruesomeness now going on. . . .

If anyone before this war had to tremble with anxiety about his brothers, then it was a Jew. . . .

No one will be able to ignore this war. Most people are still only just beginning to realize this. It is part two of the World War and its consequences will continue to destroy life as we know it. In irreparable breadth and depth. The atrocities that have already happened are mere child's play against what is yet to come. . . .

This war will be the most abominable and comprehensive slaughter that the world has ever seen. It must become so because it was started by the most abominable and thorough murderer ever to pose as national leader.

Research on the processes involved in photosynthesis offered welcome respite from the problems of the day and worries about the future. Apparatus that Otto Warburg had developed to measure gas conversions in photosynthesis was now operational in Chicago. Robert Livingston and Franck analyzed assimilation by leaves exposed to light. They used the variety *Hydrangea otakusa*, supplied by the local botanist Ezra J. Kraus. Livingston, from the School of Chemistry at the University of Minnesota, had been researching photosynthesis for some time already. Together they measured the influence of higher concentrations (up to 1.2×0.03 percent) of carbon dioxide than in the air that plants normally consume. Analyses on this already existed dating back to the nineteenth century, but their accuracy could now be improved upon. Experiments were conducted not only with fresh young leaves but also with older ones. Seasonal influences on leaf development were also taken into account. They found that even high carbon dioxide concentrations do not

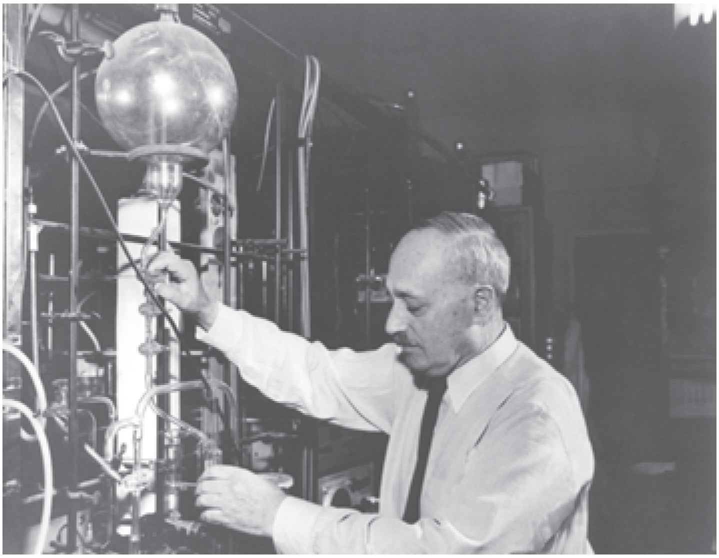


Figure 89 James Franck in the laboratory at Chicago. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

completely inhibit the process of assimilation, but it depends on the age of the leaves. Young leaves evidently tolerate higher concentrations. A leaf could be conditioned in stages to be able to take higher concentrations of CO_2.[24] Their article, published in the *American Journal of Botany*, contained few theoretical considerations.[25]

Half a year later, the next manuscript was submitted to the *Journal of Chemical Physics*. It involved the extinction of fluorescence in dyes and expanded upon ideas that Franck and Herzfeld had already proposed. It discussed various molecular conditions, such as collisions of the second kind between a dye and its solvent.[26] Their interpretation of Teller's theory on the conversion of excitation energy by collisions between excited molecules identified an alteration in the spatial configuration of larger molecules leading to the quenching of the fluorescence.

In February 1941, two other longer manuscripts were finished. Franck had two new collaborators: Charles French, who had worked with Otto Warburg in 1934–35, and Theodore Puck, who was a Gustav F. Swift Fellow in Chemistry. Fluorescence measurements were made again, this time with apparatus that was more modern. It was possible to vary the intensity of the exposure over a broad range as well as its duration. A photocell with a connected amplifier permitted measurement and registration of rapid processes of down to 0.1 second. The experiments by others, such as E. D. McAlister and Jack Edgar Myers at the Smithsonian Institution, could now be checked and extended. Hydrangea leaves were again used as samples. While working with these high-speed recordings, they observed a steep rise in the fluorescence just after the leaf had been exposed. Other experiments were performed with high carbon dioxide concentrations to study the induction phase of the photosynthetic reaction. The influence of periods of darkness as well as temperature was likewise examined.[27] Like other scientists, they too used HCN to analyze the inhibition of fluorescence. The subsequent discussion of the experiments was more a tentative exploration of the various possible chemical reactions, applying Gaffron's idea of three catalysts for the process, without yielding any concrete conclusions. All this was dealt with theoretically in a detailed publication almost fifty pages in length coauthored with Herzfeld.[28] Following allusions to other theories, it states:

> We hope the same will be true for the following theory; at least we have convinced ourselves of its usefulness, since a great number of experiments on photosynthesis performed in the laboratory of one of us during the last few years have grown out of problems by the point of view expressed below.
>
> These last remarks, superfluous for most readers, are made because discussions have convinced us that all of the workers in this field realize that one of the main purposes of a theory is to induce new experiments and that by its very nature a theory can contain only a partial truth.

The authors argued that photosynthesis probably required between ten and twelve quanta and that the reaction had to proceed in a number of steps, perhaps eight. Acceptor molecules had to be present for the CO_2. The theory of three catalysts was again presented. New findings forced them to abandon the concept of a photosynthetic unit.

After a longer pause in their correspondence, Franck wrote another letter to Max Born on 20 July 1941. It was the first written in English, but it was difficult for him to adjust to this new idiom.[29] He first reported about his children. The Liscos were in Boston; his son-in-law was in medical school at Harvard. The von Hippels were also there; Arthur had a position at MIT in Cambridge, Massachusetts. The now more numerous grandchildren were also mentioned. The Francks were housing his 81-year-old mother and 76-year-old aunt. When they had left home for America, these elderly women had been strictly forbidden to take more than the absolute essentials out of the country. For instance, only one knife, fork, and spoon were permitted for their personal use. Franck's younger brother Robert Bernhard likewise succeeded in getting out of the country, emigrating to Brazil, but contact with him remained loose.

Franck continued to devote a considerable amount of time to helping others in need. The moment he had heard about the food shortages in England he had sent the Borns a caringly packed selection of groceries. He made sure not to mention the situation arising out of the German occupation of Denmark. That would have been too risky for the Bohrs, Hilde Levi, and other friends of his. No less so for Coster and Rathenau in Holland and Peter Pringsheim, who had fled to Belgium. His letter should give away nothing, just in case it got into the wrong hands.[30] Nor does it discuss the truce with France and its occupation.

Articles in the *Aufbau* about German atrocities against Poles and Polish Jews became increasingly frequent. There were rumors of plans for a huge ghetto for all Jews in Lublin on the eastern fringes of Poland. Franck was concerned and urged Lise Meitner again to come to the States. But she again declined. It was not the voyage that worried her but the bad professional prospects in America.

Hans Gaffron's contributions on photosynthesis had occupied Franck on more than one occasion. He was to become Franck's collaborator for the next five years. Gaffron was twenty years younger than Franck. He had studied chemistry at Friedrich-Wilhelms-Universität in Berlin and had been working in the Kaiser Wilhelm Institute of Biology in Berlin since 1925. He too had collaborated with Otto Warburg, where he had done some research on the photochemistry of dyestuffs. In America he collaborated with Cornelius van Niel on photosynthesis in bacteria and found that their oxygen releases were not related to the photosynthetic process.

The first joint publication with Franck appeared under the title Photosynthesis, Facts and Interpretations, in the first volume of the periodical *Advances in Enzymology*. Its chapter titles survey the topics covered.[31]

I. Quantum Efficiency
II. Saturation Phenomena
III. Induction Periods
IV. Photo-Oxidation Processes in Plants
V. Metabolism of the Purple Bacteria and van Niel's Theory of Photosynthesis
VI. Carbon Dioxide Reduction in the Absence of Oxygen and the Reduced State of the Assimilating System of Plants
VII. The Reduction of Carbon Dioxide in the Dark

Carbon 14 analysis is mentioned in chapter III. Organic radiochemistry proved to be another useful experimental tool for identifying photosynthetic processes, and Franck's correspondence with Samuel Ruben at the University of California discusses his experiments with $^{14}CO_2$ as such a tracer.

Despite the war Franck managed to keep in touch with a few scientists in neutral European countries. Arthur Stoll in Basel, for example, received a copy of his joint paper with Herzfeld and replied on 3 October 1941:[32]

> Esteemed Colleague,
>
> I would like to thank you cordially for forwarding the offprint "Contribution to the Theory of Photosynthesis" from the "Journal of Physical Chemistry." I perused this article with great interest as well as the article "Photosynthesis" by you and Mr. Gaffron in the first volume of "Advances in Enzymology," which surprisingly appeared promptly even here at the bookstore. The application of exact physical methods and choice of suitable organisms appear to have largely secured the decomposition of photosynthesis into subprocesses and I would like to congratulate you very much on your new results.

Three more publications from the University of Chicago Department of Chemistry Fels Foundation-funded program appeared in 1941 bearing Franck's name. With the chemical engineer Sol W. Weller he analyzed photosynthetic processes using flashes of light.[33] As at Göttingen, Franck was rarely content with the first results obtained and immediately sought verification by modified experiments. His second paper with Herzfeld had already speculated about the problem. The new results obtained from the algae *Chlorella pyrenoidosa* appeared to confirm the three-catalyst theory. An experimental analysis of photo-oxidation together with Charles French, completed in July, offered a more comprehensive examination of the theory. It was found that another process besides photosynthesis takes place in a leaf when exposed to light: oxidation, that is, a form of chemical decomposition.[34] Intense radiation can cause photo-oxidation to overtake the photosynthesis and destroy the plant. This was chapter IV of the publication with Gaffron (see above). Hydrangea leaves were exposed in a modified Warburg apparatus. The leaf was rotated during exposure and CO_2 was completely absorbed by the KOH solution at the bottom of the vessel. They manometrically measured the oxygen consumption, which is a gauge for the oxidation process. The values obtained during exposure and in the dark agreed well with results by other authors, such as Warburg. They added a new step to the analysis: dipping the leaves in boiling water before taking the measurement. Even after this treatment the leaves continued to absorb oxygen under exposure to light or in the dark. So this reaction is not related to living vegetable tissue. The two authors discussed two alternative processes: Is photo-oxidation an inhibitor of photosynthesis? Or is it a process involving chlorophyll attached to a protein?

On December 24 the editors of the *American Journal of Botany* received Franck's manuscript about the evolution of carbon dioxide during the induction period of photosynthesis.[35] In it he discussed recent findings by Robert Emerson and Charlton (Tony) M. Lewis in the Carnegie Institution at Stanford, interpreting them as a back reaction, as he had indicated in his joint paper with Herzfeld.

Franck remarked about this research in a letter to Lise Meitner:[36]

> It is completely different from physics. There the simplest solution is almost always the right one, but this is absolutely not so in living tissue. Nature had the time to take very complicated paths to the solution, as they mostly offer safeguards against slip-ups. I believe I understand the physico-chemical side of photosynthesis; the chemical side, which actually interests me less, I try to understand as far as it is possible for me.

Franck's work and approach toward understanding these processes was much appreciated, and colleagues in the field sent him a number of invitations to speak about the subject. The Society of the Sigma Xi ("Devoted to the Promotion of Scientific Research") asked him to introduce a more popular audience to the research on photosynthesis. Franck opened a discussion of the kinetics of reactions with very simple observations about the stability of organic substances. Clear drawings illustrated how a reaction proceeds in stages upon exposure to photons.[37]

He mentioned new results by Robert Emerson and William Arnold indicating that photosynthesis takes place at the unusually high speed of a hundredth of a second. A portrait of Franck preceding the published version of this talk reflects his even temperament.

The year 1941 brought two further dramatic developments in the war. As commander in chief, Hitler ordered an assault on the Soviet Union on June 22. On December 7, Japanese combat aircraft attacked the American fleet in Pearl Harbor, prompting the American and British governments to declare war on

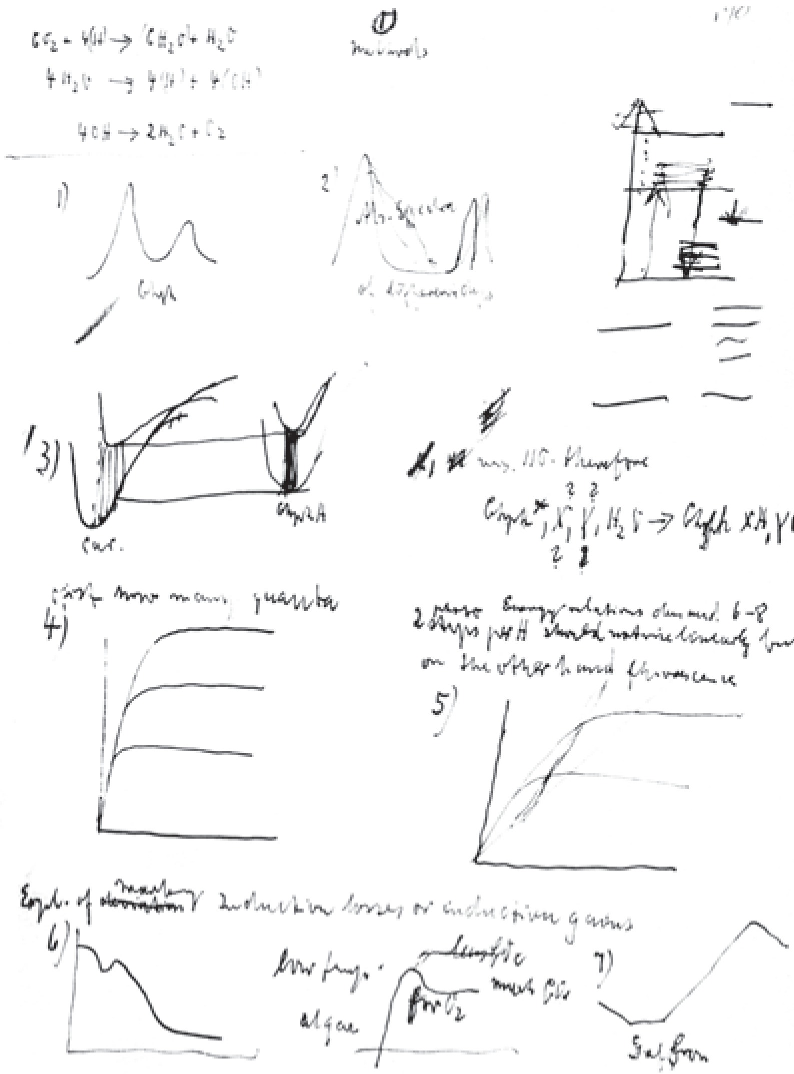


Figure 90 Figure 10 for James Franck's article: Carbon Dioxide Evolution during the Induction Period of Photosynthesis, published in the *American Journal of Botany* 29 (1942), pp. 314–317. Franck papers, Special Collections Research Center, University of Chicago Library.

Japan the following day. Hitler and Mussolini retaliated with a declaration of war on America on December 11. Now categorized as enemy aliens, German émigrés in the United States had to reckon with the possibility of internment in a camp. Only a few of them had been able to acquire American citizenship. First their radius of free movement without a permit was restricted to ten miles. That already posed problems for the Francks. How could they see their children in Massachusetts?[38] Franck was already a citizen, but neither the Liscos nor the von Hippels were. So neither of the daughters could come and care for their mother when she suffered another relapse of weakness and illness and urgently needed their company and help. On 10 January 1942 her forces failed her and she passed away. None of her siblings could come from Sweden to the funeral in Chicago, but the Liscos and the von Hippels did manage to obtain a travel permit.

It was many weeks before Franck had collected himself enough to be able to take up his correspondence with Meitner again.[39]

My dear Lise Meitner,

Accept many thanks for your two kind letters, which I received in April. I should have written to you sooner or at least have answered directly. But after this trying time, I first had to compose myself and find my way back into the stream of life. At the end of November my aunt, who was living with us, died; on January 10th Ingrid was released from her sufferings; and a week ago our elderly maid died, who had stood by Ingrid so loyally.

My aunt was old and, although I loved her too, it was more the tragedy of her death just as her children were making their way to the U.S.A. than the personal loss that shook us; and as regards the maid, she was 70 years old and it was the loss of a kindly person but not of a person to whom one was emotionally closely attached.

Now about Ingrid. She became weaker and more helpless and her sphere of activity quickly closed in on her, so a sepsis that had developed from a bladder infection encountered no resistant body and no optimistic motivation to live anymore. She would have become progressively more impaired by the multiple sclerosis and so I probably should thank fate that she was released without great subjective pain. And yet it is hard.

During the day I work a lot and forget. The company of Peter Pringsheim and Gaffron, with whom I am collaborating, is a great help as well. I will also continue to learn to think back and, as concerns the present, take pleasure in the children and grandchildren, which I have every reason to do.

He then briefly mentioned Hertha Sponer. After an interim position at Oslo she had received a professorship at Duke University in Durham, North Carolina. Despite her heavy teaching load, she had been able to do research that had received much recognition.

I also see Hertha Sponer once or twice a year, who has really developed into a trusting friend. No, I do her an injustice; she always was one, but she has turned into a mature, competent, and helpful person who has completely grown out of her little weaknesses of youth. It is you I miss. I cannot express myself in letters and I imagine that if we could talk in person, it could alleviate for you, too, the hard and uncertain times in which we live.

He also told her about how he had arranged his own life. Lisa had dissolved the apartment because his mother had moved away to live with his sister Lotte in New York, and he was living in the faculty club so as not to have to worry about keeping house.

After a dangerous and difficult escape, Peter Pringsheim had managed to slip out of Belgium and come via France to the States. His wife, Hedwig, had remained behind in Belgium. The Samuel Fels Foundation granted Franck the means to offer Pringsheim a paid position in his laboratory. In September 1942 they completed an analysis that was less immediately connected with photosynthesis. Their aim was to examine the fluorescence of a dye adsorbed on silicon dioxide—silica gel—and to understand the influence of oxygen on its extinction.[40] There were publications on this dating back forty years, but Franck and Pringsheim both had experience in theoretical and experimental analyses of such problems. Franck's idea of considering tautomeric forms—two types of molecules of identical composition but of differing configuration—played a part in their interpretation. The experiments performed on the carefully prepared samples of trypaflavine on silica gel revealed a strong quenching of the fluorescence at low oxygen pressure. At higher pressures the quenching is reduced. This contradicted standard theories. Pringsheim had already shown that two different processes had to be assumed for the two sections of the curve. The second section had to be attributed to another molecular structure whose fluorescence was hardly inhibited by the oxygen.

Gaffron, Pringsheim, and Teller tended to meet Franck in the university club for lunch—but there is unfortunately no record of any of their table conversations about politics. After a year's pause, Franck wrote another letter to Born that autumn, to report about his children and grandchildren. It expresses—in his émigré English—his feelings about the current situation.[41]

On the other hand, the time causes a greater interest in life since I want with all my heart to see still the time in which the monsters are killed off and in which mankind can start to build up again the ruins.

Since becoming involved in photosynthesis research, Franck had often critically questioned the work of other scientists on the problem, but he took pains to justify and support his claims carefully, pointing out each time that it was a matter of clarifying the issue at hand. Despite his being a newcomer in the field, this tact paid off and earned him recognition and the kind of mutual trust he had been accustomed to during his Göttingen period. Some friction did at times arise, though. Eugene Rabinowitch, who had finally found a position at MIT and was also working on the subject, contacted him. Noticing that no book about the basic elements of photosynthesis existed, he had decided to write one and asked Franck to give an assessment of his draft for the first volume. Franck replied:[42]

Yesterday I read a chapter of your book which you left with me. In reading it, I found that I am placed in an awkward position. I think you will understand that I cannot agree with you. I do not make a new theory just to make one, but because I have ample evidence that the theory of Emerson and Arnold is printably alright. I think I made it clear in my papers and those by my coworkers and now it seems that I cannot convince you.

I believe it is the case that you didn't read the papers carefully enough. But whatever the reason is, I think that you have, of course, a right to write your book according to your own judgment. I do not like to give the impression that I want to influence you in my favor, nor can I agree with what you write.

I am, therefore, concerned whether it would be better if you would desist from having me discuss the content of your book with you.

Franck had his letter typed in English because he did not always have available someone capable of taking a dictation in German. Rabinowitch's handwritten reply in German tried hard to be conciliatory.

Dear Professor,

You are surely right that I should study your papers more closely instead of bothering you with questions that you must regard as long since solved. I was counting on your old love of debate; but I have to realize that for you it is much less interesting to talk about doubts that you yourself have long since overcome than about still unresolved problems that a discussion could perhaps bring a step forward.

Rabinowitch also informed him that he would rework the theory after having first gained a more sweeping view of the field. The first volume with the survey of the photosynthetic research from 1925 onward was published with thorough citations of Franck's and Gaffron's work. By 1950 the second volume was still not ready, however.

At the end of the year Dolores Terwoord Lad from the Catholic University in Washington applied for a National Research Fellowship to work with Franck in the coming year. She needed details about the research program in Franck's department to fill out her application form. Franck hastened to send her the necessary information and additionally referred her to Herzfeld.[43] Then he listed the individual lines of research and problems under examination. The reason why it was so difficult to substitute the general scheme of photosynthesis with a series of chemical reactions was the inability to study the photochemistry in plant extracts. Active photosynthesis stops the moment the plant cell is destroyed. Isolated chloroplasts are not functional. He mentioned research by Pringsheim on cell-free plant extracts that release some oxygen upon exposure to light. They were working on a method to measure very small quantities of oxygen. Pringsheim was in the process of developing a procedure that would permit measurement with the exposure reduced to a single flash of light. They had a sensitive apparatus for measuring released CO_2, gauging its infrared absorption. Other projects were of a more biological nature, such as studying the effect of longer exposure times. Otherwise they were also researching the process of photo-reduction discovered by Gaffron.

CHAPTER 8

A Scientist's Responsibility

The subjugation of over half of Europe's population to the yoke of national socialism with its racist insanity was a constant theme in *Aufbau*. More and more reports about new ghettos appeared. The issue on 8 December 1941 published a letter about the concentration camp in Mauthausen in Upper Austria, where Jews from Holland were being held. A high-placed Nazi was quoted as saying: "Mauthausen, nobody comes out of there alive; and if the war ended tomorrow, the remainder would be knocked off today. It's poison gas that kills them."

Physicists in England and America were already becoming anxious that an atomic bomb could become a reality.[1] A few had begun to consider what plans might be brewing in Germany and whether preliminary research was even under way. The native Hungarian Leo Szilard had taken the lead in viewing the situation pessimistically. A couple of years before, he had visited Einstein about it, who knew him well because they had filed a number of patents together in Berlin. Edward Teller had accompanied him. Immediately recognizing the potential threat, Einstein had discussed with them their various options. Writing to the Belgian court was one. That country had large stockpiles of uranium ore and Einstein was acquainted with the king. Another option was writing to the American president. Choosing the latter, they had sent out a letter on 2 August 1939. But practically nothing happened. Belgium had not yet been invaded by German troops in spring 1940 when Szilard visited Einstein again, this time accompanied by Eugene Paul Wigner; and another letter had been drafted and sent out, this time to Roosevelt's advisor Alexander Sachs. The wheels had then slowly begun to turn. Inquiries were made about the feasibility of such a lethal weapon. That was the start of a technological program of unprecedented and unanticipated proportions. This bomb's destructive power would certainly be greater than any weapon that had ever been developed, and the radioactive fallout from the explosion would contaminate huge areas.

Who in America should bear the responsibility for the decision to use such a devastating bomb? The military? Politicians? Scientists? What would be the target? Would it hit Germany without fail? Would it hit Hitler and his helpers' helpers? Would it put an end to their murderous regime?—In a single blow? Would it kill many innocent people as well? Would opponents of Hitler also die? Would one's own friends be among them?

Few of the scientists working on developing the American atomic bomb were Germans, émigrés whom Hitler and his minions had pushed out. Only one of them had personally experienced the horrors of war: James Franck.

How did they feel about developing a weapon that was supposed to land a fatal blow on Hitler, but that in all likelihood would snatch away the lives of their own friends in the process?

Not a single line exists from this period about the thoughts and feelings of these men, nothing about their moments of doubt. Franck never spoke about it, not even with members of his family.

It was only in mid-1942 that a moment of urgency was added to the preliminary inquiries into the feasibility of building an atomic weapon. Various lines of research were pursued in parallel: designing a test reactor, breeding plutonium, and isolating uranium isotopes by means of diffusion or using a large mass spectrometer yet to be built. An additional group occupied itself with the risks posed by radioactivity. A separate group of scientists—separate also geographically speaking—worked on the actual manufacture of the bomb. Otto Robert Frisch was later in charge of experimentally determining the critical mass, and others dealt with the ignition mechanism and other details. It was directed by Robert Oppenheimer.

Enrico Fermi began to construct a uranium reactor with graphite as the moderator at the University of Chicago under the code name "Metallurgical Laboratory." The émigrés involved in this "Met Lab" project were subjected to rigorous security controls before being granted authorization—and American citizenship.

The Nobel laureate in physics Arthur Holly Compton was placed in charge of the multifaceted physical and chemical research under way at Chicago. It soon became evident that a person with experience was needed to coordinate the chemistry division. Compton brought up the subject during a staff meeting that summer. In response to the question of whom he had in mind, he named James Franck. There was some hesitation. It was presumed that Franck was still a German citizen despite having immigrated permanently. But the committee was unanimous in agreeing that he should immediately be made an American citizen.

So Compton asked Franck to help him out and accept the position.[2] Franck complied but was willing to collaborate on the bomb only as long as it was not clear whether the Germans were building one themselves. If the Germans turned out not to be working on one, he would not want to continue to be a part of the research. He was not fighting against the Germans; he was fighting against the Nazis, who had a stranglehold on Germany. Germans were helpless as long as they were unable to break the strength of the Nazi leadership.

The group of scientists to which Eugene Wigner and Leo Szilard belonged warmly welcomed Franck to their ranks. Franck himself was deeply divided about his work but still dutifully carried it out.

Fermi and his staff built a reactor in the old squash court on the university campus. It contained pure graphite and uranium oxide cubes, and measurements of the neutron flow were closely followed. On December 2 the reactor became critical, proving that the chain reaction in uranium fission was technically manageable.

Aside from much bureaucratic deskwork, Franck was also given a difficult scientific problem to solve. Wigner had theoretically explored the influence on the graphite moderator of constant neutron bombardment inside a reactor. The results of his calculations raised doubts about continuing work on a reactor using this

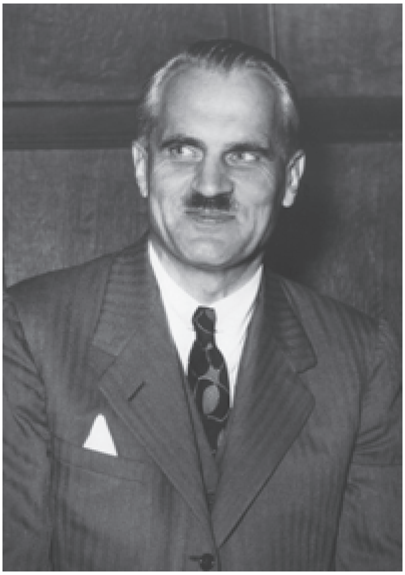


Figure 91 Arthur H. Compton. Franck papers, Joseph Regenstein Library, Special Collections Research Center, University of Chicago Library.

Figure 92 Enrico Fermi. Otto Robert Frisch collection, King's College, Cambridge. By courtesy of Otto Robert Frisch.

Figure 93 Eugene Paul Wigner. Otto Robert Frisch collection, King's College, Cambridge. By courtesy of Otto Robert Frisch.

kind of moderator. The neutron bombardment reduced the thermal conductivity of the graphite, which could lead to major problems with the cooling system.[3] Experiments were called for. Milton Burton, chief of the radiation chemistry section of the Met Lab's atomic energy project, and Franck took up these analyses.

Their experiments proved difficult because the neutron sources available to them were much weaker than the anticipated neutron load inside the finished reactor. Their initial results underscoring the seriousness of the loss in conductivity were simply waved aside as unimportant. But Franck and his team persisted and gradually managed to persuade their critics of the significance of this factor. The collaboration with the DuPont Company, which was constructing the first power reactor, was clearly less than satisfactory. Members of Franck's research team were even prohibited from installing the planned graphite samples into the reactor in order to obtain reliable data. This was not the kind of working arrangement based on mutual trust that Franck was used to in conducting productive research. It took a long time for the solution to be found to the problem of how neutron bombardment alters graphite and hampers the reactor operations.

The scene of military operations had changed fundamentally by then. The American government was supporting the Soviet Union with weapons deliveries; and its counteroffensive succeeded in gradually beating back the German troops. Allied landings on Sicily in July 1943 and in Nettuno in January 1944 as well as in Normandy on June 6 and gains on the first bridgeheads revealed the already weakened defense of the German armies. But the threat of a German victory was not yet over. The German propaganda machine was incessantly talking about a *Wunderwaffe*. Was it an atomic bomb? V-2 rockets were pounding England. There was nothing to counter them. Would they soon be carrying German atomic bombs? There was not yet enough fissile material available in America to permit a bomb to be put together. But the plutonium-production reactors were making some progress. Franck's group had to work on a method for chemically isolating this highly toxic and intensely radioactive substance from uranium and other products of fission. Franck's leadership qualities were in high demand.

In May 1944 Franck wrote in English to his friend in Stockholm. Max von Laue, Otto Hahn, and Max Planck had just had an opportunity to see her there:[4]

Dear Lise Meitner,

Thanks for your letters, one by Otto and yourself came about a week ago and the [one] to Lisa yesterday. I can not explain why letter writing to old friends and even to you seems to be so difficult for me. Believe me it is certainly not lack of interest, may be I feel the distance and the difference in our life stronger if I write[;] certainly a letter is only a very meager substitute for a personal talk, even if it is a short one. I am therefore more than glad that you saw and spoke with two of the three men for whom I feel the old friendship unaltered by distance and difference in personal experience. But many many others I hope not to see again.

Since last month I have again time left for that kind of scientific work which I like to do; I gave up and had to give up some administratical obligations since the strain was not good for my health. Real scientific work is like a fountain of youth for me and so is the daily joy to live now with Lisa and her family.

Hermann Lisco, a pathologist, had been appointed to the Met Lab to conduct radiobiological research; so his family had moved to Chicago and Franck did not have to be alone so much anymore.[5] There was more chamber music again. Franck continued to live in the university club but frequently came over for dinner and occasionally brought his visitors with him, primarily Edward Teller. His other son-in-law, Arthur von Hippel, was likewise engaged in war research at MIT.

Franck was able to tell Lise Meitner about the prospect of seeing Niels Bohr again. He and his family had managed to escape from the persecution in Denmark to Sweden with many Jewish members of his staff. Under a false name Bohr had traveled via England to America.

The 25 minutes I had of a year ago with Niels was a revelation for me. I hope to see him during the summer and hope to become a little infected by his optimism and constructive attitude towards life.

The various tasks in the Met Lab were finished up one by one in 1944 and people began wondering how the great activity that had developed could be put to future use. Many of the younger staff scientists had come from short-term academic positions, and their future employment in peacetime was an important concern for them. Compton was aware of the problem, as were the senior scientists around him. The University of Chicago ultimately decided to incorporate the scientific resources at the Met Lab. General Leslie Groves, who headed all the projects involved in designing the bomb, also considered what parts of the entire enterprise could be continued after the war. In nuclear fis-

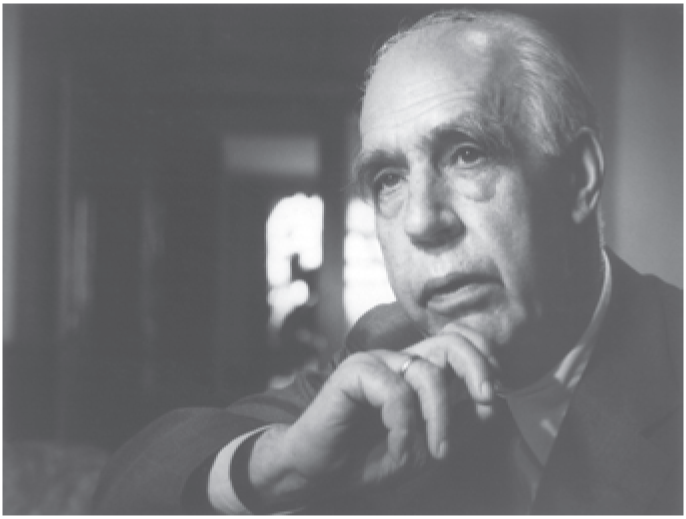


Figure 94 Niels Bohr. Niels Bohr archive, Copenhagen.

sion large amounts of kinetic energy are released by the fission products. The heat given off by the plutonium-production reactors was not being exploited to generate electricity, but this application could be of importance in peacetime. On 1 August 1944 Franck wrote down his professional assessment for a government committee in Washington:[6]

> The immediate military importance attributed by governmental agencies to the work based on nuclear fission is indicated by the unusually strong support it enjoys. Furthermore, opinion is unanimous on the even greater importance of later developments in this field for the fate of the nation and of mankind as a whole. Future supremacy can be maintained and further disaster avoided by the greatest effort. We must keep abreast and informed of scientific progress elsewhere. We must realize the danger thereby constantly produced and must avoid them by corresponding measures. According to my understanding, the task of a peacetime organization consequently contemplated will include the research necessary for military and technical applications, and the transmittal of vital information to the Government.

Franck pointed out which focuses peacetime research ought to take and how unrestricted scientific research could be organized. Then he discussed Groves's directive to the management of the Met Lab and underscored the problem of secure employment for the staff. He proposed that an interim organization be set up in collaboration with the army to plan postwar projects.[7] Franck did not forget to mention the problem of funding by Congress or the secrecy issue. Almost at that very time another group was formed in Chicago, directed by Zay Jeffries from General Electric, to work on problems similar to the ones

Franck had listed. The general debates continued, but there were too many problems and too many opinions to be clustered together in any sensible way.[8]

Occasional letters from Lise Meitner informed Franck somewhat about the fates of his friends in Germany. Otto Hahn's son, Hanno, was wounded and had to have his left arm amputated; Planck's eldest son, Erwin, had been arrested in connection with the failed assassination attempt on Hitler and was in great danger of being condemned to death. A short time later news about his execution arrived.

In spring 1945 the military defense of the Germans broke down and Hitler committed suicide. On May 8 the unconditional surrender was declared. The full extent of the gruesome extermination policy became known when the few survivors were liberated from the concentration camps. An American reconnaissance unit took Otto Hahn, Max von Laue, and other scientists in Haigerloch into custody. The small prototype reactor being built in that out-of-the-way little town in southern Germany was not yet capable of initiating a chain reaction. The hidden uranium was found and transported away. There was no sign of any finished German atomic bomb.

The bomb project in America thus lost its original legitimization. But the war with Japan had not yet been decided. American troops had only managed to conquer the island of Okinawa. Would the bomb now be deployed against Japan?

Events accelerated.[9] On June 4 a few scientists at the Met Lab had a meeting to discuss the armament situation and political policy. Franck was very probably among them. Some notes he had hastily jotted down may have been for that meeting.[10]

As outlined in other reports the basic knowledge is international that atomic power can be used to make an atomic bomb of an unheard of efficiency. We are quite certain that the United States has for the time being an advantage in this field. It consists in the fact that she succeeded in producing the explosive itself, by separating the active isotope of U as well as by producing a fissionable transuranic element in pure form and on a technical scale. We have no definite knowledge when the first bomb will be available and how efficient it will use the atomic power released by fission. But we believe a bomb able to produce a sensational destruction will be available very soon. It took the United States 3-1/2 years to reach that goal and great sacrifices in the wealth of the nation had to be made for this progress and great scientific and industrial organisations were needed.

Just the same we may expect that other great nations can and will do the same in about the same number of years if enough effort is put behind it. While they may fall somewhat behind in industrial efficiency they would have the advantage to know in a general way how we proceeded even if the U.S.A. should try to keep every thing secret. We believe also that the hope that the raw products may not be available outside of English speaking countries may turn out to be a false one. Russian territory for instance covering about 1/5 of the surface of the earth is far from explored well enough to ascertain the absence of U or Th, it would indeed be astonishing if no greater deposits would be found, if that is not already the case, and also the mines in Joachimsthal in Czechoslovakia are not at all exhausted. If an armament race in atomic bombs starts, the USA would therefore have an advantage of only a few years. Even that moderate advantage will be lost if the USA will not make every effort to continue scientific research and technical development in these fields. As will be pointed out in the second section of this memorandum.

Besides this brief memorandum, written the following day, there is no record of the discussion. It outlines rough calculations of the destructive power of the new weapon, the enormous effect of the destruction, and an estimate for the number of deaths at approximately 250,000 if deployed on a larger city:

This explosive was not developed in time to be used against Germany. It will probably not be needed to win the war with Japan. It is conceivable that its use against Japan might shorten that war. It is probable that it would not materially shorten the war. The fact that such products have been developed cannot be kept secret for a long enough time to enable the United States to gain and maintain a commanding position from a military point of view, to the world.

There followed a discussion of ideas about controls of nuclear energy.

Returned from a meeting in Washington on June 6, Compton appointed six panels from among the Met Lab staff. Rabinowitch listed how they were composed:[11]

1. Research program, Walter Zinn, chairman; Farrington Daniels, Eugene Wigner, Glenn Seaborg, Leon Jacobson, Kenneth Cole, John Howe
2. Social and political implications, James Franck, chairman; Leo Szilard, Donald Hughes, Glenn Seaborg, Joyce Stearns, James J. Nickson, Eugene Rabinowitch
3. Education, Robert S. Mulliken, chairman; Donald Hughes, J. Warner, Arthur Dempster, Thorfin R. Hogness, Cole, Eugene Rabinowitch
4. Production, Leo Szilard, chairman; Walter Bartky, John Howe, Eugene Wigner, Leon Jacobson, Farrington Daniels
5. Controls, Arthur Dempster, chairman; R. Hogness, John Howe, Eugene Wigner, Leon Jacobson, Farrington Daniels
6. Organization, Walter Bartky, chairman; Thorfin R. Hogness, Joyce Stearns, Walter Zinn

They were supposed to submit their proposals as soon as possible. The advanced state of the bomb's development meant that Franck's panel had a decisive role to play. Its members had already discussed the fundamental aspects, however. So it was just a matter of drafting a report that would convince the secretary of war and his advisors of the dangers to the country if they ordered that the bomb be dropped without first taking into account the objections raised by these physicists. Rabinowitch reworked the final draft of their report:

Political and Social Problems. It became famous as the "Franck Report."[12] This was the first time that a group of scientists presumed to set limits on what the political authorities could do.

On Monday, June 11, the report was finished and Franck wanted to deliver it personally in Washington. He and two other leading atomic physicists, Compton and Norman Hilberry, made a futile attempt to meet with Secretary of War Henry L. Stimson. Compton was given no alternative to leaving the report at Stimson's office with a letter. Franck's panel at Chicago had prepared the following summary in advance:

Summary of the "Franck Report"

The development of nuclear power not only constitutes an important addition to the technological and military power of the United States, but also creates grave political and economic problems for the future of this country.

Nuclear bombs cannot possibly remain a "secret weapon" at the exclusive disposal of this country, for more than a few years. The scientific facts on which their construction is based are well known to scientists of other countries. Unless an effective international control of nuclear explosives is instituted, a race of nuclear armaments is certain to ensue following the first revelation of our possession of nuclear weapons to the world. Within ten years other countries may have nuclear bombs, each of which, weighing less than a ton, could destroy an urban area of more than five square miles. In the war to which such an armaments race is likely to lead, the United States, with its agglomeration of population and industry in comparatively few metropolitan districts, will be at a disadvantage compared to the nations whose population and industry are scattered over large areas.

We believe that these considerations make the use of nuclear bombs for an early, unannounced attack against Japan inadvisable. If the United States would be the first to release this new means of indiscriminate destruction upon mankind, she would sacrifice public support throughout the world, precipitate the race of armaments, and prejudice the possibility of reaching an international agreement on the future control of such weapons.

Much more favorable conditions for the eventual achievement of such an agreement could be created if nuclear bombs were first revealed to the world by a demonstration in an appropriately selected uninhabited area.

If chances for the establishment of an effective international control of nuclear weapons will have to be considered slight at the present time, then not only the use of these weapons against Japan, but even their early demonstration may be contrary to the interests of this country. A postponement of such a demonstration will have in this case the advantage of delaying the beginning of the nuclear armaments race as long as possible. If, during the time gained, ample support could be made available for further development of the field in this country, the postponement would substantially increase the lead which we have established during the present war, and our position in an armament race or in any later attempt at international agreement will thus be strengthened.

On the other hand, if no adequate public support for the development of nucleonics will be available without a demonstration, the postponement of the latter may be deemed inadvisable, because enough information might leak out to cause other nations to start the armament race, in which we will then be at a disadvantage. At the same time, the distrust of other nations may be aroused by a confirmed development under cover of secrecy, making it more difficult eventually to reach an agreement with them.

If the government should decide in favor of an early demonstration of nuclear weapons it will then have the possibility to take into account the public opinion of this country and the other nations before deciding whether these weapons should be used in the war against Japan. In this way, other nations may assume a share of responsibility for such a fateful decision.

To sum up, we urge that the use of nuclear bombs in this war be considered as a problem of long-range national policy rather than military expediency, and that this policy be directed primarily to the achievement of an agreement permitting an effective international control of the means of nuclear warfare.

The vital importance of such a control for our country is obvious from the fact that the only effective alternative method of protecting this country, of which we are aware, would be a dispersal of our major cities and essential industries.

For the last five years scientists working on this and associated projects were the only ones aware of these implications of the advance of nucleonics. We are pleased to believe that the establishment of the new committee by the Secretary of War means that these implications have now been recognised by the government and that thorough study will now be made both of the possibilities of establishing a working scheme of international controls of the means of nuclear warfare, and of the alternative ways of protection of this country by redistribution of its essential industries and population.

The plan had been to give members of the Met Lab an opportunity to sign the report when Franck had returned. It was "classified," however, so further dissemination of the text was prohibited. But its main message became known. Not everyone in the laboratory was opposed to deploying the bomb against Japan. Much was at stake for America in the war in the Pacific.

It is unclear whether the decision makers in Washington knew about the Franck Report during the crucial consultations about the A-bomb. In any event, it had no impact on the final decision. Compton was present at these meetings. Franck was not, and strict secrecy requirements forbade that he be informed about the policy discussions.

On July 16 the first atomic bomb was ignited on a thirty-meter-high steel platform in the New Mexico desert. On August 6 the uranium bomb exploded above Hiroshima and three days later, the plutonium bomb over Nagasaki. Japan capitulated.

The war was over.

There is no documentation about Franck's immediate reaction, no direct accounts or letters from the time.

The *Aufbau* continued to publish regular reports about conditions in Germany: the opening of the war crimes tribunals in Nuremberg in October, revelations about the unimaginable brutality in the concentration camps, the prosecutions of Nazi criminals, the difficulties encountered in locating the guilty, and the conditions in the Allied occupied zones. Proposals about how to treat the Germans had been advanced well before Germany had finally caved in. Henry Morgenthau's Fourteen Points, made public during Roosevelt's presidency, were very radical. The aim of his plan had been to reduce Germany almost entirely to an agrarian state with a very insignificant industrial sector. Its territory would have been divided into a northern and a southern state. Although neither Roosevelt nor his successor, Harry Truman, followed this suggestion, it figured significantly in the public debate about Germany's future.

CHAPTER 9

Franck and Germany after 1945

Franck still remembered the bitter experiences of economic hardship after World War I. How much harder would it be now for the innocent victims? Various religious charitable organizations in America discussed relief programs focusing particularly on the liberated nations Belgium and Holland. But even Germany and Austria were considered. Franck and some of his friends among the Chicago faculty were thinking along the same lines and decided to launch an appeal. Franck sent a draft with a cover letter in English to Einstein on December 3.[1]

Dear Einstein,

I suppose you will remember that I hate all political publicity but in spite of that some of us, including myself, feel that it is a necessity that the immigrants in this country who came from Germany say something about the situation now prevailing there under the influence of the war and also under the influence of the Allies. Enclosed you will find a statement which, we hope, will be signed by a great many immigrants. Jewish and non-Jewish, and get, as we already know by some tests, the endorsement of Americans born in this country.* I regard it as also in the interest of the Jews to make clear that we do not want revenge extended to children and innocent people. The Morgenthau plan and the proposals made by Mr. Baruch are, according to my impression, wrong and as soon as that becomes obvious the Jews as a whole will be blamed as usual.[2] I hope you will sign the letter. It would be a tremendous help in getting other signatures from Jewish and non-Jewish immigrants of the more prominent type. Therefore, I send the letter to you before I send it to others, and I would be very grateful if you would answer immediately. Your signature would also help to prevent attacks from fellow Jews because, do not forget, you are a kind of Jewish national saint. The feeling of revenge is, of course, strong in Jewish circles; it would be ununderstandable if it were not so, but still if that goes on the Nazis will have won in their battle for demoralization of the whole world. I know we can do very little to prevent it, but what little we can do we should do. Please let me know your reaction as soon as possible.

I wish I could find an opportunity to talk with you about many things which lie heavily on my heart, but we all have our burdens nowadays and have to find a way to bear them with patience. I hope you are well.

With best regards
Yours James Franck

* It is planned to publish it in news papers and according to preliminary inquiries that will make no difficulties

The attachment read:[3]

An Appeal

We, the undersigned men and women of German and Austrian origin, enemies of Hitlerism, Nazism, and Fascism, having found refuge and opportunity in democratic America, appeal to the American public in a matter of grave importance.

Germany has now been reduced to what the *London Economist* calls a "vast derelict human slum." Thus, the crimes of Hitler's aggression and the effects of total warfare have been brought home to the German people. But, since arms were laid down in unconditional surrender, the occupation of the defeated lands has—in varying degrees—all but eliminated the possibilities of reconstruction.

The provisions of the Potsdam declaration have been carried out to a point where German industry, even in the American zone of occupation, is working at only five percent of its capacity—during Europe's greatest production crisis!

Boundary revisions have stripped Germany of twenty-five percent of all her arable land. In addition, the Russians—in their zone of occupation—have driven away all the cattle and seized every piece of agricultural machinery which they could lay hands on. The harvest has not yielded more than one-eighth of the previous year—when crops had been already drastically diminished by five years of war.

The Potsdam declaration solemnly assures the German people that they will not be exterminated but allowed to work their way back into the family of nations. In the light of recent events it has become doubtful whether this assurance can have any meaning.

German men, sorely needed to keep alive what remains of industry and agriculture in truncated Germany, are farmed out as slaves among the victorious nations. These slave battalions are not recruited from among Nazi criminals alone. Among them there are men who have been persecuted by the Nazis. Now—six months after the war has ended—these men face an end as terrible as that of Hitler's victims. The International Red Cross has convicted the French of starving their prisoners to death. There is every reason to believe that conditions are even worse among the slave laborers in Russia, where the Red Cross is not even permitted to inspect the concentration camps.

But the fate of those who remain in Germany is hardly better.

Lootings and the Black Market have wrought havoc with the possessions of guilty and innocent alike.

In Vienna, allegedly treated better than German cities, 100,000 women have been raped "not once but many times, including girls not yet in their teens and the aged."

One would dismiss such an unbelievable story as propaganda; and, yet, it is backed by the authority of the Archbishop of Westminster.

U.S. public health officials in Berlin estimate that infant mortality this winter will be as high as eighty to ninety percent. These officials predict a definite "age-group elimination" of the German people. Children under ten and old people over sixty are not expected to survive. Inmates of Nazi concentration camps suffered from semistarvation with 1,600 calories a day. In Munich, these same men—after their liberation—are now reported to be receiving 800 calories.

To the wide German graveyard, the new wave of racial warfare—which is now flourishing under Russian sponsorship in Poland and Czechoslovakia—is dumping an added fourteen million penniless and starving refugees. Norman Dodds, a spokesman for British labor, found camps for these refugees worse than the Belsen Concentration Camp "except for the gas chambers."

In two thousand years, no nation within the orbit of Christian civilisation (least of all, the American peoples) has approved or condoned such atrocities. Nor have the American people who fought this war in the name of justice and charity, accepted such a policy; but many persons and publications of great influence are now defending it on the grounds the German people have "brought this retribution upon themselves, that such retribution is just and that its victims do not deserve charity."

This, then, is the moment to speak of justice and of charity.

Among the undersigned there is not one who has ever or in any way collaborated with the Nazis. We have sacrificed our existence in the country in which we were born in order to remain true to our ideals—or we have been driven away and robbed of our possessions by those who violated these ideals. We cannot be suspected of sympathy with the moral weakness of those who collaborated with the enemy. We, as much as anybody, have the right to demand that Nazi criminals and their accomplices be punished in the name of justice.

But now we find people in a free country calling a retribution just which dooms children and the unborn; a retribution which effaces every distinction between guilt and innocence; a retribution which will make the liberated anti-Nazi envy his Nazi torturer who faces quick death after trial—whereas he, the Nazi victim, is now doomed to the slow horror of starvation.

What the American people are expected to condone is not justice. It is the principle of vendetta, or collective extermination of every member of one tribe, nation or race at the hands of another. We the undersigned—who were victims of this principle in Germany or who staked our existence on the fight against it—appeal to the American people to stand by the principle of justice. And we appeal to them in the name of charity. Many of us have barely escaped death; all of us have lost relatives or friends before the firing squads or in the torture camps of Hitler. For the last twelve years we have been haunted by the vision of helpless innocence and unavenged brutality. This vision is before us again today.

We could not have sought refuge on this continent, nor would our American friends have granted us shelter, had it not been for a mutual belief in the principle of charity. In the years of appeasement we have insisted that charity, as the cornerstone of our civilisation, may not be sacrificed to political expediency. It is our duty to reaffirm this truth today. If the American people become immune to compassion for the plight of innocent and helpless Germans because of the crimes committed by individuals unknown to them, Americans may one day look with the same cold heart upon their fellow citizens whose racial or religious background differs from their own. We know the depravities wrought by the principles of violence and blinding hatred in the minds of German youth. How can free people hope that their children will be able to enjoy the blessings of a great spiritual tradition, if today they cast aside the principles upon which that tradition is based?

This appeal is not political but moral. That it will be condemned by those anxious to subject morals to politics cannot concern us. We have learned by a stern lesson that man has to abide by charity and justice. In the name of charity and justice we have appealed to the American people when we ourselves were in distress; we would be unworthy and ungrateful if we now remained silent. Nor would we be worthy of those Germans and Austrian men and women, who, undaunted by the Nazi beast, laid down their lives for charity and justice.

Einstein replied immediately with a succinct but firm letter. Addressing him more formally than expected, he sharply rejected his friend's appeal:[4] "I may scarcely hope to dissuade you, with your good heart, from this ill-fated campaign. I would be glad if it were nonetheless so." A few days after receiving Einstein's rejection, Franck countered familiarly, reverting to German:[5]

Dear Einstein,

Please allow me to use the more personal "Du" in this letter again, as in the old days. You simply forgot that you had invited me to do so and I would very much like to be allowed to use it; it makes it so much easier for me to say what's on my mind. Please don't think that I am taking your letter lightly. If the "appeal," which I had partly written myself and partly adopted, had the result that you would oppose it if it were published, then this "appeal" would have missed its purpose. To lay my cards on the table: in that case I would probably not sign it and advise against it being publicized. On the other hand, though, I have to say that I don't understand you. There are only two possibilities; either you have misunderstood the appeal's aim, which means that it has to be altered, or you have lost all hope that morality and human kindness can play a role in political issues. If there is to be any sense in living and believing in a better future for mankind, the endeavor for a greater influence of ethical morality must not be given up; if the Nazis have robbed from people like you the belief that there is a sense in supporting this, then they have simply won. I don't believe that the latter possibility can be right and so I assume that the appeal is misleading. You have apparently gathered from it that it had been written with the aim that Germany be able to rebuild its former mighty productivity, while suggesting that the sole means of preventing that Germany once again draw the world into a war was educating the Germans in moral ethics. Nothing is further from my intentions than such a suggestion. The appeal is only supposed to make clear that making it impossible for Germans to engage in industry is not a solution to the problem nor taking away the main agricultural regions from this country which was already unable to feed itself within its old borders without imports. Both together essentially means killing off millions, particularly children and the elderly, who at least hold the highest percentage of the innocent.

Franck then explained to Einstein the possibility of imposing international controls on German industry and proposed a reformulation of the appeal.

I don't dare to raise my hopes that you would sign the appeal in the end, with these or other modifications that I myself consider necessary since a discussion with Wigner. But it would be a load off my mind if you could write me that you would not do anything to oppose it. It does seem as if public opinion in this country is becoming reasonable, namely, realizing that the Morgenthau plan together with the changes to the eastern borders cannot be done.

I am of the opinion that an appeal like the one planned will help if it originates from people who could not possibly have ascribed to Nazism. It will do more harm than good, however, if it leads to an open split within the community of immigrants. It might interest you to know that I personally am not the type of person who is willing to forgive all the sins and crimes. I would have wished that the Nazi mob had been cleared out entirely differently than has been done or as is being planned. On the other hand, I have friends in Germany to whom I am attached, not Nazis but men like Laue, Hahn, and Hertz. I do not intend ever to set foot in Germany again, because I do not want to come into contact with people who have said yes to Nazism, but I will have no part in the punishment and gradual elimination of the innocent.

Any "publicity" is so abhorrent to me that I would gladly find excuses to avoid it even in this case, if it could only agree with my conscience or, if you like, self-esteem. It really is not kindliness that drives me. Please don't be cross about this long letter and write me as soon as you have time whether you think my reasons wrong. By the way, I must confess that the issue of anti-Semitism comprises only a very small fraction of my motivations. I was stupid enough to stress this secondary reason to you because I thought it would perhaps be more important to you. I am sorry; I had no right to make this assumption, for I think exactly like you about it. Please don't take offense at what I have written. My spirits are weighed down by many, perhaps even more important things in which I am putting much work and effort without going public about them.

Warm greetings, yours, Franck.

A week later Franck dictated a long letter in English for Hertha Sponer, who was following the events in Germany with much emotional consternation.[6] Her younger sister by three years, Margot Nelly Sponer, had been working as a lecturer in linguistics at Friedrich-Wilhelms-Universität in Berlin up to her unjustified dismissal in 1942. Her opposition to the political intimidation had led to her arrest and confinement in the Neuengamme concentration camp, where she had probably died in February 1945. Hertha Sponer's brother-in-law was living in the Russian-occupied zone but was still unreachable by letter.

Franck first wrote her about his efforts involving the appeal before mentioning a change in mood in America toward Germany. He promised to send her a very good appeal launched by the Quakers. Then he addressed her worries.

Of course, I understand only too well your anxiety and desperation about your family in the Russian zone. I was glad not to have near relatives in Germany at the time of the

Nazis, but I had distant relatives in Germany and in Holland. One cousin and his mother in Hamburg were killed by them in spite of the fact that two sons of that family fell in the First World War; another cousin in Holland and her husband and several children were murdered in concentration camps in spite of the fact that her brother died in the First World War, and I could say much more. Believe me, it is not a nice feeling always to ask oneself whether one could not [have] save[d] them. I mention these things to you just to repeat again and again that you should keep your head above the water. You really do not help if every moment you are torturing yourself with ideas of how to help.

He made inquiries about the possible immigration of Hertha's relatives from Germany, but as long as no peace treaty was signed nothing could be done. A Swedish firm was able to convey their aid packages to the British zone.

The appeal was revised and the final text sent out with a letter dated December 21. It was signed by the art historian Ludwig Bachhofer, James Franck, Hans Gaffron, the Germanist Otto J. Matthijs Jolles, the physiologist Friedrich Kossler, the economist Gerhard E. O. Meyer, the professor of art Ulrich A. Middeldorf, the theologian and historian Wilhelm Pauck, the art historian Otto G. von Simson, and the anatomist Friedrich Wassermann. Not having heard from Einstein, Franck sent him a copy with a brief greeting. Einstein's secretary since 1928, Helen Dukas, typed up his response at the end of December:[7]

Dear Franck,

I still remember the Germans' "campaign of tears" after the last war far too well to fall for that again. The Germans slaughtered millions of civilians according to a carefully conceived plan in order to steal their places.* They would do it again if they could. The few white ravens among them changes absolutely nothing. From the few letters I have received from there I see that among the Germans there isn't a trace of remorse. I also see very clearly that the catering to the Germans has started all over again at the "United Nations"; these trends, the motivation behind the nursing of Germany back to strength after 1918, are most vibrant among the English; for concern about one's precious purse is stronger there, too, than any worries about one's dear fatherland.

Dear Franck! Keep your hands off this foul affair! After abusing your kind-heartedness, they will make fun of your gullibility. But even if you can't be saved, I in any case will have nothing to do with the matter. And if a suitable opportunity presents itself, I will speak out against it in public.

Warm greetings to you, yours, A. Einstein.

* If they had slaughtered you, too, it would certainly not have happened without the shedding of a few proper crocodile tears.

Einstein's unforgiving attitude did not lead to a break in their friendship, but Franck did not continue to promote the appeal.

With the collapse of the Nazi dictatorship and the new beginning with the four separately administrated Allied occupation zones, the issue of whether to reappoint the formerly dismissed Jewish professors arose along with whether the émigrés should receive material compensation. The former Prussian minister, Werner Richter, now professor of philosophy at a college in Virginia, was aware of the financial problems many émigrés were facing. He wrote to Franck in September 1945 to discuss the pension-claim issue.[8] Franck's answer was carefully considered. With reference to his own dismissal, he pointed out that he had declined all claims but many other former fellow professors from Germany were in great financial difficulties. He thought the issue ought to be broached very diplomatically because the press could play up the problem. Many American professors did not have secure retirement income either. Richter dropped his plans for the time being.

It was months before the first mailbags began to be delivered normally again after the war. In February 1946 Franck found the time to write to Born. The topic was not his work on the atomic bomb—not even by insinuation—but about the grocery packages that his daughters and other women were sending out to Holland, France, and England. It was not yet permissible to send any directly to Germany, not even to relatives. As soon as the American government permitted the mailing of food packages to Germany, Franck had the Liscos and the von Hippels repeatedly send out packages to many friends. Gustav Hertz, he informed the Borns, was in Russia, and his eldest son, Hellmuth, was in confinement in America. Franck was trying to help him because Hellmuth did not want to be sent to Russia upon release. Franck felt a bit like his foster parent even to the point of being willing to adopt him if that would improve his legal status. The year 1945 was not even out when he contacted Bohr, who had returned to Copenhagen, to ask if he could help Hertz's son. He also wrote a detailed letter to Samuel Goudsmit trying every option open to him.[9] Franck managed to arrange for Hellmuth Hertz's release via Germany to Sweden, where he had a permit to matriculate in physics at the University of Lund.

Busy though he was at the Met Lab, Franck did not abandon photosynthesis. Just before he joined the lab, he and Pringsheim had developed a new highly sensitive method for detecting oxygen. In the middle of the war Pringsheim was able to report to him about their first successful measurements. Oxygen production could be detected at pressures as low as 10^{-5} mm Hg.[10] In 1945 Pringsheim and Dolores Terwoord Lad published the first data for photosynthetic oxygen production by anaerobic bacteria. These results agreed with Gaffron's theory and the one proposed by Franck and Herzfeld.

Franck wrote to Born about his photosynthesis research, but few scientists could be convinced of his theory. He could picture himself working on the subject to the end of his life,[11]

> and I would be quite content with it if only my conscience would not force me to take a stand on a few political issues. I hate to be involved in anything political; I hate pub-

licity, but I just cannot retire into the ivory tower of free research and forget about the world and of course at our age we are probably more pessimistic than the young people. Even I am not consistent in my pessimistic point of view because I have an elementary joy in each new grandchild, and feel that whenever I have the opportunity I am a kind of professional grandfather.

Personal Happiness and Scientific Success

1946 brought Franck much personal happiness. He and Karl Herzfeld lobbied hard to arrange for an invitation to Lise Meitner to give a series of talks and a seminar on nuclear physics at Catholic University in Washington, D.C. The professor of psychology there, Rudolf Allers, was married to Lise's sister Lola, and also backed this application. Lise Meitner arrived in New York at the beginning of February and could hardly withstand the onslaught of reporters waiting to meet her. The American press had selected her as "woman of the year."[12] Her many obligations tied her up into May. Then, finally, she was able to visit her friend in Chicago. She stopped by in Durham, North Carolina, where she stayed for a few days with Hertha Sponer. There she saw how much Professor Sponer was regularly expected to accomplish. The National Conference of Christians and Jews was having a convention in Chicago just then and bestowed the honor of a "Brotherhood Citation" on Lise Meitner. Franck helped her formulate her expression of thanks.[13] It was a happy reunion with her friend and the Lisco family.

Figure 95 Hertha and James Franck. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Franck told Lise Meitner that he and Hertha had decided to get married on June 29. Lise was unable to change her travel plans, so she could not be present at their civil ceremony.

Franck wrote to Lise Meitner on July 3 from Durham, with an addendum from the mountain village of Linville, North Carolina, on July 6:[14]

Hopefully we'll be able to depart the day after tomorrow so that Hertha can get away from the hurry-scurry here. Everything is beginning to be sorted out here already. Almost everything at the institute has been settled; there is only one dog in the house now, the other has been given away; most of the errands in town have been done and last but not least we are, despite heat and hurry, really and truly properly married to each other and—do I need to say so—properly happily married. We both know it was the right thing for us, we knew that before already, but how right it is and how much we both need each other we only know now.

Now we are finally arrived at our preliminary destination on our vacation trip, have unpacked, had a nap, got caught in a storm in the middle of our walk, and are now profitably sitting at a somewhat wobbly table to write to you in time for the steamship. We've been married for a whole week today but still don't feel like a really old couple yet. It is wonderful to feel every moment that we belong together and suit each other. We do know each other rightly long enough and yet it's all new and glorious.—Of course we brought along a lot of books and draft papers that we dutifully unpacked, but I can't help but see things looking a little bleak as regards our working plans. At the moment I haven't the faintest inclination to write the paper I told you about and I believe I am not mistaken in the assumption that Hertha ultimately does not feel so terribly inclined to work either. If only we could find a way to live together permanently.

But we did also take a Goethe along and we stumbled upon an epigram in tame *Xenien* that fits so well in our conversations that if I had a talent for [?] priority claims I would almost hold it against Goethe for already knowing everything and saying so wonderfully what the likes of us have come to know from a long life of experience.

The epigram is:

Who science has and art,	Wer Wissenschaft und Kunst besitzt
He has religion too;	Hat auch Religion
Who neither of them owns	Wer diese beiden nicht besitzt
Religion is his due.	Der habe Religion

But now to you, my dear, good friend in joy and sorrow. I wish you all the best, and warm regards; and I hope that the new situation in Sweden will give you very much more satisfaction and success at work than the previous one did.

Franck did not even insinuate his intention to nominate her once again for the Nobel Prize in physics when the annual inquiries were made. His friends in Copenhagen also had to be informed about the wedding.[15] "You will be astonished to hear," he wrote in English to Niels and Margarethe Bohr,

that a few days ago Hertha Sponer and I married. We both were lonely and need each other. Of course I was full of inhibitions, the memory of Ingrid, my own age, the general situation of the world and other reasons seemed to speak against our marriage. But these reasons could not prevent us to marry, as soon as we both realized how much we need each other, and now after the step was taken I am more than grateful that fate had still so much happiness in store for both of us. A few months ago we both did not realize that we still wanted personal happiness and believed that it was enough to try to be of help to the few [?] to return [that] we are able [to] and otherwise to follow our scientific interest. Now we have learned that personal happiness and fulfillment of our duties are not mutually excluded. We only have to sacrifice a part of our married life. We both have to keep our positions in Durham respectively Chicago until we may find a solution which will permit us to live permanently together.

Not long afterwards Hilde Levi arrived from Copenhagen and Franck picked her up at the train station in Chicago.[16] She was amazed and delighted to see that the years full of grief and worry had not been able to change Franck's personality. He showed her the photosynthesis experiments in progress at the institute. Franck and Yen Guang Shiau were in the midst of redesigning the experimental setup for their analysis of chlorophyll fluorescence. The aim was to saturate the dissolved biological samples, such as algae or tobacco leaves, with different gases. Their findings for algae in aerobic and anaerobic conditions agreed well with earlier results that Franck had copublished with Charles French or Theodore Puck. They concluded that a kind of biochemical "narcotic effect" must exist that generates a substance that suppresses photo-oxidation or inhibits an overproduction of the photosynthetic products. (This finding was later confirmed.)

They were still writing this paper when Franck prepared to deliver a speech in English on February 8 before the Committee of Atomic Scientists. It became his personal credo for the standing and responsibility a scientist has in the world. It raised the alarm against building a super-bomb. By then the basic mechanism of the hydrogen bomb was known.[17]

Franck's speech before the Committee of Atomic Scientists:

To explain what we scientists regard as our social task in these times, we have to clarify the situation by three questions, why did we hide in the so-called ivory tower, why did we leave it, and what are we planning to do now that we have left it?

The term scientist is used in my discussion in the narrower sense. I restrict it to the class of men who devote their lives to free scientific research and who do not take an active interest in the application of science to practical purpose. This group of men constitutes a kind of international brotherhood, comparable in many respects to a religious order. Their common goal is the search for truth. We shall not discuss the definition of scientific truth. It may be enough to say that this definition is not based, as many people believe, on a shallow materialism, nor on a so-called naive positivism. The scientist's field in philosophy is epistemology, and we can point with pride to the whole modern development of that field beyond Locke, Hume, Kant, and so forth as being based on contributions of physicists and mathematicians. Moreover, science, besides teaching its students objectivity, reverence for nature, and modesty, contains eminent ethical values within itself. It is in this sense that we interpret and agree with Goethe's famous epigram:

Who science has and art,
He has religion too;
Who neither of them owns
Religion is his due.

Having stated the ideals of science to which we try to adhere as well as we can, I have to present the other side of the medal. First, it is a custom in science—and perhaps a principle—to select from the infinite reservoir of unsolved problems only those simple ones whose solutions seem possible in terms of available knowledge and skills. Second, we are trained to subject our results to the most severe criticism. Adherence to these two principles results in our knowing very little but on the other hand being very certain that we really know this little. We scientists seem to be unable to apply these principles to the immensely complex problems of the political world and its social order. In general we are cautious and therefore tolerant and disinclined to accept total solutions; our very objectivity prevents us from taking a strong stand in political differences in which the right is never entirely on one side. So we took the easiest way out and went into hiding in our ivory tower. We soothed our consciences by the thought that, after all, it is our research which forms the foundation on which the building of applied science is erected, but we felt that neither the good nor the evil applications were our responsibility. Our lack of active interest went so far that, though we eagerly taught future scientists, we made no effort to secure for science the position in general education which it must have in order to really benefit mankind.

I now come to our second question—when and how did we learn that there will be no cherished refuge for us anymore? During the war the scientist went wherever he was called and did whatever job was assigned to him, but this was considered to be a temporary arrangement lasting only for the duration of the emergency. The position of the atomic scientists was however a very different one. After Hahn's discovery of fission and Lise Meitner's proof that great amounts of energy were released by this process, it became clear to every physicist that an odious chance existed to make a bomb of unheard-of destructive power. Since this knowledge was international, no one had any doubt that the Nazis would do everything possible to develop and use a weapon which would decide the war—a war upon whose outcome depends the future of human existence—freedom of mental and physical enslavement.

You know the history of the Manhattan Project. You have heard that a small group of courageous men brought the situation to the attention of our government knowing exactly what terrible consequences the successful development of such a bomb was bound to bring. But all these latent dangers had to be neglected in order to meet the acute danger that the armies fighting for freedom might be the losers in this war. These scientists and the more thoughtful among the group who joined the Manhattan Project after it was formed had imagination enough to foresee that even if they were the winners in that deadly race to construct the bomb their freedom as scientists and that of pure research would be gravely endangered. They expected the people responsible for our government to say: "We have no objections to your scientific curiosity, but if it leads you to opening the box of Pandora so that all mankind may be suffocated by the deadly fumes contained therein, then we must watch every step you take and see to it that your activities are used in a way which we men of affairs deem to be in our best interest. One cannot leave such dangerous enterprises in the hands of unworldly or even irresponsible scientists." We scientists however were neither so unworldly nor so irresponsible that we did not do what we regarded as our moral duty. We stepped out of our ivory tower, though with dread and apprehension, and this step was taken not as public opinion seems to believe long after the bomb was dropped but actually considerably before that event.

And what is our duty now that we have lost our paradise? Are all the efforts of the Atomic Scientists group, are all our public speeches and lobbying merely dictated by selfish motives to get rid of the shackles which are now fastened on us? If that were the case, we would have chosen a better way out of the dilemma. We would have left nuclear research alone and turned our attention to other problems which, to us[,] are just as interesting. We would have had no objections if people had said, "Why doesn't science give the world a breathing spell to digest the terrible consequences of nuclear research and to adapt itself to the new and difficult position in which it finds itself?" But, alas, how can that be achieved without unity in the world? Would it help if we in the United States gave up nuclear research without having an enforceable world law imposing a worldwide moratorium on nuclear research? This can be achieved only by some kind of world government which, if established, would make a moratorium superfluous. No, our public activities are solely dictated by our social conscience. We are trying to atone in part for our previous sins, our lack of interest in social problems. We know that the rule of secrecy, if enforced by people without intimate knowledge of nuclear physics, can do the greatest damage. We know that imposing secrecy on results which are of only scientific interest harms and finally prevents all progress in the field of nuclear research. We admit that under prevailing political conditions a temporary protection of our country may come from secret nuclear research, but this is only a temporary and, at best partial, protection. We are trying to teach the public that it is wishful thinking to suppose that adequate protection against atomic bombs will be found. We are trying to make it clear that the construction of bigger and better bombs is to be expected which will destroy not only the population of big towns but of whole provinces. In brief we are fighting the danger of that false feeling of security which may lure mankind again into war—a war which will depopulate the world and destroy civilisation.

Later, Franck stopped expressing his opinion on nuclear arms in public. But he was one of the founding contributors to the *Bulletin of the Atomic Scientists* edited by Eugene Rabinowitch. It became the most important mouthpiece for the public debate on issues of nuclear war and peace.

Figure 96 Eugene Rabinowitch. Franck papers, Special Collections Research Center, University of Chicago Library.

Franck's universe of interests extended beyond photosynthesis. Other biological processes were equally appealing to him. Osmosis, for instance: the diffusion of a fluid through a cell wall causing a difference in concentration of a given solution to equalize. This process determines the stiffness of much vegetal material. How does this osmotic pump work, energetically speaking? What drives it thermodynamically? Joe Mayer was working on the theory in Chicago, and Franck set out to clarify with him which chemical processes are involved and to determine the balance of energy. They showed that it was possible to operate such an osmotic diffusion pump by means of chemical reactions. Their manuscript was sent to the *Archives of Biochemistry* in April 1947.[18] To shield themselves from possible priority disputes they added a footnote conceding a lack of familiarity with the copious literature on the subject.

Another paper on photosynthesis appeared that June, this time a joint publication with the plant physiologist Allan H. Brown. It was the first report of experiments with carbon 14.[19] Hevesy had successfully employed radioactive isotopes to explore biochemical processes in a variety of applications. Franck and Brown wanted to verify whether isolated chloroplasts produce oxygen out of the CO_2 in the air upon exposure to light. (Chloroplasts are the components of cells in which photosynthesis—the synthesis of starch and lipids—takes place.) This was not a new problem, of course, as experiments on the subject had been conducted back in the nineteenth century. In 1944 Otto Heinrich Warburg had postulated on the basis of his own experiments that the oxygen originates from the carbon dioxide. The investigations by Robert Hill from Britain had indicated that the oxygen comes from the water molecules. Franck's and Brown's data confirmed Hill's results.

Franck's Attitude on Reparations

Franck was attentive to events in Europe, particularly his native country, and news about many of his former colleagues reached him through Lise Meitner. In Germany academic life at universities was resuming under the close scrutiny of the occupying powers. The academic authorities of the British Military Government demanded that the dismissed professors and university lecturers from within their zone be offered their positions back.[20] The University of Göttingen submitted a list of the dismissed *Ordinariaten* from the Faculty of the Sciences, including mathematicians, on 5 February 1946. This list included the names Born, Courant, and Franck. The faculty was emphatic in assuring the authorities that it would gladly welcome their return. Whether official offers were actually sent out to all these formerly dismissed members of the staff remains uncertain, however. Among Franck's former assistants, von Hippel and Kuhn did receive invitations to return to their former positions. But that meant that the research and teaching experience they had gathered during the intervening ten years was simply being ignored. Only von Hippel was given the prospect of a promotion to *Extraordinarius*. Other faculties showed how much the Nazi mentality was still indirectly operative. The response to the reappointment directive was widespread opposition, and when there was compliance, it was begrudging and hesitant. Applicants were given preference who had been appointed to academic posts in the occupied German territories during the Nazi regime. Particularly in Poland, too many of the former holders of these vacated chairs had been arrested and killed. Rather weak excuses often came in response to inquiries by the British military authorities about why so few émigrés were being reappointed. They had, for instance, been conducting research in an entirely different field since 1933, so how could they now resume their former work?

The process of denazification was proving to be problematic, only complicating the situation. Who really had just been a mere "fellow-traveler"?[21] Some former members of the Nazi party tried to obtain personal recommendations from acquaintances in exile. These affidavits of political reliability were wryly referred to as *Persilscheine* (after a trademark laundry detergent advertised under the slogan "Persil wäscht weißer!"—Persil washes whiter!). The overwhelming majority of the members of the NSDAP found it difficult to concede any ethical weakness or admit mistakes made during the Nazi era. Lise Meitner was mortified about the inability of her friends in Germany to recognize any moral complicity, as she confided to her friend Hahn.[22] After years of involuntary silence and other hindrances, Franck finally wrote again to Otto and Edith Hahn on 18 January 1947:[23]

> Both of you do know, of course, how annoying for me the distrust is that is unjustifiably keeping Otto away from his research. Believe me, I have tried many things, apparently with little success until now. I too am very unhappy that all this misfortune is affecting the non-Nazis more than the Nazis. What is all this supposed to achieve? But I think I shouldn't say anything because, as I see it, it goes without saying.

He had spent the Christmas break with Hertha and remarked: "Having been bestowed so much happiness once again has made me much more positive about life than I had been in previous years; and I know that Hertha feels the same."

At the end of 1946 the president of the Göttingen Academy of Sciences, Rudolf Smend, professor of public law and rector of the university, asked former members who had been expelled from the academy in 1933 once again whether they would grant permission to being reinscribed on the academy's rolls. Many had not responded to his first inquiry.[24]

> On 21 August 1945 we sent you and a number of other members of our Academy the following letter: Now that the deplorable circumstances that led to your cancellation of membership no longer exist, we request permission to list you as members again. The majority of these letters have evidently got lost. We thus repeat our request that you please consider yourself as a member in the described sense. To our great gratification Messrs. Misch and Latte have long since rejoined our ranks and are participating here again.

This letter's tone clearly left much to be desired, and an exchange of rebuttals ensued between those in favor and those against its choice of words. What precisely did "deplorable circumstances" refer to? Did Smend mean the crimes by the Nazis? Franck corresponded with Born about it. Born had no qualms about accepting membership again. The issue also came up with Courant and, of course, Lise Meitner. To Hermann Weyl, Franck wrote in English:[25]

Anyway I am not so much concerned about the way in which I was dropped from membership as in the spirit in which the Akademie will work in the future, and I want to make it clear that if I do join again it will be because I regard it as a duty to help but not as an honor.

Franck's reply to Smend on 18 February 1947 questioned the meaning of "deplorable circumstances."[26]

Yet I cannot and will not raise the impression by a simple "yes" that I viewed "the deplorable circumstances that led to my cancellation of membership" as an unpleasant episode that I would like to forget as soon as possible. Too many despicable things have happened during the Nazi period in Germany's name for that to be possible. Of course I do not think that every German is equally to blame. A general guilt does, however, exist from which I cannot exclude myself. What Germany now must suffer is deeply sad and much that is being imposed upon Germany is, in my opinion, fundamentally wrong and hurtful. Many of us émigrés are trying, within the, alas, far too narrow limits of our means to check the physical misery in Germany. We can only contribute to a mental rebirth by trying to support groups in Germany from whom a mental renewal can and must emerge.

He was more explicit to Born.[27]

I found Smend's remark simply outrageous, dismissing what had happened in Germany with the words "deplorable circumstances." I can very well picture a group of humanists sitting there who perhaps even consider it a great sacrifice of theirs to ask people like you and me to consider ourselves as their fellow members and that it ought to be an honor for us. I feel I cannot tolerate such an attitude.

Rudolf Smend wrote Franck a long letter in response. Like many other people in Germany, Smend had to come to terms with an uneasy sense of communal guilt in dealing with their fellow Germans of Jewish origins. He only hinted at his own experiences of persecution by the Gestapo after the attempted assassination of Hitler on 20 July 1944. Franck could not have known how very broadly its sweep had reached.

Esteemed Colleague Franck,

Thank you very much for your kind letter of February 18th. I hasten to remove a misunderstanding that seems to exist between us; you object to the formulation we used in our earlier letter to you to describe as "deplorable circumstances" the pressure that the Ministry had exerted on the Academy and how the then presidency finally gave way under the pressure after long resistance. Confronted with the unspeakable things that have happened elsewhere, we did not want to emphasize this matter unduly. Added to this, however, is a profound abhorrence among us for fancy words, after the abominable inflated verbosity during the Third Reich. There was furthermore a distaste for strong words about the Third Reich, which nowadays are cheaply made and with which the fellow travelers of the Third Reich are again trying to shout each other down as fellow travelers of the present day, now that it has become unrisky and advantageous to give the dead monster a few more kicks after the fact.

Perhaps you will allow me to say a word about me personally. I have been politically reprimanded in Berlin and transferred to Göttingen for disciplinary reasons in 1935 to an intellectually and morally desperately derelict faculty, was finally persecuted by the Gestapo and at least had a close brush with the gallows. In October 1945 I helped write and then cosigned the so-called Confession of Guilt by the German Protestant church and I represent this line in church and academic affairs. I do not have the impression that any member of the Academy disapproves of this attitude; and when I asked during the regular meeting whether I should present to you my attitude as typical, I encountered enthusiastic acquiescence. This is our attitude—we just don't want to amplify our importance thus so particularly. That does not prevent us from saying what we think of the Third Reich where appropriate.

To underscore his point about the academy's moral stance, Smend noted that a commemoration had been held in honor of a former member, the Dutch chemist Ernst Julius Cohen, when news arrived that he had died in a gas chamber.[28] He reiterated his request that Franck rejoin as a member. Franck's reply was written more than a month later because he had difficulty finding someone able to type his letter in German. The letter opened with the remark that Smend's letter had completely cleared up the misunderstanding and that Franck was very willing to be an academy member again.

Please, Esteemed Colleague, allow me to write a few words about why and how the misunderstanding arose: Your letter, in which you wrote "the deplorable circumstances that led to your cancellation of membership" seemed to me, and also to fellow professionals who have written to me about it, as if you were labeling the entire Nazi period as "deplorable circumstances," whereas you apparently only have the Academy's negotiations with the Nazi government in view.

I mention this to emphasize that neither I nor the other colleagues concerned, who have found fault with the term, are so small-minded as to have regarded our exclusion from the Academy at the time as anything playing a major part compared to the atrocious misfortune that the Nazis have otherwise caused. Nor am I one of those people wishing to take every little thing amiss and have, I believe, expressed this clearly enough in my behavior toward many people in Germany.

I hope you understand that our reading of your words assigns a meaning that would have had to appear provocative. I would like to add that I never for an instant doubted your personal integrity during this difficult period and that I am pleased that a man like you has become president of the Academy.

Franck later attended a meeting of the academy on a visit to Göttingen, at which time he presented a report about his research on photosynthesis.

While this correspondence was still in progress, Franck received another letter from Germany from Karl Friedrich Bonhoeffer. Franck's compassionate reply on 2 March 1947 was in awareness of the tragic death of Bonhoeffer's brother Dietrich, a theologian and resistance fighter, who had been murdered by the Nazis.[29]

Dear Colleague Bonhoeffer,

Accept my heartfelt thanks for your very nice letter. I immediately showed it to [Harold] Ur[e]y who was as pleased about it as I. You really ought to be the last to have reason to reproach yourself in any way. On the contrary, we all owe you our thanks. And more so your family. It gives us confidence in the future to know that people like you continue to exist in Germany, who have kept a clear head in a sea of madness and moral degeneracy and guarded their knowledge of what is right and what is wrong. Believe me that almost all of your colleagues know about you and your family and that many are ready to help; not just those who used to live in Germany and even now cannot feel indifferent to the German fate and especially to the fates of proven friends and colleagues. I understand that it must be hard to explain to your children that all that is happening now is the result of a gangster government. This is a matter of fact but that does not mean that we over here do not find much that is happening in Germany now deplorable and disapprove of it. It is only insofar explicable as Hitler's total war also whipped up so many bad instincts that it will take a while for the whole world to be able to learn more healthy ethical compassion again.

This does not make it easier to endure when one sees oneself surrounded by hunger, cold, and misery and is unable to protect one's children and relatives.

It was not easy to help others from so far away in America, and Franck worriedly asked Bonhoeffer whether the food packages that had been sent out to him had arrived.

There were times when Franck felt obliged to speak his mind about some of his former colleagues. When Eugene Wigner forwarded to him a letter he had received from Becker for his information, Franck immediately sat down and wrote to Becker directly by hand, as can be gathered from Franck's response to Wigner (in original English) returning the enclosure.[30]

I explained that I was not sulking in my tent like Achilles, brooding over the injustice done to me. The opposite is true. Within my narrow limits, I try to help everyone whose behaviour I know was decent. I have the strongest wish that Germany should recover spiritually and materially since the one cannot be done without the other. But I also told him clearly that I had not the slightest intention of associating with people who had embraced with pleasure the Nazi philosophy. After all that happened and after so many disillusionments about people whom I trusted in earlier times, I take nothing for granted anymore; now I have to know that those I trust are deserving it. In general, I believe it was a decent letter and he could see from in it that I have no doubts regarding him, especially since you associate with him.

The person in question was probably the theoretical physicist Richard Becker at Göttingen. The ministry had ordered him to take Born's vacated position there in 1936. The number of instances of disillusionment appear to refer to some of Franck's earlier doctoral students, assistants, and other former members of his staff. Cario, Grotrian, and Stuart had succumbed more or less completely to the Nazi ideology. Stuart was complicit in the dismissal of the experimental physicist Richard Gans from his chair at the University of Königsberg in 1936 and two years later in the expulsions of Jewish members from the German Physical Society.

The problems facing postwar Germany in coming to terms with what had happened and the reconstruction were just beginning. Richard Courant traveled to Germany in 1947 on a mission connected with the U.S. Office of Naval Research, not just to gauge the mood but mainly to investigate any developments Germans had made in calculators and computing machines. He was also on the lookout for promising young students eligible for further training in America. The first days of July were spent in Göttingen. But the impression that Courant gained there of the political attitudes of his former colleagues was unfavorable. These Germans were embittered, relatively uninformed, aggressive, and overly emotional. Their criticism of the measures taken by the Allies was harsh and their fear of the Russians great. Even so, he felt that Germany and its people needed to be helped.

At the end of the summer Franck received a letter from the Ministry of Culture in Karlsruhe within the French occupied zone offering him the chair for experimental physics at Heidelberg. It was signed by the professor of public law Richard Thoma, whom Franck had known since the 1920s, having made his acquaintance at a convention of the Bunsen Society in Karlsruhe. Franck used the occasion of his reply to state clearly his opinion of Germany.[31]

Highly esteemed Ministerial Advisor Thoma,

I have not in any way lost interest in Germany; this naturally cannot be otherwise for a person who was born in Germany, grew up there, and felt like a German for over 50 years. The Hitler period did not let me forget what I owe to the former Germany, nor did it destroy the sense of friendship that attaches me to many dearly beloved people there. I am, of course, deeply sorry about the evil that the Nazis brought upon the whole world and particularly now upon Germany, where there is so much suffering among the innocent and the guilty alike. I make no secret of deeply deploring much that has happened and is happening in Germany after the defeat and am trying to help and hearten as much as is within the bounds of an individual. Your offer shows me that you believe that my return could afford for me a more direct way to help with the moral and material reconstruction of Germany than is possible from here. This would perhaps be true if I were ethically completely at liberty. This is not the case.

The reason is that years ago I became an American citizen and had taken this step as soon as it was legally possible, not just to rid myself of my involuntary statelessness, but because I seriously wanted to create a new home for myself here. One gains by such a step not only new rights but also new obligations. Neither do I have the wish to reverse this step, nor do I consider it justified.

A second, more personal reason has to be mentioned that makes impossible my acceptance of a professorship in Germany. The majority of Germans, as I believe, repudiated the murder of Jews and other races that the Nazis characterized as inferior, and I do not accuse them for not throwing themselves down the Moloch's throat when they regarded it as useless. Another considerable percentage of the population, however, were indifferent about these crimes. I do not want to come anywhere near this latter segment. I cannot imagine a profitable career as a teacher in which I had to ask myself whether this or that person with whom I had official or personal business had not belonged among this segment of the population and perhaps even still belonged among them at heart. The good Germans will have to deal with such elements themselves: as a man unwilling to forget his Jewishness, I cannot lend a helping hand.

Moreover, I am convinced that it will be virtually impossible for people who did not live in Germany during the Hitler period and the war to exert a direct influence on education in Germany. Misunderstandings are foreseeable by virtue of the different experiences alone; and as people are only too inclined to count only their own sufferings, they will constantly distrust any returned emigrants, because they did not share the special sufferings of the German population. I am honestly willing, insofar as is possible for an individual from here, to help Germany win back the standing attributing the good and merits of the German nation for the welfare of its own population and for the welfare of the world; but I cannot, for the mentioned reasons, return to Germany. I do not fail to hope that you will understand my reasons.

With all my best wishes for success in your endeavors and in great respect, I am yours very sincerely, James Franck.

In Göttingen another great anniversary was nearing. On 23 April 1948 Max Planck would be ninety. During the final years of the war, the Planck couple had been living on the Stills' family estate in the vicinity of Magdeburg, now allotted to the Soviet occupation zone. After the fighting had stopped, Pohl had managed to arrange for an American commando unit to quickly bring Planck and his wife, Marga, back to the safety of Göttingen, where they could live with some relatives. Despite many physical

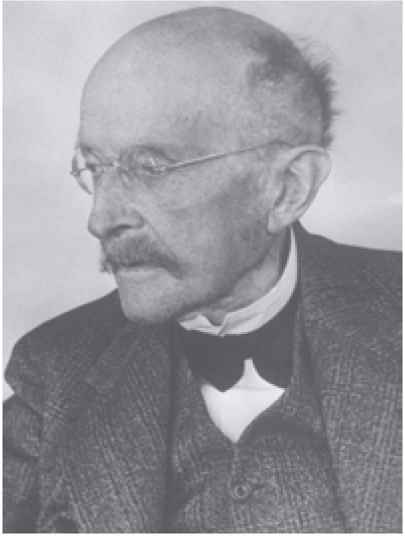


Figure 97 Max Planck. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

Figure 98 Hertha and James Franck. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

complaints, Planck felt it as his duty to do what he could to help strengthen German morale. Although he was frail, he continued to deliver speeches. Organizing a celebration in honor of his birthday was a complicated affair inside Four-Power Germany. The plan was to issue a commemorative volume of the *Annalen der Physik* because Planck had published his most important papers in this journal and had served as its longtime editor. Now Max von Laue in subdivided Germany's western sector and his former student Friedrich Möglich in the east were the editors. When Franck was approached for a contribution to the volume, he chose the topic of the luminescence of polar crystals.[32] This was his first publication in a German journal in years.

Planck did not live to see the volume. He died on 4 October 1947. So a commemoration was held. Lise Meitner arrived from Stockholm. She told Franck about difficult conversations she had had about the past with former colleagues like Walter Grotrian, Werner Heisenberg, and Carl Friedrich von Weizsäcker. Fritz Straßmann offered a position to her on Hahn's behalf as director in the new Max Planck Institute of Chemistry in Mainz. But she had serious doubts about whether she could ever build up a trusting relationship with the German staff.[33] She was afraid that any personal interactions would be ruined by suspicions that her Jewish origins and Austrian background prevented her from truly understanding their problems.

Franck gave an address in honor of Planck in New York that later appeared in the *Yearbook of the American Philosophical Society.* It reveals Franck's profound understanding of Max Planck's personality. The passage about Planck's conduct during the Third Reich is particularly perceptive:[34]

> Planck was still President of the Kaiser Wilhelm Gesellschaft when Hitler rose to power. There were friends and admirers of Planck who hoped that in the name of science, he would raise his voice in an open protest against that kind of government and what it stood for. But that did not correspond with his character. The family tradition that the law is sacrosanct was too strong in him. He hated Hitler's laws, but they were the Law and therefore must be obeyed so long as they were in force.

Franck mentioned Planck's unsuccessful interview with Hitler and how Planck's name had been abused for propagandistic purposes. He explained: "With the newspapers completely under government control, it was impossible for Planck to have a denial printed."

Soon afterward another contribution had to be written for a commemorative volume organized by French physicists in honor of the physical chemist Victor Henri. Franck wrote the article jointly with his wife. It compared the two effects of predissociation and internal conversion in polyatomic molecules. This topic was a continuation of research conducted in Göttingen and Hertha Sponer's own work at Duke University.[35]

Figure 99 Otto Hahn in his office at Göttingen. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

The ten-year contract with the Samuel Fels Fund expired. However, it contained a provision for transforming Franck's situation into a lifelong stipend. In 1951 Franck's independent laboratory was thus accordingly incorporated into the university.

The strain of the previous decade had left its mark on Franck's health. His heart problems worsened steadily even though he had given up smoking.[36] On a car drive north from Durham with his wife, he suffered a heart attack and was rushed to a hospital in Virginia. His recovery was slow, but he was eventually able to travel to their summer home on Cape Cod, where Hertha was able to nurse him. She fortunately had no teaching obligations that term.

Franck was forced to interrupt his

research—not an easy thing for him to do. In October Otto Hahn's invitation reached him to accept corresponding membership in the Max Planck Society. Franck answered in German by hand:[37]

> I shall accept this election with great pleasure, not just because it is a society that continues the old tradition of the Kaiser Wilhelm Society, but particularly because it bears the name of Max Planck and because you are the society's president.
> With my best thanks, most devotedly yours, James Franck.

In a personal letter enclosed with his official acceptance he expressed the hope that he would be able to return to Chicago before the end of the year.

Forging Ahead in Science

Hans Gaffron's updates for Franck about current experiments, visitors, and scientists interested in joining them at Chicago reflect the importance of their department. Shortly before the disintegration of the Third Reich, Otto Warburg had left Berlin, and in his absence his institute in Dahlem had been requisitioned by the Americans; it was designated the new headquarters of the Berlin High Command. So Warburg accepted an invitation by the cytochemist Dean Burk to continue his photosynthesis research in America at his institute. Gaffron reported that Warburg was thinking of staying there for one or two years but the Rockefeller people were averse to funding such a long sojourn.[38]

Franck sent greetings to his friend Albert Einstein at Princeton just in time for his seventieth birthday on March 14. The dissonance between them about the German humanitarian aid issue was a thing of the past.[39]

> I have always regarded it as one of my very greatest pieces of luck in life that I was allowed to get to know you personally so well. This way you not only allowed me to glimpse into the world of ideas of one of the few literally Great Men but also strengthened my confidence that true greatness is determined not just by the mind but also by the whole character of a person. This has meant more in my life than you can know.

Despite his now limited range of action, Franck was able to submit another important article in April 1949, a critical examination of quantum consumption in photosynthesis. As at Göttingen, these thoughts and considerations had first been intensely discussed with a collaborator or visitor before Franck was ready to put pen to paper and write up the publication. Such discussions now took place before a blackboard, no longer on some extended walk in the woods. With a piece of chalk in hand, Franck would quickly sketch a diagram or chemical reaction, as needed, to illustrate his point. This was his way of sorting out his ideas. Objections raised on these occasions often proved useful in revealing new aspects demanding deeper consideration. A given solution or critique did not always come on demand, either. There were pauses between these brainstorming sessions. There were instances when Gaffron would receive a phone call late at night from Franck with the triumphant information that he had just found the solution they had been looking for.

Otto Warburg and Erwin Negelein had found that photosynthesis required four quanta of light. The results obtained by a larger group of scientists in Farrington Daniels's laboratory at the Worcester Polytechnical Institute were lower still. The very precise measurements by Bob Emerson and Tony Lewis yielded a much higher total, however. How could these conflicting results be explained? Franck decided to go after this question. He was the first to show that cellular respiration of isolated chloroplasts functions differently from that of whole clusters of associated cells. Franck carefully scrutinized the various methods by which the biological material had been exposed to light. Warburg's experiments and series of measurements had been conducted on cells suspended in a solution. The amount of exposure always changed somewhat when the vessel was shaken; the upper part generally received more exposure than the sediment at the bottom. This difference had to be taken into account. Franck was able to back these ideas by experimental data and cited the theoretical paper he and Herzfeld had published earlier proposing a consumption of eight light quanta on thermodynamical grounds.[40] A postscript to this inquiry concerned a recent presentation of new results that Otto Warburg, M. Dean Burk and Victor Schocken from the National Cancer Institute, and Sterling B. Hendricks from the Plant Industry Station of the U.S. Department of Agriculture had obtained. Franck could not let these assertions, made public on June 22 before the Society of General Physiologists, stand without critical comment. It triggered a prolonged scientific debate with Warburg, who asserted his case with increasing vehemence and inflexibility.

It was much more pleasant for Franck to answer the call from Peter Kuiper, the in-house astronomer at Chicago, for a contribution to a collection of essays titled *The Atmospheres of the Earth and Planets*. Franck explored the possibility of photosynthesis on Mars. At certain times, astronomers observed a green belt around this planet's equator. The problem about whether biological mass could be involved was a long-standing debate. Franck did not speculate. He preferred to examine existing observations and compare the phenomena with results on Earth.[41] Chlorophyll in terrestrial plants reflects infrared light very efficiently. The Martian green belt does the opposite. So Franck drew into consideration other substances capable of photosynthesis without the requirement of being green. A photo-reduction process could also be possible on Mars, he argued, but the lack of oxygen in its atmosphere rules out a protective ozone layer against UV light. Ultraviolet destroys proteins and other organic molecules. Other shielding gases could exist on Mars, yet the absence of liquid water and the low nocturnal temperatures would prevent plant growth. If Kuiper detected reflections similar to terrestrial mosses and lichens, the latter would be the more probable option. Franck concluded with the point that seasonal colors could just as well arise from tinctures produced by chemical reactions.

In 1948, Germany experienced an economic upswing initiated by the currency reform in the western occupation zones. Max Born and his wife, Hedwig, decided to spend their vacation in the Black Forest. They found the local inhabitants there so pleasant that it helped them forget the injustices they had suffered in 1933. Born enthusiastically urged his friend to consider whether they shouldn't all spend the rest of their days together by the shores of Lake Constance. Franck's reply on 20 July 1949 was not encouraging.[42]

For, dear Born, as tempting as your plan of settling down by Lake Constance for our well-deserved old age looks, it really would not work very well for us. As concerns me personally, the strong sense of inhibition against living in Germany after what has happened speaks against it. Although this might not be decisive, there are a number of points of really great importance. They are my children and grandchildren, who would be living so far away from me if I returned to Germany that I couldn't see them anymore. There's my work, which continues to pay out a salary from year to year, despite my officially being an emeritus (from my pension I could not even live in a proper slum) and you'll understand that not much could be laid aside with all those commitments. Finally, I don't even know how long my existence will continue and I would like to be buried next to Ingrid in Chicago.

He then explained his wife's, Hertha's, situation. She still had a number of working years as professor ahead of her in order to get a decent pension. Franck wrote similar things to Lise Meitner along with a proud and detailed rundown on the grandchildren. Hertha returned to Germany again for the first time that summer to see her relatives, who were living in the eastern occupied zone. For safety's sake they met in West Berlin.

At the beginning of 1950, Franck was asked to draw up a general report about his research since 1939 for the Fels Fund. It was submitted to the director of the radiology and biophysics department, Thorfin R. Hogness, with this slightly ironic cover letter:[43]

Dear Hogness,

Enclosed you will find a few pages which Gaffron and I wrote with a little bit of nausea, but you are kind enough to want to help us in that matter and since you believe you need such a statement of self-glorification (which, however, are by no means a distortion of [the] facts), we give it to you for whatever it is worth. If you have a weak stomach, do not let it spoil your appetite for lunch.

A historical outline of what was known about photosynthesis by 1939 preceded his review of what had been achieved, what had not, and what lay ahead. Whether chlorophyll participates actively in the reaction or whether it just serves as a transmitter of the energy still remained to be clarified. Gaffron continued his research on photo-reduction. He discovered that vitamin K is produced by photosynthesis in plants. Franck admitted that the exploration of intermediary stages in the process of photosynthesis using tracer radioactive carbon had not been successful. This was a serious setback for him. His entire career as a physicist had not accustomed him to such missteps. The great complexity of problems in biology and biochemistry made possible such failures, he added. His group would continue to pursue the problem. Franck was planning to conduct analyses on the influence of X-rays. The joint publication with Joe Mayer, who had recently left Columbia for a professorship at Chicago, about the theory of osmotic pressure from ions wandering through the cells was something he deemed important.

In July 1950 Franck attended the convention of the Society of Experimental Biology. He decided to add to its full program a talk about the physical foundations of photosynthesis.[44] By this time he had become a sought-after speaker in the United States for his talent in offering a broad-ranging perspective to a professional audience.

Franck opened his talk with a reference to the complexity of the field. He then discussed chemical kinetics, specifically triggered by very short flashes of light. An analysis of anomalous fluorescence in chlorophyll followed. He tried to make clear to his listeners that the excitation of a molecule as large as chlorophyll has to be a complex process. He closed with induction phenomena. Warburg and Burk also presented their results, as did Robert Hill from England and the chemist Melvin Calvin from the University of California, Berkeley.

Figure 100 James Franck giving a presentation. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

As the year's end approached, an article was finished off for a memorial volume honoring Haber's former assistant and founder of physical chemistry in Israel, Ladislaus Farkas. Franck coauthored it with a new collaborator, Robert Platzman from Purdue University in Indiana. The topic was a difficult one: the theory of the absorption spectra of halide ions in solution.[45] It referred back to earlier papers by Gerhard Scheibe from the end of the 1920s. The purpose was to examine whether the positions of the absorption peaks were calculable from the atomic data. UV absorption by iodine ions in water was taken as a test case to see how an iodine ion could attach itself to the water molecule. Their computation was classical, not quantum mechanical. It relied on the Franck-Condon principle, and the outcome agreed well with the experimental data.

Franck's official ties with postwar Germany had been restored with his rejoining the Göttingen Academy of Science, yet these ties were far from active. Nor did he rejuvenate his decades-long membership in the German Physical Society, even though he had been elected an honorary member. In divided Germany the Deutsche Physikalische Gesellschaft was split in two, one part for the eastern zone and the other for the west. Only the western part, a confederation of the various regional splinter societies, felt authorized to continue to award the society's Max Planck Medal,[46] the highest German distinction in physics. The first medal had been awarded to Planck himself, who immediately awarded the second to Einstein. Lise Meitner and Otto Hahn were distinguished with the medal in 1949. Eleven of the thirteen medal holders nominated James Franck and Gustav Hertz for the 1951 award.[47] The difficulty of handing it to Hertz, who was beyond reach in the USSR, was circumvented by inviting Hellmuth Hertz to accept the medal on behalf of his father. Franck was informed about it on 4 April 1951. He sent his thanks to the physical society's chairman, Jonathan Zenneck.[48]

> I accept this honor with cordial thanks. It is particularly valuable to me because the medal bears the name of Max Planck, whom I have revered since my youth not just as a towering master of our science but just as strongly as a symbol of human greatness.

When national socialism had forced the academies to exclude their Jewish members, the Berlin Academy of Science naturally had to follow orders.[49] But the decision on whether Franck should be classed among the expelled members was delayed so long by inquiries and vague replies that by 1945 his expulsion had still not actually taken place. As a consequence, Franck was a registered member of the East German offshoot, the Akademie der Wissenschaften der DDR.[50] This abruptly changed, however, when he found out that the academy had expressed its loyalty to Joseph Stalin. On 1 December 1949 the president of the academy, Johannes Stroux, had sent greetings to Stalin for his seventieth birthday on behalf of the academy without first officially discussing the move with the board. Franck wrote to Stroux on 26 January 1951:[51]

> When a few months ago I responded to the invitation to attend the Academy's 200th anniversary with thanks and best wishes for a future worthy of this scholarly society's

venerable past, I was unaware of the congratulatory telegram that you, Mr. President, sent to Stalin in the name of the Academy. Now that I have been informed about the telegram and its content through its publication in “Science,” I see with dismay to what level of political servility the Academy has sunk. I herewith break all relations with the Academy and ask that my name be struck from your membership list.

Unbeknownst to Franck, the Faculty of the Sciences at the University of Göttingen had to grapple with the problem of arranging for his regular retirement benefits as a former member of the staff. It was part of the restitution procedure. But his was a complicated case because he had never submitted any application for compensation, as Minister of Lower Saxony Voigt pointed out to University *Kurator* Helmut Bojunga. At the end of 1950 the dean of the Faculty of the Sciences, the astronomer Paul ten Bruggencate, recorded:[52]

The voluntary abstention by Prof. Franck must not, in the Faculty’s assessment, by any means lead to Mr. Franck now being cast in a different position as regards the reparations measures than the other fellow emeriti or retirees placed on a state pension. Prof. Franck is a far too high-minded and selfless man to ever undertake steps on his own behalf. The Faculty is deeply troubled that Prof. Franck is working in Chicago under such unfavorable financial terms that he cannot even live together with his wife, who must rather earn her own living at another university.

In view of this situation, the Faculty has unanimously resolved to direct a petition to the Minister to settle Franck’s specially situated case equally specially and not let this highly regarded man and scientist suffer for having courageously and perspicaciously decided to provoke the National Socialists.

Franck granted power of attorney to the law firm Beyer & Keydel in Göttingen to represent him. Arthur von Hippel had influenced this choice, as he had long been acquainted with the Beyers.[53] The legal proceedings dragged on. The first payments would finally be wired to Franck at the end of 1954.[54]

Celebrating Seventy

After Hertha had returned safe and sound from Germany, and considering that Courant was now going yearly to visit Göttingen, it was time for the Francks to plan their own European trip.[55] The first stop would be England to see James’s school friend Philip Elkan. Copenhagen was a must, to see the Bohrs, but that was only possible on the return trip from Sweden. Professor Sponer-Franck had built up good scientific contacts there, and her husband wanted to visit Hellmuth Hertz in Lund. In addition, they had both been invited to speak there. Lise Meitner would unfortunately not be in Stockholm at that time, but she offered them accommodations at her apartment. There were no plans to see Franck’s sister and brother, who had both returned to Germany. The bonds between these siblings had become very loose.

The journey began at the end of June 1950, and Franck's health was stable enough for them to keep to their travel itinerary. They briefly met with Lise Meitner, and Franck was glad to see that she was under less stress than she had been while in transit in America. While they were visiting Hellmuth Hertz in Lund, news arrived that Gustav Hertz had died—presumably in an accident in the laboratory. Nothing more could be found out about it from the Soviet Union. It gradually became apparent that they had been deliberately misinformed to spoil the mood. (Gustav Hertz in fact still had 25 years of life ahead of him and would die in Germany.) Relations between the three Western allies and the Soviets were extremely tense. After Soviet scientists and technicians had succeeded in igniting a plutonium bomb at the end of August 1949, the "Cold War" was threatening to reach the boiling point.

Hertha left for Berlin to see her relatives and friends again in mid-August. Franck traveled to Copenhagen alone, where he met Werner Kroebel, now a professor at Kiel. Kroebel had been his last assistant at Göttingen. This was the first encounter with a former staff member who had made an academic career during the Third Reich, having obtained his first professorship under those difficult political circumstances.

They sailed home to America at the beginning of August and Franck returned to his science. His correspondence includes exchanges with virtually all the experts in the field, even though they were the specialists in the chemism of photosynthesis. Franck's contact in the Biochemical Laboratory at the University of Cambridge was Robert Hill. Their letters that spring concerned the transport of electrons in photosynthesis, always with a particular eye to the energetic aspects of possible reactions.[56] Franck was very candid about their experiments and his own interpretation of them. He was just as frank with Melvin Calvin.[57]

Franck and his team were able to benefit from a significant boost in interest in photosynthesis research after World War II. Established colleagues were not the only ones to read their articles. Younger physicists also felt attracted to the field and wanted to work with Franck. Warren Lee Butler, born in 1925 in Yakima, Washington, had studied physics at Portland's Reed College and earned his bachelor's degree after the war.[58] In 1944 he had been seriously wounded in a mine explosion as a member of the invasion forces in France, losing his left hand and leg as a consequence. But that did not stop him from wanting to conduct experiments and earn his doctorate under the now almost seventy-year-old specialist Franck. Declining Franck's offers of special assistance, he completed both the experimental and the theoretical work for his thesis, Measurements of Photosynthetic Rates and Gas Exchange Quotients during Induction Period, with a high degree of independence. Franck did not fully agree with Butler's interpretation of the results, but Butler was able to prove his teacher wrong. Franck fortunately had no difficulty in graciously conceding defeat when warranted.

Franck's birthday that year, August 1952, inspired many to send a card in appreciation of his achievements in science and most particularly of his kind and generous character. Einstein's warm greetings arrived unusually early, on July 7:[59]

Dear Franck,

For one who already strode through the portal of 70 with the obligatory pomp three years ago, I congratulate you with twice as much sympathy, quite apart from the camaraderie fortified by parallel strivings and experiences. Weren't we among the first to hear the snapping of the elementary processes in our inner ears? And you additionally transformed it, so to speak, into graspable reality by a magnificent experimental method—that, at least, is how it seemed to all of us.

Later developments brought unforeseen penetration into the quantitative relations, along the route Bohr, de Broglie, Schrödinger-Heisenberg-Dirac. The further progress was made, however, the more exasperatingly did the "graspability" slip away. An uneasiness about the interpretation crept in and there is no end to the consoling and soothing philosophical literature. After all this brain-racking, a state of mind has descended on theoreticians that can be described like this: Each is astonished at what the other is capable of believing. The god of mathematics just smirks, as he sees how vastly far away we are from comprehending anything in depth and yet consider ourselves so clever.

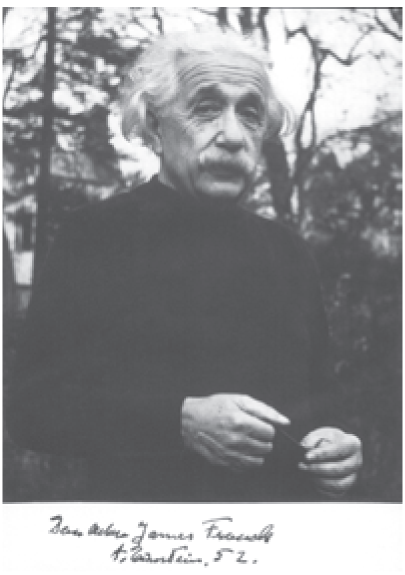


Figure 101 Albert Einstein's signed portrait with the dedication "To dear James Franck, '52." Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Well, what does it matter? We hoped and strove, as had those filled with divine curiosity before us, and like-minded souls will continue to find satisfaction in the strivings that raise us above the wretched human condition—provided they don't vanish prematurely from the Earth from the metabolic products of our efforts.

Well, that's how it is. But I clasp your hand in old companionship,

Yours, A. Einstein.

Max Born's birthday letter reminisced about Heidelberg and their time together at Göttingen.[60]

So you got your way and studied science and showed your father that the choice had been right. That was completely clear when we met up together again in Göttingen. I always felt a little pathetic with my theories when you showed me a new, impressive experiment of yours. But sometimes my speculations also did their bit. There were even many cases when we didn't know which of us had had an idea first; one of us stated it, the other said: "Hey, man, I told you that just yesterday!" But we never quarreled. It was a fine time of friendship and collaboration, too fine to last. Now almost 20 years have elapsed again since fate separated us. At least it treated us more mildly than many others. Separation and time has changed nothing of my affinity with you.

Lise Meitner naturally also sent her congratulations.[61] She remembered the early days at the *Physikalisches Institut* in Berlin with experiments that lasted into the night and the colloquium with the subsequent musical evenings at the Francks' apartment on Wielandstraße. Arthur Compton had difficulty finding the right words to describe what Franck and his nuclear research meant to American physicists. He recalled his Göttingen stay in 1927 before coming to his main point:[62]

No one knows better than I the value of your contribution during World War II, and the wonderful human spirit with which that contribution was made. There was literally no one else who could have brought unity as you did into the chemical work on our project. For this, we owe you an eternal debt of thanks. I suppose it is true that no one can tell as yet whether our efforts will ultimately result in human good or human harm, but there is no doubt that you yourself were doing the best task of which you were capable and that you did it in a spirit of thoughtful care for the welfare of humanity. This was, I think, the spirit of all of us, and it is for this reason that I am proud to have been so closely associated with you.

Much more could be said. We admire you as a man of science; but far greater is our admiration of you as a man whose soul knows no bitterness in spite of many blows, whose vision is that of a high destiny for man, and whose friendliness knows no bounds.

Peter Pringsheim's personal note confessed that without Franck's friendship he would have felt much the poorer.[63] He, just as Werner Kroebel, wrote longer biographical articles in Franck's honor.[64] The one in the German Physical Society's publication, the *Physikalische Blätter*, was authored by Hans Kopfermann, who called to mind Franck's courageous resignation in 1933.[65]

In November Franck received a letter from Robert Emerson at the University of Illinois about the convention in Gatlinburg that indicated the important role Franck also played in photosynthesis research.[66]

This letter is primarily to express to you my appreciation of your presence among those of us who are working in the field of photosynthesis. You have sometimes been distressed because you felt your contribution was not as great as you would like to make it. But as I listened to you at Gatlinburg I felt, more than I ever did before, the value of the leadership which you have brought to the field. Your presence among us was an incentive to all of us to make our own contributions on the highest possible plane.

I never heard you give so clear an exposition of the principles underlying the energy accumulation in photosynthesis.

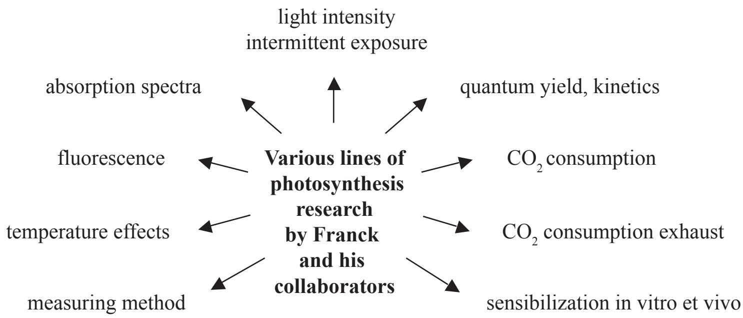


Figure 102 Various lines of photosynthesis research pursued by Franck and his collaborators.

Emerson's letter fully acknowledges Franck's continual efforts to explain to biochemists how valid the laws of physics are to their field. It was welcome moral support for Franck when he submitted a long manuscript for publication in the *Archives of Biochemistry and Biophysics* that analyzed and criticized Burk's and Warburg's results.[67] In it Franck presented the energy requirements of partial reactions in photosynthesis as prescribed by thermodynamics in order to show that the high quantum yields Warburg believed he had found could not be right. To Hellmuth Hertz he wrote about the article:

Figure 103 James Franck and Lisa Lisco, his daughter, on the front steps of Sky Cottage, reading the just arrived mail. Franck has an issue of the *New York Times* tucked under his arm. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

> I am still writing a complicated paper that I hope to finish up now within a few weeks. It is complicated because it is supposed to be a masterpiece of diplomacy, for which I have no talent. A Homeric battle is raging between Otto Warburg and his collaborators and a group of researchers here about the quantum yield of photosynthesis. Warburg's results are impossible but his observations are, in my opinion, correct; i.e., I am annoying him by trying to prove to him that his interpretation is wrong and am annoying the others who are insisting that Warburg's measurements are wrong. Result: I am sitting pleasantly between two stools.

Franck relaxed best from the stress of his scientific exertions on summer vacations with his daughters and grandchildren. The whole family often stayed in a rented frame house in the Adirondack Mountains, far away from the bustle of everyday life. The summer cottage on Cape Cod was another haven for gathering renewed energy.

Visits in Germany

The following year began with an extended European trip via England and Copenhagen to Uppsala. A letter from Göttingen's mayor dated February 11 was forwarded to Franck there, and it put him in a personal and political quandary. The city council at Göttingen wanted to confer honorary citizenship upon him and Born on the occasion of the city's millennium celebrations. Franck hesitated to reach a decision before first hearing the opinion of others. He asked the Liscos and the von Hippels. Gaffron also received an inquiry about what he thought of this distinction. To him it meant wrestling with issues of guilt and the guilty during the era of the Third Reich. Born sent him a telegram and a letter with his decision. He intended to accept. Franck wrote his decisive letters between 21 and 25 February 1953 from Uppsala.[68]

Dear Born,

My heartfelt thanks for your telegram and your nice letter which is so reasonable and wise that it has largely dissipated my doubts. So I've accepted and we both are very much looking forward to meeting Hedi and you in Göttingen. I did add a sentence in the letter to the mayor, however, saying we understood my and your selection for the distinction as that the Council of the City of Göttingen had the intention of honoring through us the millions who had fallen victim to the racist insanity of National Socialism. I hope you don't have any objections to this sentence. I showed it to Hertha, Lise Meitner, and Oskar Klein, and they found it the right thing.—Otherwise I fully agree with you. As far as my belief in communal guilt goes, I cannot exclude myself or even you—although you saw much more clearly than I. Under the Kaiser we always nicely kept our traps shut. I considered his speeches silly and stupid but ought to have known what impression they would make abroad and that they made a war possible. But more about that sometime in person.

His answer to Hans Gaffron took on a similar note. In reply to whether he would be giving an address, he declared:[69]

No, dear Gaffron, I assure you, I will not be giving any speech on behalf of *so-called* all-forgiving *Christian* love and neither will I turn the left cheek after my right cheek has been slapped. And I am firmly resolved not to get upset. If the mayor does not acknowledge my interpretation of the distinction, I can still decline; but from the wording in my letter I consider that excluded. By the way, I read the speech by [the president of West Germany, Theodor] Heuss and found it excellent.

On the other hand, I have no doubt that anti-Semitism in Germany did not die with Hitler and am little pleased that our politics in some respects are coaxing the old Nazis, of all people. After initially simply having been appalled by the Göttingen idea, I have gradually reached the opinion that *a single line* like the above one will suffice to make clear that I regard it as a matter of course that an honoring of the dead was the intention and not far-too-cheaply-made restitution. There really can't be any restitution, an awareness of guilt should just not be left out (although I am always burdened by the fact that people like you and me are certainly complicit); as long as German nationalism only ran rampant in the Kaiser's speeches, we never took it seriously enough to see that it contributed hugely toward catapulting the whole world into misery. Oh, let's not talk about this anymore. I thank you and Klara very much; your letter was and remains a fine service of friendship, I will take a good portion of it to heart, even if I cannot follow your advice entirely.

To the Göttingen mayor, Hermann Föge, Franck wrote, after a brief introduction:[70]

The message of your letter that the Council of the City of Göttingen is planning to elect my friend Born and me as honorary citizens on the occasion of the 1000th anniversary of the founding of the city and the so kind words of personal appreciation that you devote to me in your letter moved me deeply. I shall be very willing to accept the great honor. I know only too well that I as an individual do not deserve it, yet I believe I may gather from your letter that the true intention behind our election is, in a symbolic way, an honoring of the memory of the millions of people who had fallen victim to the racist insanity of National Socialism. In this awareness I am willing from the bottom of my heart to accept your great honor and attend the celebrations in Göttingen and ask you please to have the kindness to let the members of the Council know that I am very grateful.

Franck also requested that he be contacted about the scheduling, as he wanted to attend a conference in Hamburg.

The festivities in Göttingen took place at the end of June. The successor to the Kaiser Wilhelm Society, the renamed Max Planck Society, was settled in Göttingen, so the visit meant not only a reunion with their local friends there but also with the Hahn and Laue couples. Richard Courant and Hermann Nohl were joined by the telegraph inspector August Reuper and the cabinetmaker Harry Lambach as part of the select group of honorary citizens of the City of Göttingen. Franck was chosen to thank the city in the name of the six recipients on that occasion. Only one passage of his speech hints at his true feelings about the distinction:[71]

A lack of time unfortunately does not allow each one of us to say what is on his mind and only one may very briefly indicate what all of us feel, how happy we are about the honor, and to emphasize that we accept it with heartfelt gratitude. For some of us, a trace of melancholy mixes into this joyful celebration, endowing special richness to the experience of this day.

The *Göttinger Tageblatt* published interviews with Born, Courant, and Franck.[72] Franck mentioned his impressions of how democracy is cultivated in America. "Over there," he stated, "I learned that it is one's duty to criticize." About his imminent participation in the conference on the theme "Science and Freedom" in Hamburg, he remarked: "I have to do my duty and express my opinion."

This conference at the end of July was an international gathering. Franck had sent the Liscos a draft of his opening address before leaving for Göttingen. They suggested he tone down the wording a little, but he replied on 12 June 1953:[73]

> Thanks for your critique on the Hamburg talk. Hertha thinks like you do. Even so, I would not want to alter this point; I don't like to take a political stand, but when I do muster up the energy to do so, it has to be clear. I'm sure that a number of people will reprimand me, just as they will criticize my attitude with regard to the honorary citizenship. But once one considers an issue properly, one has to follow one's gut feeling and then take the consequences (in this I am thinking more about the honorary citizenship); I still wish I had first been asked personally instead of having the plan publicized. That forces me to accept in order not to offend precisely those we should be supporting.

The conference of over a hundred scientists was inaugurated in the official banquet hall by the Hanseatic city's head burgomaster Max Brauer and Professor Bruno Snell on behalf of the University of Hamburg. The subjects of the talks were chosen under the strong influence of Stalin's power politics and the American government's fear of espionage. Franck also seized this aspect.

> The importance of the issue "science and freedom," the theme of this conference, is clear to everyone present, so it would be unnecessary to waste too many words on it. We know that a large proportion of humanity is ruled by a dictatorship that opposes everything we regard as worthy of human beings, that enforces blind obedience by brutal means and is intent on establishing the rigid system of an ant state on the whole of mankind. In reward it promises heaven on earth as soon as all resistance against its pseudoreligion has been broken.
>
> Those segments of humanity who regard the liberty of culture and free personal development as the basis of their order of the state and justice understand that no system of government can be free of errors and faults. Even if a system that was the ideal solution to all problems of humanity at a given moment in time could be found, it would in the next instant already be old and behind the times. True democracy, it alone, is not dogmatic but dynamic. It conforms to a nation's evolving living conditions; it follows the will of the people, which is expressed by free speech and the voter's ballot.

The second part of Franck's address turned sharply against the senseless monitoring in America of scientists not involved in defense projects. It was destroying academic freedom. The paper issued by the American occupying forces, the *Neue Zeitung*, published a long article on the Hamburg conference.

The Francks traveled on to Berlin. Their report to Gaffron describes the most important event.[74]

Then Berlin: I was supposed to speak at Laue's colloquium and answered that Warburg would probably come and that would produce a controversy. That was right by Laue, as he was anyway steaming mad at that arrogant fellow. It turned out to be worse, though, because at the last minute the meeting was relocated to the Berlin Physical Society and that means a very large auditorium in which approx. 500–700 people came, including Warburg, Dean Burk & company. So I spoke, as I believe, quite well; that was also the opinion of my wife & a group of others. Very nicely about Warburg's merits in general, yet in particular he and Burk were simply wrong in that they had simply measured something other than they had assumed, etc., etc. Then came Warburg's arguments, counterfactually arrogant; but I became quite forthright and, purely on the face of it, I had the upper hand. It got so far that the audience cheered at his insults and stomped their feet at me.

But—to jump to the main point—Warburg & Burk now claim that they had recently succeeded in observing photosynthesis up to ten-fold of respiration, where thin layers of all the algae had been exposed simultaneously and the quantum yield lay between 4 and 5.

Franck then described his visit to Warburg's laboratory on the following day, where they discussed the details of the potential reactions. The trip continued with a stop in Göttingen so that Franck could look up Professor Günther Otto Schenck at the Institute of Organic Chemistry, to exchange thoughts on photosynthesis.

While Franck was still traveling about in Europe he had a tiff with Gaffron and Rabinowitch. The manuscript of one of his papers, The Participation of Respiratory Intermediates in the Process of Photosynthesis as an Explanation of Abnormally High Quantum Yield, had already been sent to the editors of *Archives of Biochemistry and Biophysics*, but Rabinowitch had done some last-minute alterations to the text without Franck's approval. When Franck heard about it, he was furious and vented steam in a letter to Gaffron.[75] Gaffron carefully replied to Franck that some necessary copyediting had been involved. Franck could see his point and wrote conciliatorily to Rabinowitch.[76]

As I was beginning to get totally fed up with the paper and wanted to have it quickly printed, this incomplete news initially made me very unhappy and even angry. As soon as it was revealed, though, that it only involved very necessary stylistic improvements and that you are generally very positively disposed toward the paper, my anxiety switched to joy and my anger to feelings of gratitude to you. I would like to tell you that I know only too well that my style is bad and that yours is excellent.

His correspondence with Gaffron in Chicago continued without the slightest hard feelings throughout the remainder of his trip.[77] Franck learned from him that the Samuel Fels Fund was making more money available. Gaffron also reported that Hilde Levi had visited and told him that Warburg's talk in Copenhagen had been "really exquisitely mean, so I believe you should be very outspoken."

Franck's publication about the abnormally high quantum yields claimed by Burk and Warburg has a postscript challenging his readers to recheck his own arguments carefully. Then followed thanks to Rabinowitch for stylistic revisions as well as to Gaffron, the organic chemist Edward William Fager, and Jerome Laib Rosenberg for helpful discussions. Rosenberg had been working for the Atomic Energy Commission in Chicago from 1948 to 1950 and was collaborating on the university's photosynthesis project, which brought him within Franck's range of contacts. Warburg was not willing to discuss the facts of the matter, however, and his attacks on Franck during the next few years grew increasingly strident.

Max Born had been appointed corresponding member of the Nobel Committee of the Swedish Academy of Science the year before. When he was asked to propose a winner for the prize in the coming year, Born asked Franck for his opinion. Franck informed him that he was conferring with Enrico Fermi.[78] At times they easily reached agreement, for example when they had proposed Born for the prize on an earlier occasion—in vain, as Franck ruefully noted. At other times it was evidently not so easy for the two to agree. Born had no idea that Franck's and Fermi's choice for 1954 would, in fact, be—Max Born. This time their nominee actually received it, too, together with Walther Bothe. Born's half Nobel Prize in physics was awarded for his statistical interpretation of quantum theory, and Bothe's half of it for developing the coincidence method in radiation measurement.

Franck was busy preparing a comprehensive publication together with Robert Platzman, professor of physics at Purdue University, on the physical principles underlying photochemical, radiation-chemical, and radiobiological reactions.

The rising number of atomic bomb tests by the USA and the USSR had led to a drastic increase in radioactivity in the air and in precipitation. Fifty-four test explosions had already been conducted—all of them more powerful than the one dropped over Hiroshima. The genetic risks to the world's population due to the addi-

Figure 104 Otto Warburg. Archiv der Max-Planck-Gesellschaft, Berlin-Dahlem.

tional radioactivity had to be studied. Franck and Platzman's contribution for the work *Radiation Biology* assembled the physical bases of reactions in photochemistry, radiochemistry, and radiobiology.[79] The volume, of over a thousand pages, appeared in 1954. Numerous clear diagrams of excitation and ionization processes illustrated Franck's article, with citations of many dissertations originating out of Göttingen.

The College of Medicine of Yeshiva University contacted Franck about a eulogy of Einstein in celebration of his 75th birthday. In complying, Franck apologized in a brief introduction that he was actually not the right author for the task. The following, he hoped,[80]

> may be sufficient to make it clear why Einstein is regarded as one of the greatest scientists of all times and why his fellow scientists take advantage of his anniversary to give humble tribute to his genius and his greatness as a human being.
>
> Two theories conceived in the first part of the century have changed the whole aspect of science; one, the principle of relativity, the other, the quantum theory. Einstein, the creator of the former, was also largely instrumental in furthering the development of the latter.

Then he outlined the essential results of the general theory of relativity and delved into the deeper issues:

> It means that our whole way of thinking and the language by which we communicate our experiments to others depend on this assumption. If we change it, we change our logic or, perhaps I should say, our opinion of that which we regard as our logic, and we have to readjust our language too. Expressed in other words, what we regard as a logical function of our experience, and we must always be prepared to have entirely new experience made in hitherto unexplored areas force us into readjustments.

He described Einstein's contributions to quantum theory and his opposition to the statistical interpretation before praising his personality.

> A few words must suffice to depict Einstein's personality. It is tempting to describe his character as being formed by his religious attitude towards his science. The words of Spinoza "Deus sive natura," it seems to me, will describe Einstein's patterns of thinking, for to him God and nature are one. As a real scientist he searched for the Truth objectively and stated his deductions and findings without compromise; as a human being, he has shown the same objectivity and courage in his attitude towards the problems of daily life. He dislikes the hustle and bustle of the market-place, but whenever he believes it is his duty to give an opinion, he does so clearly and unafraid. Knowing that freedom of thought and speech is just as important for democracy as for science, he will support the right of men to speak and think freely, and if needed will fight all movements which threaten these freedoms.
>
> Let us hope that Einstein's strength and health may endure for a long time so that by living and working to his own satisfaction he will continue to benefit mankind.

Franck's own health remained delicate, and he suffered some serious heart attacks. On one occasion it developed into a cardiac infarction.[81] His condition forced him repeatedly to slow down. The best place for him and his wife to go to relax was their summer cottage on Cape Cod.

It was a remodeled eighty-year-old farmhouse with an ocean view, well situated for pleasant walks. When Franck was feeling well, he would venture out into the water to have a swim in the Atlantic. Since it was not far away from Boston where the von Hippels lived, it was possible for them to come down to the Cape on visits whenever they liked. Arthur von Hippel's research at MIT on infrared-sensitive photocells for night viewers was making good progress.

In November Franck was committed to presenting a talk in Minneapolis and the subsequent discussions were lengthy. He thought them necessary, but they were a great strain for him. A worried letter by Lise Meitner was waiting for him in Chicago, to which he immediately responded:[82]

> I met the Hippels a couple of weeks ago at Princeton and enjoyed it very much.
>
> The Bohrs were also there and Einstein too. Those were fine hours with them. The Institute of Technology in Haifa had organized a little celebration at Princeton to award an honorary doctorate to Einstein and me, as we both did not want to travel to Haifa. The ceremony was very nice but the finest things by far were the visits. Bohr looked a little tired but naturally full of plans and ideas about physics and the world. Margarethe was charming and beautiful as ever . . .

Figure 105 The vacation home on Cape Cod. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

Figure 106 James Franck and Albert Einstein at Princeton. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

About Einstein I also wanted to say that he cuts a downright fabulous figure. Although he looks old, he seems to be in good condition; his mind sparks and is as interested in everything as in the old days.

Now to something sad and for the moment not to be spread further. Fermi is fatally ill. Cancer. It will probably not take more than a couple of weeks. You do know that I was not particular friends with Fermi but we were always on good terms and I always found great aesthetic pleasure in every presentation I listened to by him. Now on his deathbed I have learned to admire him also as a human being. The objectivity he had applied to the fates of other people, which had earlier often seemed to me overdone, he is now also applying to himself. He never for a moment deluded himself about his illness and takes his approaching end with stoic calmness. Completely lucidly he said one time: "I did not know how I would take such a certainty and am actually quite content that I am managing to take things as they happen to be."

Franck briefly mentioned the Nobel Prizes for Born and Bothe and related some thoughts on photosynthesis before wishing his friend a nice time in England. He asked her whether she would be attending the Nobel events. "I hope so," he added, "even though I am still very enraged that you have not been honored with your prize (Siegbahn was certainly to blame for that)." In 1939 Lise Meitner's relationship with Manne Siegbahn, director of the Physics Department of the Nobel Institute, had been very tense.

Toward the end of that year an exceptional honor was bestowed upon Franck himself. The Boston Academy of Arts and Sciences decided to award him their Rumford medal. Franck thanked George Wald, a biologist on the Harvard faculty, for his telegram bearing the good news.[83]

On 5 May 1955, Robert Hill sent his congratulations to Franck for his Rumford medal. He used this opportunity to thank Franck for the benefit of their scientific exchange through the years, which he credited to Franck's liberality.[84]

Franck's duties still fully occupied his day. New results needed to be recorded and published and the research of his advisees monitored. So some correspondence occasionally lay unanswered for a while. Robert Pohl had sent him greetings in December for his seventieth birthday. He was full of repentance about his attitude toward Hertha Sponer in the early days but glad to know she had forgiven him. Pohl had retained his directorship of the Experimental Physics Institute I at Göttingen throughout the Third Reich. Franck was only able to dictate his response in German on March 22:[85]

> Dear Pohl, you are still talking about our separation. I see between the lines as well as from our first meeting here in Chicago how very heavily our long separation has been weighing down on your soul. It was the same for me, too, but now that is fortunately over and I hope we have both fully mastered it emotionally.

He then described his friendship with Gustav Hertz and wondered what Hertz must have had to endure in the Russian totalitarian system, still hoping that he was unscathed by it. Then, addressing Pohl personally again, he continued:

> I write you this only to tell you that I can very well understand that even during the time when our paths temporarily parted ways, we could both still have differing opinions and perhaps also had to have them. The main thing is that, after both seeing each other again and talking to each other, we have found each other again and really, we can now regard the period of emotional separation as a historical fact but entirely insignificant for our relationship. It is hugely welcome to me and this is what I think and what I wanted to tell you once.

The interesting research on photosynthesis was taking place in a period of high political tension between the atomic powers, the United States and the Soviet Union. Averse though Franck was to expressing his political views in public, he was not always able to keep out of it. In the early fifties nuclear bomb development was leading to greater and greater powers of destruction. Developments in the opposite direction produced nuclear warheads small enough to be shot out of artillery. The race was on between the USA and the USSR for the most lethal arms. Physicists, Edward Teller in particular, realized early on that it was possible to build a nuclear bomb based on fusion: the hydrogen bomb. The mathematician and philosopher Bertrand Russell warned that such armaments could lead to the suicide of mankind. Max Born was listening and wrote to Russell that, while his advanced age would not permit him to continue to participate actively in science, he was nevertheless willing to support Russell's disarmament efforts as a recent Nobel laureate.[86] Born was the only physicist dismissed from Göttingen by the Nazis to return. But the Born couple preferred Bad Pyrmont over Göttingen as their residence. This spa town on the western edge of Lower Saxony was the center of the German Quakers; Hedi Born had joined that pacifist Christian community during their exile in England. Born's offer of support to Russell's cause was serious. He worked hard to organize a signature campaign at the annual meeting of Nobel laureates in Lindau. They hoped to collect an international array of influential signatures against nuclear armaments. Arthur Compton informed Franck about the planned signature campaign and asked him whether he would be willing to add his name. After some hesitation Franck decided to sign it, but only after telling Compton his point of view and giving reasons for his reservations. Agreeing fully with the proposed text, he nevertheless commented:[87]

(1) [. . .] I feel that people may think that receiving the Nobel prize should not entitle a man to assume that his opinions deserve special consideration in the field of politics.
(2) This next point is still less important. I happen to know that people in Stockholm look at the meetings of the Nobel prize winners in Lindau with mixed feelings because they think that if there is a special meeting in any one country it should not be in Germany but in Sweden. That Count Bernadotte is a member of the Royal Family (and so far as I know, not on too good terms with it) does not change the situation. Therefore, I think it would be a good idea to find out whether or not at least one Swedish-born Nobel prize winner could be approached to become a sponsor of the appeal.

Franck likewise suggested that another American be a part of it. These suggestions were taken into account, and the list of signatories to the resulting declaration of 15 July 1955 was truly international:

The Mainau Declaration

We, the Undersigned, are scientists of various countries, various races, various faiths, and various political persuasions. Superficially, the only thing that binds us is the privilege of having received the Nobel Prize.

With pleasure did we place our lives in the service of Science. It is, we believe, a path to a happier life for humanity. We are horrified to see that just this Science has placed tools into the hands of humanity to destroy itself.

Full deployment of now feasible weapons in a war could contaminate the Earth with so much radioactivity that whole nations would be obliterated. This death can befall neutral bystanders as much as the warring belligerents.

If a war between the Great Powers arose, who could guarantee that it would not develop into such a deadly clash? Thus a nation that engages in total war will bring about its own ruin and imperil the whole world.

We do not deny that peace may perhaps be maintained precisely by fear of these deadly weapons. Nevertheless we consider it self-delusion that governments should think they could prevent war in the long run through fear of these arms. Fear and tension have often engendered war. It seems just as illusory to believe that minor conflicts could continue to be decided by conventional weapons. In extreme danger no nation will hesitate to use any weapon that scientific technology can produce.

All nations have to resolve voluntarily to do away with force as the ultimate political means. If they are not prepared to do so, they will cease to exist.

A new cardiac arrest necessitated a hospital stay for Franck. His treating doctor prescribed absolute rest. As Hertha was unable to leave Durham, the Liscos took care of him. His research and his correspondence simply had to wait. In the middle of January he was finally able to reply to Kroebel, who had sent him a manuscript on atomic energy and the responsibility of mankind, asking for his criticism. Franck was, as he put it, over 90 percent in agreement with the text and Kroebel ought to have it published as it stood.[88] He used this opportunity to present his stance on pacifism.

Of course we all have to fight for ethical reasons for mankind to eliminate war. And this fight should be waged with every last bit of energy, even if one is as pessimistic as I am to think that the goal cannot be achieved within the foreseeable future. How often in history have people committed themselves to never again waging war and how pathetic was the result! In a certain sense we are now in a better position, as we have reasons of cold logic besides the ethical reasons which, I hope, will prevent humanity from fighting a war for many years to come. Atomic weapons have become so terrifying that civilization, industry, and mankind would practically be annihilated if there was a war; for any war would become a nuclear war. Both sides know that this is so; that's why neither want war. I would consider it unrealistic if one party relinquished its atomic bombs; even if both did. Because an invention that has been demonstrated to mankind as effective cannot be retracted. In a war, new atomic weapons would be built even if the old ones had been destroyed.—Which, by the way, no one could control properly.

In those days, when we raised objection to the deployment of atomic bombs, we had some hope that atomic bombs could be placed at the disposal of some kind of world government that would only intervene in case of a clear attack and would decide whether the threat of its deployment would suffice to call off an existing war or whether it really had to be used.

Little by little Franck recuperated enough to allow his wife to come and get him. He could report to Heinrich Kuhn that he had more or less recovered, although he had not yet returned to his research. But he was going out a lot on walks. He had a realistic view of his standing as a scientist.[89]

I also notice what an advantage it is (when one is working in a field like mine, in which there are so many differences of opinion) to no longer have to think about one's career and ambitions at my age.

Even so, science was not completely banished. Together with Hertha he drafted a short "Letter to the Editor," outlining their ideas about radiation-free transitions in complex molecules.[90] They concluded that an intermolecular sensibi-

Figure 107 Hertha and James Franck in Durham. Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

lization occurs at the expense of the energy of the excited state. A graph of the potential curves illustrating their point in the draft was not incorporated into the published version.

Together with Platzman, Franck prepared a talk for the Symposium on Information Theory in Biology in Gatlinburg in October 1956. The physical processes in ionizing radiation were described with a focus on such processes involving proteins.[91] There continued to be young staff members working toward their doctorates in Franck's allotted area of the Research Institute of the Samuel Fels Fund. John E. Brugger, for instance, was analyzing the afterglow of chlorophyll in vegetable material. Whenever Franck was staying with his wife in Durham, his advice to Brugger had to be sent by letter. He had this encouragement for him:[92]

I am pleased about your clear thinking in all your kinetics ideas. I feel that our cooperation which sometimes was a little bit too intensive for your pleasure, has put very good seeds in your soil so that you really stand now entirely on your own feet even in biophysical questions which have not been your original training.

A few days later he could reassure him with this counsel:

Don't go to the trouble to change your present setup because probably it would not be worthwhile to do so. Actually I think you can decide easily which of the two curves you drew corresponds better with observations.

At the turn of the year 1956–57 Franck was back in Durham, and letters again had to substitute for their usual consultations, even though Franck had little time to spare, as he was working on another article.

> Therefore, I answer only one point of your letter now. Namely some remarks which might alleviate your difficulty to understand electron emission in crystals of organic compounds, I think you are haunted by a non-existing chimera in this case.

He then explained how best to understand the processes in electron transitions. Franck continued to stand by Brugger as he was composing the final wording of his results.[93]

Franck was not able to present his talk personally at the important conference in Gatlinburg because another heart attack condemned him to total rest. So Brugger spoke in his stead. He reported about his dissertation and Franck's theory. Robert Livingston spoke about another paper by Franck.

The respite from his research granted Franck time to reflect on his life. It was in this mood that he wrote to Lise Meitner, taking up a comment she had made about Germans in one of her letters.[94]

> I'm glad that your health is better again and you have seen and spoken with some friends. A certain feeling of homelessness [*Heimatlosigkeit*] that you complain about is simply our fate. I myself feel strongly that it has given us something as well in exchange, namely, an understanding for global problems, i.e., a bit of world citizenship [*Weltbürgertum*]. It's true that I would not fit into the German setting anymore and that I, for my part, miss the old culture of Europe and its old traditions often enough over here. On the other hand, without this "transplantation" I would never have acquired an understanding for the pros and cons of both continents and a certain associated tolerance; one gains a certain understanding about the roots of these pros and cons and about almost compelling links with the history and traditions of the nations. You yourself learned early, partly from your innate sense of justice and partly through growing up in Austria with its mixture of peoples, what I only really learned to see when the destiny of world events collared me and those close to me pretty mercilessly and forced me to open my eyes.
>
> As I don't want to put more platitudes of wisdom to paper, I'll just mention one insight that was new to me. "The bane of the Germans is their old tradition of obedience before the law." For them the law is something absolute that one has to follow blindly without any personal say. This makes people order-loving, diligent, and surely also more moderate. But it kills a sense of personal responsibility and independent moral nobility.

Franck then explained his views on democracy in America, singling out personal independence as its strongest characteristic.

> Everyone is sure that his own opinion is as valuable as that of the little-loved experts. Completely irrespective of whether it's about politics, art, science, or education and the world of work. This is connected to the "too little and too late" of democracy.

He regarded democracy, although not an ideal system, as the best that this imperfect world can offer.

The terrifying question that probably no one can answer for me is whether democracy can pull its weight against totalitarian systems that do not need to worry about public opinion. [. . .] In this connection I would like to answer your question about what I think of the declaration by the German atomic physicists.—If one takes a sober political look at the whole problem, there seems to me to be no doubt that the 3 powers possessing atomic bombs (U.S.A., Russia, and England) will be forced to come to some agreement within a short time and will arrive at one as well. For all 3 powers have the same interest in not having other governments start to produce these bombs. The probability of an atomic bomb attack now is certainly not zero, but it is small, as all 3 nations could not launch an atomic attack without the certainty of causing their own downfall. But if a not strongly industrialized and overpopulated country gained possession of atomic bombs through its own manufacture or by purchase or smuggling, the probability that the bomb will be used rises, because a country like China, for ex., would gamble with a loss of human life, perhaps even welcome it, and its industry is not developed enough to make that loss vital.

For these reasons Franck assumed that there would be a treaty between the USA and Russia because the more states in possession of nuclear bombs, the more certain would be the self-destruction of humanity.

So, purely objectively, I welcome that Germany is disarming, or that a declaration by a number of atomic scientists exists. I also welcome it as a good sign that people in Germany are publicly advocating their views; this is a sign that, at least temporarily, a willingness to have one's own opinion is being felt. On the minus side there is the minor issue that many people in Germany are willing to remain unarmed in the expectation that the U.S.A. will take care of defense.

In January 1958 Gustav Hertz and Max von Laue cosigned a letter on behalf of the two German Physical Societies in divided Germany to invite all their physicist colleagues to celebrate the hundredth anniversary of Max Planck's birthday.[95] Hertz had returned after many years in the Soviet Union and had accepted a professorship at Leipzig. Max von Laue was director of what had formerly been Haber's institute in West Berlin. Letters were exchanged between the friends about who would be coming when. Franck would be traveling with Hertha, and the Borns were already looking forward to the reunion. There remained only the question of whether the East German border controls would cause difficulties. Born wanted to fly to Berlin in any case. Franck first visited the Haber institute in Berlin and his former doctoral student Dietrich Schmidt-Ott guided him through it.[96] Franck was particularly interested in Professor Georg Manecke's research there on membranes as it related to photosynthetic processes. Schmidt-Ott drove the Francks to the festive function in his own car.

The centennial celebrations were held at two different locations in walled-up Berlin. On April 24 it was held on the eastern side in what was at that time the State Opera near the Friedrichstraße train station, followed by a smaller gathering in the Magnus-Haus am Kupfergraben, where Lise Meitner spoke. On the 25th they reconvened in the conference hall in the zoo on the western side of the city. Wilhelm Westphal spoke about Planck as a person. An unexpectedly informal atmosphere was created when Westphal was reminiscing about the choral singing organized at Planck's home, familiar to all—save Gustav Hertz. Hertz was sitting almost directly opposite the speaker and made a remark that Westphal failed to catch. Walking up to the edge of the podium, he asked Hertz to repeat it. Comments and responses were bantered back and forth between them until it culminated in the loud challenge: "Then sing something, Gustav!" to the amusement of the audience. Werner Heisenberg delivered the honorary address. The number of guests was large. Almost all the notable physicists of two generations had come; the third generation, the students, saw for the first time the two women—Lise Meitner and Hertha Sponer—whose names had been recorded in the annals of science decades before and many men whose names are attached to famous experimental discoveries or physical formulas. Newspapers on both sides of the iron curtain covered the celebrations at length. Franck wrote a long letter to the von Hippels and Liscos about it.[97]

Berlin and the conference were somewhat hectic but very interesting and nice. Hertha met her pastor-widow sister and her pastor-wife daughter and her husband as well as her dentist brother, all from Leipzig. For the event all of us, including Born (Hedi did not come along), Pringsheim, and Lise Meitner, stayed in the same hotel. Hahn came by every few minutes, Courant disturbed us with moderation. Westphal, Laue and wife, and a number of other guests surrounded us during the off-session hours. Hertz and wife were likewise here both mornings. E.g., Weisskopf, Hertha's old admirer Kneser, etc., etc. Most of them send all of you their warmest regards, incl. Olly Westphal and Prof. Breysig née Friedburg, and naturally all the above-named and the Göttingers, who are mentioned further down. We also went to the Laues' for tea and ate with Westphal. But these were all only our "extracurricular activities." The "meetings" on the 24th and 25th including banquet on the Eastern side with exquisite southern Russian wines and champagne and in the West wonderful western wines, goose-liver patés and other delicacies as appetizers, etc., etc., were not lacking, of course. The festivities, in the style of eastern potentates in the wonderfully beautiful and ostentatiously renovated opera house in Berlin, in glaring contrast to the surrounding heaps of rubble of the shot-up neighborhood and the poverty of the Eastern population, was a sad combination. It wasn't made better by the political speeches by some of the Eastern representatives, held in the East contrary to firm commitments to avoid politics, but were avoided in the West, revealing that it is not easy to negotiate with the Russians. In the East, Hahn spoke briefly and extremely nicely, Laue unfortunately long, surely well, but so quietly that even people with normal hearing could not understand him, and Lise Meitner about Planck's personality, simply wonderfully. She spoke freely in front of a small group of the East. Phys. Society. Sadly she is quite weak and looked as if it was an effort for her to keep standing upright. (She was decorated with the Pour le Mérite, just as Hahn and Laue; they were honorary guests of Heuss at noon.) I said to her: "Lise, you were simply loveable." She quipped in reply: "A little late, dear Franck." But she really was loveable with all her tender frailty and mental strength. Everyone in the hall felt it. She really did deeply feel every word she said.

Born is "full of pep" and not willing to budge an inch either to the right or the left. After Chief Mayor Ebert (son of [Weimar-Republic-] President Ebert) had delivered a miserable philistine propaganda speech, I only succeeded with some effort in dissuading Born from responding to him. I had to tell him, you're here only as a guest and not scheduled as a speaker. Save it up. He did, but when at dinner he was sitting next to Minister Grotewohl and he gave him a cue word calling for a clear answer, he delivered him a clear and calm Philippic as had certainly not happened to him for a long while. He remained mute and Born continued to converse with Grotewohl's wife and told us, "what a pity that this prole has such a nice wife." On the 2nd day (in the conference hall [in West Berlin]) Trendelenburg (or Freudenberg?) spoke briefly and properly (he sends Arthur his regards), then for almost an hour long Heisenberg, in the main about his new theory. Wonderful, as far as I can understand it, far away from the goal of being a proven theory or even being completely calculated out, nevertheless magnificent as a general concept. Then Hertz spoke about the influence of Planck's elementary quantum on experimental

Figure 108 Centennial celebration of Max Planck's birthday in the Magnus-Haus. From left to right: Lise Meitner, the mayor of East Berlin Friedrich Ebert, Hans Frühauf, Otto Hahn, Max von Laue, and Walter Friedrich. By courtesy of Churchill Archives Centre, Lise Meitner Papers, MTNR 8/4/2.

research. After the great, but somewhat misplaced Heisenberg lecture, Hertz's natural, light, and unassuming manner was like a breath of fresh air in an oppressively odorous, overheated hall. Charming. Then Westphal spoke, simply and neatly about Planck's personality; entirely nice, but not comparable with the beautiful, profound, and short talk of the day before by Lise Meitner.

Franck and Hertz saw each other again after so many years. Pringsheim had already met Hertz in 1955 in Wiesbaden and had briefed Franck about Hertz's pragmatic attitude toward his position and politics. So nothing more stood in the way of a warm reunion between the two old friends.

When the first president of the Federal Republic of Germany, Theodor Heuss, traveled to the United States that spring, his trip brought him to Chicago and he used the opportunity to say a complimentary word about James Franck in a speech at the faculty club.[98]

Whenever his scientific work permitted it, Franck drove to Durham to see his wife. Her teaching duties and research work prevented her from leaving town. After corresponding with Emerson about an article by the photosynthesis researcher and director of Hopkins Marine Station at Stanford University Lawrence Rogers Blinks that needed further clarification, Franck formulated his own conceptions of long wavelength limits of radiation for photosynthesis and chlorophyll fluorescence.[99]

Gaffron had assumed the directorship of the photosynthesis research program in 1952, but he would soon be taking a better paid position at Florida State University, where research on photosynthesis was also being pursued. This required some adjustment for Franck, as Gaffron had filled in for him whenever he had been away on sick leave. For medical reasons Franck was tied to Chicago. He had to see his doctor twice a year for a medical examination, as he informed Lise Meitner in a birthday letter to her on 1 November 1959. He was already making plans for a European trip and was thinking of the future. But every once in a while heartrending memories of the past would return:[100]

I interrupted this letter because Hermann and Lisa picked me up for a fine concert. The vocalist Irmgard Seefried offered a beautiful program of songs. Mozart, Hugo Wolf, Schumann, Schubert, and a Brahms as an encore. I must confess that during the last one I got watery eyes at the memory of wonderful days with our Ingrid; well, I don't have to ask you: Do you still remember? I know that you haven't forgotten either. And isn't it almost as if it had been yesterday?

The past also came back to life with a postcard that Lise Meitner sent him from Göttingen. She had traveled there to attend Otto Hahn's eightieth birthday celebration. Franck replied from Durham on 17 March 1959:

The view on the card is just like the view from our balcony in the old Göttingen apartment. I can't quite evade the feeling of homesickness when I look at it. Well, one shouldn't be unfair. If I think of how many good things our new home country has offered all of us, that is, my family and me, and still is offering us, I have every reason to be more than satisfied.

Now that Hans Gaffron and his wife were settled at Florida State, correspondence had to serve as a substitute for his former daily conversations with Franck. At his vacation home on the Cape, Franck had the necessary peace to formulate results and considerations for publication. He commented about this to Lise Meitner in August 1959.

I, on the contrary, agonize over every word, as it never comes out as I want it; it always still is like my school essays. "Laborious and clumsy," my teachers used to say; nor is this likely to change much, as it doesn't hurt much, because as has been usual for the past few years, I only want to finish up one or two papers.

Franck was concentrating on an article for the *Handbuch der Pflanzenphysiologie*, being edited by Werner Ruhland for publication by Springer Publishers.[101] Franck had signed the contract in 1955, but writing the manuscript wore him out. Francis Wheeler Loomis, who had visited Franck in Göttingen at the end of the 1920s and had offered him his help in America as head of the department of physics at the University of Illinois at Urbana Champaign, wrote the historical introduction to the volume. It reviewed early efforts at understanding photosynthesis. Franck chose to write about the fluorescence of chlorophyll in cells and chloroplasts and their relations to the primary acts in photosynthesis. He praised Hans Kautsky's early findings:

A large number of observations since on chlorophyll fluorescence and afterglow under various conditions, conducted at a number of institutes, have generally yielded results in very good agreement.

Conversely, no agreement has been reached with regard to the conclusions to be drawn from these observations about the photochemical primary processes. This unsatisfactory state of affairs is explained in that many observations can be interpreted in different ways on the basis of plausible assumptions. The necessity of examining closely whether such assumptions agree with the totality of the observations on photosynthesis has often not been adequately drawn into account and in some cases the observational data only gradually became comprehensive enough to make real verification possible.

The remaining 46 pages are devoted to an attempt at a theory from existing observations and research. Yet Franck admitted that much still remained open.

Only on rare occasions did Franck comment publicly about the offenses and crimes perpetrated in Germany between 1933 and 1945. But he did not skirt the topic in letters to his old friends. When the lengthy negotiations for an Institute for Nuclear Research in West Berlin had come to a successful conclusion, its chemistry department was supposed to be located in a building named after Otto Hahn and the envisaged physics department in one bearing Lise Meitner's name. For various reasons the latter construction was postponed. So at von Laue's urgings the existing building was ultimately named the "Hahn-Meitner Institute for Nuclear Research." Busts of the two namesakes were going to be set up in the building's entrance area. Lise Meitner was not at all pleased about the idea, but Franck urged her persuasively:

Of course you're not happy about the bust, but we are. It is certainly good that a Hahn-Meitner Institute is being founded and your bust simply belongs inside it. Look, you really must also consider, among other things, that by looking at the sculptures future members of the institute will be compelled directly or indirectly to reflect and contemplate. The Germans have reason enough for that and it is good that they are aware of this and will remain so.

Retrospectives on Accomplishments—Memories among Friends

Heinrich Kuhn wanted to dedicate his book *Atomic Spectra* to his teacher Franck. So he asked Franck for his permission, to which Franck replied from Durham on 7 January 1960:[102]

Your modesty is far too great if you think it possible that your book were not good enough. That's sheer nonsense. Even though your book cannot be totally free of errors it is guaranteed ten times better than any book I could write, not to say that I ever did.

I am planning to write a short monograph of my own about the physics of photosynthesis but have to see whether I get around to it.

When Kuhn's book appeared, Hertha Franck made good use of it in her lectures. Franck thanked the author for his complimentary copy with the comment: "Such dedications mean more than many other distinctions that one receives if one gets old enough."

Franck's wife was constantly overworked and her arthritis was also worsening, so they decided to take a vacation in Germany. Hertha planned to go to Bad Tölz on a health cure and Franck wanted to travel about on his own in the meantime to visit friends.

Two letters and a telegram in May 1961 surprised Franck with congratulations on his Golden Jubilee as a university teacher. They were signed by Minister of Culture Voigt, University of Göttingen rector Flammersfeld, and *Kurator* Dahnke. Franck had totally forgotten about it himself. His longest reply was addressed to Prorector Helmuth Plessner. Thinking back, he wrote,[103]

In those days we believed we had a peaceful life dedicated to science ahead of us. Well, despite everything, it was not easy but science was a great consolation in all situations in life. We mustn't give up hope in intellectual and moral progress for humanity and, like you and all those working along with you at Göttingen University, we must patiently assist in attaining it. I wish all of you luck, success, and satisfaction in your fine and important mission. My last visit with you makes me wish another occasion to converse with you will present itself.

The research continued, but now the intervals between articles grew longer. In his greetings for the new year 1961 he wrote to Lise Meitner:[104]

It takes so much energy and time to digest the new literature in my narrow field, where digesting means almost always interpreting the data differently from the way the observers do. This limits one and is probably also arrogant but I simply can't change my belief that normal physics has to apply to biology, too, and this most authors seem not to assume. So I'm writing all the time and partly rejecting what I have written.

In the fall he traveled to Pittsburgh to discuss a contribution with Jerome Rosenberg, who had just left Chicago for a professorship in chemistry there, and Charles Weiss, Jr., from the Laboratory of Chemical Biodynamics at Berkeley, for an international conference at New York University. The research did not advance as fast as planned, however. Their aim was to ascertain which of two hypotheses applied to the first step in photosynthesis: Melvin Calvin's notion of light-induced ionization with electron donors and acceptors or James Franck and his collaborators' idea that the chloroplast dyes absorb the light before the known photochemical processes occur. The threesome managed to back their idea thoroughly, including various excitation stages for chlorophyll and regroupings of the surrounding electrons, and to refute Calvin's notion.[105]

Attending the conference was very gratifying for Franck and he received much applause. His talk began with an acknowledgment of the contributions by Max Planck, Albert Einstein, and Niels Bohr to the theoretical foundations of photochemistry. These presentations were published in the volume *Luminescence of Organic and Inorganic Materials* edited by Hartmut Kallmann and Grace Marmor Spruch. (Hartmut Kallmann had reemigrated to America in indignation at the revival of anti-Semitism in postwar Germany.)

Hertha Sponer-Franck's talk about the delayed fluorescence and phosphorescence of crystalline organic compounds at very low temperatures was also published in that volume.

Rosenberg was not available for the summer of 1962 because he was spending his sabbatical in Israel, so Franck set out to finish another of their joint papers by himself. It was an attempt to solve Calvin's idea in a different way. But Franck began to have qualms about their reasoning and wrote to Rosenberg to call off publication.

Despite his pressing load of projects, Franck went ahead with his travel plans. They wanted to visit friends again, and Hertha had to do something about her arthritis.[106] A cure stay in Baden-Baden was scheduled. Franck wanted to go first to London to see his school friend Philip Elkan and also to see Lise Meitner, who had resettled in Cambridge. A visit with Robert Hill was likewise on the itinerary. The next stop would be Copenhagen to visit the Bohr family; and Hilde Levi could not be passed by. In Antwerp they intended to stop and see Peter Pringsheim. Franck decided to accept Count Lennart Bernadotte's invitation and attend the convention of Nobel laureates in Lindau in June, where he would meet Niels Bohr, Max Born, Otto Hahn, Gustav Hertz, Georg von Hevesy, and Lise Meitner.[107]

The scientific program at Lindau opened with Bohr's presentation on atomic physics and human knowledge. Harold Urey followed with a talk titled The Problem of the Abundance of the Elements. Robert Hofstadter's talk was Recent Results on Nucleon Structure. Bohr initially only felt a little unwell, but his condition deteriorated and he had to be hurried back to Copenhagen. On the second day Franck spoke about the physical foundations of photosynthesis. As Warburg had also arrived, there was another debate, but this time it stayed within the limits of propriety. Sir John Cockcroft chose the topic Up-to-date Account of the Present Situation and the Prospects in the Field of Atomic Energy or as Nuclear Power. Sir Edward Appleton's talk was Recent Studies of

Figure 109 James Franck in discussion with students at Lindau 1962. By courtesy of the photographer Rauchwetter.

the Ionosphere. The third day also had a full schedule. John Bardeen's report, Recent Developments in Superconductivity, was followed by Born's considerations on color theory with color slides on Goethe's observations. Walter Brattain delved into the latest developments in semiconductor physics in his presentation, Surface Properties of Semiconductors. The fourth day was devoted exclusively to Heisenberg's talk about advances made in the unified theory of elementary particles.

The meeting ended with an excursion to Mainau, Count Bernadotte's floral island on Lake Constance, providing enough leisure for private conversations among old friends. Gustav Hertz's reunion with Lise Meitner revived memories of their collaboration in Berlin.

Afterwards Franck traveled on alone, since Hertha had accepted some distinguished invitations to give talks in Japan and India. Despite the long and straining voyage, all fortunately went well.

For Max Born's eightieth birthday Franck wrote his friend a longer letter. He reminisced about the start of their friendship in Heidelberg and compared their talents. A slightly depressed mood perhaps swayed this rather severe self-critique:[108]

> Basically, dear Born, in later life we did not change primarily. We developed according to "the prevailing law upon our entrance." You have retained your Calvinist attitude. Your papers and books are written articulately and finely and they do not age; for inst.,

Figure 110 James Franck and Max Born at the conference in Lindau. By courtesy of the photographer Werner Stuhler, Lindau.

in my view there is no finer book about optics than yours. New editions have added to the old text but never was anything wrong in the old version.

I, on the contrary, have a tinge of the Romantic. In general, I don't read my old papers anymore so as not to experience any disappointments, yet a short while ago I did have occasion to leaf through them. It was a little better than I had thought, as experimental errors were rare and the interpretations, peculiarly enough, were quite often quite accurate; no wonder, but rarely precise, albeit the interpretations were based more on hunches than on sharply defined series of proofs. If they were of use it was because they led to further experiments.

You, dear Born, would have become a very good physicist at all stages in the development of physics. I, obversely, only fit into the period of the evolution of modern physics during which anyone with enough pleasure in it and a little bit of imagination could arrive at more important results than had been prophesied for him over his cradle. Our disparity helped us to complement each other so well during the beautiful Göttingen period.

As many as eight years before, he had written to Gustav Hertz:

If I had stayed with pure physics, I'd have had to admit that the scientific results of the last decade were puny. But perhaps they weren't so puny after all, if one considers that I had applied myself toward a physical explanation of biological phenomena and am now stuck over my ears in attempts to understand photosynthesis a bit better.

A symposium on the mechanism of photosynthesis in green plants in October 1963 offered an opportunity for Franck and Rosenberg to develop the principles of a theory on energy utilization in photosynthesis.[109] Franck's later publications do not present new, specially obtained experimental data, but, as he loved to do, they critically reassess the interpretations of results by other scientists with partial alterations to the theory. This time Franck and Rosenberg discussed photosynthesis with long-wave radiation of 680 and 700 nm. More than sixty talks were delivered and discussed at the symposium from October 14 to 18. They were grouped into nine topics. The research on photosynthesis had become increasingly specialized during the past decade. Jerome Rosenberg jointly presented a second talk with his collaborator from Turkey, Tevfik Bigat.

Either Franck or Rosenberg was evidently not completely satisfied with their joint article because they added new material for another publication. The first lines indicate what they deemed important:[110]

Our model for energy utilization in photosynthesis differs from most current proposals in that it requires only one type of center for photochemical reactivity, namely a chlorophyll *a* molecule exposed to water and its solutes and complexed with cytochrome *f* and one other electron-transport enzyme. Although many types of pigments may participate in energy collection, it is of relatively little importance which pigment absorbs radiation so long as the resulting energy can be delivered to the exposed chlorophyll *a* as excitation of the first excited singlet state. An important exception occurs in those pigment bearing units containing at least some longer wavelength absorbing form of chlorophyll *a*, a crystalline modification.

So the issue was once again the radiation absorption within the infrared range of the spectrum. More than sixty papers by other authors were cited, none, however, by Calvin and just five self-citations of articles by himself and collaborators. Franck would not live to see this article in print.

Bohr had suffered a mild heart attack at the meeting in Lindau but recovered again in Copenhagen. The Bohr couple were able to celebrate their golden wedding anniversary and go to Italy, but a second heart attack on November 18 cut his life short. The planned jubilee marking fifty years since the publication of Bohr's atomic model in 1913 turned into a major commemorative event in July 1963. Franck traveled to Copenhagen and remembered his friend in an obituary:[111]

Niels Bohr's research and personality are an example that for the few great figures in science character and professional importance are on a par. To arrive at the highest scientific achievements, not just a rare degree of talent is called for, but also a rare degree of strength of character, diligence, courage, extreme love of Truth, and an ability to recognize the really essential and to concentrate on it. These are a few of the indispensable preconditions for success in research and it also influences one's entire philosophy of life and way of living.

Following an excursus about the broad-reaching significance of Bohr's research, he described the influence he exerted on his pupils.

What Bohr taught them by example and through discussion was the art in which he was an exemplary master to all: Thinking problems through to the last, the merciless battle against self-deception, the courage not to falter before apparently insurmountable hurdles. The word "taught" is actually not appropriate here, since characteristics of personality cannot be taught; but one can demonstrate their importance and thus prod it into activity in those who already latently possess them, so to speak. Bohr once made a comment in a conversational way that is revelatory about his way of thinking and working. He said: "One should never let oneself be content with only doing what one can do; one should rather always do what one actually cannot do."

Franck also gave some examples of Bohr's political activism, his decision to help build the atomic bomb, and his attempts to prevent its deployment in the war against Japan. One gets the impression that he was speaking about his own motivations.

Some people did not understand Bohr's decision to collaborate on the atomic bomb, as little as they did the decisions by others. It was a grim necessity. That the manufacture of such a bomb very probably could succeed was known to all physicists in the world who read the professional literature. Should we let our hands lie idly in our laps and wait until Hitler might eventually get his hands on such a bomb? News that to those familiar with physics indicated clearly that such research was under way in Germany, were frequently published at length, even in the daily papers. A single bomb dropped on a large city in the West would have meant Hitler's victory over an unprepared West. Was it permissible for a war to be lost that would have spread throughout the whole world the criminal tyranny that had already enslaved Germany? When it became clear that Hitler would not gain possession of a bomb, Bohr raised a voice of caution. As he was staying in Los Alamos, we in Chicago could not learn about his efforts under the prevailing wartime conditions.

The traveling and memorials for his friend exhausted Franck. He looks dreadfully tired on a photograph depicting him among other participants.

Although his health problems restricted his productivity, his delight in other people and science in general was undiminished. When the director of the Laboratory for Biophysical Chemistry at the University of Minnesota, Rufus Lumry, asked Franck about Warren Lee Butler's qualifications, Franck replied on 28 October 1963 to describe the circumstances of his thesis under his mentorship:[112]

His experiments are absolutely reliable, and he masters in an astonishing way, the modern art of carrying out complicated experiments. He is just as successful on other types of studies in plant physiology.

I heard him give a talk about this matter when he was invited at Duke University and was duly impressed by his important results and his presentation, and about his general acclaim he gained by the audience. I could continue but these examples are enough to make it clear why I am enthusiastic about his work.

At the turn of the year 1963–64 the German ambassador to the United States, K. Heinrich Knappstein, sent Franck a color picture book about his native country of "yesterday and today," *Deutschland Gestern und Heute*, with a personal dedication. Having taken the time to look through the volume, Franck sent his thanks:[113]

These excellent reproductions of the country and its peoples and of its works of art fanned my never quite extinguished homesickness and heightened my anticipation for our planned visit to Germany in the spring. The essays are equally interesting to read.

He mentioned the passage about the extreme high points and catastrophic low points in the history of Germans and their culture. Posing the question why, he believed he could find the answer in that, throughout his lifetime at least, the nation left the solution to political problems in principle entirely to the government. Neither did he or his fellow classmates at university ever stop to think about the nonsense the emperor, Wilhelm II, was saying.

Many meetings with young German students in the last few years have nevertheless made me optimistic again. At least the scientist groups among the students, hundreds of whom I became acquainted with (e.g., at Lindau 2 years ago) in free and candid discussions, are neither nationalistic nor militaristic, rather the opposite. Among the ranks of the older generation there are surely many still who only blamed Hitler for having lost the war. If young people stay the way they are, then one really can have some hope.

The new travel plans were quite similar to the last in 1962. The first stop was London to meet Lise Meitner, then onwards to Antwerp to see Peter Pringsheim.[114] In Copenhagen Margarethe Bohr would be paid a visit. Sweden could not be left out either, if Franck wanted to stop by in Lund to see Hellmuth Hertz as well as arrange the indispensable reunion with his sister-in-law Marta Josephson. Traveling via Kiel to see Kroebel and Lochte-Holtgreven, the route would continue to Berlin. The wall was making Gustav Hertz feel very isolated

Figure 111 James Franck and Max Born 1964 in Göttingen. Franck's gesture is typical of him. He is about to pull his pocket watch out and ask: "Do we still have time?" Lisa Lisco collection, Special Collections Research Center, University of Chicago Library.

over there. Göttingen would be at the end of their itinerary, but the intervening months brought a few more alterations to their plans. Hilde Levi was anxious to see Franck in Copenhagen as well, and he did not want to disappoint her.

More changes were made to their trip. On their way to Berlin the Francks would meet up with Lise Meitner to visit Gustav Hertz together. They left some extra luggage at the zoo station with Heinrich Gobrecht, professor of physics at the Technical University, to avoid having to check it through East German customs.[115] They subsequently also visited the von Laues and Westphals, of course. But in the middle of May they eventually made their way to Göttingen. On the evening of the 20th the Franck couple met Otto Hahn and his secretary, Marie-Luise Rehder, at the "Sonne" for a meal. (Hahn's wife, Edith, could not be among the party because she was in a mental clinic, but she was already recovering.) They spent a pleasant evening together reminiscing about old times. Mrs. Rehder spoke with Franck the next morning on the phone. Not long afterwards he suddenly suffered a heart attack, and the summoned physician, the professor for internal medicine Rudolf Schoen, could only establish death at his clinic.[116]

The faculty of the sciences organized obsequies at the University of Göttingen; and Franck was buried, as he had wished, beside his first wife in Chicago.

In May 1966 the University of Chicago and the Samuel F. Fels Fund sponsored a major symposium in Franck's memory, organized by Robert Platzman. The chosen topic was the exchange of energy in molecular systems. The participating specialists came from the fields of physical chemistry, photochemistry, and photosynthesis. Eugene Rabinowitch gave the talk at lunchtime, speaking about Franck's involvement in drafting the Franck Report and in the political debate, and in the evening Hans Gaffron, Edward Teller, and Robert Pohl, Jr., on behalf of his father reminisced about Franck's personality.

Hertha Franck had also intended to speak, but her friends managed to persuade her to abstain. She was no longer able to give proper expression to her thoughts. She was initially in care in America but spent her final days in a home in Germany.

The University of Chicago named a building after James Franck. The University of Jerusalem offers an annual "James Franck Lecture." And Germany? There is no institute bearing his name, no scientific award in his memory. Perhaps this book will help keep his memory alive.

Appendix I

List of Publications by James Franck

Über die Beweglichkeit der Ladungsträger der Spitzenentladung. *Verh. Phys. Ges.* Berlin 1906, 8, 252–263.

Über die Beweglichkeit der Ladungsträger der Spitzenentladung. *Ann. Phys.* Leipzig 1906, 21, 972–1000.

(with R. Pohl) Eine Methode zur Bestimmung der Ionenbeweglichkeit in kleinen Gasmengen. *Verh. Phys. Ges.* Berlin 1907, 9, 69–75.

(with R. Pohl) Die Ionenbeweglichkeit in Helium. *Verh. Phys. Ges.* Berlin 1907, 9, 194–199.

(with R. Pohl) Zur Frage nach der Geschwindigkeit der Röntgenstrahlen. *Verh. Phys. Ges.* Berlin 1908, 10, 117–136.

(with R. Pohl) Zur Frage nach der Geschwindigkeit der Röntgenstrahlen II. *Verh. Phys. Ges.* Berlin 1908, 10, 489–494.

(with W. Westphal) Über die Ladung von Gasionen. *Verh. Phys. Ges.* Berlin 1909, 11, 276–280.

Über die Ionenbeweglichkeit der radioaktiven Restatome und die Masse des Gasions. *Verh. Phys. Ges.* Berlin 1909, 11, 397–405.

(with W. Westphal) Über doppelt geladene Gasionen. *Verh. Phys. Ges.* Berlin 1909, 11, 146–154.

Über die Ionenbeweglichkeit in Argon und den Einfluss geringer Mengen Sauerstoffs auf diese Grösse. *Verh. Phys. Ges.* Berlin 1910, 12, 291–298.

(with A. Wehnelt) Über Beziehungen zwischen Faradayschem Gesetz und Gasentladungen. *Verh. Phys. Ges.* Berlin 1910, 12, 444–456.

Über das Vorkommen freier Elektronen in chemisch trägen Gasen bei Atmosphärendruck. *Verh. Phys. Ges.* Berlin 1910, 12, 613–620.

(with R. W. Wood) Über die Beeinflussung der Fluoreszenz von Jod- und Quecksilberdampf durch Beimengung von Gasen mit verschiedener Affinität zum Elektron. *Verh. Phys. Ges.* Berlin 1911, 13, 78–83.

(with R. W. Wood) The influence upon the fluorescence of iodine and mercury of gases with different affinities for electrons. *Phil. Mag.* 1911, 21, 314–318.

(with R. W. Wood) Über die Überführung des Resonanzspektrums der Jodfluoreszenz in ein Bandenspektrum durch Zumischung von Helium. *Verh. Phys. Ges.* Berlin 1911, 13, 84–87.

(with R. W. Wood) Über die Überführung des Resonanzspektrums der Jodfluoreszenz in ein Bandenspektrum durch Zumischung von Helium. *Phys. Z.* 1911, 12, 81–83.
(with R. W. Wood) Transformation of a resonance spectrum into a band spectrum by presence of helium. *Phil. Mag.* 1911, 21, 265–268.
(with P. Pringsheim) Über das elektrische und optische Verhalten der Chlorflamme. *Verh. Phys. Ges.* Berlin 1911, 13, 328–334.
(with L. Meitner) Über radioaktive Ionen. *Verh. Phys. Ges.* Berlin 1911, 13, 671–675.
(with G. Hertz) Über einen Zusammenhang zwischen Quantenhypothese und Ionisierungsspannung. *Verh. Phys. Ges.* Berlin 1911, 13, 967–971.
(with R. Pohl) Bemerkung zu den Versuchen des Hrn. Marx über die Geschwindigkeit der Röntgenstrahlen. *Ann. Phys.* Leipzig 1911, 34, 936–940.
(with W. Westphal) On the question of valency in gaseous ionization. *Phil. Mag.* 1911, 22, 547–551.
(with W. Westphal) Über eine Beeinflussung der Stossionisation durch Fluoreszenz. *Verh. Phys. Ges.* Berlin 1912, 14, 159–166.
(with G. Hertz) Bemerkung zu unserer Notiz über einen Zusammenhang zwischen Ionisierungsspannung und Quantenhypothese. *Verh. Phys. Ges.* Berlin 1912, 14, 167–168.
Über die Überführung des Resonanzspektrums der Jodfluoreszenz in ein Bandenspektrum durch zugemischte Gase. *Verh. Phys. Ges.* Berlin 1912, 14, 419–422.
(with G. Hertz) Über durch polarisiertes Licht erregte Fluoreszenz von Joddampf. *Verh. Phys. Ges.* Berlin 1912, 14, 423–425.
(with G. Hertz) Über eine Methode zur direkten Messung der mittleren freien Weglänge von Gasmolekülen. I. *Verh. Phys. Ges.* Berlin 1912, 14, 596–604.
(with R. Pohl & P. Pringsheim) Erwiderung an Herrn Marx. *Verh. Phys. Ges.* Berlin 1912, 14, 1124–1125.
Bericht über Ionenbeweglichkeit. *Jahrb. Radioakt. u. Elektronik* 1912, 9, 235–270, 475.
(with G. Hertz) Messung der Ionisierungsspannung in verschiedenen Gasen. *Verh. Phys. Ges.* Berlin 1913, 15, 34–44.
(with G. Hertz) Über Zusammenstösse zwischen Gasmolekülen und langsamen Elektronen. *Verh. Phys. Ges.* Berlin 1913, 15, 373–390.
(with G. Hertz) Notiz über Bildung von Doppelschichten. *Verh. Phys. Ges.* Berlin 1913, 15, 391–393.
Über den Einfluss der Elektronenaffinität auf die Ladung von Kanalstrahlen. *Phys. Z.* 1913, 14, 623–624.
(with G. Hertz) Über Zusammenstösse zwischen langsamen Elektronen und Gasmolekülen. II. *Verh. Phys. Ges.* Berlin 1913, 15, 613–620.
(with G. Hertz) Über einen Zusammenhang zwischen Stossionisation und Elektronenaffinität. *Verh. Phys. Ges.* Berlin 1913, 15, 929–934.
(with G. Hertz) Über einen Zusammenhang zwischen Stossionisation und Elektronenaffinität. *Verh. Phys. Ges.* Berlin 1913, 14, 1115–1117.
(with G. Hertz) Zur Theorie der Stossionisation. *Verh. Phys. Ges.* Berlin 1914, 16, 12–19.
(with E. von Bahr) Über Ionisation durch positive Ionen. *Verh. Phys. Ges.* Berlin 1914, 16, 57–68.
(with G. Hertz) Über Zusammenstösse zwischen Elektronen und den Molekülen des Quecksilberdampfes und der Ionisierungsspannung desselben. *Verh. Phys. Ges.* Berlin 1914, 16, 457–467.
(with G. Hertz) Über die Erregung der Quecksilberresonanzlinie 253,6 nm durch Elektronenstösse. *Verh. Phys. Ges.* Berlin 1914, 16, 512–517.
(with G. Hertz) Über die relative Intensität der Gasspektra bei der Glimmentladung in Gasgemischen. *Verh. Phys. Ges.* Berlin 1916, 18, 213–220.

(with G. Hertz) Über die Kinetik von Elektronen und Ionen in Gasen. *Phys. Z.* 1916, 17, 409–416, 430–440.
(with G. Hertz) Die Bestätigung der Bohr'schen Atomtheorie im optischen Spektrum durch Untersuchungen der unelastischen Zusammenstösse langsamer Elektronen mit Gasmolekülen. *Phys. Z.* 1919, 20, 132–143.
(with P. Knipping) Die Ionisierungsspannungen des Heliums. *Phys. Z.* 1919, 20, 481–488.
(with P. Knipping & T. Krüger) Über einen Zusammenhang zwischen Stossionisation und der Dissoziationsarbeit neutraler Moleküle. *Verh. Phys. Ges.* Berlin 1919, 21, 728–732.
Bemerkungen über die Intensitätsverteilung in Serienspektren. *Z. Phys.* 1920, 1, 2–10.
(with F. Reiche) Über Helium und Parhelium. *Z. Phys.* 1920, 1, 154–160.
(with P. Knipping) Über die Anregungsspannungen des Heliums. *Z. Phys.* 1920, 1, 320–332.
(with E. Einsporn) Über die Anregungspotentiale des Quecksilberdampfes. *Z. Phys.* 1920, 2, 18–29.
Über Anregungsspannungen von Spektrallinien des Quecksilberdampfes. *Z. Elektrochem.* 1920, 26, 305.
Spektroskopische Tatsachen und die Methode des Elektronenstosses im Zusammenhang mit der Bohr'schen Atomtheorie. *Verh. Ges. Deutsch. Naturf. u. Ärzte* 1920, 86, 242–262.
Bemerkungen über die Verbreiterung von Spektrallinien. *Festschr. Kaiser Wilhelm Ges.* Berlin 1921, 77–81.
(with W. Grotrian) Bemerkungen über angeregte Atome. *Z. Phys.* 1921, 4, 89–99.
Über eine optische Messung der Elektronenaffinität. *Z. Phys.* 1921, 5, 428–432.
(with W. Grotrian) Über den Einfluss eines Magnetfeldes auf die Dissoziation angeregter Moleküle. *Z. Phys.* 1921, 6, 35–39.
Über Lichtanregung und Ionisation von Atomen und Molekülen durch Stösse langsamer Elektronen. *Z. Phys.* 1921, 22, 388–391, 409–414, 441–448, 466–471.
Einige aus der Theorie von Klein und Rosseland zu ziehende Folgerungen über Fluoreszenz, photochemische Prozesse und die Elektronenemission glühender Körper. *Z. Phys.* 1922, 9, 259–266.
Bemerkung über Anregungs- und Ionisierungsspannung des Heliums. *Z. Phys.* 1922, 11, 155–160.
(with G. Cario) Über Zerlegung von Wasserstoffmolekülen durch angeregte Quecksilberatome. *Z. Phys.* 1922, 11, 161–166.
(with W. Grotrian) Über die Absorptionsbanden von Quecksilberdampf. *Z. techn. Phys.* 1922, 3, 194–197.
Bemerkungen über Stossionisation. *Verh. Phys. Ges.* Berlin 1922, 3, 29–31.
Heinrich Rubens. *Verh. Phys. Ges.* Berlin 1922, 3, 76–91.
(with R. Pohl) Rubens und die Quantentheorie. *Naturwissenschaften* 1922, 10, 1030–1033.
(with G. Cario) Über sensibilisierte Fluoreszenz von Gasen. *Z. Phys.* 1923, 17, 202–212.
Über sensibilisierte Fluoreszenz von Gasen. *Z. Phys.* 1923, 24, 450–451.
(with P. Pringsheim) Fluoreszenz von Gasen. *Naturwissenschaften* 1923, 11, 559–563.
Neuere Erfahrungen über quantenhaften Energieaustausch bei Zusammenstössen von Atomen und Molekülen. *Ergeb. Exact. Naturw.* 1923, 2, 106–123.
Zur Frage nach der Ionisierungsspannung positiver Ionen. *Z. Phys.* 1924, 25, 312–316.
Atome und Molekülstösse und ihre chemische Bedeutung. *Naturwissenschaften* 1924, 12, 1063–1068.
Excitation of light by impacts (in Czechoslovakian). *Cas. pro pest. matemat. a fays.* 1925, 54, 377–389.
(with M. Born) Bemerkungen über die Dissipation der Reaktionswärme. *Ann. Phys. Leipzig* 1925, 76, 225–230.
(with M. Born) Quantentheorie und Molekelbildung. *Z. Phys.* 1925, 31, 411–429.

(with P. M. S. Blackett) Anregung von Spektren des Wasserstoffs durch Elektronenstoss. *Z. Phys.* 1925, 34, 389–401.
Elementary processes of photochemical reactions. *Trans. Faraday Soc.* 1925, 21, 536–542.
Quantenchemische Probleme chemischer Reaktionen. *Z. Elektrochem.* 1925, 31, 350–357.
(with G. Cario) Über die Auslöschung der Resonanzfluoreszenz des Quecksilbers durch Gaszusatz. *Z. Phys.* 1926, 37, 619–624.
Der Wirkungsquerschnitt bei atomaren Stossprozessen. *Naturwissenschaften* 1926, 144, 211–214.
Elementarprozesse photochemischer Reaktionen. (Bemerkungen über die homöopolare Bindung.) *Z. Phys. Chem.* 1926, 120, 144–156.
(with P. Jordan) Anregung von Quantensprüngen durch Stösse. *Handbuch d. Phys.* (first ed.) 1926, 23, 641–775.
(with P. Jordan) *Anregung von Quantensprüngen durch Stösse*. Berlin: Springer 1926.
(with H. Kuhn & G. Rollefson) Beziehung zwischen Absorptionsspektren und chemischer Bindung bei Alkalihalogeniddämpfen. *Z. Phys.* 1927, 43, 155–163.
(with H. Kuhn) Über ein Absorptions- und ein Fluoreszenzspektrum von Silberjodidmolekülen und die Art ihrer chemischen Bindung. *Z. Phys.* 1927, 43, 164–171.
(with T. R. Hogness) Über den Nachweis der Relativgeschwindigkeit der Zerfallsprodukte bei optischen Dissoziationsprozessen. *Z. Phys.* 1927, 44, 26–31.
(with H. Kuhn) Über Absorption und Fluoreszenz von Silberbromid- und Silberchloriddampf. *Z. Phys.* 1927, 44, 607–614.
Über eine Rotverschiebung der Resonanzfluoreszenz durch vielfach wiederholte Streuung. *Naturwissenschaften* 1927, 15, 236–238.
Nobel lecture, 11 December 1926. Stockholm: Imprimerie Royale 1927.
Bandenspektrum und chemische Bindung. *Atti del Congr. Intern. Fis.* (Como 1927), 1, 65–71 (Bologna) 1928.
Einige wichtige experimentelle Grundlagen der Bohr'schen Atomtheorie. *Z. Phys. Chem. Unterricht* 1928, 41, 18–27.
Beitrag zum Problem der Wiedervereinigung von Ionen und Elektronen. *Z. Phys.* 1928, 47, 509–516.
A few remarks on the problem of the recombination of positive ions and electrons, *J. Franklin Inst.* 1928, 205, 473–479.
(with G. E. Gibson) Notiz über die Auslöschung der D-Linien in Flammen durch Chlorzusatz. *Z. Phys.* 1928, 50, 691.
(with G. Scheibe) Über Absorptionsspektren negativer Halogenionen in Lösung, *Z. Phys. Chem.* 1928, A139, 22–31.
Energie-Stufen von Atomen und Molekülen und ihre Beziehung zur chemischen Bindung. *Ber. Deutsch. Chem. Ges.* 1928, 61B, 445–459.
(with H. Sponer) Beitrag zur Bestimmung der Dissoziationsarbeit von Molekülen aus Bandenspektren. *Nachr. Ges. Wiss. Göttingen*, math. phys. class 1928, 241–253.
(with A. von Hippel) Der elektrische Durchschlag und Townsend's Theorie. *Z. Phys.* 1929, 57, 696–704.
Bestimmung thermochemischer Grössen aus spektroskopischen Daten. *Z. Elektrochem.* 1930, 36, 581–589.
(with E. Rabinowitch) Über die Aktivierungswärme bimolekularer Gasreaktionen und über die Chlorknallgasreaktion. *Z. Elektrochem.* 1930, 36, 794–799.
(with M. Born) Beitrag zum Problem der Absorptionskatalyse. *Nachr. Ges. Wiss. Göttingen*, math. phys. class 1930, 77–89.
Experimentalphysik. In: *Aus fünfzig Jahren deutscher Wissenschaft*. Edited by Gustav Abb. Berlin: de Gruyter & Co. 1930.
Beziehungen zwischen Spektroskopie und Chemie. *Naturwissenschaften* 1931, 19, 217–225.

(with F. Haber) Zur Theorie der Katalyse durch Schwermetallionen in wässriger Lösung und insbesondere zur Autooxydation der Sulfitlösungen. *Sitzungsber. Preuss. Akad. Wiss.*, phys. math. class 1931, 250–256.

(with H. Sponer & E. Teller) Bemerkungen über Prädissoziationsspektren dreiatomiger Moleküle. *Z. Phys. Chem.* 1932, B18, 88–101.

(with H. Kuhn) Schlüsse auf Bindungsfestigkeit und Bindungsart aus kontinuierlichen Absorptionsspektren. *Naturwissenschaften* 1932, 20, 293–295.

(with H. Kuhn) Conclusions on the strength and nature of binding from the continuous absorption spectrum. *Bull. Acad. Sci. Utd Provinces Agra and Oudh, Allahabad* 1933, 2, 223–226.

(with A. Eucken) Umsatz von Translationsenergie in Schwingungsenergie bei molekularen Stossprozessen. *Z. phys. Chem.* 1933, B20, 460–466.

Über den Lösungszustand des Wasserstoffs im Palladium und Hydrierungskatalyse. *Nachr. Ges. Wiss. Göttingen*, math. phys. class 1933, 293–296.

(with R. W. Wood) Ultraviolet absorption of heavy water vapor. *Phys. Rev.* 1934, 45, 667–668.

(with E. Rabinowitch) Some remarks about free radicals and the photochemistry of solutions. *Trans. Faraday Soc.* 1934, 30, 120–130.

Beitrag zum Problem der Kohlensäure-Assimilation. *Naturwissenschaften* 1935, 23, 226–229.

(with H. Levi) Zum Mechanismus der Sauerstoff-Aktivierung durch fluoreszenzfähige Farbstoffe. *Naturwissenschaften* 1935, 23, 229–230.

(with H. Levi) Beitrag zur Untersuchung der Fluoreszenz in Flüssigkeiten, *Z. Phys. Chem.* 1935, B27, 409–420.

Remarks on photosynthesis. *Chem. Rev.* 1935, 17, 433–438.

(with R. W. Wood) Fluorescence of chlorophyll in its relation to photochemical processes in plants and organic solutions. *J. Chem. Phys.* 1936, 4, 551–560.

(with K. F. Herzfeld) Remarks on the photochemistry of polyatomic molecules. *J. Phys. Chem.* 1937, 41, 97–107.

(with K. F. Herzfeld) An attempted theory of photosynthesis. *J. Chem. Phys.* 1937, 5, 237–251.

Fundamentals of photosynthesis. *J. Wash. Acad. Sci.* 1938, 27, 317–329.

(with E. Teller) Migration and photochemical action of excitation energy in crystals. *J. Chem. Phys.* 1938, 6, 861–872.

(with C. A. Rieke) Note on the explanation of the D-lines in the spectrum of the night sky. *Astrophys.* 1939, 89, 463–464.

(with R. Livingston) Assimilation and respiration of excised leaves at high concentrations of carbon dioxide. *Amer. J. Bot.* 1940, 27, 449–458.

(with H. Gaffron) Photosynthesis: Facts and interpretations. *Adv. Enzymology* 1941, 1, 199–262.

(with R. Livingston) Remarks on the fluorescence, phosphorescence, and photochemistry of dyestuffs. *J. Chem. Phys.* 1941, 9, 184–190.

(with K. F. Herzfeld) Contribution to a theory of photosynthesis. *J. Phys. Chem.* 1941, 45, 978–1025.

(with C. S. French & T. T. Puck) The fluorescence of chlorophyll and photosynthesis. *J. Phys. Chem.* 1941, 45, 1268–1300.

(with S. Weller) Photosynthesis in flashing light. *J. Phys. Chem.* 1941, 45, 1359–1373.

(with C. S. French) Photooxidation processes in plants. *J. Gen. Physiol.* 1941, 25, 309–324.

Some fundamental aspects of photosynthesis. *Sigma Xi Quart.* 1941, 29, 81–105.

Carbon dioxide evolution during the induction period of photosynthesis. *Amer. J. Bot.* 1942, 29, 314–317.

(with P. Pringsheim) Phosphorescence of absorbed trypaflavine and its quenching by oxygen. *J. Chem. Phys.* 1943, 11, 21–27.

Photosynthetic activity of isolated chloroplasts. *Rev. Mod. Phys.* 1945, 17, 112–119.

(with P. Pringsheim & D. T. Lad) Oxygen production by anaerobic photosynthesis of algae measured by a new micromethod. *Arch. Biochem.* 1945, 7, 103–142.

Proposal of a method for the separation of He_3 from He_4. *Phys. Rev.* 1946, 70, 561.

(with Y. G. Shiau) Chlorophyll fluorescence and photosynthesis in algae, leaves, and chloroplasts. *Arch. Biochem.* 1947, 14, 253–295.

(with J. E. Mayer) An osmotic diffusion pump. *Arch. Biochem.* 1947, 14, 297–313.

Max Planck. *Yearbook Amer. Phil. Soc.* 1947, 284–291.

Bemerkungen über Lumineszenz von Ionenkristallen. *Ann. Phys.* Leipzig 1948, 3, 62–68.

(with H. Sponer) Comparison between predissociation and internal conversion in polyatomic molecules. In: *Contribution à l'Étude de la Structure Moléculaire (Vol. Commémoratif Victor Henri)*. Edited by L. Brillouin, J. Duchesne & Harald H. Nielsen, 169–179. Liège: Desoer 1948.

(with A. H. Brown) On the participation of carbon dioxide in the photosynthetic activity of illuminated chloroplast suspensions. *Arch. Biochem.* 1948, 16, 55–60.

(with R. Livingston) Remarks on intra- and inter-molecular migration of excitation energy. *Rev. Mod. Phys.* 1949, 21, 505–509.

Possibility of photosynthesis on Mars. In: *The Atmospheres of the Earth and Planets*. Edited by G. P. Kuiper, 355–356. Chicago: Univ. of Chicago Press 1949.

An interpretation of the contradictory results in measurements of the photosynthetic quantum yields and related phenomena. *Arch. Biochem.* 1949, 23, 297–314.

The relation of the fluorescence of chlorophyll to photosynthesis. In: *Photosynthesis in Plants*. Edited by J. Franck & W. E. Loomis, 293–348. Ames, Iowa: State College Press 1949.

A critical survey of the physical background of photosynthesis. *Ann. Rev. Plant Physiol.* 1951, 2, 53–86.

The physical background of photosynthesis. *Symposia Soc. Exper. Biol.*, no. 5 (Carbon dioxide fixation and photosynthesis), 1951, 160–175.

(with R. Platzman) Theory of the absorption spectra of halide ions in solution. In: *L. Farkas Mem. Vol., Res. Council Israel*, spec. publ. no. 1, 21–36, Jerusalem 1952.

Participation of respiratory intermediates in the process of photosynthesis as an explanation of abnormally high quantum yields. *Arch. Biochem. & Biophys.* 1953, 45, 190–229.

(with R. Platzman) The role of the hydration configuration in electronic processes involving ions in aqueous solution. *Z. Phys.* 1954, 138, 411–431.

(with R. Platzman) Physical principles underlying photochemical, radiationchemical, and radiobiological reactions. In: *Radiation Biology*. Edited by A. Hollaender, 1, part 1, 191–253. New York: McGraw-Hill 1954.

Physical problems of photosynthesis. *Daedalus* Stockh. 1955, 86, 17–42.

(with F. L. Allen) Photosynthetic evolution of oxygen by flashes of light. *Arch. Biochem. & Biophys.* 1955, 58, 124–143.

(with H. Sponer) Remarks on radiationless transitions in complex molecules. *J. Chem. Phys.* 1956, 25, 172.

General remarks on chlorophyll-sensitized photochemical reactions in vitro. In: *Research in Photosynthesis*. Edited by H. Gaffron et al., 19–21. New York: Interscience 1957.

A theory of the photochemical part of photosynthesis. In: *Research in Photosynthesis*. Edited by H. Gaffron et al., 142–144. New York: Interscience 1957.

(with R. Platzman) A physical mechanism for the inactivation of proteins by ionizing radiation. In: *Symposium on Information Theory in Biology*. Edited by H. P. Yockey, R. L. Platzman & H. Quastler, 262–275. New York: Pergamon 1958.

(with J. E. Brugger) Experimental and theoretical contribution to studies of the afterglow of chlorophyll in plant materials. *Arch. Biochem. & Biophys.* 1958, 75, 465–496.

Remarks on the long-wavelength limits of photosynthesis and chlorophyll fluorescence. *Proc. Nat. Acad. Sci. Wash.* 1958, 44, 941–948.

Photosynthesis. *Technion Yearbook* 1958, 15, 39–41.

A reply to the comments by Tollin on Franck's theory of the primary steps in photosynthesis. *Arch. Biochem. & Biophys.* 1959, 80, 378–382.

Fluoreszenz des Chlorophylls in Zellen und Chloroplasten und ihre Beziehung zu den Primärakten der Photosynthese. In: *Die CO_2-Assimilation*. Edited by W. Ruheland, *Handbuch der Pflanzenphysiol.* 1960, 5 (part 2), 689–735.

(with J. L. Rosenberg & C. Weiss, Jr.) The primary photochemical step in photosynthesis: A comparison of two theories. In: *Luminescence of Organic and Inorganic Materials*. Edited by H. P. Kallmann & G. M. Spruch, 11–29. New York: Wiley 1962.

(with J. L. Rosenberg) Principles of a theory of energy utilization in photosynthesis. In: *Photosynthetic Mechanisms in Green Plants*. Nat. Acad. Sci. Nat. Res. Council Publ. 1963, no. 1145, 101–111. Washington.

Niels Bohr's Persönlichkeit. *Naturwissenschaften* 1963, 50, 341–343.

(with J. L. Rosenberg) A theory of light utilization in plant photosynthesis. *J. Theor. Biol.* 1964, 7, 276–301.

Kuhn, H: James Franck. *Biogr. Mem. FRS.* Nov. 1965, 11, 53.

Appendix II

The Franck Report

The scientific advisory panel chaired by James Franck that compiled this report included: Donald J. Hughes, James J. Nickson, Eugene Rabinowitch, Glenn T. Seaborg, Joyce C. Stearns, and Leo Szilard. The original sixteen-page report attached to Arthur H. Compton's introductory synopsis for the Secretary of War dated 12 June 1945 is located at the U.S. National Archives, Washington, D.C.: Record Group 77, Manhattan Engineer District Records, Harrison-Bundy File, folder no. 76.*

Political and Social Problems

I. Preamble

The only reason to treat nuclear power differently from all the other developments in the field of physics is its staggering possibilities as a means of political pressure in peace and sudden destruction in war. All present plans for the organization of research, scientific and industrial development, and publication in the field of nucleonics are conditioned by the political and military climate in which one expects those plans to be carried out. Therefore, in making suggestions for the postwar organization of nucleonics, a discussion of political problems cannot be avoided. The scientists on this Project do not presume to speak authoritatively on problems of national and international policy. However, we found ourselves, by the force of events, [in] the last five years in the position of a small group of citizens cognizant of a grave danger for the safety of this country as well as for the future of all the other nations, of which the rest of mankind is unaware. We therefore felt it our duty to urge that the political problems, arising from the mastering of nuclear power, be recognized in all their gravity, and

*The present transcription is based on the copy from the records of the Chief of Engineers at JRLSC, Franck papers B 18 F 23. Original emphasis. Minor handwritten emendations on the original are here enclosed in slashes, deletions in braces. Misspellings have been silently corrected; square brackets indicate my additions.

Each page is stamped "SECRET" with the warning: "This document contains information affecting the national defense of the United States within the meaning of the Espionage Act, U.S.C. 50; 31 and 32. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law." Followed by the update: "THIS PAGE REGRADED UNCLASSIFIED Order Sec Army By TAG per 720564."

that appropriate steps be taken for their study and the preparation of necessary decisions. We hope that the creation of the [Interim Advisory] Committee by the Secretary of War to deal with all aspects of nucleonics, indicates that these implications have been recognized by the government. We feel that our acquaintance with the scientific elements of the situation and prolonged preoccupation with its world-wide political implications, imposes on us the obligation to offer to the Committee some suggestions as to the possible solution of these grave problems.

x x x

Scientists have often before been accused of providing new weapons for the mutual destruction of nations, instead of improving their well-being. It is undoubtedly true that the discovery of flying, for example, has so far brought much more misery than enjoyment and profit to humanity. However, in the past, scientists could disclaim direct responsibility for the use to which mankind had put their disinterested discoveries. We cannot take the same attitude now because the success which we have achieved in the development of nuclear power is fraught with infinitely greater dangers than were all the inventions of the past. All of us, familiar with the present state of nucleonics, live with the vision before our eyes of sudden destruction visited on our own country, of [a] Pearl Harbor disaster, repeated in thousandfold magnification, in every one of our major cities.

In the past, science has often been able to provide adequate protection against new weapons it has given into the hands of an aggressor, but it cannot promise such efficient protection against the destructive use of nuclear power. This protection can come only from the political organization of the world. Among all arguments calling for an efficient international organization for peace, the existence of nuclear weapons is the most compelling one. In the absence of an international authority which would make all resort to force in international conflicts impossible, nations could still be diverted from a path which must lead to total mutual destruction, by a specific international agreement barring a nuclear armaments race.

II. Prospectives of Armaments Race

It could be suggested that the danger of destruction by nuclear weapons can be prevented—at least as far as this country is concerned—by keeping our discoveries secret for an indefinite time, or by developing our nucleonic armaments at such a pace that no other nations would think of attacking us from fear of overwhelming retaliation.

The answer to the first suggestion is that although we undoubtedly are at present ahead of the rest of the world in this field, the fundamental facts of nuclear power are a subject of common knowledge. British scientists know as much as we do about the basic wartime progress of nucleonics—with the exception of specific processes used in our engineering developments—and the background of French nuclear physicists plus their occasional contact with our Projects, will enable them to catch up rapidly, at least as far as basic scientific facts are concerned. German scientists, in whose discoveries the whole development of this field has originated, apparently did not develop it during the war to the same extent to which this has been done in America; but to the last day of the European war, we have been living in constant apprehension as to their possible achievements. The knowledge that German scientists were working on this weapon and that their government certainly had no scruples against using it when available, was the main motivation of the initiative which American scientists have taken in developing nuclear power on such a large scale for military use in this country. In Russia, too, the basic facts and implications of nuclear power were well understood in 1940, and the experiences of Russian scientists in nuclear research is [*sic*] entirely sufficient to enable them to retrace our steps within a few years, even if we would make all attempts to conceal them. Furthermore, we should not expect too much success from attempts to keep basic information secret in peacetime, when scientists acquainted with the work on this and associated Projects will be scattered to many colleges and research institutions and many of them will continue to work on problems closely related to those on which our developments are based. In other words, even if we can retain our leadership in basic knowledge of nucleonics for a certain time by maintaining the secrecy of all results achieved on this and associated Projects, it would be foolish to hope that this can protect us for more than a few years.

It may be asked whether we cannot achieve a monopoly on the raw materials of nuclear power. The answer is that even though the largest now known deposits of uranium ores are under the control of powers which belong to the "western" group (Canada, Belgium and British Indies); the old deposits in Czechoslovakia are outside this sphere. Russia is known to be mining radium on its own territory; and even if we do not know the size of the deposits discovered so far in the USSR, the probability that no large reserves of uranium will be found in a country which covers 1/5 of the land area of the earth (and whose sphere of influence takes in additional territory), is too small to serve as a basis for security. Thus, we cannot hope to avoid a nuclear armament race, either by keeping secret from the competing nations the basic scientific facts of nuclear power, or by cornering the raw materials required for such a race.

x x x

One could further ask whether we cannot feel ourselves safe in a race of nuclear armaments by virtue of our greater industrial potential, including greater diffusion of scientific and technical knowledge, greater volume and efficiency of our skilled labor corps, and greater experience of our management—all the factors whose importance has been so strikingly demonstrated in the conversion of this country into an arsenal of the Allied Nations in the present war. The answer is that all that these advantages can give us, is the accumulation of a larger number of bigger and better atomic bombs—and this only if we produce these bombs at the maximum of our capacity in peace time, and do not rely on conversion of a peace time nucleonics industry to military production after the beginning of hostilities.

However, such a quantitative advantage in reserves of bottled destructive power will not make us safe from sudden attack. Just because a potential enemy will be afraid of being "outnumbered and outgunned," the temptation for him may be overwhelming to attempt a sudden unprovoked blow—particularly if he would suspect us of harboring aggressive intentions against his security or "sphere of influence." In no other type of warfare does the advantage lie so heavily with the aggressor. He can place his "infernal machines" in advance in all our major cities and explode them simultaneously, thus destroying a major part of our industry and killing a large proportion of our population, aggregated in densely populated metropolitan districts. Our possibilities of retaliation—even if retaliation would be considered compensation for the loss of tens of millions of lives and destruction of our largest cities—will be greatly handicapped because we must rely on aerial transportation of the bombs, particularly if we would have to deal with an enemy whose industry and population are dispersed over a large territory.

x x x

In fact, if the race of nuclear armaments is allowed to develop, the only apparent way in which our country could be protected from the paralyzing effects of a sudden attack is by dispersal of industries which are essential for our war effort and dispersal of the population of our major metropolitan cities. As long as nuclear bombs remain scarce (this will be the case until uranium and thorium cease to be the only basic materials for their fabrication) efficient dispersal of our industry and the scattering of our metropolitan population will considerably decrease the temptation of attacking us by nuclear weapons.

Ten years hence, an atomic bomb containing perhaps 20 kg of active material, may be detonated at 6% efficiency, and thus have an effect equal to that of 20,000 tons of TNT. One of these may be used to destroy something like 3 square miles of an urban area. Atomic bombs containing a larger quantity of active material but still weighing less than one ton may be expected to be obtainable within ten years which could destroy over ten square miles of a city. A nation which is able to assign 10 tons of atomic explosives for the preparation of a sneak attack on this country, can then hope to achieve the destruction of all industry and most of the population in an area from 500 square miles upwards. If no choice of targets, in any area of five hundred square miles of American territory, will contain a large enough fraction of the nation's industry and population to make their destruction a crippling blow to the nation's war potential and its ability to defend itself, then the attack will not pay, and will probably not be undertaken. At present, one could easily select in this country a hundred blocks of five square miles each whose simultaneous destruction would be a staggering blow to the nation. (A possible total destruction of all the nation's naval forces would be only a small detail of such a catastrophe.) Since the area of the United States is about six million square miles, it should be possible to scatter its industrial and human resources in such a way as to leave no 500 square miles important enough to serve as a target for nuclear attack.

We are fully aware of the staggering difficulties of such a radical change in the social and economic structure of our nation. We felt, however, that the dilemma had to be stated, to show what kind of alternative methods of protection will have to be considered if no successful international agreement is reached. It must be pointed out that in this field we are in a less favorable position than nations which are either now more diffusely populated and whose industries are more scattered, or whose governments have unlimited power over the movement of population and the location of industrial plants.

If no efficient international agreement is achieved, the race of nuclear armaments will be on in earnest not later than the morning after our first demonstration of the existence of nuclear weapons. After this, it might take other nations three or four years to overcome our present headstart, and 8 or 10 years to draw even with us if we continue to do intensive work in this field. This might be all the time we have to bring about the re-groupment of our population and industry. Obviously, no time should be lost in inaugurating a study of this problem by experts.

III. Prospectives of Agreement

The prospect{ive} of nuclear warfare and the type of measures which have to be taken to protect a country from total destruction by nuclear bombing, must be as abhorrent to other nations as to the United States. England, France, and the smaller nations of the European continent, with their congeries of people and industries, are in an entirely hopeless situation in the face of such a threat. Russia, and China are the only great nations which could survive a nuclear attack. However, even though these countries value human life less than the peoples of Western Europe and America, and even though Russia, in particular, has an immense space over which its vital industries could be dispersed and a government which can order this dispersion, the day it is convinced that such a measure is necessary—there is no doubt that Russia, too, will shudder at the possibility of a sudden disintegration of Moscow and Leningrad, almost miraculously preserved in the present war, and of its new industrial cities in the Urals and Siberia. Therefore, only lack of mutual *trust*, and not lack of *desire* for agreement, can stand in the path of an efficient agreement for the prevention of nuclear warfare. The achievement of such an agreement will thus essentially depend on the integrity of intentions and readiness to sacrifice the necessary fraction of one's own sovereignty, by all the parties to the agreement.

x x x

From this point of view, the way in which the nuclear weapons, now secretly developed in this country, will first be revealed to the world appears of great, perhaps fateful importance.

One possible way—which may particularly appeal to those who consider the nuclear bombs primarily as a secret weapon developed to help win the present war—is to use it without warning on an appropriately selected object in Japan. It is doubtful whether the first available bombs, of comparatively low efficiency and small size, will be sufficient to break the will or ability of Japan to resist, especially given the fact that the major cities like Tokyo, Nagoya, Osaka and Kobe already will largely be reduced to ashes by the slower process of ordinary aerial bombing. Certain and perhaps important tactical results undoubtedly can be achieved, but we nevertheless think that the question of the use of the very first available atomic bombs in the Japanese war should be weighed very carefully, not only by military authority, but by the highest political leadership of this country. If we consider international agreement on total prevention of nuclear warfare as the paramount objective, and believe that it can be achieved, this kind of introduction of atomic weapons to the world may easily destroy all our chances of success. Russia, and even allied countries which bear less mistrust of our ways and intentions, as well as neutral countries, will be deeply shocked. It will be very difficult to persuade the world that a nation which was capable of secretly preparing and suddenly releasing a weapon, as indiscriminate as the rocket bomb and a {million?} /thousand/ times more destructive, is to be trusted in its proclaimed desire of having such weapons abolished by international agreement. We have large accumulations of poison gas, but do not use them, and recent polls have shown that public opinion in this country would disapprove of such a use even if it would accelerate the winning of the Far Eastern war. It is true, that some irrational element in mass psychology makes gas poisoning more revolting than blasting by explosive, even though gas warfare is in no way more "inhuman" than the war of bombs and bullets. Nevertheless, it is not at all certain that the American public opinion, if it could be enlightened as to the effect of atomic explosives, would support the first introduction by our own country of such an indiscriminate method of wholesale destruction of civilian life.

Thus, from the "optimistic" point of view—looking forward to an international agreement on prevention of nuclear warfare—the military advantages and the saving of American lives, achieved by the sudden use of atomic bombs against Japan, may be outweighed by the ensuing loss of confidence and wave of horror and repulsion, sweeping over the rest of the world, and perhaps dividing even the public opinion at home.

From this point of view a demonstration of the new weapon may best be made before the eyes of representatives of all United Nations, on the desert or a barren island. The best possible atmosphere for the achievement of an international agreement could be achieved if America would be able to say to the world, "You see what weapon we had but did not use. We are ready to renounce its use in the future and to join other nations in working out adequate supervision of the use of this nuclear weapon."

This may sound fantastic, but then in nuclear weapons we have something entirely new in the order of magnitude of destructive power, and if we want to capitalize fully on the advantage which its possession gives us, we must use new and imaginative methods. After such a demonstration the weapon could be used against Japan if a sanction of the United Nations (and of the public opinion at home) could be obtained, perhaps after a preliminary ultimatum to Japan to surrender or at least to evacuate a certain region as an alternative to the total destruction of this target.

x x x

It must be stressed that if one takes a pessimistic point of view and discounts the possibilities of an effective international control of nuclear weapons, then the advisability of an early use of nuclear bombs against Japan becomes even more doubtful—quite independently of any humanitarian considerations. If no international agreement is concluded immediately after the first demonstration, this will mean a flying start of an unlimited armaments race. If this race is inevitable, we have all reason to delay its beginning as long as possible in order to increase our headstart still further. It took us three years, roughly, under forced draft of wartime urgency, to complete the first stage of production of nuclear explosives—that based on the separation of the rare fissionable isotope U^{235}, or its utilization for the production of an equivalent quantity of another fissionable element. This stage required large-scale, expensive constructions and laborious procedures. We are now on the threshold of the second stage—that of converting into fissionable material the comparatively abundant common isotopes of thorium and uranium. This stage requires no elaborate plans and can provide us in about 5–6 years with a really substantial stockpile of atomic bombs. Thus it is to our interest to delay the beginning of the armaments race at least until the successful termination of this second stage. The benefit to the nation, and the saving of American lives in the future, achieved by renouncing an early demonstration of nuclear bombs and letting the other nations come into the race only reluctantly, on the basis of guesswork and without definite knowledge that the "thing does work," may far outweigh the advantages to be gained by the immediate use of the first and comparatively inefficient bombs in the war against Japan. At the least, pros and cons of this use must be carefully weighed by the supreme political and military leadership of the country, and the decision should not be left to /considerations, merely, of/ military tactics.

One may point out that the scientists themselves have initiated the development of this "secret weapon" and it is therefore strange that they should be reluctant to try it out on the enemy as soon as it is available. The answer to this question was given above—the compelling reason for creating this weapon with such speed was our fear that Germany had the technical skill necessary to develop such a weapon without any moral restraints regarding its use. {illegible deleted sentence}

Another argument which could be quoted in favor of using atomic bombs as soon as they are available is that so much taxpayers' money has been invested in these Projects that the Congress and the American public will require a return for their money. The above-mentioned attitude of the American public opinion in the question of the use of poison gas against Japan shows that one can expect it to understand that a weapon can sometimes be made ready only for use in extreme emergency; and as soon as the potentialities of nuclear weapons will be revealed to the American people, one can be certain that it will support all attempts to make the use of such weapons impossible.

Once this is achieved, the large installations and the accumulation of explosive materials at present earmarked for potential military use, will become available for important peace time developments, including power production, large engineering undertakings, and mass production of radioactive materials. In this way, the money spent on war time development of nucleonics may become a boon for the peace time development of national economy.

IV. Methods of International Control

We now consider the question of how an effective international control of nuclear armaments can be achieved. This is a difficult problem, but we think it to be soluble. It requires study by statesmen and international lawyers, and we can offer only some preliminary suggestions for such a study.

Given mutual trust and willingness on all sides to give up a certain part of their sovereign rights, by admitting international control of certain phases of national economy, the control could be exercised (alternatively or simultaneously) on two different levels.

The first and perhaps simplest way is to ration the raw materials—primarily, the uranium ores. Production of nuclear explosives begins with processing of large quantities of uranium in large isotope separation plants or huge production piles. The amounts of ore taken out of the ground at different locations could be controlled by resident agents of the international Control Board, and each nation could be allotted only an amount which would make large scale separation of fissionable isotopes impossible.

Such a limitation would have the drawback of making impossible also the development of nuclear power production for peace time purposes. However, it does not need to prevent the production of radioactive elements on a scale which will revolutionize the industrial, scientific and technical use of these materials, and will thus not eliminate the main benefits which nucleonics promises to bring to mankind.

An agreement on a higher level, involving more mutual trust and understanding, would be to allow unlimited production, but keep exact bookkeeping on the fate of each pound of uranium mined. Certain difficulty with this method of control will arise in the second stage of production, when one pound of pure fissionable isotope will be used again and again to produce additional fissionable material from thorium. These [difficulties] could perhaps be overcome by extending control to the mining and use of thorium, even though the commercial use of this metal may cause complications.

If check is kept on the conversion of uranium and thorium ore into pure fissionable materials, the question arises how to prevent accumulation of large quantities of such materials in the hands of one or several nations. Accumulations of this kind could be rapidly converted into atomic bombs if a nation would break away from international control. It has been suggested that a compulsory denaturation of pure fissionable isotopes may be agreed upon—they should be diluted after production by suitable isotopes to make them useless for military purposes (except if purified by a process whose development must take two or three years), while retaining their usefulness for power engines.

x x x

One thing is clear: any international agreement on prevention of nuclear armaments must be backed by actual and efficient controls. No paper agreement can be sufficient since neither this [n]or any other nation can stake its whole existence on trust into [*sic*] other nations' signatures. Every attempt to impede the international control agencies must be considered equivalent to denunciation of the agreement.

It hardly needs stressing that we as scientists believe that any systems of controls envisaged should leave as much freedom for the peace[ful] development of nucleonics as is consistent with the safety of the world.

Summary

The development of nuclear power not only constitutes an important addition to the technological and military power of the United States, but also creates grave political and economic problems for the future of this country.

Nuclear bombs cannot possibly remain a "secret weapon" at the exclusive disposal of this country, for more than a few years. The scientific facts on which their construction is based are well known to scientists of other countries. Unless an effective international control of nuclear explosives is instituted, a race of nuclear armaments is certain to ensue following the first revelation of our possession of nuclear weapons to the world. Within ten years other countries may have nuclear bombs, each of which, weighing less than a ton, could destroy an urban area of more than five square miles. In the war to which such an armaments race is likely to lead, the United States, with its agglomeration of population and industry in comparatively few metropolitan districts, will be at a disadvantage compared to the nations whose population and industry are scattered over large areas.

We believe that these considerations make the use of nuclear bombs for an early, unannounced attack against Japan inadvisable. If the United States would be the first to release this new means of indiscriminate destruction upon mankind, she would sacrifice public support throughout the world, precipitate the race of armaments, and prejudice the possibility of reaching an international agreement on the future control of such weapons.

Much more favorable conditions for the eventual achievement of such an agreement could be created if nuclear bombs were first revealed to the world by a demonstration in an appropriately selected uninhabited area.

If chances for the establishment of an effective international control of nuclear weapons will have to be considered slight at the present time, then not only the use of these weapons against Japan, but even their early demonstration may be contrary to the interests of this country. A postponement of such a demonstration will have in this case the advantage of delaying the beginning of the nuclear armaments race as long as possible. If, during the time gained, ample support could be made available for further development of the field in this country, the postponement would substantially increase the lead which we have established during the present war, and our position in an armament race or in any later attempt at international agreement will thus be strengthened.

On the other hand, if no adequate public support for the development of nucleonics will be available without a demonstration, the postponement of the latter may be deemed inadvisable, because enough information might leak out to cause other nations to start the armament race, in which we will then be at a disadvantage. At the same time, the distrust of other nations may be aroused by a confirmed development under cover of secrecy, making it more difficult eventually to reach an agreement with them.

If the government should decide in favor of an early demonstration of nuclear weapons it will then have the possibility to take into account the public opinion of this country and of the other nations before deciding whether these weapons should be used in the war against Japan. In this way, other nations may assume a share of responsibility for such a fateful decision.

To sum up, we urge that the use of nuclear bombs in this war be considered as a problem of long-range national policy rather than military expediency, and that this policy be directed primarily to the achievement of an agreement permitting an effective international control of the means of nuclear warfare.

The vital importance of such a control for our country is obvious from the fact that the only effective alternative method of protecting this country, of which we are aware, would be a dispersal of our major cities and essential industries.

Abbreviations in the Notes

AAG	Akademie der Wissenschaften zu Göttingen, archive
ADPG	Archiv der Deutschen Physikalischen Gesellschaft
BA	Bundesarchiv Berlin
BBAA	Berlin-Brandenburgische Akademie der Wissenschaften, archive
BHSA	Bayerisches Hauptstaatsarchiv
ChAC	Churchill Archives Centre, Churchill College, Cambridge
Conv.	Author's conversation with a contemporary of James Franck
DMA	Deutsches Museum, archive
GStA	Geheimes Staatsarchiv, Preußischer Kulturbesitz
HSTA	Senat der Freien und Hansestadt Hamburg Staatsarchiv, Hamburg
HUBA	Humboldt-Universität Berlin, university archive
Inter.	Thomas H. Kuhn's & Maria Mayer-Goeppert's interview with James Franck, 9–14 July 1962 (partly also with Hertha Sponer-Franck), publ. in: *Sources for the History of Quantum Physics*
JF	James Franck
JRLSC	University of Chicago, Joseph Regenstein Library, special collections
LBI	Leo Baeck Institute, New York
LMUA	Ludwig-Maximilians-Universität, archive
MPGA	Max-Planck-Gesellschaft, archive
NBA	Niels Bohr Archive
NSUBH	Niedersächsische Staats- und Universitätsbibliothek, manuscripts dept.
RFA	Rockefeller Foundation, archive
RSA	Royal Society Archive
SAG	Stadtarchiv Göttingen
SBBHA	Staatsbibliothek zu Berlin, Preußischer Kulturbesitz, manuscripts dept.
SPVA	Springer Verlag, archive
UBGA	Universitätsbund Göttingen, archive
UGA	Universität Göttingen, university archive

Notes

Preface

1. MPGA, Abt. V a Rep. 14 Haber collection: Interview J. Jaenicke with JF, p. 3.

2. Chopping this biography up into the various spheres of physics, photosynthesis research, politics, academia, and home life would not, in my opinion, reflect clearly enough the heavy stamp and influence of each one of them on James Franck's life as a whole. It was therefore not possible to avoid incorporating scientific detail into the present account.

Chapter 1

1. Erklärung von 75 Notabeln gegen den Antisemitismus, 12 Nov. 1880. In: *Quellen zum Politischen Denken der Deutschen im 19. und 20. Jahrhundert*. Edited by Rudolf Buchner & Winfried Baumgart. Vol. VI, Darmstadt 1978, pp. 260–261.

2. Kuhn, Heinrich: James Franck 1882–1964. *Biogr. Mem. Roy. Soc.* 11 Nov. 1965. Beyerchen, Alan D.: Emigration from country and discipline. The journey of a German physicist into American photosynthesis research. In: *Forced Migration and Scientific Change. Emigré German-Speaking Scientists and Scholars after 1933*. Edited by Mitchell G. Ash & Alfons Söllner. German Historical Institute, Washington D.C., Cambridge Univ. Press 1996, pp. 71–85.

Chapter 2

1. Eilers, Georg: *Hamburgs Vergangenheit*. Hamburg 1922, pp. 274 f.

Jochmann, Werner & Hans-Dieter Loose (eds.): *Hamburg—Geschichte der Stadt und ihrer Bewohner*. Vol. I. Hamburg 1922.

An einen Hohen Senat—Jahresberichte der Verwaltungsbehörden über das Jahr 1885. Hamburg 1886, pp. 5 f.

2. Feilchenfeld, Alfred: Aus der älteren Geschichte der portugiesisch-israelitischen Gemeinde in Hamburg. Hamburg 1848.

Feilchenfeld, Alfred: Die älteste Geschichte der deutschen Juden in Hamburg. Berlin 1889.

Feilchenfeld, Alfred: Anfang und Blüthezeit der Portugieser-Gemeinde in Hamburg. *Zeitschrift des Vereins für hamburgische Geschichte* 10 (1899), no. 2, pp. 199–240.

3. Inter., pp. 54, 55.

Geiger, Abraham: Zur gegenwärtigen Lage. *Jüdische Z. für Wissenschaft und Leben* 4 (1866), pp. 81 f.

Schwabacher, Isaac S.: Geschichte und rechtliche Gestaltung der Portugiesisch-Jüdischen und Deutsch-Israelitischen Gemeinde zu Hamburg. Berlin 1914.

Plaut, W. Gunter: The Rise of Reform Judaism. A Source Book of Its European Origins. New York 1963, pp. 31 f.

4. *Allgemeine Zeitung des Judentums*. Edited by Ludwig Phillippson. Bonn 46 (1882), p. 377. On the lack of members in the Portuguese community in Hamburg, cf. Ibid., 50 (1886), p. 696.

5. Lisa Lisco estate, private collection: Franck family tree.

Dettmer, Frauke: Juden im Amt Ritzebüttel und der Stadt Cuxhaven. Hamburg 1882, p. 18.

Krohn, Helga: Die Juden in Hamburg—Die politische, soziale, und kulturelle Entwicklung einer jüdischen Großstadtgemeinde nach der Emanzipation 1848–1918. Dissertation, Hamburg 1970, pp. 79 f., 164 f. A number of Jews named Franck are mentioned in this thesis, but none are indicated as being related to Jacob Franck.

6. Swinne, Edgar: Richard Gans, Hochschullehrer in Deutschland und Argentinien. Berlin 1992, pp. 9 f.

Zinke, Friedrich Wilhelm: Nobelpreisträger James Franck, pp. 40 f., with a letter by JF to Zinke, pp. 41 f., in which he writes quite positively about his school experiences. In: *Wilhelm-Gymnasium Hamburg* 1888–1981. *Eine Dokumentation über* 100 *Jahre Wilhelm-Gymnasium*. Edited by Peter-Rudolf Schulz. Hamburg 1981.

7. Conv. with the Liscos: Franck occasionally told his family members about nightmares from his school days.

8. Inter., pp. 1, 2.

9. An einen Hohen Senat—Jahresberichte der Verwaltungsbehörden über das Jahr 1885. Hamburg 1886, p. 5.

10. Conv. with the Liscos.

11. JRLSC, Franck papers B 21 F 3: JF's school report by the Wilhelm Gymnasium.

12. Conv. with the Liscos.

13. Breslauer, Bernhard: *Die Zurücksetzung der Juden an den Universitäten Deutschlands*. Denkschrift im Auftrage des Verbandes der Deutschen Juden. Berlin 1911. There is no record about whether the Francks knew this text. As was then usual, scientists are not listed separately in the published statistics. One of Breslauer's comments on p. 6, par. 3, is of particular interest: "What does strike the eye, though, is that the figures for the baptized [Jews] rose considerably and that such speculation concerning baptism is not entirely false." Inter., pp. 54, 55.

14. HSTA, Stammrolle Jahrgang 1882, Militär-Ersatzbehörden DII 107. Vol. 1; Meldewesen A 30; Jüdische Gemeinden 705, vol. 2, p. 451 (K); Staatsangehörigkeitsaufsicht; Wede II, no. 585.

15. Witte, K.: 100 Jahre Physik in Hamburg. *Phys. Bl.* 41 (1985), p. 379. This was true until 1919. Inter., pp. 5, 14.

16. Ruprecht-Karls-Universität Heidelberg, Universitätsarchiv Vorlesungsverzeichnisse; personal files on JF's residence in Heidelberg 1902–03.

17. Schäfer, Dietrich: *Mein Leben*. Berlin, Leipzig 1926, pp. 150 f.

Köhnke, Klaus Christian: *Der junge Simmel in Theoriebeziehungen und sozialen Bewegungen*. Frankfurt am Main 1996, pp. 141 f. Köhnke quotes from a letter by Schäfer, a teacher at Friedrich-Wilhelms-Universität in Berlin since 1903, to Franz Böhm, dated 26 Feb. 1908. When Georg Simmel was supposed to receive an appointment to the University of Heidelberg in 1908, Dietrich Schäfer prevented his candidacy on anti-Semitic grounds, despite backing by Max Weber, Wilhelm Windelband, Heinrich Rickert, Gothein, and Georg Jellinek.

"Whether Simmel is baptized or not, I don't know, nor did I want to ask. But he is an Israelite, through and through, in his outward appearance, in his behavior and his mentality."

18. Born, Max: *My Life. Recollections of a Nobel Laureate*. London 1978, pp. 65 f.

19. Inter., pp. 6, 16.

Pohl, Robert W.: Von den Studien- und Assistentenjahren James Francks—Erinnerungen an das Physikalische Institut der Berliner Universität. *Phys. Bl.* 28 (1972), pp. 542 f. Also: JRLSC, Franck papers B 23 F 18, Engl. version. Pohl reported that sheer chance had determined that Franck find a position as a graduate student under Warburg. Franck had despaired about his studies in chemistry and geology, but his friends had tried to console him, advising him "to try physics as a major." In an interview, Franck pointed out that this recollection by Pohl probably involved Franck's initial idea in Berlin to stop studying chemistry. The lack of lectures on current problems in chemistry at Heidelberg had proved too serious a deficiency. Franck decided to take chemistry as a minor in Berlin. Pohl also contended in his article that Warburg had discouraged Franck for anti-Semitic reasons. No indication of this can be found either in the interview or among Franck's papers.

Walther Kaufmann wrote to E. Wiechert on 20 Jun. 1898 about the possibility of his appointment to Berlin, mentioning Warburg's suspicious nature and having himself experienced similar behavior by Warburg. NSUBA, Cod. Ms. E. Wiechert.

Wilhelm Westphal was not able to confirm to the author Pohl's inference that Warburg was an anti-Semite.

HUBA, Vorlesungs- und Personalverzeichnisse.

20. Franck, James: Emil Warburg zum Gedächtnis. *Naturwiss*. 19 (1931), pp. 993–997.

Kant, Horst: Emil Warburg und die Physik in Berlin. *Dahlemer Archivgespräche*, vol. 2, 1997. Edited by Hubert Laitko & Renate Zott, Berlin 1997, pp. 64 f.

21. JRLSC, Franck papers B 21 F 3: praise by the police from 28 Jul. 1904.

22. Inter., pp. 6 f.

Personal communication by Wilhelm Westphal to the author.

23. Warburg had worked on a similar topic in 1897: Warburg, Emil: Ueber die Electrisierung der Luft durch Spitzenentladung. *Ann. Phys*. 63 (1897), pp. 411 f.

The issue for Warburg was analyzing dust-free air and the polarity a point takes on in the process.

24. Inter., pp. 8, 21.

Thomson, Joseph John: *Conductions of Electricity through Gases*. Cambridge 1903.

Thomson, Joseph John: *Electricity and Matter*. Westminster 1904.

25. JRLSC, Franck papers B 11 F 1: Protokollbuch Januar 1905.

26. Inter., p. 9.

27. HUBA, Philosoph. Fakultät. Litt P. No. 4, Vol. 204: Acta Promotionen, pp. 504 f.

28. Franck, James: Über die Beweglichkeit der Ladungsträger der Spitzenentladung. *Verh. Dt. Phys. Ges*. 8 (1906), pp. 252–263.

29. It is improbable that he intended to express having abandoned his Jewish beliefs. Nor would it agree with Franck's later statements (1933) or his response to the persecution of Jews. After 1945 Franck clearly professed his allegiance to Judaism; see his letter to the ministerial advisor Richard Thoma from 22 Sep. 1947 quoted here at the end of the section about Franck's attitude on reparations.

30. JRLSC, Franck papers B 2 F 4: E. Drude to JF.

Planck, Max: Paul Drude. *Verh. Dt. Phys. Ges*. 8 (1906), pp. 599 f.

"Still fresh in the minds of all of those concerned is that Thursday, the 5th of July, when in the afternoon the Faculty of Philosophy were assembled at the university to conduct the doctoral examinations and instead of the expected came the news about the shattering occurrence."

31. Inter., p. 55.

Chapter 3

1. Inter., p. 22.
2. Conv. with the Liscos and personal communication by Dr. R. O. Pohl to the author.
3. Franck, James: Heinrich Rubens. *Verh. Dt. Phys. Ges.* 3 (1922), pp. 76–91.
Franck, James & Robert W. Pohl: Rubens und die Quantentheorie. *Naturwiss.* 10 (1922), pp. 1030–1033.
4. Heinrich, Rudolf & Hans Reinhard Bachmann et al.: *Walther Gerlach: Physiker, Lehrer, Organisator: Dokumente aus seinem Nachlaß*. Exhibition catalog by the Deutsches Museum. Munich 1989, p. 40.
5. Hettner, Gerhard & Otto Hahn: Zur Erinnerung an Otto v. Baeyer. *Naturwiss.* 34 (1947), pp. 193–194.
6. Franck, James & Robert Pohl: Eine Methode zur Bestimmung der Ionenbeweglichkeit in kleinen Gasmengen. *Verh. Dt. Phys. Ges.* 9 (1907), pp. 69–75.
Franck, James & Robert Pohl: Die Ionenbeweglichkeit in Helium. *Verh. Dt. Phys. Ges.* 9 (1907), pp. 194–199.
7. Franck, James & Robert Pohl: Zur Frage der Geschwindigkeit der Röntgenstrahlen. *Verh. Dt. Phys. Ges.* 10 (1908), pp. 117–136, 489–494.
Franck, James & Robert Pohl: Bemerkungen zu den Versuchen des Hrn. Marx über die Geschwindigkeit der Röntgenstrahlen. *Ann. Phys.* 34 (1911), pp. 936–940.
8. Franck, James, Robert Pohl & Peter Pringsheim: Erwiderung an Herrn Marx. *Verh. Dt. Phys. Ges.* 14 (1912), pp. 1124–1125.
Franck, James & Robert W. Pohl: Peter Pringsheim. *Phys. Bl.* 20 (1964), pp. 133–134.
9. Brüche, Ernst: W. H. Westphal zum 80. Geburtstag. *Phys. Bl.* 18 (1962), pp. 127–130.
10. Franck, James & Wilhelm Westphal: Über doppelt geladene Gasionen. *Verh. Dt. Phys. Ges.* 11 (1908), pp. 146–154.
Franck, James & Wilhelm Westphal: Über die Ladung von Gasionen. *Verh. Dt. Phys. Ges.* 11 (1909), pp. 276–280.
11. Franck, James: Über die Ionenbeweglichkeit in Argon und den Einfluß geringer Mengen Sauerstoff auf diese Größe. *Verh. Dt. Phys. Ges.* (1910), pp. 291–298.
12. Westphal, Wilhelm: Arthur Wehnelt zum 70. Geburtstag. *Forschung und Fortschritte* 18 nos. 10/11 (1940), p. 124.
13. Wehnelt, Arthur & James Franck: Über Beziehungen zwischen Faradayschem Gesetz und Gasentladungen. *Verh. Dt. Phys. Ges.* 12 (1910), pp. 444–456.
14. Franck, James: Über das Vorkommen freier Elektronen in chemisch trägen Gasen bei Atmosphärendruck. *Verh. Dt. Phys. Ges.* 12 (1910), pp. 613–620.
15. HUBA, Personalakte James Franck, 16 Dec. 1910.
16. HUBA, Vorlesungsverzeichnis 1911 f. Ausgewählte Kapital aus der Elektronentheorie. Über neuere elektrische und optische Untersuchungen.
17. Seabrook, William: *Doctor Wood*. New York 1941, pp. 58 f.
Inter., pp. 56 f.
18. Franck, James & Robert W. Wood: Über die Beeinflussung der Fluoreszenz von Jod- und Quecksilberdampf durch Beimengungen von Gasen verschiedener Affinität zum Elektron. *Verh. Dt. Phys. Ges.* 13 (1911), pp. 78–83.
Franck, James & Robert W. Wood: The Influence upon the Fluorescence of Iodine and Mercury of Gases with Different Affinities for Electrons. *Phil. Mag.* 21 (1911), pp. 314–318.
Wood, Robert & James Franck: Über die Überführung des Resonanzspektrums der Jodfluoreszenz in ein Bandenspektrum durch Zumischung von Helium. *Phys. Z.* 12 (1911), pp. 81–83.
Wood, Robert & James Franck: Transformation of a Resonance Spectrum into a Band Spectrum by Presence of Helium. *Phil. Mag.* 21 (1911), pp. 265–268.
Franck, James: Über die Überführung des Resonanzspektrums der Jodfluoreszenz in ein

Bandenspektrum durch zugemischte Gase. *Verh. Dt. Phys. Ges.* 14 (1912), pp. 419–422.

Franck, James & Gustav Hertz: Über durch polarisiertes Licht erregte Fluoreszenz von Joddampf. *Verh. Dt. Phys. Ges.* 14 (1912), pp. 423–425.

19. Franck, James & Peter Pringsheim: Über das elektrische und optische Verhalten der Chlorflamme. *Verh. Dt. Phys. Ges.* 13 (1911), pp. 328–334.

20. Sexl, Lore & Anne Hardy: *Lise Meitner*. Reinbek 2002, pp. 47, 119.

Sime, Ruth Lewin: *Lise Meitner—A Life in Physics*. Berkeley 1996, p. 43.

Lemmerich, Jost: *Lise Meitner zum* 125. *Geburtstag*. Berlin 2003 (exhibition catalog), pp. 28, 122.

21. Franck, James & Lise Meitner: Über radioaktive Ionen. *Verh. Dt. Phys. Ges.* 13 (1911), pp. 671–675.

22. JRLSC, Franck papers B 21 F 5: marriage certificate, 23 Dec. 1907.

23. Conv. with the Liscos.

24. Lemmerich, Jost: *Dokumente zur Gründung der Kaiser-Wilhelm-/Max-Planck-Gesellschaft*. Berlin 1981 (exhibition catalog), pp. 54 f.

Althoffs Pläne für Dahlem. Denkschrift für Kaiser Wilhelm II. In: *Idee und Wirklichkeit einer Universität. Dokumente zur Geschichte der Friedrich-Wilhelms-Universität zu Berlin*. Edited by Wilhelm Weischedel et al. Berlin 1960, pp. 483 f.

25. Hund, Friedrich: *Geschichte der Quantentheorie*, 2nd ed. Mannheim, Vienna, Zurich 1975, pp. 18 f.

26. Kuczera, Josef: *Gustav Hertz*. Leipzig 1985.

Gedenkheft zum 100. Geburtstag von Gustav Hertz. *Wiss. Z. Karl-Marx Uni. Leipzig*. Math. sci. series 36 (1987), p. 6.

27. Pohl, Robert & Peter Pringsheim: *Die lichtelektrischen Erscheinungen*. Braunschweig 1914, p. 13.

28. Lindemann, Friedrich: Über die Berechnung der Eigenfrequenzen der Elektronen im selektiven Photoeffekt. *Verh. Dt. Phys. Ges.* 13 (1911), p. 482.

29. Franck, James & Gustav Hertz: Über einen Zusammenhang zwischen Quantenhypothese und Ionisierungsspannung. *Verh. Dt. Phys. Ges.* 13 (1911), pp. 957–971.

30. SBBHA, Stark papers: JF to J. Stark, 28 Aug. 1910; 23 Jan. 1911; 3 Apr. 1911.

He informed Stark that owing to a case of sickness in the family he had been in Egypt for two months "and arrived home a short while ago so exhausted that I am suffering from severe insomnia, among other things." The circumstances around this trip to Egypt could not be ascertained.

Franck, James & Gustav Hertz: Bemerkungen zu unserer Notiz über einen Zusammenhang zwischen Ionisierungsspannung und Quantenhypothese. *Verh. Dt. Phys. Ges.* 14 (1912), pp. 167–168.

31. Franck, James: Bericht über Ionenbeweglichkeit. *Jahrb. Radioaktivität u. Elektronik* 9 (1912), pp. 235–270, 475.

32. Franck, James & Gustav Hertz: Über eine Methode zur direkten Messung der mittleren freien Weglänge von Gasmolekülen. *Verh. Dt. Phys. Ges.* 14 (1912), pp. 596–604.

33. Franck, James & Gustav Hertz: Messung der Ionisierungsspannung in verschiedenen Gasen. *Verh. Dt. Phys. Ges.* 15 (1913), pp. 34–44.

See also DMA, NL 089 17–28/A, 100: JF & G. Hertz to A. Sommerfeld, 18 Jun. 1913.

34. JRLSC, Franck papers B 11 F 7: notebooks by Gustav Hertz.

35. Franck, James & Gustav Hertz: Über Zusammenstöße zwischen Gasmolekülen und langsamen Elektronen. *Verh. Dt. Phys. Ges.* 14 (1913), pp. 373–390.

36. Franck, James & Gustav Hertz: Über Zusammenstöße zwischen langsamen Elektronen und Gasmolekülen II. *Verh. Dt. Phys. Ges.* 15 (1913), pp. 613–620.

37. Franck, James & Gustav Hertz: Über einen Zusammenhang zwischen Stoßionisation und Elektronenaffinität. *Verh. Dt. Phys. Ges.* 15 (1913), pp. 929–934.

Franck, James & Gustav Hertz: Über einen Zusammenhang zwischen Stoßionisation und Elektronenaffinität. *Phys. Z.* 14 (1913), pp. 1115–1117.

Franck, James & Gustav Hertz: Zur Theorie der Stoßionisation. *Verh. Dt. Phys. Ges.* 16 (1914), pp. 12–19.

38. Bahr, Eva von & James Franck: Über Ionisation durch positive Ionen. *Verh. Dt. Phys. Ges.* 16 (1914), pp. 57–68. Ms. in JRLSC Franck papers B 11 F 4.

39. Franck, James & Gustav Hertz: Über Zusammenstöße zwischen Elektronen und Molekülen des Quecksilberdampfes und die Ionisierungsspannung desselben. *Verh. Dt. Phys. Ges.* 16 (1914), pp. 457–467.

Franck, James & Gustav Hertz: Über die Erregung der Quecksilberresonanzlinie 253.6 µm durch Elektronenstöße. *Verh. Dt. Phys. Ges.* 16 (1914), pp. 512–517.

Gustav Hertz provided a detailed account of these experiments from 1913–14 after the death of James Franck. In the introduction he mentioned having spoken just a few weeks ago about the significance of those experimental results. Ms. in JRLSC, Franck papers B 24 F 3.

40. ADPG, Protokollbuch 1914 Sign. 10009.

41. SBBHA, Dep. Runge-Du Bois Reymond papers: Letter diary, mostly letters to Runge. Planck to Runge, 19 Apr. 1988 and 23 Feb. 1908. See also: Hentschel, Klaus & Renate Tobies (eds.): *Brieftagebuch zwischen Max Planck, Carl Runge, Bernhard Karsten, und Adolf Leopold*. Berlin 1999, pp. 106, 168.

Not long previously, in 1910, the theoretical physicist Woldemar Voigt in Göttingen also had skeptical things to say about interpreting spectrum lines: Voigt, Woldemar: *Lehrbuch der Kristallphysik*. Leipzig 1910, p. 5: "There has been hope to gain the deepest insights into questions about molecular constitution from analyses of the spectra of glowing gases and vapors; and these bodies undoubtedly do exhibit conditions suggesting the view that they involve molecular effects under particularly simple and therefore transparent conditions. [. . .] But this hope has been considerably disappointed by the developments in spectroscopy in recent years."

42. Warburg, Emil: Bemerkungen zu der Aufspaltung der Spektrallinien im elektrischen Feld. *Verh. Dt. Phys. Ges.* 15 (1913), pp. 1259 f.

43. Bohr, Niels: On the Constitution of Atoms and Molecules. *Phil. Mag.* 26, no. 151, Jul. 1913, pp. 1–25, with addenda under the same heading in Sep., p. 476, and Nov., p. 857.

44. Comments by Franck from a much later date are interesting in this regard: Inter., p. 21, and his obituary: Franck, James: Niels Bohrs Persönlichkeit, *Naturwiss.* 50 (1963), pp. 341–343:

"It should be emphasized that Gustav Hertz and the writer of these lines also were initially unable to grasp the great importance of Bohr's paper. We really should have had every reason to read it carefully, as we had just completed our experiments on the excitation of mercury line 2537 Å by electron collisions. We read Bohr's paper before submitting our manuscripts for printing but decided to send them off without mentioning Bohr's work, as we found an apparent difficulty in explaining the strong ionization of the mercury arc if, as Bohr concluded, the energy required to ionize the atoms substantially exceeded the excitation potential. This difficulty would in fact have existed if the electrons in the arc only took their energy from the electric field. Now we know that temperature ionization prevails in the arc plasma. It may be understandable that we thought we saw a contradiction, as nothing was known about plasma theory."

Johannes Stark published an objection to Franck's and Hertz's paper (*Verh. Dt. Phys. Ges.* 18 (1916), pp. 42–51). He argued that it was possible to interpret the excitation "without relying on Planck's light quantum hypothesis." *Verh. Dt. Phys. Ges.* 16 (1914), pp. 512–517.

45. *Niels Bohr: Collected Works*. Vols. 2–4. Edited by Ulrich Hoyer. Amsterdam, New York, Oxford 1981.

Hund, Friedrich: *Geschichte der Quantentheorie*. Mannheim, Vienna, Zurich 1975, pp. 65 f.

Pais, Abraham: *Niels Bohr's Times—Physics, Philosophy, and Politics*. Oxford 1991, p. 183.

46. *Reden in schwerer Zeit, gehalten von Professoren der Universität Berlin*. Published by Zentralstelle für Volkswohlfahrt und dem Verein für volkstümliche Kurse. Berlin 1914.

47. "Und es mag am deutschen Wesen einmal noch die Welt genesen."

48. Planck, Max: *Physikalische Rundblicke*. Leipzig 1922, p. 82: Dynamische und statische Gesetzmäßigkeit. Rede gehalten bei der Feier zum Gedächtnis des Stifters der Friedrich-Wilhelms-Universität Berlin am 3 August 1914.

49. Inter., p. 55.

This situation elicits the first testimony by Franck about his position on the religion of his ancestors. Franck's reply evidently defused the perhaps unintentional anti-Semitic undercurrent to the suggestion that he get himself baptized. But whether consciously or unconsciously, he placed the Protestant faith and the Jewish faith on the same moral level. An effectuated baptism would not make him "better," as he put it, or "fitter." There are no indications here of any concept of "race." I know of no record of whether Franck ever regarded himself as having the physical appearance of a Jew.

50. UAG, Personalakte James Franck, according to information by Franck, p. 37. The distinctions "Eisernes Kreuz II. Klasse 1914, I. Klasse 1917" are also recorded there.

51. Born, Max: *My Life. Recollections of a Nobel Laureate*. London, New York 1978, pp. 161, 164, 169 f.

52. Haber, Fritz: *Fünf Vorträge*. Berlin 1924. On chemistry at war, pp. 27–41; on the history of gas warfare, pp. 76–92.

Stolzenberg, Dietrich: *Fritz Haber. Chemiker, Nobelpreisträger, Deutscher Jude*. Weinheim 1994, chap. 17, esp. p. 245.

MPGA, Abt. V Rep. 13 no. 1480: report by Otto Lummitsch.

53. MPGA, Abt. V a Rep. 14 Haber collection: Interview by J. Jaenicke with JF, p. 4. JF: "Haber needed people. How the contact was initiated I don't know. He could certainly use a man who belonged to his field and was a soldier in addition. I received a letter, it appealed to me."

In the interview JF added: "I never understood why gas was described as something particularly evil. One thing was as bad as another. War per se is a crime."

Haber encouraged Franck to join the poison-gas unit. He did not voluntarily sign up, as Ulf Rosenow has alleged. See Rosenow, Ulf: Die Göttinger Physik unter dem Nationalsozialismus, note 36, p. 581, in: *Die Universität Göttingen unter dem Nationalsozialismus*. Edited by Heinrich Becker, Hans-Joachim Dahms & Cornelia Wegeler. 2nd ed. Munich 1998.

54. Leitner, Gerit von: *Der Fall Clara Immerwahr. Leben für eine humane Wissenschaft*. Munich 1993.

55. Conv. with the Liscos.

56. Franck, James & Gustav Hertz: Über die relative Intensität der Gasspektra bei der Glimmentladung in Gasgemischen. *Verh. Dt. Phys. Ges.* 18 (1916), pp. 213–222.

57. Franck, James & Gustav Hertz: Über Kinetik von Elektronen und Ionen in Gasen. *Phys. Z.* 18 (1916), pp. 409–416, 430–440.

58. Aufruf: An die Kulturwelt 1914 (drafted by Ludwig Fulda, president of the Goethebund).

The list included the names of fifteen scientists.

Brocke, Bernhard vom: Wissenschaft und Militarismus. Der Aufruf der 93 "An die Kulturwelt" und der Zusammenbruch der internationalen Gelehrtenrepublik im Ersten Weltkrieg. In: *Wilamowitz nach 50 Jahren*. Darmstadt 1985.

Remane, Horst: Der Chemiker und Nobelpreisträger Emil Fischer und der "Krieg der Geister." *Acta Leopoldina* no. 45 (2005), pp. 399–412.

DMA, W. Wien papers NL 56/005 contains a large collection of original documents on this subject.

Wolff, Stefan: Physicists in the “Krieg der Geister,” *Historical Studies in the Physical and Biological Sciences* 33, no. 2 (2003), pp. 337 f.

59. Conv. with the Liscos.

60. JRLSC, Franck papers B 21 F 18: Ernennung zum Professor.

61. Conv. with the Liscos.

62. MPGA, Abt. II Rep. 14 B: L. Meitner to O. Hahn, 25 Oct. 1916.

63. ChAC, MTNR: L. Meitner to E. Schiemann, 29 Nov. 1918.

64. Conv. with the Liscos.

65. Inter., p. 38.

66. Franck, James & Gustav Hertz: Die Bestätigung der Bohr’schen Atomtheorie im optischen Spektrum durch Untersuchungen der unelastischen Zusammenstöße langsamer Elektronen mit Gasmolekülen. *Phys. Z.* 20 (1919), pp. 132–143.

67. Ellwein, Thomas: *Die deutsche Universität—Vom Mittelalter bis zur Gegenwart*. Frankfurt am Main 1991, pp. 228 f. on university expansion and crisis.

68. JRLSC, Franck papers B 21 F 19: Vertrag mit der Kaiser-Wilhelm-Gesellschaft.

69. Inter., p. 74.

70. The lower-level *Diplom* degree would be introduced only later.

71. Vogt, Annette: *Wissenschaftlerinnen im Kaiser-Wilhelm-Instituten A–Z*. Publications out of the Archives of the Max Planck Society. Vol. 12 Berlin 1999, p. 71. Afterwards, Thea Krüger accepted Franck’s suggested topic for her dissertation. She later married Paul Knipping.

72. In deciding between these two experimental findings, the path to take was to compare the calculated work of dissociation Q_H against measurements of the resonance potential and ionization potential. Franck, James, Paul Knipping & Thea Krüger: Über einen Zusammenhang zwischen Stoßionisation und Dissoziationsarbeit neutraler Moleküle. *Verh. Dt. Phys. Ges.* 21 (1919), pp. 728–732.

73. Maushart, Marie-Ann: *“Um mich nicht zu vergessen.” Hertha Sponer—ein Frauenleben für die Physik im 20. Jahrhundert*. Bassum 1997, pp. 24 f.

Tobies, Renate: *Physikerinnen und spektroskopische Forschungen*. Zum 100. Geburtstag von Hertha Sponer. Johann Gutenberg Universität, Mainz 1996. Lecture cycle no. 5.

74. ADPG Protokollbuch: 1910–1921 Sign. 10009: meetings of 7 May & 21 Sep. 1920 discuss in depth whether to continue the *Verhandlungen* as well as about the publication of new journals.

Einstein-Sommerfeld-Briefwechsel. Edited by Armin Hermann. Basel, Stuttgart 1968, p. 61.

ADPG, Protokollbuch 1919 Sign. 10009: Franck was elected acting secretary at the meeting on 8 May 1919.

75. Franck, James: Bemerkungen über die Intensitätsverteilung in Serienspektren. *Z. Phys.* 1 (1920), pp. 2–10. The manuscript was received on November 14.

At his request Franck’s given name, which he did not like for some unknown reason, never appeared in full in any of his publications.

76. Franck, James & Paul Knipping: Die Ionisierungsspannung des Heliums. *Phys. Z.* 20 (1919), pp. 481–488.

77. SBBHA, Landé papers 19: JF to A. Landé, 21 Dec. 1919.

78. Roy. Swedish Academy Stockholm, Archive: F. Haber to S. Arrhenius, 6 Nov. 1919 & 5 Dec. 1919.

79. SBBHA, Landé papers 19: JF to A. Landé, 7 Jan. 1920. It regarded a correction to the helium paper. My insertions.

80. Franck, James & Fritz Reiche: Über Helium und Parahelium. *Z. Phys.* 1 (1920), pp. 154–160.

81. Franck, James & Paul Knipping: Über die Anregungsspannungen des Heliums. *Z. Phys.* 1 (1920), pp. 320–332.

82. Inter., p. 44.
83. JRLSC, Franck papers B6 F 3: F. Paschen to JF, 20 Jun. 1920.
84. SBBHA, Fajans papers 11 fog 6: JF to K. Fajans, 2 Aug. 1920.
85. ChAC, MTNR 4/60: L. Meitner to J. Jaenicke c. 1954.
Personal communication by Wilhelm Westphal to the author.
86. Franck, James & Erich Einsporn: Über die Anregungspotentiale des Quecksilberdampfes. *Z. Phys.* 2 (1920), pp. 18–29.
87. MPGA, Abt. III Rep. 19 no. 225 Debye papers: JF to Debye, 20 Jul. 1920.
88. Forman, Paul: Die Naturforscherversammlung in Nauheim September 1920. In: *Physiker zwischen Autonomie und Anpassung*. Edited by Dieter Hoffmann & Mark Walker. Weinheim 2007, pp. 29–90.
Kleinert, Andreas: Der Berliner Einsteintöter. In: *Naturwissenschaft und Technik incl. Geschichte*. Edited by Helmuth Albrecht. Stuttgart 1993, pp. 199 f.
Schönbeck, Charlotte: *Albert Einstein und Philipp Lenard—Antipoden in der Physik und Zeitgeschichte*. Schriften der math.-nat. Klasse, Heidelberger Akad. d. Wiss. 8 (2000).
89. Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born 1916–1955*. Trans. by Irene Born. New York 1971, p. 31. M. Born to A. Einstein, 16 Jul. 1920.
90. JRLSC, Franck papers B 1 F 5: N. Bohr to JF, 18 Oct. 1920; JF to Bohr 24 Oct. 1920.
91. Franck, James & Walter Grotrian: Bemerkungen über angeregte Atome. *Z. Phys.* 4 (1921), pp. 89–99.
92. AAG, Pers. 20, 1016 & 1018, as well as Pers. 16, 285.
Nomination by C. Runge & E. Wiechert, 23 Jan. 1921 for election of JF as corresponding member.

Chapter 4

1. Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born 1916–1955*. Trans. by Irene Born. New York 1971, pp. 25 f. A. Einstein, 3 Mar. 1920, orig. emphasis.
2. SBBHA, Born papers no. 1866: E. Wende to M. Born, 18 Apr. 1920; M. Born to E. Wende, undated (May 1920?).
3. Chronik der Georg-August-Universität für die Rechnungsjahre 1916–1920; 1921–1923; course catalogs.
Reid, Constance: *Courant in Göttingen and New York. The Story of an Improbable Mathematician*. New York 1976, p. 82, D. Hilbert to R. Courant: “Franck + Born are the best imaginable replacement for Debye! [. . .] We have Born’s energy to thank for it!”
4. *Niels Bohr Collected Works*. Edited by J. R. Nielson, vol. 3. Amsterdam, New York, Oxford 1976, p. 67: Ehrenfest to N. Bohr, 27 Nov. 1921.
5. UAG, Personnel file James Franck: Vereinbarung zwischen James Franck und dem Preußischen Kultusministerium, 6 Oct. 1920; investiture and nomination as director of Physics Institute II, 15 Nov. 1920. My emphasis and insertion.
Personnel questionnaire filled out in JF’s hand.
JRLSC Franck papers B 20 F 21: Designation as full professor, Göttingen 15 Nov. 1920.
6. The ministry also granted reimbursement for his third-class train ticket, as a travel expense related to the negotiations. Officially Franck could not claim compensation for his moving expenses to Göttingen, but he received 9,372.50 RM anyway.
7. JRLSC, Franck papers B 21 F 65 as well as ChAC, MTNR 5/7 Abschiedsgedicht.
8. Conv. with the Liscos.
9. JRLSC, Franck papers B 1 F 5: JF to N. Bohr, 22 Nov. 1920; retraction: JF to N. Bohr 15 Apr. 1921.

10. Robertson, Peter: *The Early Years. The Niels Bohr Institute 1921–1930*. Copenhagen 1979, pp. 16–65.

11. Reid, Constance: *Courant in Göttingen and New York. The Story of an Improbable Mathematician*. New York 1976, pp. 82, 89, 102.

12. JRLSC, Franck papers B 9 F 2: JF to C. Still, 2 Apr. 1920.

13. GStA, rep. 76 V c sect. I titl. I no. 67, May 1920–April 1924, p. 52: Carl Runge and Wilhelm Westphal were on the special committee for physics. At the elections in 1922 Max Wien was selected for experimental physics.

See also: no. 68, p. 192: Members of the Japan committee included Max Planck, Fritz Haber, Richard Willstätter, and Otto Hahn. In 1923 Franck received 200 yen for his institute. General Electric made available $15,000 in cooperation with AEG and Siemens for the promotion of electrophysics. Max Planck became the chair, and its members were Max von Laue, James Franck, Fritz Haber, Walther Nernst, and Max Wien. Arnold Berliner was its administrator.

14. UAG, personnel file of Valentiner.

15. Conv. with the Liscos.

16. ChAC, MTNR: L. Meitner to her mother, Göttingen, 24 Mar. 1921.

17. JRLSC, Franck papers B 9 F 2: JF to C. Still and his wife, 2 Apr. 1921. My insertion.

18. Mehra, Jagdish: *The Solvay Conferences on Physics*. Dordrecht, Boston 1975, pp. 13 f. & 95 f.

19. Vorlesungsverzeichnis der Georgia-Augusta Universität 1921 f.

20. UGA, staff file Rausch von Traubenberg, Heinrich. From information by Charlotte Schönbeck.

21. Oldenberg, Otto: James Franck in Göttingen. *Am. J. Phys*. 39 (1971), pp. 41–43. This article includes some biographical details about its author.

22. MPGA, Abt. II Rep. 19 no. 225 Debye papers: JF to P. Debye, 24 Feb. 1921. JF explained there details about Falkenhagen's departure, whose research direction did not fit within Franck's agenda.

UAG, XVI IV C 4 V h 32 vol. II 1 a: JF to the Kurator, 5 Aug. 1921.

23. Westphal papers: JF to W. Westphal, undated as well as by personal communication to the author.

24. Greatly simplified, the Klein-Rosseland theory shows that for thermodynamical reasons a collision reaction that proceeds at a given point in time in a given direction must proceed correspondingly in the opposite direction within that unit of time.

25. UA Braunschweig, personal file Cario, Günter.

26. JRLSC, Franck papers B 1 F 5: JF to N. Bohr, 16 Sep. 1921.

27. Franck, James: Einige aus der Theorie von Klein und Rosseland zu ziehenden Folgerungen über Fluoreszenz, photochemische Prozesse und die Elektronenemission glühender Körper. *Z. Phys*. 9 (1922), pp. 259–266.

28. Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born 1916–1955*. New York 1971, p. 70. M. Born to A. Einstein, 30 Apr. 1922. The present translation is somewhat corrected.

29. Allusion is made to the illiberal Carlsbad decrees of 1819, a series of social restrictions, including censorship of the press and state interference by an official *Universitätskurator*, effectively halting the reform movement in Germany. The "demagogue persecution" particularly targeted political opponents in academia.

30. Hund, Friedrich: *Geschichte der Quantentheorie*. Vienna, Zurich, 2nd ed. 1975, pp. 102 f.

Minkowski, Rudolf: Lecture Notes of Niels Bohr's Lecture in Göttingen 1922. See: *A Guide to the Archival Collection in the Niels Bohr Library at the Institute of Physics*, College Park 1999.

31. Holl, Frank: Produktion und Distribution wissenschaftlicher Literatur. Der Physiker Max Born und sein Verleger Ferdinand Springer 1913–1970. Frankfurt am Main 1996, p. 62. Springer's impressions of Bohr's talks.

32. Bohr's model was unable to explain doublets and triplets in spectra or the Zeeman and Stark effects. Electron spin had yet to be discovered.

33. UBGA, Cod. Ms. Hilbert.

34. Ramsauer, Carl: Physik-Technik-Pädagogik. Erfahrungen und Erinnerungen. Karlsruhe 1949, p. 106.

Personal communication by Charlotte Schönbeck to the author on 28 Sep. 2004.

Hanle, Wilhelm: *Memoiren*. Giessen 1989, private printing.

35. Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born 1916–1955*. New York 1971, pp. 61 f. M. Born to A. Einstein, 29 Nov. 1921.

36. JRLSC, Franck papers B 23: W. Pauli to JF for his 70th birthday 1952.

The degree of Pauli's esteem for Franck is evident from his letter to Heinrich Heesch, 30 Sep. 1930 (UBGA, Cod. Ms H. Heesch). Heesch wanted to go to Göttingen and Pauli had some advice for him: "4. I must draw your attention particularly to Mr. Franck, the most prominent and nicest person in Göttingen physics. When he preaches morals to you, especially about the necessity to protect those with sensitive feelings, then respect him and love him but don't take what he says seriously. But if he is talking about physics, then always take what he says seriously, no matter how stupid it may seem to you at first. For no one knows better than he what physics is all about."

Also in: Meyenn, Karl von (ed.): *Wolfgang Pauli Wissenschaftlicher Briefwechsel*, vol. III 1993, p. 743.

37. Inter., pp. 91, 97; app. pp. 319, 331.

38. Cario, Günther & James Franck: Über Zerlegung von Wasserstoffmolekülen durch angeregte Quecksilberatome. *Z. Phys.* 11 (1922), pp. 161–166.

39. JRLSC, Franck papers B 5 F 4: L. Meitner to JF, 16 Nov. 1922.

40. UAG, Math.-naturw. Fak. Prom. 1922–1923 No. 5, vol. Lit. B, C, D, E, F 1922–1923; Specialia Litt & L Fol. I.

41. UA Braunschweig: personnel file Günther Cario.

42. JRLSC, Franck papers B 1 F 3: N. Bohr to JF, 15 Jul. 1922, JF to N. Bohr, 29 Jul. 1922.

43. UGA, XVI C II Phys. Inst. budget 1922–1923.

44. JRLSC, Franck papers B 6 F 4: M. Planck to JF, 2 Dec. 1922.

45. Ibid., B 8 F 5: Ministry to JF, Aug. 1923; JF to Ministry, 1 Sep. 1923.

46. ChAC, MTNR: L. Meitner to JF, 20 Oct. 1923.

47. JRLSC, Franck papers B 3 F 9: F. Haber to JF, 15 Jan. 1924. After Franck declined, Walther Nernst became Rubens's successor.

48. Cario, Günther & James Franck: Über sensibilisierte Fluoreszenz von Gasen. *Phys. Z.* 23 (1923), pp. 202–212.

Inter., pp. 98–99.

Franck, James: Über sensibilisierte Fluoreszenz von Gasen. *Phys. Z.* 24 (1923), pp. 450–451.

49. Franck, James & Peter Pringsheim: Fluoreszenz von Gasen, *Naturwiss.* 11 (1923), pp. 559–563.

50. Stuewer, Roger H.: *The Compton Effect: Turning Point in Physics*. New York 1975.

Stuewer, Roger H.: The Compton Effect: Transition to Quantum Mechanics, *Ann. Phys.* 11–12 (2000), pp. 977–991.

51. Rump, W.: Über den Dopplereffekt beim Übergang von der Resonanzfluoreszenz zur Spiegelung, *Z. Phys.* 29 (1924), pp. 196 f.

Rump alluded to: Ross, *Proc. Nat. Acad. Sci.* 9 (1923), pp. 246 f., who had worked on the problem of reflection.

52. Hoffmann, Banesh & Helen Dukas: *Albert Einstein. Creator and Rebel*. New York 1972, p. 150.

53. Hentschel, Klaus: *The Einstein Tower. An Intertexture of Dynamic Construction, Relativity Theory, and Astronomy*. Stanford 1997, p. 94.

Freundlich was able to make the adjustments himself.

54. JRLSC, Franck papers B 2 F 7: JF to A. Einstein 29 Mar. 1923.

55. BA, Akten des Reichsjustizministeriums R 22 Pers.: Felix Stumpf. Stumpf was born in 1885 in Halle, took his Dr. of philosophy in Berlin, and was employed as a private lecturer at the Berlin Polytechnic 1920–23. Evidently on 1 May 1923 he started working for the *Reichspatentamt*, where he advanced to its advisory board.

56. Conv. with the Liscos.

57. Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born 1916–1955*. New York 1971, p. 80. M. Born to A. Einstein, 25 Aug. 1923.

58. Hermann, Armin: Deutsche Physikalische Gesellschaft 1899–1945. In: *Festschrift: 150 Jahre Deutsche Physikalische Gesellschaft*. Edited by T. Mayer-Kuckuk, Weinheim 1995, p. 85.

Wien, Willy: *Aus dem Leben und Wirken eines Physikers*. Leipzig 1930, p. 47.

59. RFA, 81 Sc. I B 10 F 144: R. A. Millikan to W. Rose, 3 Oct. 1923.

60. "Die heutigen Plünderungen in Charlottenburg" and "Aufmarsch der Hitler-Garde," *Vossische Zeitung*, 7 Nov. 1923. Cited in Pommerin, Reiner: Die Ausweisung von "Ostjuden" aus Bayern 1923. Ein Beitrag zum Krisenjahr der Weimarer Republik. *Vierteljahreshefte f. Zeitgesch.* 39 (1986), pp. 311 f.

I thank Mr. W. Wirtz, Kaufering, for pointing out this article.

The decree of 5 Oct. 1923 regarded infractions of the usury laws by foreigners, thus illegal enrichment. "Deportation from the Reich is the appropriate measure to make such persons innocuous to the German economy."

Ophir, Z. Baruch & Falk Wiesemann: *Die jüdischen Gemeinden in Bayern 1918–1945*. Munich, Vienna 1979, pp. 19 f.

61. SPVA, B 186 I, 186 II; F 124.

Holl, Frank: *Produktion und Distribution wissenschaftlicher Literatur*. Frankfurt am Main 1996, p. 141; list of 20 planned volumes, pp. 143 f. Quarrels about delinquent authors.

Sarkowski, Heinz: *Der Springer Verlag: Stationen seiner Geschichte*, part I. 1842/1945. Berlin, Heidelberg, New York, pp. 261 f.

62. Conv. with the Kuhns and personal communication by Werner Kroebel to the author.

63. RFA, IEB Si Sub. 2 B 34 F 484: JF, M. Born & R. Pohl to W. Rose, 18 Mar. 1924.

Hanle, Wilhelm: *Memoiren*, Gießen 1989, private publication.

64. Franck, James: Zur Frage der Ionisierungsspannung positiver Ionen. *Z. Phys.* 25 (1924), pp. 312–316.

65. The 2 presumably refers to the two reactants.

66. Ramsauer, Carl: Über den Wirkungsquerschnitt der Gasmoleküle gegenüber langsamen Elektronen. *Ann. Phys.* 64 (1922), pp. 513–540.

Inter., p. 64.

67. Minkowski, Rudolf & Hertha Sponer: Über die freie Weglänge langsamer Elektronen in Gasen. *Z. Phys.* 15 (1923), pp. 399–408.

Sponer, Hertha: Über die freie Weglänge langsamer Elektronen in Edelgasen. *Z. Phys.* 18 (1923), pp. 249–257.

Hund, Friedrich: Theoretische Betrachtungen über die Ablenkung von freien langsamen Elektronen in Atomen. *Z. Phys.* 13 (1923), pp. 241–263.

DMA, F. Hund papers, film 344, diary. Hund mentions consultations with JF in many instances.

68. DMA, Sommerfeld papers 17–28/A, 100/2: JF to A. Sommerfeld, 8 Oct. 1924.

69. Conv. with the Liscos.

70. Franck, James: Atome und Molekülstöße und ihre chemische Bedeutung. *Naturwiss.* 12 (1924), pp. 411–429.

On the Franck-Condon principle: Condon, Edward U.: A theory of intensity distribution in band systems. *Phys. Rev.* 28 (1926), pp. 1182–1201, and Condon: Nuclear motions associated with electron transitions in diatomic molecules. *Phys. Rev.* 32 (1928), pp. 858–872.

Sponer, Hertha: Molekülspektren und ihre Anwendung auf chemische Probleme II. Berlin 1936.

71. Born, Max & James Franck: Bemerkungen über die Dissipation der Reaktionswärme. *Ann. Phys.* 76 (1925), pp. 225–230.

Born, Max & James Franck: Quantentheorie und Molekülbildung. *Z. Phys.* 31 (1925), pp. 411–429.

72. Franck later had doubts about the formation of quasi-molecules. See J. Franck & P. Jordan: *Anregung von Quantensprüngen durch Stöße*, Berlin 1926, p. 254.

73. JRLSC, Polányi papers B 2 F 2: JF to M. Polányi, 3 July 1925.

74. AMPG, K. F. Bonhoeffer papers: JF to K. F. Bonhoeffer, 3 July 1925. My insertions.

75. Elsasser, Walter: *Memoirs of a Physicist in the Atomic Age*, Bristol 1978.

Harry Rubin: Walter M. Elsasser, *Nat. Acad. Sci. United States of America. Biogr. Mem.* 68 (1995), pp. 103 f. The anti-Semitism among the students at Willy Wien's institute that Rubin describes was also experienced by Hilde Levi (personal communication to the author).

76. Knorr, M.: Das Wechselspiel zwischen Theorie und Experiment, dargestellt am Beispiel der Elektroneninterferenz—eine physikhistorische Analyse. Thesis for state examination at the Inst. of Didactics, Univ. Gießen 1982.

77. Conv. with the Liscos.

78. Labs, D.: Hans Kienle. *Phys. Bl.* 31 (1975), pp. 222–223.

79. UAG, Sek. I B.3e.c. 63.i. 31 Oct. 1924: Dekan Borsche. The Faculty of the Sciences donated 500 goldmarks for the memorial.

The unveiling took place on All Souls' Day, on 23 Nov. 1924 in the presence of Reichspräsident Hindenburg.

80. According to the minutes. GStA, C. H. Becker papers, Sachakten 7034; transcription of U I 1678 U I T Berlin, 25 Aug. 1925.

81. Bohr, Niels: Zur Polarisation des Fluorescenzlichtes. *Naturwiss.* 12 (1924), p. 1115.

82. NBA: Max Born to Niels Bohr, Göttingen, 15 Dec. 1924. My insertion.

83. Born, Max: Die chemische Bindung als dynamisches Problem. *Naturwiss.* 12 (1924), pp. 1200 f.

84. Oldenberg, Otto: Über Elementarvorgänge bei Ausstrahlung der Jodbanden. *Z. Phys.* 25 (1924), p. 136.

Franck's idea had been to observe light emissions in chemiluminescence. Thermal stimulation was supposed to put halogen atoms into the 2P1 state, others into the 2P2 state. It was not possible, however, to distinguish between chemiluminscence and thermal luminescence in the recombination.

85. RSA, CSAC 63/1/79 papers of Patrick Blackett: I Correspondence.

A 11. Blackett to Council, 11 Mar. 1924, applying for a Moseley Research Studentship. "I wish to work under Professor Franck at a problem concerning spectroscopy and electron impact, which has arisen out of my work on the photograph of α-tracks. As the experimental technique for such work has been highly developed in Göttingen I feel that it would be a great advantage to work there."

A 13. "Essentially the first experiment which Franck and I did together consisted in passing a narrow beam of electrons through hydrogen at low pressure and observing the spectra with a slit of the spectroscope at right angles to the electron beam."

B 10. Little notebook. Bibliographic entries on interactions between electrons and gases.

B 11. Little notebook. Entries on experiments started in January 1924, with some sketches of the apparatus set-ups. The entries show that the experimentation continued on Sundays.

86. Hertz, Gustav: Über die Anregung von Spektrallinien durch Elektronenstoß. *Z. Phys.* 22 (1924), pp. 18–26, esp. pp. 21 f.

Hertz probably informed Franck about his experiments on the excitation of spectrum lines by electron collision before his results were published. The cathode for generating the beam of electrons was a very thin strip of platinum bent into a U-shape with a notch in the middle. A spot of barium oxide at the notch created a limited area of high temperature for higher electron emission.

87. Born alludes to this conversation in NBA: Max Born to Niels Bohr, 3 Mar. 1925.

"Yesterday evening we arrived home and with the first onslaught of unfinished business owing to the trip now behind me I must write you to express my thanks for the fine days in Copenhagen. . . . Yesterday evening I spoke with Franck until late at night and all day today and told him about what I had heard during the visit with you. He was naturally most interested to know your stance on our chemical work; I attempted to explain your position to him. Franck has meanwhile thought up an experiment that can illuminate the controversial issue somewhat. He wants to write to you about it himself, though, and so I will leave it now."

88. Blackett, Patrick M. S. & James Franck: Anregung von Spektren des Wasserstoffs durch Elektronenstoß. *Z. Phys.* 34 (1925), pp. 389–401.

89. DMA, Grimm papers, JF to H. G. Grimm, 8 May 1925.

90. JRLSC, Franck papers B 1 F 5: JF to N. Bohr, 20 (27?) Apr. 1925.

91. Pauli, Wolfgang: Über den Zusammenhang des Abschlusses der Elektronengruppen im Atom mit der Komplexstruktur der Spektren. *Z. Phys.* 31 (1925), pp. 765–783.

92. RFA, Coll. IEB B 34 F 484: Meeting 18 Jun. 1924 Göttingen.

93. Conv. with Friedrich Hund: "Landau was keen on becoming dean, and everybody was afraid of that." ("Landau wollte unbedingt Dekan werden, und alle hatten Angst davor.")

94. Kramers, Hendrik A. & Werner Heisenberg: Über die Streuung von Strahlung durch Atome. *Z. Phys.* 31 (1925), pp. 681–708.

95. Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born 1916–1955*. Trans. by Irene Born. New York 1971, p. 84. M. Born to A. Einstein, 15 Jul. 1925.

96. Heisenberg, Werner: Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen. *Z. Phys.* 33 (1925), pp. 879–893.

97. Inter., p. 51.

Born, Max & Pascual Jordan: Zur Quantenmechanik. *Z. Phys.* 34 (1925), pp. 858–888.

98. Born, Max, Werner Heisenberg & Pascual Jordan: Zur Quantenmechanik. II. *Z. Phys.* 35 (1926), pp. 557–615.

99. Hund, Friedrich: *Geschichte der Quantentheorie*. 2nd ed. Mannheim 1975, pp. 145 f., 153 f.

100. Hund, Friedrich: *Geschichte der Quantentheorie*. 2nd ed. Mannheim 1975, pp. 117 f.

101. Franck, James: Elementary Processes of Photochemical Reactions. *Trans. Faraday Soc.* 21 (1925), pp. 536–542.

102. Miethe, Adolf: Gold aus Quecksilber. *Naturwiss.* 13 (1925), pp. 635–637.

In a letter to N. Bohr of 27 Apr. 1925, JF speculated about how this process in an arc light converting mercury to silver and gold might work. He suspected that doubly ionized Hg molecules were involved (JRLSC, Franck papers B 2 F 5).

103. SPVA, B: F, sheet 137, I: JF to F. Springer, 29 Jul. 1925; Hertha Sponer to F. Springer, 17 May 1929.
104. Conv. with the Liscos.
105. RFA, IEB Sc. I Subs 3 B 59 F 992: JF to W. Rose, 24 Jul. 1926.
106. UGA, course catalogs.
107. RFA, IEB S I Subs 2 B 34 F 484: Visit to Göttingen 8 Oct. 1925?
108. Born, Max: Quantenmechanik der Stoßvorgänge (vorläufige Mitteilung). *Z. Phys.* 37 (1926), p. 863 and Born, Max: Quantenmechanik der Stoßvorgänge. *Z. Phys.* 38 (1926), pp. 803–827.
109. Personal communication by Friedrich Hund to the author.
110. Conv. with the Liscos.
111. Franck, James: Der Wirkungsquerschnitt bei atomaren Stoßprozessen. *Naturwiss.* 14 (1926), pp. 211–214. My insertions.
112. SPVA, B: F, sheet 124: JF to F. Springer, 29 Mar. 1926. Our emphasis.
113. NBA: JF to N. Bohr, 9 Jul. 1926.
114. JRLSC, Franck papers B 3 F 12: W. Heisenberg to JF, 29 Apr. 1926. See also Heisenberg to Max Born, Copenhagen 26 May 1926, p. 1 among Jordan's papers SBBHA.
115. Smith, Alice Kimball & Charles Weiner: *Robert Oppenheimer*. Cambridge, Mass., London 1980, pp. 100 f.
116. GStA, Rep. 76 V e Sekt. 2 Titel XXIII Lit. A Nr. 129, pp. 44 f. Der Reichsminister des Inneren an den Preußischen Minister für Wissenschaft, Kunst, und Volksbildung, Berlin 14 Jun. 1926.

Chapter 5

1. JRLSC, Franck papers B 5 F 9: Vetenskapsakademiens Sekr. to JF, telegram 12 Nov. 1926 & letter.

Science, Technology, and Society in the Time of Alfred Nobel. Edited by Carl Gustav Bernhard, Elizabeth Crawford & Per Sorbom. Oxford, New York, Toronto, Sydney, Paris, Frankfurt 1981.

Crawford, Elizabeth & J. I. Heilbron: Die Kaiser-Wilhelm-Institute für Grundlagenforschung und die Nobel-Institute. In: *Forschung im Spannungsfeld von Politik und Gesellschaft, Geschichte, und Struktur der Kaiser-Wilhelm-/Max-Planck-Gesellschaft*. Edited by Rudolf Vierhaus & Bernhard vom Brocke. Stuttgart 1990, pp. 835 f.

Ehrensvärd, Ulla: *Medaljgravören Erik Lindberg* 1873–1966. Stockholm 1974, pp. 313 f.

Ellaa Waldenstein did the artwork on the diploma.

The gold medal was designed by Erik Lindberg.

As a laureate, Franck joined the influential circle of nominators for the award in physics; cf. Crawford, Elizabeth et al. In 1927 he suggested A. H. Compton, O. Stern, and W. Gerlach; 1928 O. Stern and W. Gerlach as well as R. Wood; 1929 O. Stern, R. Wood, F. Paschen, A. Sommerfeld, L. de Broglie, Davisson, E. Warburg; 1930 O. Stern, F. Paschen, A. Sommerfeld; 1931 O. Stern, F. Paschen, A. Sommerfeld, R. Wood, P. Debye.

2. JRLSC, Franck papers B 6 F 4: M. Planck to JF, 12 Nov. 1926.
3. Stargardt, auction catalog 676 (2002), p. 494: F. Haber to JF, 12 Dec. 1926.
4. JRLSC, Franck papers B 8 F 8: A. Sommerfeld to JF, 13 Nov. 1926.
5. JRLSC, Franck papers B 9 F 6: G. P. Thomson to JF, 14 Nov. 1926 (illegible words).
6. UGA, personnel file J. Franck: JF to Kurator, 1 Dec. 1926.
7. Lisa Lisco estate, private collection: Dagmar Franck to the Franck grandparents, 29 Nov. 1926.
8. *Les Prix Nobel en 1926*, Stockholm Imprimerie Royal 1927, pp. 65 f. (orig. English). Cf. the draft of Franck's speech among his papers, JRLSC.

9. MPGA Abt. V c Rep. 1 Franck: JF to Reiche, 1 Jan. 1927, my insertion.

10. Franck, James: Über eine Rotverschiebung der Resonanzfluoreszenz durch vielfache Streuung. *Naturwiss.* 15 (1927), pp. 236–238.

That issue of the *Naturwissenschaften* for Runge's 70th birthday appeared too late. An obituary was placed before the other texts written in his honor.

11. SBBHA, Runge-DuBois Reymond papers 648. JF's address at Runge's grave.

12. JRLSC, Franck papers B 6 F 8: M. Polányi to JF, 23 Apr. 1927.

13. AAG, Scient 9385, 2; 221: JF to Thiersch, 4 May 1927, my insertion.

14. RFA, Log. Trowbridge vol. 3, 1926–27 folder 1–15.

15. Landrock, Konrad: Friedrich Georg Houtermans (1903–1966). Ein bedeutender Physiker des 20. Jahrhunderts. *Naturwiss. Rundschau* 56 (2003), pp. 187–198.

16. GStA, C. H. Becker papers, Sachakten 1038 & 1041, my insertion.

17. *Die Universität unter dem Nationalsozialismus*. Edited by Heinrich Becker, Hans-Joachim Dahms & Cornelia Wegeler. 2nd ed. Munich 1998, p. 30, figs. 1 & 2.

Even during the kaiserreich the authorities were already compiling such official lists. Prussian Minister von Gossler arranged that the faiths of all staff members at Prussian universities be recorded in 1870, 1880 & 1890. See MPGA, Abt. V a Rep. 5 Haber collection.

18. Franck, James & Thorfin R. Hogness: Über den Nachweis der Reaktionsgeschwindigkeit der Zerfallsprodukte bei optischen Dissoziationsprozessen. *Z. Phys.* 44 (1927), pp. 26–31.

19. Conv. with the Kuhns.

20. Franck, James & Heinrich Kuhn: Über ein Absorptions und Fluoreszenzspektrum von Silberjodidmolekülen und die Art ihrer chemischen Bindung. *Z. Phys.* 43 (1927), pp. 164–171.

21. Franck, James, Heinrich Kuhn & Günther Rollefson: Beziehungen zwischen Absorptionsspektren und chemischer Bindung bei Alkalihalogeniddämpfen. *Z. Phys.* 43 (1927), pp. 155–163.

22. UAG, 4 V h 33 vol. II, pp. 357, 363, 382 f., 391, 394 f.

23. DMA, W. Wien papers NL56/2/3: JF to W. Wien, 1 Jan. 1927.

24. Franck, James: Bandenspektrum und chemische Bindung. *Atti Congresso Internationale dei Fisici* (Como, 1927), vol. 1, 1928 Bologna, pp. 65–71.

25. Conv. with the Kuhns.

26. Franck, James: Beitrag zum Problem der Wiedervereinigung von Ionen und Elektronen. *Z. Phys.* 47 (1928), pp. 509–516.

27. Gehrenbeck, Richard K.: Electron diffraction fifty years ago. *Phys. Today*, Jan. (1978), pp. 34–41.

28. Conv. with the Kuhns.

29. Conv. with Prof. F. Hund.

30. UGA, staff file J. Franck: JF to Kurator, 5 Sep. 1927.

31. These titles are in original English. JRLSC, Franck papers B 7 F 9: JF to W. Meggers, 10 Oct. 1927.

32. Conv. with the Liscos.

33. RFA, UVA 691 B 119 F 1927: F. T. Lyman to JF, 2 Nov. 1927; JF to T. Lyman, 21 Nov. 1927.

JRLSC, Franck Papers B 7 F 9: JF to Kemble, 19 Dec. 1927.

34. Conv. with the Liscos.

35. Franck, James & Gerhard Scheibe: Über Absorptionsspektren negativer Halogenionen in Lösung. *Z. phys. Chem.* A 139 (1928), pp. 22–33.

36. Franck, James: Habers Arbeiten über Anregung und Ionisation durch chemische Reaktionen. *Naturwiss.* 16 (1928), pp. 1075–1078.

37. Franck, James & Hertha Sponer: Beitrag zur Bestimmung der Dissoziationsarbeit

von Molekülen aus Bandenspektren. *Nachr. Ges. Wiss. Göttingen*, math. phys. class (1928), pp. 241–253.

38. LMUA, Akte OC-N-10a.

39. GStA, Hauptabt. I Sig. 76 Va Sekt 6 Tit IV Nr. 24 vol. II: Kurator to the minister, 28 Dec. 1928.

40. BHSA, Akte MK 697789: One note from 15 Jan. 1929 contains details about Franck's interview with Staatsrat Hauptmann. The representative of the Bavarian diet, Stang wrote a letter on 9 Mar. 1929 in opposition to the appointment of either Debye, Franck, or Gerlach. It contained all sorts of disqualifying allegations about these three nominees, surely at Johannes Stark's behest: "James Franck, native Hamburger, now in Göttingen, international family heritage, known member of the Central Association of German Citizens of the Jewish Faith." The Munich faculty did not make any statement about Stark's interference.

41. ChAC, MTNER: JF to L. Meitner, 24 Jan. 1929.

42. GStA, Hauptabt. I Sig. 76 Va Sekt 6 Tit. IV Nr. 24 vol. II: in-house letter 7 Feb. 1929; minister to JF, 18 Mar. 1929, pp. 20, 21.

43. DMA, Sommerfeld papers NL 089-019, folder 5.10: JF to A. Sommerfeld, 5 Feb. 1929. Franck also alluded to his reasons for his acceptance and his refusal of the call to Munich. One "very strongly positive argument for my answering the Munich call had constantly appeared to me to be the possibility of coming into closer contact with you [. . .] When we were in Munich we encountered such a cordial reception among all those colleagues we had dealings with, and truly not least of all from your esteemed wife, that we were more than halfway decided to move to Munich [. . .] Quite contrary to my expectations, the reservations that I had had in the first place—the nationalistic attitude of the environs—are absolutely no longer substantial."

Anti-Semitism at the University of Munich is discussed in: *Einstein-Sommerfeld Briefwechsel*. Edited by Armin Hermann. Basel, Stuttgart 1968, pp. 89 f.

44. Hippel, Arthur von: *Life in Times of Turbulent Transitions*. Author's edition, Boston 1982.

45. Hippel, Arthur von & James Franck: Der elektrische Durchschlag und Townsends Theorie. *Z. Phys*. 57 (1929), pp. 696–704.

46. JRLSC, Franck papers B 5 F 4: L. Meitner to JF, beginning of 1929.

Maushart, Marie-Ann: *"Um mich nicht zu vergessen." Hertha Sponer—Ein Frauenleben für die Physik im* 20. *Jahrhundert*. Bassum 1997, pp. 46–47.

The surviving source material does not permit a reconstruction of who might have started the rumor that Ms. Sponer was supposed to be going to the KWI of Physical Chemistry and Electrochemistry.

47. ChAC, MTNR: JF to L. Meitner, 2 Feb. 1929.

48. MPGA Abt. I Rep. 1 a no. 1650, pp. 1–7. Application to the president 5 Mar. 1929 for the construction of an Institute of Theoretical Physics.

49. Sakrowski, Heinz: *Der Springer Verlag. Stationen seiner Geschichte*. Part I: 1842–1945. Berlin, Heidelberg, New York 1992, p. 254. Ferdinand Springer had already been conferred an honorary doctorate by the University of Frankfurt in 1922.

50. *Aus fünfzig Jahren deutscher Wissenschaft. Die Entwicklung ihrer Fachgebiete in Einzeldarstellungen*. Edited by Gustav Abb. Berlin, Munich 1930, pp. 310–322.

51. Personal communication by Heinrich Gobrecht to the author.

52. *Physiker über Physiker. Wahlvorschläge zur Aufnahme von Physikern in die Berliner Akademie 1870–1929 von Hermann von Helmholtz bis Erwin Schrödinger*. Edited by Christa Kirsten & Hans Günther Treder. Berlin 1975, p. 254.

53. Reid, Constance: *Courant in Göttingen and New York. The Story of an Improbable Mathematician*. New York 1976, pp. 124 f.

Göttinger Tageblatt, 12 Nov. 1929. Das neue mathematische Institute: Felix Kleins Idee, Rockefellers Geld.

54. Inter., p. 97.
55. Conv. with the Liscos.
56. Inter., p. 106.
57. Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born 1916–1955*. Trans. by Irene Born. New York 1971, pp. 106 f. M. Born to A. Einstein, 19 Dec. 1929.
58. RFA, S 1 Sus. B 64 /Tb Log III, 14 May 1929.

RFA, RG 12.I B 31 F Jones Log III, 25 Mar. 1930.

59. Born, Max & James Franck: Beitrag zum Problem der Adsorptionskatalyse. *Nachr. Ges. Wiss. Göttingen*, math. phys. class (1930), pp. 77–89.
60. ChAC, MTNR: JF to L. Meitner, 27 May 1930.
61. Franck, James: Bestimmung thermodynamischer Größen aus spektroskopischen Daten. *Z. Elektrochem.* 26 (1930), pp. 581–589.
62. Franck, James & Eugene Rabinowitch: Über die Aktivierungswärme bimolekularer Gasreaktionen und über die Chlorknallgasreaktion. *Z. Elektrochem.* 36 (1930), pp. 794–799.

Rabinowitch carried out related experiments at the PTR. Its statutes provide for accommodating such guest researchers.

See: GStA, Rep. 76V e Sekt. 2 Titel XXIII Lit. A Nr. 129 as well as: *Z. Instrum. Kunde* 52 (1932) nos. 4–5, 153–183, 201–224. "Dr. Rabinowitsch from the University of Göttingen worked on a verification of the Born-Franckian wave-mechanical theory of adsorption catalysis."

63. Personal communication by Werner Kroebel to the author.
64. Conv. with the Liscos.
65. Conv. with the Kuhns.
66. Details about W. Dames are available in the files of the former Berlin Document Center, BDS Sig. Dames, Wilhelm, born 14 Feb. 1904.

Inquiry by the Nazi party district (*Gau*) of South Hannover about Dames before his appointment as government advisor at the PTR: "No expert opinion has been recorded, however."

Political evaluation form was "incompletely filled out."

Dames was a member of the *Bund "Reichsflagge"* in the winter of 1922–23 and a machine-gun squadron commander (M:G:K—"Maschinen-Gewehr-Kompanie") who appeared with his men for the *Deutscher Tag* in Nuremberg in the summer of 1923.

"Since the summer of 1923 Dames has been active in the 51st unit [*Standarte*] of the SS." In 1934 Dames was transferred to do service in academia in the "Deutsche Dozentenschaft."

Additional details are in the staff file of Friedrich-Wilhelms-Universität, Humboldt-Universität Berlin, university archive Sig. Z-DI/186 K 7 Wilhelm Dames.

Personal details: born 14 Feb. 1904 in Würzburg, of the Lutheran faith, married with 1 child; physics studies at Würzburg 1924–26, 1928–30, at Munich 1926–28, Berlin 1930–31, doctorate at Würzburg 30 Jul. 1931, supernumerary assistant at Experimental Physics Institute II in Göttingen 1931–33; 1933–35 regular assistantship; 1935 regular assistantship in Berlin.

Dames was enlisted 1924 in the *Reichswehr*, detachment 7, was a registered member of the NSDAP from 17 Mar. 1933, Nazi member card no. 1,588,651; Nazi Lecturers League member from 1933, in the SS from June 1932, Arms and Ammunition Supply 1932, Unit 51, noncommissioned officer's training (*Unterführer*) 1933–34.

For more on W. Dames, see: BA Sig. R 21 10048 in the Heisenberg folder: Transcription of a letter by Johannes Stark, Berlin-Charlottenburg, 6 Aug. 1938 to (Reichsminister) Rust. Besides presenting the then quite common charge against Werner Heisenberg as an advocate of Einstein's theory of relativity, it also criticizes Dames as assistant to the Jew Franck.

Dames's letter to the minister, Berlin 25 Aug. 1938 closes with his response to these accusations: "I lived in seclusion in a basement room, pursued separate investigations, partly also in the field of defense technology and as early as the beginning of 1932 made contacts with the two above-mentioned National Socialists Tromsdorf and Schornstein. Thereafter I exercised a kind of surveillance of the institute, collected arms and ammunition for the NSDAP in my room at the institute, and kept them until they could be stored elsewhere in the winter of 1932/33. Pertinent records are in my possession."

See also: Lemmerich, Jost: Ein Angriff von Johannes Stark auf Werner Heisenberg über das Reichsministerium für Wissenschaft, Erziehung, und Volksbildung (REM). In: *Werner Heisenberg im Spiegel seiner Leipziger Schüler und Kollegen*. Edited by Helmut Rechenberg & Gerald Wiemers. Leipzig 2005.

67. Chronik der Georg-August-Universität zu Göttingen für die Rechnungsjahre 1927–1930. *Göttinger Tageblatt*, 1 Nov. 1931, 1 May 1931.

68. Personal communication by Dietrich Schmidt-Ott to the author.

69. Conv. with the Kuhns.

70. Conv. with the Liscos.

71. A local pun on Mozart's "Eine kleine Nachtmusik" (little serenade for strings).

72. Papers of Heinrich Kuhn: JF to H. Kuhn, 1930.

73. Franck, James: Beziehungen zwischen Spektroskopie und Chemie. *Naturwiss*. 19 (1931), pp. 217–225. The Wills Memorial Lecture.

74. RFA, 1.1 64/ Tis. Log V 15 Jan. 1931.

75. UAG, Sek. I. B. 3c. 63h Ostmarkfeier. The East Mark designated the border regions between Germany and Poland.

76. Walcher, Wilhelm: Gustav Hertz an der Technischen Hochschule zu Berlin 1928–1935. *Wiss. Z. Karl-Marx-Univ. Leipzig*, sci. ser. 36 (1987) 6, pp. 612–625.

77. RFA, RF S. 1.1 Sub. p. 717, 30 Mar. 1931 and p. 12, I B31. F. Jones Log I, 30 Mar. 1931.

78. JRLSC, Franck papers B 3 F 9: F. Haber to JF, 2 Jan. 1930. My insertion.

79. Franck, James & Fritz Haber: Zur Theorie der Katalyse durch Schwermetalle in wässeriger Lösung und insbesondere zur Autooxidation der Sulfitlösungen. *Sitz. Ber. Preuß. Akad. Wiss*., Phys.-Math. Kl., 1931, pp. 250–256. In this publication Franck's given name appears in full instead of the usual initial.

80. JRLSC, Franck papers B 3 F 9: F. Haber to JF, 14 Feb. 1931. My insertion.

81. ChAC, MTNR: JF to L. Meitner, 16 Jun. 1931.

82. JRLSC, Franck papers B 17 F 1: undated draft for Prof. Franck's course on atomic physics for students from all the faculties.

83. Personal communication by Dietrich Schmidt-Ott to the author.

84. Personal communication by Arthur von Hippel to the author.

85. AMPG, Abt. V a Rep. 5 1200: F. Haber to Richard Willstätter, 21 Oct. 1931.

86. Conv. with Prof. F. Hund.

87. ChAC, MTNR: JF to L. Meitner, 20 Dec. 1931.

88. Vierhaus, Rudolf & Bernhard vom Brocke: *Forschung im Spannungsfeld von Politik und Gesellschaft. Geschichte und Struktur der Kaiser-Wilhelm-/Max-Planck-Gesellschaft*. Stuttgart 1990, pp. 276 f.

89. *Reichsgesetzblatt* I, 1931, p. 699, third ordinance on salary cuts. Circular by the Prussian minister of finance 16 Dec. 1931.

90. Personal communication by Heinrich Gobrecht to the author.

91. Rasetti, F: Über die Natur der durchdringenden Berylliumstrahlung. *Naturwiss*. 14 (1932), p. 252.

92. Franck, James, Hertha Sponer & Edward Teller: Bemerkungen über Prädissoziationsspektren dreiatomiger Moleküle. *Z. phys. Chem*. B 18 (1932), pp. 88–101.

93. Resolution of the math.-sci. department. Protokollbuch II, Univ. Göttingen. pp. 122 f: ". . . deduction of 1% of the earnings by faculty members to retain 4 assistantships remains to be checked for legality."

94. JRLSC, Franck papers B 1 F 6: JF to K. Bonhoeffer, 29 Feb. 1932.

95. DMA, Sommerfeld papers: E. U. Condon to A. Sommerfeld, Princeton, 4 May 1932.

96. GStA, Rep 76 Va Sekt 6 Tit. IV 24 vol. II. After Franck declined an appointment to the University of Heidelberg as successor to Lenard, Pohl was asked, but he likewise declined. Members of the Göttingen faculty had begged him to stay. *Göttinger Nachrichten* & *Göttinger Zeitung* 15–20 Apr. 1932.

97. JRLSC, Franck papers B 2 F 9: W. E. Tisdale to Lauder W. Jones, Paris, 22 Jan. 1932. See also Macrakis, Kristie: *Rockefeller Funds Reich Science: The Decision to Fund the Kaiser Wilhelm Institute for Physics* 1934–39. Cambridge, Mass. 1985.

98. JRLSC, Franck papers B 3 F 9: F. Haber to JF, Berlin, 24 Aug. 1932.

99. UGA, Kurat. Göttingen XVI V C II Phys. Inst. Etat II—1940.

100. Weber-Reich, Traudel: *Des Kennenlernens wert*. Göttingen 1993, p. 363. Mrs. Paquin had studied mathematics and physics in Berlin and Zurich from 1912 to 1914. In 1926 she was Professor Nohl's private secretary: personal communication by Mrs. Paquin to the author.

101. Einstein, Albert: Zu Dr. Berliners siebenzigsten Geburtstag. *Naturwiss*. 20 (1932), p. 913.

102. Franck, James & Heinrich Kuhn: Schlüsse auf die Bindungsfestigkeit und Bindungsart aus kontinuierlichen Absorptionsspektren. *Naturwiss*. 20 (1932) pp. 923–925.

103. HUBA, Philosophische Fakultät, draft of a report by the dean 13 Dec. 1932 about the appointment committee meeting for Nernst's successor. Detailed response to Nernst's meddlesome remarks about the appointee's duties. The faculty rejected Nernst's suggestions.

104. JRLSC, Franck papers B 5 F 8: W. Nernst to JF, 7 Dec. 1932.

105. Inter. p. 47. MPGA, Abt. V a. Rep. 5 Haber collection. Interview of JF by J. Jaenicke: "Nernst didn't want me to become his successor. I don't know why. He had set his mind on it. He did not dislike me personally. He gave a bad lecture in physics and must have known it."

106. JRLSC, Franck papers B 3 F 9: F. Haber to JF, 22 and 23 Nov. 1932.

107. Ibid., B 6 F 4: M. Planck to JF, 16 Dec. 1932. Also: GStA, Rep 76 Va Sekt. 6 Tit. IV no. 24 vol. 3. A letter to the Universitätskurator of 6 Feb. 1933 also indicates that Franck intended to accept the appointment to Berlin. In it he requests reimbursement for travel expenses to Berlin also for his two assistants, von Hippel and Cario.

Chapter 6

1. UGA, Kurat. Gött. XVI V c II Phys. Etat II—1940.
2. JRLSC, Franck papers B 6 F 4: M. Planck to JF, 5 Feb. 1933.
3. ChAC, MTNR: JF to L. Meitner, 11 Feb. 1933.
4. UGA, Fakultät to JF, 10 Feb. 1933.
5. Stargardt auction catalog 1998 no. 562: M. Planck to JF, 2 Mar. 1933. My insertion.
6. Lemmerich, Jost: *Lise Meitner zum 125th Geburtstag*. Exhibition catalog. Berlin 2003, p. 69: Lise Meitner to Otto Hahn, 21 Mar. 1933.
7. *Die Universität Göttingen unter dem Nationalsozialismus*. Edited by Heinrich Becker, Hans-Joachim Dahms & Cornelia Wegeler. 2nd ed. Munich 1998. *Göttingen, Geschichte einer Universitätsstadt*. Vol. 3, 1866–1989. Edited by Rudolf von Tadden & Günter Trittel in collaboration with Marc-Dietrich Ohse. Göttingen 1999, pp. 704 f.
8. UBGH, Franck papers: JF to D. Coster, 23 Mar. 1933 (postmark).
9. Reid, Constance: *Courant in Göttingen and New York. The Story of an Improbable Mathematician*. New York 1976, p. 139.
10. JRLSC, Franck papers B 2 F 3: R. Courant to JF, 30 Mar. 1933.
11. Kirsten, Christa & Hans-Jürgen Treder: *Albert Einstein in Berlin*, part I: *Darstellung und Dokumente*, Berlin 1979, pp. 243 f. On Einstein's political attitude see also pp. 68 f.

Grundmann, Siegfried: *The Einstein Dossiers. Science and Politics—Einstein's Berlin Period*. New York 2004, pp. 270 f.

12. English trans. in: *Physics and National Socialism. An Anthology of Primary Sources*. Edited by Klaus Hentschel. Basel, Boston 1996, doc. 6, p. 19.

13. Reid, Constance: *Courant in Göttingen and New York. The Story of an Improbable Mathematician*. New York 1976, pp. 139 f. The slight alterations and completions to this quote are based on the German edition: *Richard Courant 1888–1972. Der Mathematiker als Zeitgenosse*. Berlin, Heidelberg, New York 1979, p. 164.

14. Conv. with the Liscos.

15. UGA, XVI ch 11 I as well as UGA Rek. PA Vitzthum.

16. Conv. with the Liscos.

17. Conv. with the Kuhns.

18. MPGA, Abt. V a Rep. 5 Haber collection: JF to F. Haber, 15 Apr. 1933. Illegible words.

19. JRLSC, Franck papers B 7 F 4–7.

20. English trans. in: *Physics and National Socialism. An Anthology of Primary Sources*. Edited by Klaus Hentschel. Basel, Boston 1996, doc. 9, pp. 26–31.

21. JRLSC, Franck papers B 5 F 4: L. Meitner to JF, 18 Apr. 1933.

22. Ibid., B 6 F 8: M. Polányi to JF, 18 Apr. 1933.

23. Ibid., B 2 F 8: P. P. Ewald to JF, 19 Apr. 1933.

24. Ibid., B 7 F 3: Rabbi Joachim Prinz to JF, 19 Apr. 1933.

25. Ibid., B 7 F 7: JF to M. Neisser, 20 Apr. 1933.

26. Ibid., B 3 F 9: F. Haber to JF, 21 Apr. 1933.

27. Ibid., B 2 F 4: H. Dießelhorst to JF, 22 Apr. 1933.

28. Ibid., B 3 F 10: E. Hahn to JF, 22 Apr. 1933. At that time her husband, Otto, was in the USA. English trans. in: *Physics and National Socialism. An Anthology of Primary Sources*. Edited by Klaus Hentschel. Basel, Boston 1996, doc. 10, pp. 31 f.

29. JRLSC, Franck papers B 1 F 2: R. Atkinson to JF, 19 Apr. 1933.

30. English trans. in: *Physics and National Socialism. An Anthology of Primary Sources*. Edited by Klaus Hentschel. Basel, Boston 1996, doc. 11, p. 33.

31. NSUBH, M. Pohlenz papers.

32. JRLSC, Franck papers B 4 F 10: JF to A. Kühn, 24 Apr. 1933.

33. Personal communication by Grete Paquin to the author.

34. Conv. with the Kuhns.

35. Born, Max: *My Life. Recollections of a Nobel Laureate*. London 1978, pp. 251–254.

36. English trans. in: *Physics and National Socialism. An Anthology of Primary Sources*. Edited by Klaus Hentschel. Basel, Boston 1996, doc. 13, pp. 36–40, esp. pp. 36, 38 f.

37. JRLSC, Franck papers B 7 F 2: G. Rathenau to JF, 29 Apr. 1933.

On Gerhart Rathenau, see: Jakob, Volker & Annet van der Voort: *Anne Frank war nicht allein. Lebensgeschichten deutscher Juden in den Niederlanden*. Berlin, Bonn 1988, pp. 129 f.

These essays are unsigned. The biographical details are the only basis on which to link them to particular individuals. Conv. with Prof. G. Rathenau.

38. JRLSC, Franck papers B 5 F 2: F. London to JF, 15 May 1933.

39. English trans. in: *Physics and National Socialism. An Anthology of Primary Sources*. Edited by Klaus Hentschel. Basel, Boston 1996, doc. 17, pp. 46–49, esp. p. 48.

40. Reid, Constance: *Courant in Göttingen and New York. The Story of an Improbable Mathematician*. New York 1976, p. 147.

41. JRLSC, Franck papers B 5 F 4: F. Haber to JF, 30 Apr. 1933.

Ibid., B 5 F 3: H. Mark to JF, 6 May 1933; JF to H. Mark, 9 May 1933.

42. Ibid., B 4 F 7: President Jüdischer Verb. to JF, 2 May 1933.

Ibid., B 7 F 3: Reichsbund jüdischer Frontsoldaten to JF, 4 May 1933.

43. *Göttingen im Dritten Reich. Dokumente aus dem Stadtarchiv Göttingen*. no. 1, 1994.

44. JRLSC, Franck papers B 6 F 1: JF to O. Oldenberg, 16 May 1933 and 15 Sep. 1933.
45. Franck, James: Über den Lösungszustand des Wasserstoffs in Palladium und Hydrierungskatalyse. *Nachr. Ges. Wiss. Göttingen* math. phys. class (1933), pp. 293–296. A doctoral student of Franck, B. Duhm, had conducted the experiments. His thesis appeared in *Z. Phys*. 88 (1934), pp. 434 f., with "wholehearted" acknowledgment of his advisor, Franck.
46. JRLSC, Franck papers B 6 F 5: JF to R. Pohl, 20 May 1933.

Pohl wrote to the Kurator on 30 Oct. 1933: "I submit herewith in attachment [?] the application to dismiss the senior assistant of Physics Institute II, Miss Prof. Sponer, on 30 Jun. 1934, as Prof. Franck's successor will undoubtedly find it important to fill his institute's primary assistantship with an academically promising younger staff member." From UGA, XVI IV C 4 V h32 vol. II 1a Betr. Ass. u. Hilfsass. Phys. Inst. Abt. Exp. Physik, p. 405.

47. SBBHA, Born papers: JF to Born, 27 May 1933.
48. GStA, 76 V a Sekt 6 Tit IV: no. 24, vol. 3.

Many exchanges with the rector and the chancellor of the University of Göttingen document JF's resignation in the ministry's files.

49. MPGA Abt. I Rep. 1 KWG für physikalische Chemie und Elektrochemie sheet 27. Haber to Planck, Berlin-Dahlem, 27 May 1933.

Haber wrote to Planck to thank him for his words about his departure during the society's plenary meeting, and continued: "As concerns Mr. Franck, he would not accept a state position; but since he wants to stay in the country as long as he is offered the prospect of continuing his research, you will, I believe, not find it hard to have him return to the institute to which he had once belonged, as a member scientist or guest researcher; and you will make available to him compensation by the Kaiser Wilhelm Society in either capacity in the form of a personal wage and the staffing and operating disbursements he needs to continue his life work as a scientist. The institute is large enough to grant the scope all 3 gentlemen need; and if it is imbued with the spirit of these 3 men, it will surely continue on undiminished, if not—as would be anticipated—at a higher level on the world stage."

50. Widmann, Horst: *Exil und Bildungshilfe. Die deutschsprachigen akademischen Emigranten in der Türkei nach 1933*. Bern, Frankfurt 1973.
51. Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born 1916–1955*. Trans. by Irene Born. New York 1971, pp. 113 f. A. Einstein to M. Born, 30 May 1933.
52. SBBHA, Born papers: M. Born to JF, 11 Jun. 1933 with a transcription of Heisenberg to Born, 2 Jun. 1933. My insertion.
53. Ibid., JF to Born, 16 Jun. 1933; Born to JF, 10 Jul. 1933.
54. Wolff, Stefan: Frederick Lindemanns Rolle bei der Emigration der aus Deutschland vertriebenen Physiker. In: *The Yearbook of the Research Centre for German and Austrian Exile Studies*. Vol. 2 (2000), pp. 25–58.
55. Conv. with the Kuhns.
56. JRLSC, Franck papers B 4 F 3: G. Hochheim to JF, 27 Jun. 1933. Orig. emphasis. My insertions.
57. MPG, A I. Abt. Rep. 1: P. Lenard to the senate of the KWG, 28 Jun. 1933.
58. GStA, Rep. 76 Akt. 6 Tit. IV no. 24, vol. 3, p. 20.

The reich ministry of education found out about Franck's intention to hold lectures in the USA through the German consulate in Boston and the foreign office. Franck replied on 22 Jul. 1933 to the Kurator's inquiry: "To my dismay I read today in the paper the news that I have accepted the Speyer Guest Professorship in Baltimore, Johns Hopkins University for the winter semester."

He regretted that he had not been the one to inform the authorities, but he had declined all offers until then.

"I had always given the reason that I absolutely could not decide before Christmas, as I first wanted to examine whether I would be able to find an occupation and source of earnings outside the civil service in Germany."

Franck then argued that his desire to go to Baltimore for a quarter of a year was not identical with emigrating from Germany. He rather preferred to continue looking for further opportunities.

59. JRLSC, Franck papers B 1 F 5: A. Berliner to JF, 14 Jun. 1933; JF to Berliner, 7 Jul. 1933. My insertion.

60. Franck, James & Eugene Rabinowitch: Some remarks about free radicals and the photochemistry of solutions. *Trans. Faraday Soc.* 39 (1934), pp. 120–130.

61. JRLSC, Franck papers B 4 F 7: JF to A. Kühn, 29 Aug. 1933.

62. Ibid., B 2 F 8: JF to A. Eucken, 29 Aug. 1933 (draft?). My insertions.

63. Ibid., B 6 F 1: JF to Oldenberg, 15 Sep. 1933.

64. Ibid., B 1 F 5: N. Bohr to JF, 23 Oct. 1933.

65. BA RDd1 27079/2 sheet 240/241 (PTR). My insertions.

Beyerchen, Alan: *Scientists under Hitler. Politics and the Physics Community in the Third Reich*. New Haven, London 1977, pp. 103 f.

The quoted letter to Frick was signed by Tepohl, Beuthe, Eck, and Voigt. Stark was presumably behind this petition because the signers did not have access to the details in the charges it makes.

During the denazification proceedings E. U. Condon wrote to JF on 26 Feb. 1947 about Stark's case. Franck's response on 5 Mar. 1947 was: "A man of this type, who felt himself to be neglected and who believed that the modern development of science went in an entirely wrong direction, was bound to become a Nazi. The Nazis said they wanted to change everything: that is what he wanted. The Nazis believed in the bad influence of the Jews; that is what he believed after Einstein's success with the principle of relativity. He, therefore, became a Nazi at an early date, and a fervent one." Franck concluded about Stark's denazification proceedings: "He is now an old man, and it is not altogether excluded that even he may have learned a little bit from the experiences of the Nazi days. I cannot believe that he would be dangerous anymore." Orig. English. JRLSC, Franck papers B 9 F 1.

66. SBBHA, Born papers: JF to M. Born, 24 Nov. 1933.

67. Papers of Heinrich Kuhn, Oxford: JF to H. Kuhn, 11 Feb. 1934. My insertions.

68. Conv. with Dr. H. Levi.

69. Aaserud, Finn: *Redirecting Science. Niels Bohr, Philanthropy and the Rise of Nuclear Physics*. Cambridge 1990, pp. 122 f., 134–138.

70. JRLSC, Franck papers B 1 F 7: M. Born to JF, 1934.

71. SBBHA, Born papers: F. Hund to M. Born, 10 May 1934.

72. JRLSC, Franck papers B 2 F 3: R. Courant to JF, 21 Jul. 1934.

73. ChAC, MTNR: JF to L. Meitner and O. Hahn, 24 Sep. 1934.

74. SBBHA, Born papers: JF to M. Born, 29 Oct. 1934. My insertions.

75. Conv. with Dr. H. Levi: The physics of photosynthesis and fluorescence began to figure in their conversations.

Inter., 112: Franck gave some more concrete reasons for his research on photosynthesis—among other things, a lack of appropriate equipment at the Baltimore laboratory. He then mentioned it in connection with Kautsky's publication, without alluding to any involvement by Hilde Levi in Copenhagen.

76. Aaserud, Finn: *Redirecting Science. Niels Bohr, Philanthropy, and the Rise of Nuclear Physics*. Cambridge 1990, pp. 90 f.

77. Krebs, Hans: *Otto Warburg*. Stuttgart 1979, pp. 56 f.

78. Franck, James: Beitrag zum Problem der Kohlensäureassimilation. *Naturwiss.* 23 (1935), pp. 226–229.

79. JRLSC, Franck papers B 1 F 5: JF to A. Berliner, 25 Feb. 1935.

80. Franck, James & Hilde Levi: Zum Mechanismus der Sauerstoffaktivierung durch fluoreszenzfähige Farbstoffe. *Naturwiss.* 23 (1935), pp. 229–230.

Franck, James & Hilde Levi: Beitrag zur Untersuchung der Fluoreszenz in Flüssigkeiten. *Z. phys. Chemie* B 27 (1935), pp. 409–420.

81. Papers of Heinrich Kuhn, Oxford: JF to H. Kuhn, 11 Nov. 1934 and 20 Nov. 1934.

82. JRLSC, Franck papers B 4 F 2: K. F. Herzfeld to JF, 22 Jan. 1935. My insertions.

83. Ibid., B 1 F 4: A. Berliner to JF, 10 Dec. 1934.

84. Ibid., B 6 F 2: G. Paquin to JF, 28 Dec. 1934.

85. Jakob, Volker & Annet van der Voort: *Anne Frank war nicht allein. Lebensgeschichten deutscher Juden in den Niederlanden*. Berlin, Bonn 1988, pp. 129 f. about G. W. Rathenau.

Conv. with Prof. G. Rathenau.

86. JRLSC, Franck papers B 5 F 3: H. Maier-Leibnitz to JF, 1 May 1935.

87. Personal communication by Arthur von Hippel to the author.

88. Conv. with the Liscos. Georg von Hevesy later recounted in his autobiography, *Adventures in Radioisotope Research* (New York 1962, vol. 1, p. 27), having immersed it in a chemical solvent to efface and conceal it from the German occupiers. Bohr eventually sent the gold back to the Swedish Academy for reminting in 1950; and it was reawarded to Franck in a ceremony held at the University of Chicago on 31 Jan. 1952 (cited by Birgitta Lemmelin on the Nobel Prize Web site, medals).

89. SBBHA, Born papers: JF to M. Born, 8 Jan. 1935.

90. Franck, James, Max Planck. *Yearbook Am. Phil. Soc.* (1947), pp. 284–292. Orig. English, p. 291.

91. Papers of Heinrich Kuhn, Oxford: JF to H. Kuhn, 11 June 1935.

Chapter 7

1. Conv. with the Liscos.

2. Franck, James: Remarks on photosynthesis. *Chem. Rev.* 17 (1935), pp. 433–438.

3. Franck, James & Robert W. Wood: Fluorescence of chlorophyll in its relation to photochemical processes in plants and organic solutions. *J. Chem. Phys.* 4 (1936), pp. 551–560.

4. JRLSC, Franck papers B 4 F 11: JF to Hilde Levi, 1 Jan. 1936. My insertions.

5. Conv. with the Liscos.

6. Franck, James & Karl F. Herzfeld: Remarks on the photochemistry of polyatomic molecules. *J. Phys. Chem.* 41 (1936), pp. 97–107.

7. Franck, James & Karl F. Herzfeld: An attempted theory of photosynthesis, *J. Chem. Phys.* 5 (1937), pp. 237–251.

8. These articles are not discussed in great detail because very many of the chemical reactions assumed at that time were revised by later research. It was only toward the end of Franck's life that the methods of physical measurement and techniques in analytic chemistry had improved enough to produce reliable findings about photosynthesis.

9. Franck, James: The fundamentals of photosynthesis. *J. Washington (D.C.) Acad. Sci.* 27 (1937), pp. 317–329.

10. *The Memoirs of Herbert Hoover*. New York 1952, vol. III: *The Great Depression 1929–1941*, chap. 12.

11. Lisa Lisco estate, private collection: JF to American Consul, Berlin, 2 Jun. 1938.

12. Conv. with the Liscos.

13. RFA, box 146, f. 1802 interviews. WW 13 May 1939 Isaiah Bowman.

14. JRLSC, Franck papers, B 8 F 1: Samuel S. Fels Fund Philadelphia.

15. Ibid., B 4 F 3: T. R. Hogness to JF, 9 May 1938.

16. *The Presidents of the University of Chicago. The University of Chicago Faculty. A Centennial View*. University Library, Chicago 1992.

17. François-Poncet, André: *Botschafter in Deutschland 1931–1938*. Berlin, Darmstadt, Vienna 1961, p. 311 (trans.: *The Fateful Years: Memoirs of a French Ambassador in Berlin. 1931–1938*, 1st ed., New York 1947).

Ambassador Dodd's Diary, 1933–1938. Edited by William E. Dodd, Jr., and Martha Dodd. New York 1941.

Fromm, Bella: *Als Hitler mir die Hand küsste*. Reinbek 1993, pp. 219, 233, 241, 253.

18. *Wissenschaft und Glaube—Reden und Ansprachen zur 200-Jahrfeier der Georg-August-Universität zu Göttingen*. Oldenburg, Berlin 1938.

19. ChAC, MTNR: JF to L. Meitner, 23 Oct. 1938. My insertion.

20. MPGA, Abt. II Rep. 14 A no. 992 Hahn papers: JF to O. Hahn, 26 Feb. 1939. My emphasis and insertion.

One comment in this letter about their time together during World War I concurs with a remark Meitner had once written to Hahn: "Your fondness for Franck is based on mutuality; what you wrote to me about him matches to an almost comical degree what he wrote to his wife about a certain person whom I don't want to make conceited." MPGA, Abt. III Rep. 14 Hahn papers: L. Meitner to O. Hahn, 16 Mar. 1915.

21. Lisa Lisco estate, private collection: JF to Lisa Lisco, 2 Jan. 1939.

For information about the Liscos' ancestry, see: Heyer, Friedrich: Die Predigerfamilie Lisco. *Jahrbuch der Berlin-Brandenburgischen Kirchengeschichte*, vol. 54 (1986), pp. 159 f.

22. Franck, James & Edward Teller: Migration and photochemical action of excitation energy in Crystals. *J. Chem. Phys*. 6 (1938), pp. 861–872.

Teller, Edward & Judith Shoolery: *Memories*. Cambridge, Mass., 2001, p. 126. Teller mentioned the "Göttinger" émigrés in Chicago and "Papa" Franck, as he used to address him in his letters. Despite a few differences of opinion on politics, Franck and Teller were close. Franck's letter to Lewis M. Stevens from 22 Nov. 1960 is one testimony of this (orig. English): "It interested me very much that you met my good friend Edward Teller. He is an excellent scientist and a gracious and decent man who is willing to stick to his convictions even if his views and the way he has defended them has made him unpopular with many of his colleagues. I too disagree with him and we discussed this matter together but our different opinions has not changed in the least our good friendship and the warm feeling we hold together."

23. JRLSC, Franck papers B 3 F 3: T. Mann to JF, 17 Apr. 1939.

24. Cultivators were interested in plant growth at artificially elevated levels of carbon dioxide to explore plant productivity factors; it was also of interest for climate regulation.

25. Livingstone, Robert & James Franck: Assimilation and respiration of excised leaves at high concentrations of carbon dioxide. *Amer. J. Botany* 27 (1940), pp. 449–458.

26. Franck, James & Robert Livingstone: Remarks on the fluorescence, phosphorescence, and photochemistry of dyestuffs, *J. Chem. Phys*. 6 (1941), pp. 184–190.

27. Franck, James, Charles S. French & Theodore T. Puck: The fluorescence of chlorophyll and photosynthesis. *J. Phys. Chem*. 45 (1941), pp. 1268–1300.

28. Franck, James & Karl F. Herzfeld: Contribution to a theory of photosynthesis. *J. Phys. Chem*. 45 (1941), pp. 978–1025.

29. SBBHA, Born papers: JF to M. Born, 20 Jul. 1941.

Max Born comments about his decision to correspond in English in 1940: "I was not more fluent in it than in German in those days, but after the outbreak of war it was more in accordance with my frame of mind." Born, Max (ed.): *The Born-Einstein Letters. The Correspondence between Albert Einstein and Max and Hedwig Born,* 1916–1955. Trans. by Irene Born. New York 1971, p. 140.

30. The concentration camps in Holland are discussed in: Jacob, Volker & Annet van der Voort: *Anne Frank war nicht allein. Lebensgeschichten deutscher Juden in den Niederlanden*. Berlin, Bonn 1988, pp. 59 f.

31. Franck, James & Hans Gaffron: Photosynthesis, Facts and Interpretation. *Advances in Enyzmology and Related Subjects* 1 (1941), pp. 199–262.

Hans Gaffron's eulogy of JF and his research on photosynthesis: Ms. 16 pp. JRLSC, Franck papers B 18 F 38a.

32. JRLSC, Franck papers B 9 F 3: A. Stoll to JF, 3 Oct. 1941.

33. Weller, Sol & James Franck: Photosynthesis in flashing light. *J. Phys. Chem.* 45 (1941), pp. 1359–1373.

34. Franck, James & Charles S. French: Photooxidation processes in plants. *J. General Physiol.* 25 (1941), pp. 309–324.

35. Franck, James: Carbon dioxide evolution during the induction period of photosynthesis. *Am. J. Botany* 29 (1942), pp. 314–317.

36. ChAC, MTNR: JF to L. Meitner, undated, probably 1941.

37. Franck, James: Some fundamental aspects of photosynthesis. *Sigma Xi Quarterly* 29 (1941), pp. 81–105.

38. Conv. with the Liscos.

39. ChAC, MTNR: JF to L. Meitner, 10 May 1942.

40. Franck, James & Peter Pringsheim: Phosphorescence of adsorbed trypaflavine and its quenching by oxygen. *J. Chem. Phys.* 11 (1943), pp. 21–27.

41. SBBHA, Born papers, JF to M. Born, 3 Sep. 1942. Orig. English.

42. JRLSC, Franck papers B 7 F 1: JF to E. Rabinowitch, 13 Jul. 1942 (orig. English); E. Rabinowitch to JF, 18 Jul. 1942.

43. Ibid., B 9 F 6: JF to Dolores Terwoord Lad, 29 Dec. 1942.

Chapter 8

1. Documents about atom-bomb development are reprinted, e.g., in *The American Atom*. Edited by Philip L. Cantelon, Richard G. Hewlett & Robert C. Williams. Philadelphia 1991, 2nd ed. 1994.

Leo Szilard: His Version of the Facts. Edited by Spencer R. Weart & Gertrud Weiss Szilard, Cambridge, Mass., 1978.

2. There is no clear documentary evidence dating from 1941–42 to explain this decision to collaborate on developing the atomic bomb. Franck discusses Bohr's decision to involve himself in this project in his address at Niels Bohr's funeral in 1963. Franck, James: Niels Bohrs Persönlichkeit, *Naturwiss.* 50 (1963), pp. 341–343. This passage might just as well be taken as a justification for his own actions (my insertion):

"Some people have not been able to understand Bohr's decision, nor that of others, to collaborate on the atomic bomb. It was a dire necessity. All physicists in the world who read the literature knew that the manufacture of such a bomb could very probably succeed. Should one fold one's arms and wait until Hitler eventually got his hands on such a bomb? Reports, which those familiar with physics could see as clear indicators that such research was going on in Germany, were often available for all to read at length, even in the daily papers. A single bomb dropped on one of the larger cities of the West would have meant victory for Hitler over an unprepared western world. Could one allow a war to be lost that would have let the criminal tyranny that had already enslaved Germany spread throughout the whole world? When it became clear that Hitler would no longer be able to gain possession of the bomb, Bohr raised his voice in alarm. As he was staying in Los Alamos, we in Chicago could not learn about his efforts [against nuclear armament] under the prevailing wartime conditions."

3. Wigner, Eugene Paul: Graphite disease in the W pile. N-1585, 14 Sep. 1944. The dislocations in the graphite store energy that can be released suddenly, in one instance in the UK, causing a fire in one of the first graphite-moderated reactors.

4. ChAC, MTNR: JF to L. Meitner, 9 May 1944. Original spelling.

5. Conv. with the Liscos.
6. JRLSC, Franck papers B 18 F 5; JF to Vannevar Bush, 1 Aug. 1944. Orig. English.
7. Compton, Arthur H.: *Atomic Quest. A Personal Narrative*. London 1956, pp. 139 f., 231 f.
JRLSC, Franck papers B 1 F 19: JF to A. H. Compton, 2 Nov. 1956.
Ibid., B 7 F 1: JF to E. Rabinowitch, 18 Jan 1957. About the accuracy of Compton's account of events in the Met Lab: "Yes, I have read at least part of Compton's memories. May be I was hasty in my judgment but whatever I saw gave me the impression that Compton tried as hard as possible to be honest and decent." (Orig. English.)
Collected Works of Eugene Wigner. Part A. Edited by Arthur Wightman. Chicago 1992, pp. 37 f, 59 f., 99 f.
8. JRLSC, Franck papers B 18 F 10: Enrico Fermi, JF, Zay Jeffries, et al. to A. Compton, 18 Nov. 1944: "The results obtained in the Metallurgical Project are so outstanding and fraught with future consequences that improper postwar policies might prove to be very damaging, or even disastrous, to the United States and the fate of mankind.
You expressed the thought that the men in the Metallurgical Project are in the most favoured position of any in the United States to intelligently speculate on the future of Nucleonics—at least within the scope of the activities of the Metallurgical Project." (Orig. English.)
9. Ibid., B 18 F 17: Notes, handwritten JF, undated.
10. Ibid., B 18 F 16: Memorandum, 5 Jun. 1945. Orig. English.
11. Ibid., B 18 F 14: E. Rabinowitch's notes about the composition of the working groups 6 Jun. 1945.
12. Kimball Smith, Alice: *A Peril and a Hope*. Chicago 1962, pp. 38 f.
JRLSC, Franck papers B 18 F 22; F 23: Political and Social Problems. The so-called "Franck Report."
Leo Szilard wrote another memorandum after the Franck Report that had just as little effect. Niels Bohr tried to influence the decision about whether to deploy the atomic bomb, but neither could he alter the decision reached. In response to Alice Kimball-Smith's inquiry, Franck tried to reconstruct how exactly the Franck Report had been drawn up, in his letter to her dated 22 Jul. 1958 (B 8 F 9). Not all the text had originated from him—the style was much better than his own, he conceded. He had probably asked Rabinowitch for assistance, as on other occasions as well. JRLSC, Franck papers B 7 F 1: JF to E. Rabinowitch, 18 Jan. 1957.

Chapter 9

1. JRLSC, Franck papers B 2 F 7: JF to A. Einstein, 3 Dec. 1945, © Hebrew University Jerusalem.
2. The presidential advisor on economic affairs, Bernard M. Baruch, a wealthy Jewish financier who had been pushing for restrictive controls on the wartime economy, was also promoting a stringent plan for the international control of nuclear weapons. Soon afterwards, in 1946, he was appointed the U.S. representative of the new United Nations Atomic Energy Commission. The rejections of the Baruch Plan, and its less punitive predecessor, the Acheson-Lilienthal Plan, helped trigger the nuclear arms race of the Cold War.
The former secretary of the treasury, Henry Morgenthau, Jr., another wealthy Jew and determined lobbyist for American aid to refugee European Jews, was also advocating inordinately harsh peace terms for Germany.
3. JRLSC, Franck papers B 2 F 7: An Appeal, 3 Dec. 1945. It is unclear whether Franck mailed this version of the "Appeal" to Einstein or whether another version exists.
4. Ibid., B 2 F 7: Einstein to JF, 6 Dec. 1945, © Hebrew University Jerusalem.
The Austrian Modernist writer Hermann Broch jumped into the fray so Einstein did not need to raise any public objection to the "Appeal." See Broch's annotated collected works, vol. II, pp. 428–452.

Broch's letters to JF, 30 Jan. and 27 Feb. 1946.

For Thomas Mann's attitude see his diaries: *Tagebücher* 1944–1946. Frankfurt 1986. Edited by Inge Jens, notes, pp. 755 f.

5. JRLSC, Franck papers, B 2 F 7: JF to A. Einstein, 11 Dec. 1945, B 8 F 12.

6. Ibid., JF to Hertha Sponer, 18 Dec. 1945. Orig. English.

7. Ibid., B 2 F 7: Letter signed by L. Bachhofer, J. Franck et al., 21 Dec. 1945; A. Einstein to JF, 30 Dec. 1945. The familiar "Du" returns in Einstein's reply. Trans. in Hentschel, Klaus: *The Mental Aftermath. The Mentality of German Physicists, 1945–1949*, Oxford 2007, pp. 165 f.

8. JRLSC, Franck papers, B 7 F 8: JF to Werner Richter, 10 Sep. 1945.

9. NSUBH: JF to S. A. Goudsmit, 29 Oct. 1947.

The Dutch-American atomic physicist at MIT's Radiation Lab, Samuel Abraham Goudsmit, was serving as chief scientific officer in the Alsos Mission set up by the Allies to hunt down the researchers of the German uranium project.

10. JRLSC, Franck papers B 6 F 8: P. Pringsheim to JF, 1 Jul. 1944 on oxygen determination.

The method was published by M. Pollak, P. Pringsheim & D. J. Terwoord in *Phys. Chem.* 12 (1944), pp. 295 f.

Franck, James, Peter Pringsheim & Dolores T. Lad: Oxygen production by anaerobic photosynthesis of algae measured by micromethod. *Archives Biochem.* 7 (1945), pp. 103–145.

11. SBBHA, Born papers: JF to M. Born, Feb. 1946. Orig. English.

12. ChAC, MTNR: JF to L. Meitner, 18 Feb. 1946; L. Meitner to JF, 10 May 1946.

13. ChAC, MTNR: 1/7. Christian-Jewish Brotherhood Chicago.

Lemmerich, Jost: *Lise Meitner zum* 125. *Geburtstag*. Exhibition catalog. Berlin 2003, pp. 122 f.

14. ChAC, MTNR: JF to L. Meitner, 3 & 6 Jul. 1946 (illegible word; the epigram translation is taken from JF's speech, 8 Feb. 1947, cited further below).

15. JRLSC, Franck papers B 1 F 5: JF to N. & M. Bohr, 1946. Orig. English (illegible word).

16. Conv. with Dr. H. Levi.

17. JRLSC, Franck papers B 18 F 27: Franck's Speech to the Emergency Committee of Atomic Scientists, 8 Feb. 1947. Orig. English.

18. Franck, James & J. E. Mayer: An osmotic diffusion pump. *Archives Biochem.* 14 (1947), pp. 297–313.

19. Brown, Allan H. & James Franck: On the participation of carbon dioxide in the photosynthetic activity of illuminated chloroplast suspension. *Archives Biochem.* 16 (1948), pp. 55–60.

20. Szabó, Anikó: *Vertreibung Rückkehr Wiedergutmachung. Göttinger Hochschullehrer im Schatten des Nationalsozialismus*. Göttingen 2000, pp. 507 f.

21. Hentschel, Klaus & Gerhard Rammer: Kein Neuanfang: Physiker an der Universität Göttingen, 1945–1955. *Zeitschrift Gesellschaftswissen.* 8 (2000), p. 718.

22. See L. Meitner's letter to Otto Hahn, 27 Jun. 1945, trans. in *Physics and National Socialism. An Anthology of Primary Sources*. Edited by Klaus Hentschel. Basel, Boston 1996, doc. 108, pp. 332 ff.

23. JRLSC, Franck papers B 3 F 10: JF to O. Hahn, 18 Jan. 1947.

24. Schubert, Ernst: Wissenschaftliche Unabhängigkeit und gesellschaftliche Verantwortung: Der Wandel von Leitbildern in der Geschichte der Akademie. *Jahrbuch der Akademie der Wissenschaften zu Göttingen 2000*, 2001, pp. 71, 111 f.

JRLSC, Franck papers B 3 F 8: R. Smend to JF, 28 Dec. 1946, trans. in Hentschel, Klaus: *The Mental Aftermath. The Mentality of German Physicists* 1945–1949, Oxford 2007, p. 154. Reference is made to the philosopher Georg Misch and the classical philologist Kurt Latte.

25. JRLSC, Franck papers 5 10 F 5: JF to H. Weyl, 11 Feb. 1947. Orig. English.

26. JRLSC, Franck papers B 3 F 8: JF to R. Smend, 18 Feb. 1947; R. Smend to JF, 25 Mar. 1947; JF to R. Smend, 12 May 1947.

27. SBBHA, Born papers, JF to M. Born, 8 Mar. 1947, trans. in Hentschel, Klaus: *The Mental Aftermath. The Mentality of German Physicists 1945–1949*, Oxford 2007, p. 155.

28. Schubert, Ernst: Wissenschaftliche Unabhängigkeit und gesellschaftliche Verantwortung: Der Wandel von Leitbildern in der Geschichte der Akademie. *Jahrbuch der Akademie der Wissenschaften zu Göttingen 2000*, 2001, pp. 97–124, esp. pp. 119, 121 f.

29. MPGA, Abt. III Rep. 23, K. F. Bonhoeffer papers: JF to K. F. Bonhoeffer, 2 Mar (1947?). Harold Clayton Urey had joined the university staff in 1945 as Distinguished Service Professor of Chemistry at the Institute for Nuclear Studies.

30. JRLSC, B 10 F 5: JF to E. Wigner, 26 May 1947. Orig. English.

31. Ibid., B 3 F 12, JF to R. Thoma, 22 Sep. 1947.

32. Franck, James: Bemerkungen über Lumineszenz von Ionenkristallen. *Ann. Phys.* 3 (1948), pp. 62–68.

33. Lemmerich, Jost: Lise Meitner—eine Chance zur Rückkehr nach Deutschland. In: *Physik im Nachkriegsdeutschland*. Edited by Dieter Hoffmann. Frankfurt am Main 2003, pp. 191 f.

34. Franck, James. Max Planck. *Yearbook Amer. Phil. Soc.* (1947), p. 284.

35. Franck, James & Hertha Sponer: Comparison between predissociation and internal conversion in polyatomic molecules. In: *Contribution à l'Etude de la Structure Moléculaire. Volume commémoratif Victor Henri*. Liège 1948, pp. 169–179.

36. Conv. with the Liscos.

37. MPGA, Abt. III Rep. 14 Hahn papers: JF to O. Hahn, 16 Oct. 1948.

38. JRLSC, Franck papers B 3 F 7: H. Gaffron to JF, 15 Nov. 1948. M. Dean Burk, Ph.D., was a leading chemist at the National Cancer Institute.

39. Ibid., B 2 F 7: JF to A. Einstein, 13 Mar. 1949. Greetings on Einstein's seventieth birthday.

40. Franck, James: An interpretation of the contradictory results in measurements of the photosynthesis quantum yields and related phenomena. *Archives Biochem.* 23 (1949), pp. 297–314.

41. Franck, James: Possibility of photosynthesis on Mars. In: *The Atmospheres of the Earth and Planets*. Edited by C. P. Kuiper. Chicago 1949, pp. 355–356.

42. SBBHA, Born papers: JF to M. Born, 20 Jul. 1949.

43. JRLSC, Franck papers B 4 F 4: JF to T. R. Hogness, 30 Jan. 1950. Orig. English.

44. Franck, James: A critical survey of the physical background of photosynthesis. *Annal Rev. Plant Physiol.* 2 (1951), pp. 53–86.

Franck, James: The physical background of photosynthesis. *Symposia of the Society of Experimental Biology* 5 (1955), pp. 160–175.

45. Platzman, Robert & James Franck: Theory of the absorption spectra of halide ions in solution. *L. Farkas Memorial Vol. Res. Council Israel*, Jerusalem 1952, spec. publ., no. 1, pp. 21–36.

46. Beyler, Richard, Michael Eckert & Dieter Hoffmann: Die Planck Medaille. In: *Physiker zwischen Autonomie und Anpassung*. Weinheim 2007, pp. 217 f.

47. ADPG: M. von Laue to J. Zenneck, H. Ebert, 5 Apr. 1951.

Results of the submissions by the bearers of the Max Planck medal for the election of the medal recipient(s) for 1951. See also *Verhandlungen DPG* 1951, p. 131.

48. ADPG: JF to J. Zenneck, 25 May 1951.

49. *Die Preußische Akademie der Wissenschaften zu Berlin 1914–1945*. Edited by Wolfram Fischer, Rainer Hohlfeld & Peter Nötzold. Berlin 2000, pp. 96.

50. ABBA, personnel file Franck.

51. JRLSC, Franck papers B 2 F 4: JF to Deutsche Akademie, 26 Jan. 1951.

52. UAG, P A 8 to 10. Naturw. Fakultät: Bruggencate to the Senate, Dec. 1950. Minister to Kurator, 11 Apr. 1951.

53. Personal communication by H. Beyer to the author. Beyer also represented M. Born and R. Courant in their compensation cases.

54. Szabó, Anikó: *Vertreibung, Rückkehr, und Wiedergutmachung*. Göttingen 2000, pp. 197 f., 409 f.

Szabó, Anikó: Re-Emigration und Wiedergutmachung. Die Ordinarien Max Born und James Franck. In: *Physik im Nachkriegsdeutschland*. Edited by Dieter Hoffmann. Frankfurt am Main 2003, pp. 206 f.

Schlüpmann, Klaus: *Vergangenheit im Blickfeld eines Physikers. Hans Kopfermann,* 1895–1963. http://www.aleph99.org/etusci/ks/index.htm also contains a description of Franck's fate and restitution procedure.

55. Conv. with the Liscos.

56. JRLSC, Franck papers B 4 F 3: JF to R. Hill, 5 Mar. 1952. "I was grateful to you for your letter of February 6th because it showed me again how much you are striving to effect a reconciliation between opinions of biochemists and physicists." (Orig. English.)

57. Ibid., B 2 F 1: JF to M. Calvin, 12 Nov. 1952.

58. Ibid.: JF to Rufus Lumry, 28 Oct. 1963.

Benso, A. A.: Warren Lee Butler (1925–1984) *Biogr. Mem. Nat. Acad. Sci.* 74 (1998), pp. 58–75.

59. JRLSC, Franck papers B 2 F 7: A. Einstein to JF, 7 Jul. 1952, © Hebrew University of Jerusalem.

60. Ibid., M. Born to JF, Aug. 1952.

61. ChAC, MTNR: L. Meitner to JF for 29 Aug. 1952, draft.

62. JRLSC, Franck papers B 2 F 2: H. Compton to JF, 15 Aug. 1952.

63. Ibid., B 6 F 7: P. Pringsheim to JF, 1 Jul. 1952.

Ibid., B 21 F 50: Pringsheim, P: James Franck (in honor of his 70th birthday, August 26, 1952).

64. Ibid., B 21 F 49: Kroebel, W. Zum 70. Geburtstag von James Franck. *Naturwiss.* 17 (1952), pp. 385–386.

65. Kopfermann, H.: James Franck 70 Jahre. *Phys. Bl.* 9 (1952), p. 411.

66. JRLSC, Franck papers B 2 F 8: R. Emerson to JF, 13 Nov. 1952.

67. Franck, James: Participation of respiration intermediates in the process of photosynthesis as an explanation of abnormally high quantum yields. *Archives Biochem. and Biophys.* 45 (1953), pp. 190–229.

68. JRLSC, Franck papers B 4 F 1: JF to H. Hertz, 25 Apr. 1953.

SBBHA, Born papers: JF to M. Born, 25 Feb. 1953. The telegram mentioned in this letter could not be located.

69. Conv. with the Liscos.

Lisa Lisco estate, private collection: JF to H. Gaffron, 25 Feb. 1953. Orig. emphasis.

It is not clear precisely which speech by T. Heuss Franck meant, possibly his address at the unveiling of the monument in Bergen-Belsen (the site of a concentration camp) in 1952.

70. JRLSC, Franck papers B 3 F 8: JF to Oberbürgermeister Föge, 21 Feb. 1953.

71. Draft manuscript of Franck's handwritten speech. Undated. Reprinted in *Göttinger Jahrbuch 1954*, Göttingen 1954.

Göttinger Tageblatt, 29 Jun. 1953.

The government gazette of New York State also published a report on 30 Apr. 1953 that James Franck and Max Born had become honorary citizens of Göttingen.

72. See the notice in: *Göttinger Tageblatt*, 29 Jun. 1953.

73. Lisa Lisco estate, private collection: JF to L. Lisco, 12 Jun. 1953.

Typescript: JF's speech at the conference "Wissenschaft und Freiheit" in Hamburg 1953. "Science and Freedom." *Proceedings of a Conference Convened, 6th Congress for Cultural Freedom, Hamburg, July* 23–26, 1953. Würzburg 1955, p. 21. Full text of J. Franck's Opening Address: *Neue Zeitung*, 25 & 28 Jul. 1953.

74. Lisa Lisco estate, private collection: JF to H. Gaffron, 18 Jul. 1953.

75. JRLSC, Franck papers B 3 F 7: JF to H. Gaffron, undated, beginning of 1953.

The handwriting and many cross-outs in the letter reveal Franck's agitation.

76. Ibid., B 1 F 2: JF to E. Rabinowitch, 15 Mar. 1953. Draft.

77. Ibid., H. Gaffron to JF, 27 Feb. (no year) 1953?; H. Gaffron to JF, 30 Apr. 1953. Orig. English.

Lisa Lisco estate, private collection: JF to Gaffron, 18 Jul. (no year) 1953?

Warburg attempted to motivate the National Academy of Sciences in Washington, D.C., to issue an official opinion on his controversy with Franck. See the academy's inquiry to Calvin, Farrington, Emerson, Franck, Goddard, and Hendricks of 3 Aug. 1955.

78. JRLSC, Franck papers B 1 F 7: M. Born to JF, 25 Nov. 1953; JF to M. Born, 4 Dec. 1953.

79. Platzman, Robert & James Franck: Physical principles underlying photochemical, radiation-chemical, and radiobiological reactions. In: *Radiation Biology*. Edited by An Hollaender, vol. 1, part 1, pp. 191–253.

80. Lisa Lisco estate, private collection: Typed manuscript, 4 pp. for the Einstein Festschrift 1954. Orig. English.

81. Conv. with the Liscos.

82. ChAC, MTNR: JF to L. Meitner, 26 Nov. 1954.

83. JRLSC, Franck papers B 10 F 1: JF to G. Wald, 13 Dec. 1954.

84. Ibid., B 4 F 3: R. Hill to JF, 5 May 1955.

85. R. W. Pohl and Dr. R. Pohl papers: JF to R. W. Pohl, 22 Mar. 1955, reply to Pohl's letter of 18 Dec. 1954. Quoted with the kind permission of Dr. R. Pohl, Göttingen.

86. Lemmerich, Jost: *Der Luxus des Gewissens. Max Born, James Franck, Physiker in ihrer Zeit*. Exhibition catalog, Berlin 1982, pp. 156 f.

87. JRLSC, Franck papers B 2 F 2: JF to A. Compton, 17 May 1955. Orig. English.

88. Ibid., B 4 F 9: JF to W. Kroebel, 15 Jan. 1956. W. Kroebel's draft manuscript was titled: Die Atomenergie und die Verantwortung des Menschen.

89. Papers of Heinrich Kuhn, Oxford: JF to H. Kuhn, 15 Mar. 1956.

90. Franck, James & Hertha Sponer: Remarks on radiationless transitions in complex molecules. *J. Chem. Phys*. 25 (1956), p. 172. Draft version in: JRLSC, Franck papers B 12 F 12.

91. Platzman, Robert & James Franck: A physical mechanism for the inactivation of proteins by ionizing radiation. In: *Symposium on Information Theory in Biology*. Edited by H. P. Yockey, R. L. Platzman & H. Quastler. New York 1958, pp. 262–275.

92. JRLSC, Franck papers B 1 F 9: JF to J. Brugger, 1 Apr. 1956, 24 Apr. 1956, 29 Jan. 1957, 21 Feb. 1957. Orig. English.

93. Brugger, J. E. & James Franck: Experimental and theoretical contribution to studies of the afterglow of chlorophyll in plant material. *Arch. Biochem. and Biophys*. 75 (1958), pp. 465–496.

94. ChAC, MTNR: JF to L. Meitner, 27 Jun. 1957.

95. ADPG: G. Hertz & M. von Laue: An Kolleginnen und Kollegen, Jan. 1958.

96. Personal communication by Dietrich Schmidt-Ott to the author.

97. Lisa Lisco estate, private collection: JF to Kinder und Enkel, 26 Apr. (undated) 1958? Emphasis added to indicate English vocabulary in the original German. My insertions.

Hoffmann, Dieter: *Ein Jubiläum wird gefeiert: Die Planck-Feier(n) in Berlin* 1958. Preprint series no. 33/95 Max Planck Institute for History of Science, Berlin 1995.

98. No manuscript of Theodor Heuss's speech during his Chicago visit could be found either among the Heuss papers or in the files of the federal presidential office. The faculty club's files and interviews among the staff yielded no clues either. The fact that such a speech did take place is based on a handwritten draft, containing numerous cross-outs, of Franck's thank-you letter to Heuss: " . . . which you also stressed so strongly in your fine speech in the Quadrangle Club in 1958." JRLSC, Franck papers B 3 F 1.

99. Franck, James: Remarks on the long-wavelength limits of photosynthesis and chlorophyll fluorescence. *Proc. Nat. Acad. Sci. Wash.* 44 (1958), pp. 941–948.

100. ChAC, MTNR: JF to L. Meitner, 1 Nov. 1959, 17 Mar. 1959, Aug. 1959.

101. Franck, James: Fluorescenz des Chlorophylls in Zellen und Chloroplasten und ihre Beziehung zu den Primärakten der Photosynthese. In: *Handbuch der Pflanzenphysiologie* 5, *Die CO_2-Assimilation*. Part 2. Edited by W. Ruhland. 1960, pp. 689–735.

102. Papers of Heinrich Kuhn: JF to H. Kuhn, 7 Jan. 1960.

103. Lisa Lisco estate, private collection: JF to Prorektor der Georg-August-Universität Göttingen, 2 Jun. 1961, draft.

104. ChAC, MTNR: JF to L. Meitner, Jan. 1961?

105. Franck, James, Jerome L. Rosenberg & C. Weiss, Jr.: The primary photochemical step in photosynthesis: A comparison of two theories. In: *Luminescence of Organic and Inorganic Materials*. Edited by H. P. Kallmann & G. M. Spruch. New York 1962, pp. 11–19. See also Rosenberg, Jerome L.: The contributions of James Franck to photosynthesis research. *Photosynth. Res.* 80 (2004), pp. 71–76.

106. Conv. with the Liscos.

107. Sterio, Alexander Dées de: *Nobel Preisträger in Lindau*, Solothurn 1963.

108. Lisa Lisco estate, private collection. Draft. See also *Physikalische Blätter* 18, no. 12 (1962), pp. 541 f.

109. Franck, James & Jerome L. Rosenberg: Principles of a theory of light utilization in plant photosynthesis. In: *Photosynthesis Mechanisms in Green Plants*. Washington, D.C.: Nat. Acad. Res.: Con. publ. no. 1145 (1963), pp. 101–111.

110. Franck, James & Jerome L. Rosenberg: A theory of light utilization in plant photosynthesis. *J. Theor. Biol.* 1964, 7, 276–301.

111. Franck, James: Niels Bohrs Persönlichkeit. *Naturwiss.* 50 (1963), pp. 341–343.

112. JRLSC, Franck papers B 2 F 1: JF to R. Lumry, 28 Oct. 1963. Orig. English.

113. Ibid., B 3 F 8: JF to K. H. Knappstein, undated, beginning of 1964.

114. Conv. with the Liscos.

115. Personal communication by Heinrich Gobrecht to the author.

116. ChAC, MTNR: Marie-Luise Rehder to L. Meitner, 27 May 1964.

Name Index

Stanford Nuclear Age Series
General Editor, Martin Sherwin

Confronting the Bomb:
A Short History of the World Nuclear Disarmament Movement
By Lawrence S. Wittner
2009

Apocalypse Management:
Eisenhower and the Discourse of National Insecurity
By Ira Chernus
2008

Spying on the Nuclear Bear:
Anglo-American Intelligence and the Soviet Bomb
By Michael S. Goodman
2007

The End of the Pacific War: Sixty Years Later
Edited by Tsuyoshi Hasegawa
2007

Eisenhower, Science Advice, and the Nuclear Test-Ban Debate, 1945–1963
By Benjamin P. Greene
2006

The Week the World Stood Still: Inside the Secret Cuban Missile Crisis
By Sheldon M. Stern
2005

A World Destroyed: Hiroshima and Its Legacies, 3rd edition
By Martin Sherwin
2003

Averting "The Final Failure":
John F. Kennedy and the Secret Cuban Missile Crisis Meetings
By Sheldon M. Stern
2003

The Struggle Against the Bomb: Volume Three,
Toward Nuclear Abolition, A History of the World Nuclear Disarmament Movement, 1971–Present
By Lawrence S. Wittner
2003

Another Such Victory: President Truman and the Cold War, 1945–1953
By Arnold A. Offner
2002

Einstein and Soviet Ideology
By Alexander Vucinich
2001

Cardinal Choices:
Presidential Science Advising from the Atomic Bomb to SDI
Revised and Expanded Edition
By Gregg Herken
2000

The Fate of the Earth and The Abolition
By Jonathan Schell with a New Introduction by the Author
2000

The Struggle Against the Bomb: Volume Two,
Resisting the Bomb, A History of the World Nuclear Disarmament Movement, 1954–1970
By Lawrence S. Wittner
1997

James B. Conant:
Harvard to Hiroshima and the Making of the Nuclear Age
By James G. Hershberg
1993

The Struggle Against the Bomb: Volume One,
One World or None, A History of the World Nuclear Disarmament Movement Through 1953
By Lawrence S. Wittner
1993

A Preponderance of Power:
National Security, the Truman Administration, and the Cold War
By Melvyn P. Leffler
1992

The Wizards of Armageddon
By Fred Kaplan with a New Foreword by Martin J. Sherwin
1983, reissued 1991

Robert Oppenheimer: Letters and Recollections
Edited by Alice Kimball Smith and Charles Weiner with a New Foreword by Martin J. Sherwin
1980, reissued 1995

The Advisors: Oppenheimer, Teller, and the Superbomb
By Herbert F. York with a New Preface and Epilogue Historical Essay by Hans A. Bethe
1976, reissued 1989

The Voice of the Dolphins and Other Stories
By Leo Szilard
1961, reissued 1991

Atomic Energy for Military Purposes
By Henry D. Smith, Preface by Philip Morrison
1945, reissued with a New Foreword, 1989

"James Franck was a great physicist and an exemplary human being. This definitive biography of James Franck's life is a welcome addition to the history of that remarkable generation of physicists who transformed our understanding of the universe."

—Martin J. Sherwin, from the Foreword

STANFORD NUCLEAR AGE SERIES

Stanford University Press
WWW.SUP.ORG

ISBN-10: 0-8047-6310-0
ISBN-13: 978-0-8047-6310-3
90000
9 780804 763103