Gender, Politics, and Radioactivity Research in Interwar Vienna

The Case of the Institute for Radium Research

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ABSTRACT

This essay explores the significance of political and ideological context as well as experimental culture for the participation of women in radioactivity research. It argues that the politics of Red Vienna and the culture of radioactivity research specific to the Viennese setting encouraged exceptional gender politics within the Institute for Radium Research in the interwar years. The essay further attempts to provide an alternative approach to narratives that concentrate on personal dispositions and stereotypical images of women in science to explain the disproportionately large number of women in radioactivity research. Instead, the emphasis here is on the institutional context in which women involved themselves in radioactivity in interwar Vienna. This approach places greater importance on contingencies of time and place and highlights the significance of the cultural and political context in a historical study while at the same time shedding light on the interrelation between scientific practices and gender.

"AS THIS WORK HAS NOW BEEN ORGANIZED after several years of tentative efforts[,] each collaborator has *his or her* particular share to take in making the practical preparations necessary for an experiment. Besides[,] each has *his or her* particular theme for research which he pursues and where he can count on the help from one or more of his fellow workers. Such help is freely given[,] certain workers having spent

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months preparing the means required for another worker[']s theme." When Hans Pettersson, a Swedish physicist working at the Institut für Radiumforschung (Institute for Radium Research) in Vienna, submitted this description in a report to the International Education Board in April 1928, several women physicists were already part of his research team on artificial disintegration.[1] A number of other women explored radiophysics and radiochemistry as collaborators at the institute, formed their own research groups, and worked alongside some of the best-known male physicists in the field. More specifically, between 1919 and 1934 more than one third of the institute's personnel were women. They were not technicians or members of the laboratory support staff but experienced researchers or practicum students who published at the same rate as their male counterparts.

Marelene Rayner-Canham and Geoffrey Rayner-Canham have already drawn attention to the fact that women clustered in radioactivity research in the early twentieth century. Identifying three different European research schools on radioactivity—the French, English, and Austro-German—the Rayner-Canhams argue that women "seemed to play a disproportionately large share in the research work in radioactivity compared to many other fields of physical science."[2] Through prosopographical studies of important women in these three locations, the authors address the puzzle of why so many women were attracted to this particular field. The explanations they propose focus mainly on the character of mentors, directors, and chief collaborators. The more supportive these figures were, the easier it was for women to be accepted into physics laboratories specializing in radioactivity. Once they gained professional access to the field, women developed strong networks and maintained close contacts with one another, thus fortifying and sustaining their positions.

A second set of explanations touch on research practices—the fact that radioactivity research involved meticulous, routine, and repetitive work. The Rayner-Canhams, like many others, hold that women were more willing than men to perform monotonous tasks and to endure the hardships of dealing with radioactive materials.[3] Finally, they point to the structure and subject matter of the discipline as a reason for the unusually high concentration of women in it. In the early twentieth century, radioactivity was a comparatively new field that was thought to be on the edge of mainstream science. Because it lacked the strong male hierarchies of more established fields, it was easier for women to gain access; moreover, it had an aura of excitement for anyone seeking a meaningful career. In addition to such explanatory approaches, scholars have explored the role of women in early radio-

[1] Hans Pettersson, Report to the International Education Board, Apr. 1928 [in English], archives of the Göteborgs Universitetsbibliotek (hereafter cited as **GUB archives**), Sweden (emphasis added). Experiments on artificial disintegration involved the transmutation of one element into another by bombardment with alpha particles and the consequent emission of long-range particles. Throughout this essay I will refer to the Institut für Radiumforschung as the "Radium Institute."

[2] Marelene Rayner-Canham and Geoffrey Rayner-Canham, eds., *A Devotion to Their Science: Pioneer Women of Radioactivity* (Philadelphia: Chemical Heritage Foundation, 1997) (hereafter cited as **Rayner-Canham and Rayner-Canham, eds., *Devotion to Their Science***), p. 12.

[3] The Rayner-Canhams base their claim on Margaret Rossiter's work. See Margaret W. Rossiter, "Sexual Segregation in the Sciences: Some Data and a Model," *Signs,* 1978, *4:*146–151; Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (Baltimore: Johns Hopkins Univ. Press, 1984); and Rossiter, *Women Scientists in America: Before Affirmative Action, 1940–1972* (Baltimore: Johns Hopkins Univ. Press, 1995). They also compare radioactivity to other subdisciplines of physics such as astronomy and crystallography. See, e.g., F. H. Portugal and J. S. Cohen, *A Century of DNA* (Cambridge, Mass.: MIT Press, 1977); Maureen Julian, "Women in Crystallography," in *Women of Science: Righting the Record,* ed. G. Kass-Simon and Patricia Farnes (Bloomington: Indiana Univ. Press, 1989), pp. 300–334; and John Lankford and Rickey Slavings, "Gender and Science: Women in American Astronomy, 1859–1940," *Physics Today,* 1990, *43*(3):58–65.

activity research through a variety of biographical studies that aim to provide missing pieces of the history of the discipline, recover forgotten women scientists, or do justice to the role of Marie Curie as a pioneer in the field.[4]

While these approaches recover the importance of women's scientific contributions, they also create a master narrative that presents radioactivity research in general terms, hiding differences among the various geographical localities and historical contexts. The lack of comparative analyses that take into account the particular institutional, cultural, and political circumstances of the different research schools strengthens the assumption that women clustered in radioactivity research in all European institutes. It also encourages a monolithic understanding of disciplinary practices and laboratory cultures by assuming that work in radioactivity involved tedious tasks that women performed more readily than their male colleagues throughout the different institutional settings.

It is a fact that during the early twentieth century women could be found in the most prestigious laboratories of the day, probing the chemical, physical, and biological phenomena of radioactive substances. Ellen Gleditsch in Oslo, Lise Meitner in Berlin, and Jarmila Petrova in Prague are just a few of those who worked extensively in radioactivity. Nonetheless, studies indicate that the only institutes with a significant percentage of women researchers were the Radium Institute in Vienna and Marie Curie's laboratory in Paris. Between 1910 and 1919 women accounted for 16 percent of the total number of researchers at the Vienna institute; the figure stood at 38 percent in 1934. At Curie's Laboratoire du Radium women made up between 25 and 30 percent of researchers from 1906 to 1934. In contrast, although Ernest Rutherford welcomed and supported women's participation in science, there were no women among his students or collaborators in Cambridge during the 1920s. Gleditsch seems to have had only a couple of female students in her laboratory, and it is still unclear whether there were any women experimenters in Meitner's group.[5]

[4] Marelene Rayner-Canham and Geoffrey Rayner-Canham, *Women in Chemistry: Their Changing Roles from Alchemical Times to the Mid-Twentieth Century* (Philadelphia: Chemical Heritage Foundation, 1998), p. 94; and Rayner-Canham and Rayner-Canham, eds., *Devotion to Their Science,* p. 18. For further work see, e.g., Anne-Marie Weidler Kubanek and Grete Grzegorek, "Ellen Gleditsch: Professor and Humanist," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 51–75; Rayner-Canham and Rayner-Canham, "Stefanie Horovitz, Ellen Gleditsch, Ada Hitchins, and the Discovery of Isotopes," *Bulletin for the History of Chemistry,* 2000, *25*(2):103–109; Ruth Sime, *Lise Meitner: A Life in Physics* (Berkeley: Univ. California Press, 1996); Charlotte Kurner, *Lise, Atomphysikerin: Die Lebensgeschichte der Lise Meitner* (Weinheim: Beltz & Gelberg, 1998); Patricia Rife, *Lise Meitner and the Dawn of the Nuclear Age* (Boston: Birkhäuser, 1999); Tina Crossfield, "Irene Joliot-Curie: Following Her Mother's Footsteps," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 97–123; Rosalynd Pflaum, *Grand Obsession: Madame Curie and Her World* (New York: Doubleday, 1989); Helena Pycior, "Marie Curie's 'Anti-Natural Path': Time Only for Science and Family," in *Uneasy Careers and Intimate Lives: Women in Science, 1789–1979,* ed. Pnina Abir-Am and Dorinda Outram (New Brunswick, N.J.: Rutgers Univ. Press, 1989), pp. 191–215; Pycior, "Reaping the Benefits of Collaboration While Avoiding Its Pitfalls: Marie Curie's Rise to Scientific Prominence," *Social Studies of Science,* 1993, *23:*301–323; Pycior, "Marie Curie: Time Only for Science and Family," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 31–50; and Robert Rosner and Brigitte Strohmaier, eds., *Marietta Blau: Sterne der Zetrümmerung* (Vienna: Böhlau, 2003).

[5] On Petrova see Emilie Tesinska, "Women in the Field of Radioactivity: The Case of the Czech Physical Chemist and Radiobiologist Jarmila Petrova," paper presented at the International Conference on Women Scholars and Institutions, Prague, 8–11 June 2003. For the Paris figures see Astrid Schürmann, "Promoting International Women's Research in Radioactivity: The Curie Laboratory in Paris," paper presented at the International Conference on Women Scholars and Institutions. The Rayner-Canhams argue that Rutherford provided a welcoming environment in his laboratory and in the past had a few women working with him: Rayner-Canham and Rayner-Canham, eds., *Devotion to Their Science,* p. 20. According to Horst Kant, from 1912 to 1938 almost 14 percent of the researchers in Lise Meitner and Otto Hahn's department at the Kaiser Wilhelm Institute for Chemistry in Berlin were women. However, the role of those women in the laboratory has not been investigated. See Horst Kant, "Von KWI für Chemie zum KWI für Radioaktivität," *Dahlemer Archivgespräche,* 2002, *8:* 57–92.

This essay complicates historians' general assumption that there was a disproportionately large number of women engaged in radioactivity research in the early years. It considers the significance of institutional context, particularly with regard to work culture and the gender politics of collaboration—a topic that has been largely unaddressed in earlier studies of the major radioactivity research centers. Focusing especially on the case of Vienna, I argue here that a unique constellation of progressive politics and supportive, politically aware personalities created the local conditions that led women to play an extraordinarily significant role in the Radium Institute. These factors merged nicely with the peculiarities of radioactivity research. As an interdisciplinary field, radioactivity offered scientists unique opportunities for crossing disciplinary boundaries. Often this proved a successful strategy for women seeking to sustain their roles as active experimenters. It is important to add that in Vienna between the wars neither the meaning of "woman" nor that of "experimental physicist specializing in radioactivity" remained fixed and stable. As the careers of some of the women who worked in Vienna show, these categories depended on both political and scientific changes that shaped the Radium Institute in the early twentieth century.

My approach restores importance to the contingencies of time and place, highlighting the significance of the cultural and political context for historical study; at the same time, it sheds light on the interrelation between scientific practices and gender more generally. It does not, however, underestimate the role of individuals who held administrative and scientific positions. On the contrary, it traces the power relations that enabled them to take advantage of the interdisciplinarity of the field and to pursue exceptional gender politics in the Radium Institute.

By "gender" I refer here to two intertwined aspects of a social process that are always co-produced and are specific to the historical and cultural setting in which this process is taking place. First, "gender" signifies the process of attributing meaning to sexual differences as a result of the dominant discourse of the time. This attribution further defines and at the same time is defined by relations of power between men and women. Second, "gender" also signifies the process by which the men and women in question embody those meanings and power relations. The shift from the discourse that names what is a man and what is a woman in every historical and cultural context to the embodiment of these meanings in a specific context is what makes every historical setting, and the concept of gender that depends on it, unique.

In the case of Vienna, my analysis suggests that during the 1920s the Social Democrats challenged the traditional and dominant images that described social gender roles, reattributed meaning to sexual differences according to socialist ideology, and offered practical venues in which both men and women could personify these novel discursive constructions. A specific focus on the individuals who worked at the Radium Institute shows how they embodied those meanings, what kinds of individual actions contributed to this process, and how particular people lived out the structures of power.

ESTABLISHMENT OF THE INSTITUTE FOR RADIUM RESEARCH IN VIENNA

"I wanted, as far as it was within my power, to prevent from falling on my fatherland the shame that the scientific exploitation that nature conferred upon it as a privilege would be snatched away by others. I had no other choice, under the somewhat cumbersome governmental procedures and really pressing circumstances, than to reach into my own pocket and at least to try to smooth the path." So Karl Kupelweiser, in a 1908 letter to the Austrian

Academy of Sciences, explained his donation of 500,000 kronen, an impressive sum at the time, to establish an institute for radium research. A Viennese lawyer and a powerful industrialist, Kupelweiser was the son of the famous painter Leopold Kupelweiser. True to his bourgeois background, he was interested in the cultural, political, and academic life of Vienna. In 1907 he had made a generous contribution to the Biological Station in Lunz, whose first director—not coincidentally—was his son, the biologist Hans Kupelweiser. Like the generous patrons of the Italian Renaissance, Kupelweiser sought in funding the Radium Institute to boost his prestige and to play an active role in the academic life of Vienna.[6]

At the same time, Kupelweiser's offer was viewed as a patriotic act that fostered the country's progress and increased the empire's prestige. As research on radium had already sparked a great deal of interest, scientists such as the Curies, Ernest Rutherford, William Ramsay, and Emil Warburg had approached the Austrian Academy of Sciences in hopes of receiving considerable quantities of pitchblende from the Bohemian mines in St. Joachimstal.[7] The mines were under the control of the Hapsburg empire, and thus the Viennese physicists served as intermediaries between the international scientific community and the mine's administrators. The role of radium merchants, however, did not please the Viennese academics. Rather than seeing "their" radium being "snatched away by others," the Viennese physicists, with Kupelweiser's support, wanted to establish their own radium research center. On 28 October 1910, the Institute for Radium Research opened its doors as the first specialized research institute on radioactivity in Europe, the result of Kupelweiser's private initiative, the support of the Austrian Academy of Sciences, which promised an annual donation, and the cooperation of the state, which offered the site where the building was constructed. (See Figure 1.) As Victor Hess later recalled, "It was the only [institute] of its kind in the world. It was a true pleasure to have all of these excellent apparatuses and facilities at one's disposal."[8]

[6] Karl Kupelweiser to the Austrian Academy of Sciences, 2 Aug. 1908, Archiv der Österreichische Academie der Wissenschaften (hereafter cited as **ÖAW archives**); much of this letter appears in Wolfgang Reiter, "Stefan Meyer: Pioneer of Radioactivity," *Physics in Perspective,* 2001, *3:*106–127 (the passage I cite here is on p. 114). I argue that Kupelweiser did not intend to profit from the radium industry but that he made this generous donation because he wanted to patronize science. This interpretation is supported by his additional donations to the medical society of Vienna; see Isidor Fischer, *Geschichte der Gesellschaft der Ärtze in Wien 1837–1937* (Vienna: Springer, 1938), p. 115. Leopold Kupelweiser was a member of an artistic circle that included the painter Moritz von Schwind, the musician Franz Lachner, and the composer Franz Schubert. He was also acquainted with the family of Ludwig Wittgenstein. See Heinz Löffler, "Limnology in Austria: A Condensed Synopsis," in *Groundwater Ecology: A Tool for Management of Water Resources,* ed. Christian Griebler *et al.* (Luxembourg: European Communities, 2001), p. 15; and Reiter, "Vienna: A Random Walk in Science," *Phys. Perspect.,* 2001, *3:*462–489, on p. 476.

[7] Praising his gifts, Franz Exner calls Kupelweiser "the patriotic friend of science": Almanac of the Austrian Academy of Sciences, 1912, p. 327, ÖAW archives (here and throughout this essay, translations are mine unless otherwise indicated). For requests for pitchblende see Kaiserliche Akademie der Wissenschaften in Wien, Konzepte, 25 015, ÖAW archives. One list of radium recipients included the Chemistry Institute in Krakau and Eduard Riecke's institute at the University of Göttingen: 1908 report of the Ministry of Public Affairs, no. 904, ÖAW archives. See also Maria Rentetzi, "Gender Politics and Radioactivity Research in Vienna, 1910–1938" (Ph.D. diss., Virginia Tech, 2003), pp. 75–80. It should be noted that when I did my research in the ÖAW archives the collections were uncatalogued but that a large part of the archive has since been catalogued. As a rule, I refer to documents by their titles; these should enable sources to be found even if some collections are now identified differently.

[8] Stefan Meyer, "Die Vorgeschichte der Gründung und das erste Jahrzehnt des Institutes für Radiumforschung," in *Festschrift des Institutes für Radiumforschung Anlässlich seines 40jährigen Bestandes (1910–1950)* (Vienna, 1950), pp. 1–26, on p. 13 (opening of the institute); and Reiter, "Stefan Meyer" (cit. n. 6), p. 116 (quoting Hess). As Reiter argues, the Institut du Radium in Paris, which opened in 1915, resembled the Vienna institute in its architecture.

Figure 1. *The Institute for Radium Research on the day of its ceremonial opening, 28 October 1910. (Courtesy of the Central Library of Physics, Vienna.)*

Franz Exner was named the institute's official director (*Vorstand*). Born to a Viennese bourgeoisie family, Exner had been a member of the Austrian Academy of Sciences since 1885 and *ordinarius Professor* at the University of Vienna since 1891. In the scientific community he was known not only for his original work on atmospheric electricity, color theory, spectral analysis, and radioactivity but also from the wide circle of students he mentored. Among them, Stefan Meyer (1872–1949) occupied a prominent position.

Meyer belonged to a family of Jewish intellectuals and chose to study physics at the University of Vienna under Exner and Ludwig Boltzmann. From early on he expressed a strong interest in radioactivity and became known for his studies on the magnetic properties of the radiation of radium and polonium. In 1900 he became *Privatdozent* at the University of Vienna, and in 1906 he succeeded Boltzmann as head of Vienna's Institute for Theoretical Physics, a position he held for a year. In 1908 he became *ausserordentlicher Professor* and Exner's assistant. When the International Radium Standards Committee was founded in 1910, Meyer was appointed as the secretary. By the time the Radium Institute was established he was known to the international community for both his scientific achievements and his pleasant personality. Recognizing his merit, Exner named his student the institute's day-to-day director (*Leiter*), in charge not only of the building and the purchase of instruments and furniture but also of the research agenda.

Research carried out during the institute's first decade led to the award of at least two Nobel Prizes and involved a surprising number of creative young researchers with backgrounds in fields such as biology, physiology, chemistry, geology, and physics. Victor Hess, the institute's *ordentlicher Assistent* (first assistant) until 1919, received the Nobel Prize in Physics in 1936 for his 1912 discovery of cosmic radiation. Friedrich Paneth worked as *ausserordentlicher Assistent* (second assistant) from 1912 to 1919 and collaborated with Georg Hevesy to conduct the first radioactive-tracer experiment in 1913.[9] Hevesy's main research focused on investigations of radium and lead isotopes that later led to their clinical use, work for which he received the Nobel Prize in Chemistry in 1943. Otto Hönigschmid was responsible for establishing radium standards. His collaborator Stefanie Horovitz determined the atomic weight of lead using pitchblende from the Bohemian mines; this work offered the most convincing confirmation of the existence of isotopes. Hans Molisch, later president of the University of Vienna, embarked on his scientific career with a study of the influence of radium emanations on plants. Heinrich Mache and Eduard Suess worked on the absorption of radium emanations in human blood through inhalation and drinking.[10]

Once established, the institute became the official standard keeper for radioactive measurements in Austria and acted as an information center for scientific questions pertaining to radium. It also supplied the Radium Station at Vienna's General Hospital with radium for medical use. However, under a condition imposed by Kupelweiser, medical research and experiments on living organisms were excluded from the institute's agenda. Devoted exclusively to chemical and physical investigations of radium, the institute offered possibilities only for *Praktikum,* i.e., laboratory research positions for Ph.D candidates to complete their thesis requirements.[11] Thanks to Kupelweiser's initiative, Exner and his colleagues enjoyed well-equipped laboratories and were able to perform their research undisturbed. Most important, they institutionalized radioactivity research in Austria, boosted their own scientific prestige, and consolidated their scattered research activities to

[9] On Hess's work see Victor Hess, "Persönliche Erinnerungen aus dem ersten Jahrzehnt des Instituts für Radiumforschung," in *Festschrift des Institutes für Radiumforschung Anlässlich seines 40jährigen Bestandes (1910–1950)*, pp. 43–45. On Paneth's work with Hevesy see Liste der Assistenten, 1934, ÖAW archives. See also Stefan Meyer, "Das erste Jahrzehnt des Wiener Instituts für Radiumforschung," *Jahrbuch der Radioactivität und Elektronik*, 1920, *17*(1):1–29, on p. 11.

[10] Friedrich Paneth, "Aus der Frühzeit des Wiener Radiuminstituts die Darstellung des Wismutwasserstoffs," in *Festschrift des Institutes für Radiumforschung Anlässlich seines 40jährigen Bestandes (1910–1950)*, pp. 49–52; Otto Hönigschmid and Stefanie Horovitz, "Sur le poids atomique du plomb de la pechblende," *Comptes Rendus des Séances de l'Académie des Sciences, Paris*, 1914, *158:*1796–1798; Hönigschmid and Horovitz, "Über das Atomgewicht des Uranbleis," *Monatshefte für Chemie*, 1914, *35:*1557–1560; Hönigschmid and Horovitz, "Über das Atomgewicht des Uranbleis," *Sitzungsberichte der Kaiserliche Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Klasse, Abteilung IIa*, 1914, *123:*2407–2432; Hans Molisch, "Über das Treiben der Pflanzen mittels Radium," *ibid.*, 1911, *120:*1007–1014; Molisch, "Über der Einfluss der Radiumemanation auf die höhere Pflanzen," *ibid.*, 1912, *121:*501–512; and Heinrich Mache and Eduard Suess, "Über die Aufnahme von Radiumemanation in das menschliche Blut bei der Inhalations- und Trinkkur," *ibid.*, pp. 1055–1070.

[11] Meyer, "Das erste Jahrzehnt des Wiener Instituts für Radiumforschung" (cit. n. 9), pp. 12, 10. Because the Radium Institute was a research institute, there were no teaching facilities in the building. For a detailed description of the Austrian academic system see Olga Tausky-Todd, "Olga Tausky-Todd: An Autobiographical Essay," in *Mathematical People: Profiles and Interviews*, ed. Donald Albers and G. L. Alexanderson (Boston: Birkhäuser, 1985), pp. 309–336, on p. 316.

shape a new scientific field. By maintaining relations with medical institutes and industry, they stabilized and strengthened the connections of radioactivity research with medicine, clinical radiology, and industrial chemistry.

At this intersection of a number of disciplines, women who entered radioactivity research could choose different paths and take advantage of its multiple applications. Indeed, the fact that radioactivity stood on the border of physics, chemistry, biology, and medicine played an enormous role in sustaining women's positions in the field, as they could pursue work in hospitals, medical laboratories, and technical companies. The case of Marietta Blau, a practicum student at the Radium Institute in the late 1910s, is a significant example of how research on the border zone between physics and medicine offered women the flexibility to shift careers from the academy to medical institutions and to industry. After defending her thesis at the University of Vienna in 1919, Blau became a research assistant at the Laboratory for Medical Radiology at Guido Holzknecht's clinic at the Allgemeine Krankenhaus (General Hospital) of Vienna and continued her research at the Radium Institute. In 1921 she moved to Berlin and obtained a position at a company that manufactured X-ray tubes. Later she worked as a research assistant at the Institute of Medical Physics in Frankfurt am Main and instructed doctors in radiobiology.[12]

Overall, between 1910 and 1919 eight women were among the forty-eight authors who published in the pages of the *Mitteilungen aus dem Institut für Radiumforschung,* the annual bulletin of the institute.[13] Encouraged by the experimental culture specific to the Vienna institute and supported by the social politics of the 1920s, some of those young women scientists developed into experienced researchers during the institute's second decade.

RED VIENNA: POLITICS AND GENDER

Peace treaties at the end of World War I led to the establishment of the First Austrian Republic, with Vienna as its capital, in November 1918. In the elections of February 1919 the Social Democrats emerged as a strong political power. Supported by the working class, especially in Vienna, the party was run by a group of progressive Viennese intellectuals, many of them Jewish, including Otto Bauer and Karl Renner. Realizing that they could not rule alone, they were forced to form a coalition government with the conservative Christian Social party.[14] A second coalition, formed at the end of 1919, with slight differences in parliamentary composition, gave the socialists time to put forward reforms in education and the military and to secure the full legal equality of women under the constitution. By June 1920, however, the coalition was dissolved, marking the end of the socialists' power at the national level.

[12] Marietta Blau, Curriculum Vitae, 1941, Grenander Department of Special Collections and Archives, State University of New York, Albany; and Peter Galison, "Marietta Blau: Between Nazis and Nuclei," *Physics Today,* 1997, *50*(11):42–48, on p. 42.

[13] The eight women who appear as authors are Eleonore Albrecht, Marietta Blau, Friederike Friedmann, Bertha Heimann, Stefanie Horovitz, Helene Souczek, Hilde Fonovitz, and Grete Richter; see Veröffentlichungen des Institutes für Radiumforschung der Österreichische Akademie der Wissenschaften, *Mitteilungen aus dem Institut für Radiumforschung*, 1910–1919, ÖAW archives. These articles initially appeared in the *Sitzungsberichte der Kaiserliche Akademie der Wissenschaften in Wien*; the institute's researchers were required to present their work to the Austrian Academy of Sciences for publication in its *Sitzungsberichte*. The same papers were then bound annually in the *Mitteilungen*.

[14] Anson Rabinbach, *The Crisis of Austrian Socialism: From Red Vienna to Civil War, 1927–1934* (Chicago: Univ. Chicago Press, 1983), p. 23.

During these years, having achieved the two practical goals of the prewar feminist movement—the right to vote and admission to higher education—women seemed to have lost any specific motive for further political engagement.[15] The lack of an independent feminist political forum, in combination with the support of women's rights by the Social Democrats, prompted many women to participate in the party's efforts. Apparently feminists' support was decisive in the Viennese municipal elections of May 1919, when the Social Democrats won an absolute majority on the city council, holding 100 of the 165 seats. According to Anson Rabinbach, "the shift to Socialist hegemony" was in part "a result of the extension of the franchise to women and young adults." It is not a coincidence that by 1921 women accounted for 26 percent of Social Democrat party members in Vienna.[16]

While in power, the aim of the Social Democrats was to transform working-class culture and education, to alter the behavior of the workers, and to use the city as a laboratory for the party's social experiment. With these goals in mind, they challenged traditional gender roles and attempted to construct gender according to the socialist ideology. In Red Vienna popular magazines, the party's newspapers, the trade unions, and mass media such as cinema and radio shaped the gender discourse of the 1920s, while specific further reforms made it possible for Viennese men and women to endorse the party's efforts.

As Helmut Gruber emphasizes, the "new woman" was presented in the socialist literature as intelligent, educated, engaged in politics and social life, dressed in unrestrictive garments, and professionally successful. "The working class woman of yesterday—careworn in appearance, imprisoned by her clothes, unapproachable by those who needed her—was to be abolished by waving a magic wand." The strategies for these transformations varied. By equalizing males' and females' wages, the socialists made it possible for women to gain status through their work. The city's social support services, such as nurseries and kindergartens, recognized women's double role as workers and mothers, while access to birth control and abortion became part of the socialists' program. New domestic technologies such as electric irons, sewing machines, and vacuum cleaners were supposed to reduce the burden of housework. Most important for women's emancipation were educational reforms and, especially, the increasing role of public education in character formation (*Erziehung*) and intellectual training (*Bildung*). Especially for Jewish women, as Edith Prost argues, "*Bildung* was a possibility for emancipation—emancipation as a Jew and as a woman."[17]

The Social Democrats' tradition of supporting women's active social personae goes back even before the 1920s. The Verein Jugendlicher Arbeiter, the party's major youth organization, admitted women for the first time in 1914. In 1908 the party had established the

[15] In November 1918 women were granted the right to vote for the National Assembly and the provisional assemblies and to stand for office. They won full legal equality under the constitution in 1920. At the University of Vienna, women were admitted to the Faculty of Philosophy, which included the sciences, in 1897. It was not until 1918/1919, however, that they were admitted to the Technische Hochschule of Vienna; the Faculty of Law at the University of Vienna denied their admittance until 1920. For a detailed account of Vienna's feminist movement see Harriet Anderson, *Utopian Feminism: Women's Movement in Fin-de-Siècle Vienna* (New Haven, Conn.: Yale Univ. Press, 1992).

[16] Rabinbach, *Crisis of Austrian Socialism* (cit. n. 14), p. 26; and Helmut Gruber, *Red Vienna: Experiment in Working-Class Culture, 1919–1934* (New York: Oxford Univ. Press, 1991), p. 20.

[17] Gruber, *Red Vienna,* p. 148; and Edith Prost, "Emigration und Exil österreichischer Wissenschafterinnen," in *Vertriebene Vernunft,* Vol. 1: *Emigration und Exil österreichischer Wissenschafter 1930–1940,* ed. Friedrich Stadler (Munich: Jugend & Volk, 1987), pp. 444–470, on p. 450. See also Carla Esden-Tempska, "Civic Education in Authoritarian Austria," *History of Education Quarterly,* 1990, *2:*187–211, esp. p. 192.

Kinderfreunde, a parents' association, through which they aimed to reduce the burdens of childcare that fell disproportionately on mothers. Despite these efforts, some critics argue that the party's intended cultural, economic, and legal changes did not fundamentally alter women's subordinate social role. As Johanna Gehmacher claims, "The Social Democratic model of comradeship in gender relations merely covered the increase of women's reproductive tasks within the party's reform program."[18]

It is true that various municipal programs lacked sensitivity to gender issues. Nonetheless, it would be shortsighted not to acknowledge that in fact the Social Democrats provided the framework of a potentially unique political culture that could enable women to shape spaces for themselves in the factory, the laboratory, and the household. These advances came at a high price: women working in academia, especially, were often obliged to sacrifice motherhood, to accept an overly burdensome workload, and to settle for a diminished personal and intimate life. Yet the Social Democrats made it possible for them to enter the academic scene. Despite constant feminist petitions and political pressure before World War I, women had been excluded from several academic institutions. The socialist political agenda in education forced these institutions to accept women as students.[19] At the same time, the labor and feminist movements of Red Vienna gave a boost to the number of women enrolled at the city's university. Immediately after World War I only 15 percent of students at the university were female; by the end of 1933/1934 their numbers had reached 26 percent.[20]

Moreover, both in the scientific institutes that were created through the city's initiatives and in private endeavors that benefited from municipal support, women accounted for one third of the research personnel and often held high positions in the organizations' hierarchies. Persuasive examples can be found at Vienna's Pädagogische Institut, the Lehrinstitut (a training center for psychoanalysts), the Wiener Psychoanalytische Vereinigung, and the Vivarium (an institute for experimental biology).[21] Clearly, the Radium Institute was not the only Viennese scientific organization with a concern for gender politics.

[18] Johanna Gehmacher, "Men, Women, and the Community Borders: German-Nationalist and National Socialist Discourses on Gender, 'Race,' and National Identity in Austria, 1918–1938," in *Nation, Empire, Colony: Historicizing Gender and Race,* ed. Ruth Roach Pierson and Nupur Chaudhuri (Bloomington: Indiana Univ. Press, 1998), pp. 205–219, on p. 209. On the Social Democrats' initiatives with regard to women's social engagement see Anson Rabinbach, "Politics and Pedagogy: The Austrian Social Democratic Youth Movement, 1931–1934," *Journal of Contemporary History,* 1978, *13:*337–356.

[19] As indicated in note 15, above, the Technische Hochschule opened its doors to women in 1918/1919. The next year twenty women registered as matriculated (*ordentlicher*) students and seventeen as nonmatriculated (*ausserordentlicher*) students (auditors); most of them chose to study technical chemistry. See Edith Lassmann, "Das Frauenstudium an den Technischen Hochschulen Wien und Graz," Lassmann file, International Archive of Women in Architecture, Virginia Tech Library, Blacksburg, Virginia. When the Faculty of Law began admitting women in 1920 it opened the opportunity for women to join the upper ranks of the civil service in one of the higher-status professions. See Waltraud Heindl, "Zur Entwicklung des Frauenstudiums in Österreich," in *"Durch Erkenntnis zu Freiheit und Glück": Frauen an der Universität Wien (ab 1897)*, ed. Heindl and Marina Tichy (Schriftenreihe des Universitätsarchivs, 5) (Vienna: Universitätsverlag, 1990), pp. 17–26.

[20] Prost, "Emigration und Exil österreichischer Wissenschafterinnen" (cit. n. 17), p. 468; and Renate Tuma, "Die österreichischen Studentinnen der Universität Wien (ab 1897)," in *"Durch Erkenntnis zu Freiheit und Glück,"* ed. Heindl and Tichy, pp. 79–107.

[21] From 1920 to 1934 at the Vivarium, a privately established research center for experimental biology, 39 (36 percent) of the 109 scientists who were listed as either practicum students or research personnel were women. This high percentage is not surprising; as Ute Deichmann has noted, "many Jewish, liberal and social scientists worked at the Vivarium": Ute Deichman, *Biologists under Hitler* (Cambridge, Mass.: Harvard Univ. Press, 1996), p. 18. See also Rentetzi, "Gender Politics and Radioactivity Research in Vienna" (cit. n. 7), pp. 144, 244–249. For the participation of women in several other scientific endeavors in Vienna during the same period see Gerhard Benetka, "The Vienna Institute of Psychology: Obituary for a Once Important Research Institution," in *The Cultural Exodus from Austria,* ed. Friedrich Stadler and Peter Weibel (New York: Springer, 1995), pp. 127–131;

While they held municipal power the socialists also set the stage for a radical program of social reforms, some of which had a direct impact on the Radium Institute. As a counterbalance to their lack of national political influence, the socialists tried in Vienna to create a state within a state, paying particular attention to city services such as public housing, education and the welfare system. A key figure in transforming the latter was Julius Tandler. His efforts to reshape the public health and welfare system of Vienna put his ties to the physics and medical communities of the city to use and gave Meyer and his institute the chance to play an important role in the socialist reforms. At the same time, Meyer's connections to Tandler offered practical opportunities for financing some of his personnel, including women.

Tandler, a prominent anatomist, was one of the few Jews with a chair at the medical faculty of Vienna's university. His inside knowledge of Vienna's medical system and his strong socialist ideology made him an ideal guide for the Social Democratic reforms in public health. Appointed as the city's councillor of welfare in 1920, Tandler was soon able to reshape the medical clinics and the general hospital of the city. An increased budget was essential in improving the quality of services and making them accessible to all citizens.[22]

Tandler's socialist program included the promotion of new scientific methods in medicine, including the use of radium. In 1929 he asked Meyer to provide the municipal hospital in Lainz with 5 grams of radium; eventually, he envisioned a more ambitious project such as the establishment of a radium station and a pavilion for cancer therapy. Hoping to profit from the long experience of French physicians, Tandler visited Paris twice in 1929. During the summer of 1930 he went to the Radiumhemmet in Stockholm, one of the leading centers for radium therapy in Europe. A few months later, at a city meeting at the Rathaus (City Hall) on 20 December 1930, Tandler was ready to promote his plan. He depended heavily on Meyer's help to realize this ambitious and costly endeavor. As Emil Maier, a physician at the hospital in Lainz, informed his colleagues in Stockholm, Meyer and his personnel at the Radium Institute offered not only to provide the radium but also to build a "radium gun," a device with a strong radium preparation used in cancer therapy. Furthermore, as Maier added, "The consultant of the municipality of Vienna for the radium purchase is Herr Professor Stefan Meyer."[23]

The pavilion for radium therapy opened in 1931, and a year later the radium station was established.[24] Known as the Physikalische Laboratorium am Strahlen-Institut, the station

Benetka, *Psychologie in Wien: Sozial- und Theoriegeschichte des Wiener Psychologischen Instituts, 1922–1938* (Vienna: Universitätsverlag, 1998); and Sheldon Gardner and Gwendolyn Stevens, *Red Vienna and the Golden Age of Psychology, 1918–1938* (New York: Praeger, 1992).

[22] Karl Sablik, *Julius Tandler: Mediziner und Sozialreformer* (Vienna, 1983); and Gruber, *Red Vienna* (cit. n. 16), pp. 65–73.

[23] On the radium for the hospital and Tandler's further plans see Meyer, "Die Vorgeschichte der Gründung und das erste Jahrzehnt des Institutes für Radiumforschung" (cit. n. 8), p. 20; and Gerhart Alth, *50 Jahre Strahlentherapie Lainz* (Vienna, 1981), p. 12. See also Gard to Maier, 8 Aug. 1930 (visit to the Radiumhemmet); Julius Tandler to Ahlboom, 20 Dec. 1930 (city meeting); Maier to the Radiumhemmet, 30 Dec. 1930 (radium gun); and Maier to Ahlboom, 3 Jan. 1931 (Meyer's role), archive of the hospital in Lainz, Vienna (not catalogued).

[24] Alth, *50 Jahre Strahlentherapie Lainz,* p. 12; and Dieter Kogelnik, "The History and Evolution of Radiotherapy and Radiation Oncology in Austria," *International Journal of Radiation Oncology, Biology, Physics,* 1996, *35*(2):219–226, on p. 224. With the full support of the Social Democrat party and the city's mayor, Karl Seitz, Tandler also established a new pavilion for the cure of tuberculosis, with three hundred beds and modern facilities, at the municipal hospital. At the time, tuberculosis was known as the "Viennese disease" because of the exceptionally high numbers of patients there; see A. Luger, *70 Jahre Krankenhaus der Stadt Wien-Lainz* (Vienna, 1977), p. 3.

functioned as the point of entry to the field of radium therapy for two of the Radium Institute's collaborators. Franz Urbach directed the Physikalische Laboratorium and worked on radium dosimetry and instrumentation from 1932 to 1934, when Hilde Fonovits-Smereker succeeded him.[25] Through his connections to Tandler and the physicians at the hospital in Lainz, Meyer offered both of them the chance to cross the border between physics and medicine, bringing their expertise in instrumentation and experimentation from the Radium Institute to the municipal hospital. As we shall see, these kinds of exchanges and career paths marked laboratory life at the institute throughout the 1920s and early 1930s, developments deeply influenced not only by its own experimental culture but by Vienna's political context as well.

THE TRANSITIONAL PERIOD: THE RADIUM INSTITUTE DURING THE EARLY 1920S

With Exner's retirement in 1920, Meyer became the official director; he was kept busy seeking financial resources to ensure the survival of his institute, supporting the experimental work of his colleagues, and engaging in academic politics for the sake of his research personnel. Indeed, the end of World War I proved to be a difficult time for both the country and the institute. As Meyer wrote to Rutherford, "The so called peace has aggravated the difficulties enormously and I fear, we will not be able to continue scientific work, if at all we may continue our life." Inflation was out of control—the Austrian currency had only 2 percent of its prewar value—and food and fuel were in short supply. Meyer's institute could not afford to purchase even the most prestigious science journals. Without knowledge of the foreign literature, research became problematic. As a temporary solution, in response to Meyer's gentle request, Rutherford kindly arranged to purchase the radium that had been lent to him before the war by the Austrian Academy of Sciences. By the end of 1921 Meyer received a check for over £500, which helped to support ongoing research at the institute and temporarily relieved its financial problems. In addition, some of the institute's international friends supplied the library with subscriptions to *Nature,* the *Philosophical Magazine,* and a number of the other prominent scientific journals necessary for keeping up with current research.[26]

One significant problem was that the institute's former staff and the key figures who had worked there during the 1910s were now scattered. Hönigschmid had moved to the University of Munich, Horovitz left for Warsaw, and Hevesy went to Budapest. Paneth had accepted the position of *Extraordinarius Professor* at the University of Hamburg in 1919, and Karl Herzfeld took over his tasks as *ausserordentlicher Assistent* for a short time. In December 1919 the duties of assistant were turned over to Hilde Fonovits, but without a salary. Born in Vienna in 1893, Fonovits was one of the women who received

[25] Franz Urbach, "Einiges aus dem Physikalischen Laboratorium eines Krankenhauses," *Zeitschrift für das Gesamte Krankenhauswesen,* 1933, *25:*537–541; Meyer, "Die Vorgeschichte der Gründung und das erste Jahrzehnt des Institutes für Radiumforschung" (cit. n. 8), p. 20; Brigitte Bischof, "Frauen am Wiener Institute für Radiumforschung" (M.A. thesis, Univ. Vienna, 2000), p. 67; and Rentetzi, "Gender Politics and Radioactivity Research in Vienna" (cit. n. 7), pp. 250–253. For a detailed account of Urbach's dismissal from the radium station with the rise of the Nazis see Wolfgang Reiter, "The Year 1938 and Its Consequences for the Sciences in Austria," in *Cultural Exodus from Austria,* ed. Stadler and Weibel (cit. n. 21), pp. 188–205.

[26] Stefan Meyer to Ernest Rutherford, 22 Jan. 1920 [in English], ÖAW archives. On the purchase of the radium see Rutherford to Meyer, 25 July 1921, 17 Oct. 1921, ÖAW archives; and Elisabeth Rona, *How It Came About: Radioactivity, Nuclear Physics, Atomic Energy* (Oak Ridge, Tenn.: Oak Ridge Associated Univ. Press, 1978), pp. 21–22. On the provision of the scientific journals see Almanac of the Austrian Academy of Sciences, 1921, pp. 194–195, ÖAW archives.

her education at the University of Vienna during World War I. A student of Exner and of the theoretical physicist Gustav Jäger, Fonovits graduated in June 1919 with a doctoral degree in physics and a dissertation focused on the factors necessary to obtain alpha-ray saturation. Her practicum was done at the Radium Institute, and thus her first article, published directly from her dissertation, appeared in the *Mitteilungen* in 1919. Just a year later, in December 1920, Fonovits was formally accepted as *ausserordentlicher Assistentin* in the institute, with a monthly salary of 1,000 kronen.[27]

In the meantime, Fonovits got married. As Hilde Fonovits-Smereker she held a joint appointment as *Assistentin* to the Second Physics Institute and the Radium Institute during 1920/1921.[28] When her son was born in 1922 she found it difficult to combine motherhood with a scientific career. In a letter to Meyer she confessed that "unfortunately I have not been successful, despite all my searching, in finding a reliable employee to substitute for me during the day in my child's care and so it is impossible for me to keep my position as an assistant." Fonovits was ready to give up her career in order to fulfill the obligations of motherhood. "I am very sorry," she admitted, that "I have to quit the job I loved, but I have not found a way to combine my professional and domestic duties." The position was then given to Sebastian Geiger, a Swiss engineer, who held it for two years. In June 1924 Gustav Ortner, who had received a doctoral degree in physics from the University of Vienna at the end of 1923, succeeded him.[29]

The position of *ordentlicher Assistent* also became vacant just after the end of World War I, as Hess accepted the job of *ausserordentlicher Professor* at the University of Graz. The physicist Karl Przibram succeeded Hess at the Radium Institute in 1919. The son of Gustav Przibram, a Hungarian Jewish industrialist, Karl belonged to a dynasty. His mother, Baroness Charlotte Schey, came from one of Vienna's richest families. As Przibram described it, "In my parents' house the prevailing spirit was that of the cultivated Jewish middle-class liberal era, with its unconditional belief in progress and its open-mindedness to all the achievements of the arts and sciences."[30] Raised in this stimulating environment, Przibram studied physics at the University of Vienna under Exner and Boltzmann and then moved to the University of Graz to work with the physicist Leopold Pfaundler.

During the academic year 1902/1903 Przibram visited the Cavendish Laboratory in Cambridge to work with J. J. Thomson. In 1905 he completed his *Habilitation* at the

[27] On Paneth and Herzfeld see Klaus Ruthenberg, "Friedrich Adolf Paneth (1887–1958)," *International Journal for Philosophy of Chemistry,* 1997, *3:*103–106; and Meyer, "Die Vorgeschichte der Gründung und das erste Jahrzehnt des Institutes für Radiumforschung" (cit. n. 8), p. 26. On the unsalaried appointment of Fonovits see Bischof, "Frauen am Wiener Institute für Radiumforschung" (cit. n. 25), p. 66; for her education see Hilde Fonovits, Curriculum Vitae, Archiv der Universität Wien (hereafter cited as **UW archives**); for her first article see Hilde Fonovits, "Über die Erreichung des Sättigungsstromes für alpha-Strahlen im Plattenkondesator," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1919, *128:*761–793; on her salaried appointment see Meyer to the Professorenkollegium der Philosophischen Fakultät der Universität, 27 Oct. 1920, ÖAW archives.

[28] At the turn of the twentieth century the University of Vienna had three different physics institutes: the First Physics Institute, directed by Victor Lang; the Institute for Theoretical Physics, directed by Ludwig Boltzmann; and the Second Physics Institute, directed by Franz Serafin Exner. Yet another university institute was established in 1920: the Third Physics Institute, which focused on general physics and was directed by Felix Ehrenhaft.

[29] Hilde Fonovits-Smereker to Meyer, 9 Sept. 1922, ÖAW archives. On Fonovits-Smereker's appointment at the Second Physics Institute see Personalstand, Universität Wien, academic year 1920/1921, UW archives; and Bischof, "Frauen am Wiener Institute für Radiumforschung," p. 67. On Geiger's appointment see Geiger file, Mitarbeiten/Assistenten, ÖAW archives. For Ortner's education see Gustav Ortner, Curriculum Vitae, Rigorosenakt, no. 021, UW archives.

[30] Berta Karlik, "Karl Przibram Nachruf," *Almanach der Österreichischen Akademie der Wissenschaften,* 1974, *124:*379–387, on p. 380; this is also the source of the biographical information on Przibram. For his views on this period in the life of the institute see Karl Przibram, "1920 bis 1938," in *Festschrift des Institutes für Radiumforschung Anlässlich seines 40jährigen Bestandes (1910–1950)* (cit. n. 8), pp. 27–34, on p. 27.

University of Vienna and worked as *Privatdozent*. In 1912, with Meyer's encouragement, he entered the Radium Institute to pursue a research project on coloring and luminescence caused by radioactive rays. In 1916 he was honored with the title of *ausserordentlicher Professor* at the University of Vienna. Przibram was the obvious choice to succeed Hess at the institute. In 1921 he discovered the phenomenon of radiophotoluminescence; he also worked extensively on the coloring of crystals and the fluorescence of fluorites. His investigations led to one of the two main research projects at the institute throughout the 1920s and 1930s and attracted a number of women researchers. His chief collaborator was Maria Belar, but he also worked with Elisabeth Kara-Michailova, Luisa Gröger, Marie Hoschtalek, and Berta Zekert.

Information on the professional staff who held the primary administrative positions at the institute—that is, the director and the two assistants—is summarized in Table 1. It also contains information on the affiliation of these scientists with the University of Vienna up to 1938/1939.

In the midst of the institute's postwar reorganization, in November 1921, Meyer received a letter from the Swedish physicist Hans Pettersson asking permission to use the facilities for his own research. Hans was the son of Otto Pettersson, the founder of oceanography in Sweden and a professor of chemistry at the Stockholm Högskola. He studied physics at Uppsala University under Knut Angström. From October 1911 to August 1912 he worked at the University College in London under William Ramsay. In 1913 he was appointed to the staff of the Svenska Hydrografiska Biologiska Kommissionen. A year later he defended his dissertation and obtained a lectureship at the Göteborg Högskola, torn between work in radioactivity and hydrography, a conflict his daughter Agnes Rodhe has described as a struggle between his father's wishes and his own interests.[31] His position as a lecturer paid so poorly that he had to work as an assistant hydrographer at his father's oceanographic station in Bornö to supplement his income.

Table 1. Professional and Career Information for the Director and the Assistants of the Radium Institute (RI), 1919–1938

Name	Position at RI	Years at RI	Position at University of Vienna
Meyer, Stefan	Director	1919–1938	1900 Privatdozent 1908 ausserordentlicher Professor 1911 wirklicher Extraordinarius Professor 1915 ordentlicher Professor 1920 wirklicher ordentlicher Professor 1938 Dismissed
Przibram, Karl	ordentlicher Assistent	1919–1938	1905 Privatdozent 1916 ausserordentlicher Professor 1927 wirklicher ausserordentlicher Professor 1938 Dismissed
Fonovits-Smereker, Hilde	ausserordentlicher Assistent	1919–1922	None
Geiger, Sebastian	ausserordentlicher Assistent	1922–1924	None
Ortner, Gustav	ausserordentlicher Assistent	1924–1938	1939 ausserodentlicher Professor

[31] Hans Pettersson to Meyer, 28 Nov. 1921, ÖAW archives. Most of the biographical information on Pettersson comes from interviews I conducted with his daughter, Agnes Rodhe, 22 Sept. 2001, Göteborg, and with Artur Svansson, an oceanographer and biographer of Otto Pettersson, 21 Sept. 2001, Göteborg. See also G. Deacon, "Hans Pettersson, 1888–1966," *Biographical Memoirs of the Fellows of the Royal Society,* 1966, *12:*405–421. On his work with Ramsay see Berta Karlik, "Hans Pettersson Nachruf," *Alm. Österreich. Akad. Wiss.,* 1970, *119:*303–317, on p. 305.

In the summer of 1921 Pettersson approached Rutherford, suggesting some experiments with radium. Rutherford's response was not very encouraging, for it implied that Pettersson would need his own radium sources: "I am not sure from your letter whether you have the use of 200mg of radium for several years for your experiments." Rather than issuing the invitation Pettersson must have hoped for, Rutherford continued, "I am sorry that I will not be in Edinburgh this year, but will be in Cambridge in the 4th week of September." In his response, Pettersson mentioned that some years earlier Stefan Meyer had offered him the use of radium at the institute in Vienna. "I am unfortunately not able to get any large quantity of radium in this country," Pettersson explained; he went on to wonder "whether Meyer is able to keep his offer open under the present state of things." Rutherford did not seem willing to extend a warm invitation, and in his last response he claimed that the laboratory would be closed for the first three weeks of September: "I am afraid that this will make it rather difficult to see you unless you are able to stay in England over some time." Even Pettersson's strategic mention of his father did not help: "My father, late chairman of the Nobel committee for chemistry, sends you his best remembrances."[32]

Probably because his correspondence with Rutherford had not yielded results, Pettersson accepted an invitation from Prince Albert I of Monaco to work on the radium concentration of the deep-sea sediments collected by the *Challenger* expedition. Unfortunately, the Musèe Oceanographique—the institute in Monaco—lacked important apparatus that Pettersson needed for his work. At the end of 1921, aware of the low cost of living in postwar Vienna and the remarkable instruments at the Vienna institute, Pettersson turned to Meyer, his old contact.[33] His request was very modest: besides measuring the radioactivity of sea sediments, he hoped to work on the disintegration of radioactive elements if a small amount of radium bromide could be made available to him.

Meyer had been hospitable to foreign scientists on other occasions, and Pettersson offered further incentive to accede to his request. In a postscript he added, "I bring with me a sensitive thread electrometer with a voltammeter, and my institute in Göteborg, Sweden, will provide me with the necessary resources for my work." Since the Radium Institute was having a hard time supporting its own scientists, it would have been impossible to provide Pettersson with more than work space. After receiving Meyer's positive response, Pettersson and his wife, the chemist Dagmar Pettersson, settled in Vienna. Impressed by the "friendly and stimulating atmosphere" at the institute, Pettersson threw himself into intensive research on artificial disintegration, establishing a strong research team and enlisting a number of patrons to support the work.[34]

By this point Meyer had brought stability to the institute. The positions vacated by the old core workers had been redistributed to younger researchers, and, most important, there were funds available and promising research projects to work on. In the following period the personnel of the Vienna institute produced an impressive body of work: Przibram's group contributed greatly to the understanding of radioluminescence, and Pettersson's collaborators seriously challenged assumptions about the nature of the atomic nucleus put forward by Rutherford and his colleagues at the Cavendish Laboratory in England.

[32] Rutherford to Pettersson, 24 June 1921; Pettersson to Rutherford, 4 July 1921; Rutherford to Pettersson, 12 July 1921; and Pettersson to Rutherford, 17 July 1921, GUB archives. Pettersson had contacted Meyer from Bornö in 1914, asking permission to perform some of his measurements in Vienna. See Petersson to Meyer, 26 Apr. 1914, 24 May 1914, ÖAW archives.

[33] Agnes Rodhe to Maria Rentetzi, 29 Oct. 2001. According to Rodhe, Otto Pettersson was the one who approached the prince of Monaco, a friend of his, and asked whether Hans could work in his laboratory: Rodhe to Rentetzi, 11 Aug. 2003.

[34] Pettersson to Meyer, 28 Nov. 1921 (quotation), 14 Dec. 1921, 4 June 1922, ÖAW archives.

HANS PETTERSSON'S RESEARCH GROUP ON ARTIFICIAL DISINTEGRATION

During the 1920s research at the institute took shape within the context of disciplinary changes. As early as 1919 Rutherford had reported that the nucleus of nitrogen disintegrated when bombarded by radium C alpha particles and that long-range particles (protons) were emitted. The same year he moved from Manchester to the Cavendish Laboratory and, with generous material resources to organize his research, embarked on studies of the phenomena of artificial disintegration. Over the next years, after intensive work, Rutherford and his close collaborator James Chadwick concluded that light elements such as beryllium, magnesium, and silicon were not disintegratable. Rutherford's group, mainly young male students of physics, staked their research results to the reliability of the scintillation counter, an instrument deployed for counting tiny flashes of light produced on a zinc sulfide screen by the impact of charged particles.[35]

Pettersson and his collaborator Gerhard Kirsch from the Vienna institute were the first to challenge Rutherford's results; they claimed, contrary to Rutherford, that light elements do emit long-range particles. Kirsch received his doctoral degree from the University of Vienna in 1920. The next year he was hired as an *ausserordentlicher Assistent* at the Second Physics Institute while also conducting research at the Radium Institute. When Pettersson arrived in Vienna, Kirsch became his main collaborator. As Roger Stuewer has elegantly described, Pettersson and Kirsch presented the most serious challenge to the accuracy of Rutherford's theories and experimental results and—most important—to his credibility in the field.[36] At stake was not only the authority of the Cavendish Laboratory in the world of radioactivity and Rutherford's theoretical satellite model for the atomic nucleus. The material culture of the Cambridge group—its experimental methods, the instruments and the politics of collaboration they embodied—was also under vigorous attack.

The need for specialized personnel led enthusiastic young researchers to enter the institute and some who were working on other projects to shift to Pettersson's group. A considerable number of women physicists—including Marietta Blau, Elisabeth Kara-Michailova, and Elisabeth Rona—participated in the work, elevating the Radium Institute to what Peter Galison has called a "mecca" for women working on radioactivity. In addition, a number of female practicum students—such as Berta Karlik, Hertha Wambacher, Theodora Kautz, Erna Bussecker, Felicitas Weiss-Tessbach, Selma Schneidt, and Elsa Holesch—oriented their research projects around the investigations of Pettersson's group. Regular financial support from Swedish sponsors and from the International Education Board, which later was converted into the Rockefeller Foundation, secured the research and financed the participants.[37]

[35] Radium C was the historical name for bismuth. On Rutherford's work in Cambridge see Jeffrey Hughes, "The Radioactivists: Community, Controversy, and the Rise of Nuclear Physics" (Ph.D. diss., Univ. Cambridge, 1993).

[36] On the controversy between Rutherford's and Pettersson's research teams see Roger Stuewer, "Artificial Disintegration and the Vienna–Cambridge Controversy," in *Observation, Experiment, and Hypothesis in Modern Physical Science,* ed. Peter Achinstein and Owen Hannaway (Cambridge, Mass.: MIT Press, 1985), pp. 239–307.

[37] Peter Galison, *Image and Logic* (Chicago: Univ. Chicago Press, 1997), p. 150. On the support of the International Education Board/Rockefeller Foundation see Pettersson, Report to the International Education Board (cit. n. 1); Rodhe interview; and Svansson interview. Theodora Kautz studied physics and mathematics at the University of Vienna under Meyer and Gustav Jäger, graduating in 1926: Theodora Kautz, Rigorosenakt, no. 9216, UW archives; and Theodora Kautz, "Ermittlung der Halbierungszeit von RaD mittels Warmemessung eines alten Ra-Präparates," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1926, *135:*93–97. She left the institute to become a schoolteacher. Meyer kept in touch with her and in 1934 informed her that the

In the late autumn of 1922 two of Rutherford's students, L. Bates and J. Rogers, were assigned to study long-range alpha particles from radium C. When Pettersson and Kirsch published their first paper challenging Rutherford's findings, "Experiments on the Artificial Disintegration of Atoms," Bates and Rogers already had their response in hand. On 22 September 1923 they reported in *Nature* that radium C emits not only alpha particles in the usual range of 7 cm but particles of longer ranges as well. Thus, they argued, when Pettersson and Kirsch thought they were observing disintegration protons they were in fact observing long-range alpha particles from the source. Both laboratories mobilized teams to investigate each others' work and to shore up their own results. While Rutherford enlisted research students who never neglected to acknowledge his support, Pettersson enrolled more experienced experimenters. His wife Dagmar was the first woman to enter the debate, presenting a paper to a meeting of the Austrian Academy of Sciences on 3 April 1924.[38]

Born in 1888, the daughter of a prosperous civil engineer, Dagmar Pettersson, née Wendel, received a private education and entered the University of Uppsala to study chemistry as her major and mathematics as her minor. (See Figure 2.) She finished her studies in 1914 and got a position as a chemist in an agricultural laboratory in Skenja, Sweden, where she played a leading role in building a new chemistry lab. Wishing to return to Göteborg and be closer to her parents, she was soon looking for a new position. Dagmar had met Hans Pettersson when both were students in Uppsala, but it was not until her return to Göteborg that they developed a relationship. Hans offered to help by asking his father to hire Dagmar as a chemist at the Bornö station.[39]

After his son's intervention, Otto employed Dagmar to measure the salinity of deep-water samples as a research assistant at Bornö. Two years later, in 1917, Hans and Dagmar were married. When he moved to Monaco she joined him, not only as his wife but as a colleague with considerable experience in chemistry. When they moved to Vienna in late 1922 she got a position at the Technische Hochschule, working in a lab as a chemist; she

granddaughter of the president of the academy, Eduard Suess, was her student: Meyer to Theodora Kautz, 11 May 1934, ÖAW archives. Erna Bussecker graduated in 1929 after studying physics and mathematics under Meyer and Jäger: Erna Bussecker, Rigorosenakt, no. 10210, UW archives; and Erna Bussecker, "Verflüchtigungskurven von RaB und RaC, die auf Gold bei einfachem und zweifachem Rückstoß niedergeschlagen sind," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1928, *137:*117–126. For a piece by Weiss-Tessbach see Felicitas Weiss-Tessbach, "Mikrokalorimetrische Messung der Absorption der alpha Strahlung von RaC," *ibid.*, 1928, *138:*601–607. Selma Schneidt was born in Komotan, Bohemia, and was a fellow student of Bussecker: Selma Schneidt, Rigorosenakt, no. 10442, UW archives; and Selma Schneidt, "Das elektrochemische Verhalten von Polonium in Lösungen verschiedener H-Ionenkonzentration," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1929, *138:*754–765. Elsa Holesch, a student of Meyer and Hans Thirring, graduated in 1931: Elsa Holesch, Rigorosenakt, no. 11257, UW archives.

[38] For a long time it was thought that the alpha particles emitted by a given substance had a definite range. In 1906, in studying the radiation emitted by thorium, Otto Hahn discovered that alpha rays from the same source can have different ranges. In 1919 Rutherford established the presence of particles having a range of 9.0 cm from a radium active deposit; see L. Bates and J. Rogers, "Particles of Long Range from Polonium," *Proceedings of the Royal Society of London, Series A,* 1924, *105:*360–369. In their experiments, Bates and Rogers observed particles emitted from radium C that had even longer ranges: 9.3 cm, 11.1 cm, and 13.2 cm; see Bates and Rogers, "Long-Range α-Particles from Radium Active Deposits," *Nature,* 1923, *112:*435–436. For the initial challenge from Pettersson's group see Gerhard Kirsch and Hans Pettersson, "Experiments on the Artificial Disintegration of Atoms," *Philosophical Magazine,* 1923, *47:*500–512. For Dagmar's contributions to this debate see Dagmar Pettersson, "Über die maximale Reichweite der von Radium C ausgeschleuderten Partikeln," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1924, *133:*149–162; and D. Pettersson, "Long-Range Particles from Radium-Active Deposit," *Nature,* 1924, *113:*641–642.

[39] Otto Pettersson already had a female chemist as an assistant and seems to have been fairly open in accepting women in his lab: Svansson interview. Most of the biographical information on Dagmar Pettersson comes from the Rodhe interview.

Figure 2. *Dagmar Pettersson at the Radium Institute, circa 1925. According to her daughter, Agnes Rodhe, she was not fond of being photographed. This is one of the few pictures of her. (Courtesy of the Central Library of Physics, Vienna.)*

simultaneously did research at the Radium Institute in support of Hans's project. Although their three-year-old daughter joined them in Vienna in 1924, Dagmar was able to continue her work. Her tasks were not just supplementary to her husband's research; as her diary indicates, she was involved in designing apparatus for the group's experiments and her own, counting scintillations, and critiquing Hans's manuscripts. The fact that her husband was himself a scientist probably made it easier for her to combine motherhood with her scientific research.[40]

Directly addressing Bates and Rogers's experiments, Dagmar attempted to undermine their results by altering the scintillation method. In a letter to *Nature* and a lengthy publication that appeared in the *Sitzungsberichte* of the Austrian Academy of Sciences, she argued that "the use of a greatly improved microscope made it relatively easy to distinguish between scintillations from H and from alpha-particles, so that they could be counted separately."[41] Her results indicated that there were no long-range alpha particles emitted from the source and, thus, that Bates and Rogers's argument was not valid.

Dagmar's first ambitious articles in the world of radioactivity research were actually her last ones as well. Shortly after her publications appeared, Rutherford and Chadwick challenged her observations, criticizing both her experimental setup and her apparatus. But her claims had clearly made an impression in Cambridge. Much later, in a letter to his father, Pettersson described Bates's interesting account of the episode: "I was visited by my

[40] Rodhe to Rentetzi, 29 Oct. 2001, 11 Jan. 2004. On couples in science see Pnina Abir-Am, Helena Pycior, and Nancy Slack, *Creative Couples in the Sciences: Lives of Women in Science* (New Brunswick, N.J.: Rutgers Univ. Press, 1996).

[41] D. Pettersson, "Long-Range Particles from Radium-Active Deposit" (cit. n. 38), p. 642.

enemy, nowadays friend, former colleague of Rutherford, now with Porter in University College, where I met him in May. He described very dramatically how Dagmar's letter to *Nature*—in which she opposed the results of Bates and Rogers—had hit like a bomb at the Cavendish laboratory and how B[ates] had been scolded by R[utherford] in spite of his being right to a certain degree."[42]

In preparing her experiments Dagmar had the technical assistance of Elisabeth Kara-Michailova, who worked on improving the optical systems used by Pettersson's group. Born in 1897 to a prosperous bourgeois family, Kara-Michailova spent her childhood in Vienna and received a private education.[43] Her father, Ivan Kara-Michailoff, was a Bulgarian physician, and her mother, Mary Slade, was an English musician. In 1907 her parents decided to move to Sofia, where they settled down to play an influential role in the artistic and scientific life of the city. Ten years later Kara-Michailova returned to Austria, this time alone, to enter the University of Vienna. Between 1917 and 1921 Kara-Michailova studied physics, mathematics, chemistry, mineralogy, and philosophy, eventually taking a major in physics and a minor in mathematics, with Meyer and Jäger as the referees of her final exams.

From early on, even before she completed her thesis, Kara-Michailova collaborated closely with Przibram, with whom she published extensively, not only in the *Mitteilungen* but also in the prestigious *Zeitschrift für Physik*. Before she shifted to Pettersson's group in 1923, she focused on the phenomena of photoluminescence and the luminescence of radium and conducted photoelectric measurements of the brightness of luminescence in relation to the duration of the radiation. In collaboration with Hans Pettersson, she altered the optical system of the scintillation counter to suit the needs of the group's experiments and offered her expertise in fluorescence and lighting measurements in order to improve the method.[44] (See cover illustration.)

By the mid 1920s, although both the Vienna and the Cambridge groups had immensely improved the scintillation counter, its main disadvantage continued to be the difficulty of distinguishing between flashes produced by different kinds of particles. The intense, strenuous task of observing scintillation flashes—and the unreliable results this very subjective method entailed—slowly but steadily pushed both the Cambridge and the Vienna laboratories to alter their material culture. As Pettersson reported later, "the subjective character of all observations made by the scintillation method[,] added to the strain on the eyes of the counters which it involves, has made it most desirable to develop novel methods of studying the atomic fragments, less exacting and less subject to errors."[45]

[42] Ernest Rutherford and James Chadwick, "On the Origins and Nature of the Long-Range Particles Observed with Sources of Radium C," *Phil. Mag.,* 1924, *50:*889–913; and H. Pettersson to O. Pettersson, 22 Aug. 1927, in Otto Pettersson–Gustaf Ekman Correspondence, Regional Archives, Göteborg. I would like to thank Artur Svansson for providing and translating this letter.

[43] Regarding Kara-Michailova's help see D. Pettersson, "Über die maximale Reichweite der von Radium C ausgeschleuderten Partikeln" (cit. n. 38), p. 153. For biographical information see Elisabeth Kara-Michailova, Rigorosenakt, no. 5215, UW archives; and Snezha Tsoneva-Mathewson, Marelene Rayner-Canham, and Geoffrey Rayner-Canham, "Elizaveta Kara Michailova: Bulgarian Pioneer of Radioactivity," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 205–208.

[44] Elisabeth Kara-Michailova and Hans Pettersson, "Über die Messung der relativen Helligheit von Szintillationen," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1924, *133:*163–168. For her work with Przibram see Kara-Michailova and Karl Przibram, "Orientierte Gleitbüschel auf Kristallflächen," *Zeitschrift für Physik,* 1920, *2:*297; Kara-Michailova and Przibram, "Über Radiolumineszenz und Radio-Photolumineszenz," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1922, *131:*511–530; and Kara-Michailova and Przibram, "Über Radiolumineszenz und Radio-Photolumineszenz," *ibid.*, 1923, *132:*285–298.

[45] Pettersson, Report to the International Education Board (cit. n. 1). See also, more generally, Clinton Chaloner, "The Most Wonderful Experiment in the World: A History of the Cloud Chamber," *British Journal for the History of Science,* 1997, *30:*357–374.

Pettersson assigned the development of one of the novel techniques, that of photographic emulsions, to Blau, who had just returned to the institute from Berlin. In early 1924 she focused on the photographic effects of protons. Her first attempt was to observe recoil protons produced by alpha particles in paraffin. With the weak radioactive sources available to her she could observe only the lower-energy particles. The single strong source in use at the time was polonium. As Blau described it, "to prevent darkening of the plate by gamma radiation, one worked with polonium, which was prepared by Dr. E. Rona in highly concentrated preparations. After a tedious series of indefinite experiments, it finally worked in 1926, and in the following year the method could be applied to the disintegration of various atoms with alpha particles." Surprised and pleased by Blau's results, Pettersson wrote to his sister on 7 March 1926, "By indescribable tenacity, she has succeeded at an almost hopeless job I suggested to her two years ago."[46]

Elisabeth Rona, known as "the polonium woman," was probably the most experienced experimenter among the women at the institute. She was born in 1890 in Budapest to a prosperous Jewish family. Her father, Samuel Rona, a physician who had close contacts with Louis Wickham and H. Dominici, the founders of radium therapy in Paris, was influential in introducing the field in Budapest.[47] Having grown up in a stimulating environment, Rona studied physics at the University of Budapest, spent a few months at the chemical division of the Institute of Animal Physiology in Berlin, and then pursued further graduate studies at the University of Karlesruhe, in Germany, with a focus on physical chemistry. There she was introduced to radioactivity research by Kasimir Fajans, a Polish radiochemist who was working on radioactive isotopes. In the spring of 1914, after having developed a strong friendship with Fajans that would last for years, Rona left to spend the summer with Ramsay's group in England.

During World War I Rona worked in Hungary with Hevesy, who had just left the Radium Institute in Vienna to accept the position of lecturer at the University of Budapest. His research on radioactive elements as tracers of chemical reactions attracted Rona's interest. This collaboration with Hevesy placed Rona among the key figures of the radioactivity community, such as Rutherford, Frederic Soddy, Alexander Fleck, Lise Meitner, and Otto Hahn.[48] Meitner and Hahn offered her a fellowship to work in their radioactivity depart-

[46] Marietta Blau, Curriculum Vitae, Leopold Halpern Papers (personal archive); and H. Pettersson to Mellbye, 7 Mar. 1926, Agnes Rodhe Papers [in Swedish; English translation by Rodhe] (personal archive). Blau's work on this topic can be traced in her publications: Marietta Blau, "Die photographische Wirkung von H-Strahlen aus Paraffin und Aluminium," *Z. Phys.,* 1925, *34:*285–295; Blau, "Über die photographische Wirkung natürliche H-Strahlen," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1925, *134:*427–436; Blau, "Über die photographische Wirkung natürliche H-Strahlen," *ibid.,* 1927, *136:*469–480; Blau, "Über die photographische Wirkung von H-Strahlen aus Paraffin und Atomfragmenten," *Z. Phys.,* 1928, *48:*751–764; and Blau, "Über photographische Intensitätsmessungen von Poloniumpräparaten," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1928, *137:*259–268.

[47] Marelene Rayner-Canham and Geoffrey Rayner-Canham, "Elizabeth Rona: The Polonium Woman," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 209–216; and Rona, *How It Came About* (cit. n. 26), p. 2.

[48] At the time Hevesy became involved in one aspect of a controversy concerning the production of isotopes and their relationship to the periodic table. While Soddy was enmeshed in a dispute with Fajans over the group displacement laws that defined the production of radioactive isotopes, a second, related dispute arose between Soddy and the British group working in Manchester. See Linda Merricks, *The World Made New: Frederick Soddy, Science, Politics, and Environment* (Oxford: Oxford Univ. Press, 1996), p. 48. Antonoff, a Russian research student working with Rutherford in Manchester, claimed to have isolated "uranium Y," an unknown element. Soddy and Fleck, unable to repeat his experiments, engaged in a fierce public dispute with Rutherford's student. Hoping to apply his radioactive tracer method to the problem, Hevesy asked Rona to repeat the controversial experiment. She succeeded in separating the uranium Y from all the interfering elements and proved that it was a beta emitter with a half-life of 25 hours. "Soon after my paper was published by the Hungarian Academy

ment in the Kaiser Wilhelm Institute in Berlin-Dahlem before Meyer invited her to conduct her research in the Radium Institute in 1924/1925. Adopting the techniques of Pettersson's group, on 10 February 1926 she presented her work on improved methods for measuring the absorption and range of H-rays and on polonium as a more suitable source than radium C to the Austrian Academy of Sciences.[49]

Besides requiring new apparatus for tracing particles, the Vienna group was in need of radioactive sources, preferably polonium, which was extensively used in the artificial disintegration experiments. Because polonium did not emit the beta particles that interfered in scintillation counting, it was a particularly useful radioactive source. The Viennese group was eager to obtain the technical expertise for preparing polonium sources, which were used mainly in the Wilson chamber experiments.[50] At the time Irene Curie was one of the few experts within the radioactivity community who could extract and prepare polonium sources, a process that involved the tedious tasks of chemical separation of the element, purification, and concentration on a small surface.

In May 1926 Pettersson reported to his father that "I have now managed to get Meyer to write a letter to Curie asking to send one of our scientists, Frau Doctor Rona, chemist and specialist in polonium, to her lab for three weeks in order to learn the art from Irene Curie. . . . If she is allowed to go, we will have no problems next year and can make our own polonium samples." No doubt recalling his own problems with the Curies, Pettersson added, "I first thought of going myself but desisted for the reason that a man coming to the Paris lab will get a much less friendly welcome than a woman." Otto Pettersson—probably in his usual authoritative fashion—had tried to persuade Curie to accept his son in her lab just a few years earlier and had been refused. Nevertheless, Curie welcomed Rona once Pettersson managed to obtain a small grant from a Swedish sponsor to fund her trip. On Rona's return to the Radium Institute a few weeks later, Curie was generous enough to donate a strong polonium source concentrated on a small silver disc. Most of the subsequent studies on artificial disintegration performed at the institute were done using either Curie's source or the preparations Rona was now able to make.[51]

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of Science," Rona recalls, "Soddy, Hahn, and Meitner also verified Antonoff's results": Rona, *How It Came About,* p. 8.

[49] Elisabeth Rona, "Absorptions- und Reichweitebestimmung an 'natürlichen' H-Strahlen," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1926, *135:*117–126. On her work in Berlin see Rona, *How It Came About,* p. 10; see also Almanac of the Austrian Academy of Science, 1925, p. 216, ÖAW archives.

[50] In 1923, responding to the Viennese threat to undermine their authority in the field, the Cambridge team employed a Wilson cloud chamber in their research. Rutherford was enthusiastic about the instrument's performance, and soon his workers were using the cloud chamber to track the paths of particles. Pettersson did not want to miss the opportunity to use the device to support his own theoretical claims and experimental results. On 21 November 1923, with financial support from the International Education Board, he ordered a Shimizu-Wilson ray-tracking apparatus. This was a reciprocating form of Wilson's original instrument that made it possible to take more photographs per second. A young doctoral student, Roudolf Holoubek, was assigned to study the tracks of H-particles from aluminum, carbon, and iron using the new instrument. As Pettersson reported in 1926, the use of a strong polonium source in Holoubek's experiments enabled him to take fewer photographs than P. M. S. Blackett did using the same method in Cambridge: Hans Pettersson, Report on the investigations regarding artificial disintegration, 1926, GUB archives. See also Roudolf Holoubek, "Die Sichtbarmung von Atomtrümmerbahnen," *Z. Phys.,* 1927, *42:*704–720; and Holoubek, "Der Nachweis von Atomtrümmern nach der Wilson-Methode," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1927, *136:*321–336.

[51] H. Pettersson to O. Pettersson, 24 May 1926, Rodhe Papers [in Swedish, translated by Rodhe] (personal archive). The account of Otto Pettersson's failed attempt to send Hans to the Curies' laboratory comes from the Rodhe interview. Pettersson's already uncomfortable relations with the Curies deteriorated when he visited their institute in Paris in 1936. Commenting on his letter that described the situation, Karlik suggested that "you must remember, too, what queer people they are. As regards Irene I don't think you should feel puzzled by anything she does. Her manners are really perfectly *intolerable*": Berta Karlik to H. Pettersson, 9 Apr. 1936, GUB archives.

While the rest of Pettersson's group was working feverishly on new and more reliable techniques for counting particles produced by atomic disintegration, Kara-Michailova focused on the design and construction of the scintillation counter. On 5 May 1927 she presented another scintillation study to the Austrian academy.[52] This time the focus was on the brightness of scintillations produced by H-particles in relation to their velocity. As she pointed out, the most important question for the scintillation method was to determine the lower limit of particle velocity at which the scintillations were noticeable to the observer. Kara-Michailova's steps in designing her new experiment involved a noteworthy exchange of instrument parts with Georg Stetter's mass spectrograph.

Stetter had previously been a practicum student at the Radium Institute. After receiving his doctoral degree from the University of Vienna he was hired as an *ausserordentlicher Assistent* at the Second Physics Institute in 1922. Working in Pettersson's group, he constructed a mass spectrograph that modified Francis William Aston's original device. Stetter was the first to replace Aston's photographic plates with Pettersson and Kara-Michailova's model of the scintillation counter. Yet the transfer in instrument parts went both ways. As Kara-Michailova acknowledged in the paper she presented to the academy, "I am much obliged to Herrn Dr. Stetter for letting me use his apparatus as well as for his help with the research."[53] The transformation of the instrument—literally from Kara-Michailova's workbench to Stetter's and back again—was indicative of a dying experimental culture. Its performance dependent on the fragile eyesight of the observer, the scintillation counter was put aside as experimenters sought more trustworthy and objective methods of research.

In a last attempt to save the scintillation counter, Kara-Michailova worked with Berta Karlik to suggest a theoretical explanation of the phenomenon of scintillation on zinc sulfide screens. They addressed the main point at issue between the two groups: the brightness of the scintillations produced by H-particles. Karlik had entered the Radium Institute as a practicum student in 1927. She was born in 1904 to an upper-class Viennese family. Her father, Carl Karlik, was director of the national mortgage institution for Lower Austria and Burgenland. She lived in a small castle in Mauer, a Viennese suburb, to which she returned for her summer holidays throughout her adulthood. As befitted a member of her class, she learned to play the piano and to speak several languages while also studying painting. When she entered the University of Vienna in 1923, Karlik intended to take the exams that could enable her to become a teacher and study physics and mathematics on the side. Things turned out otherwise. Attracted by physics, she combined research at the Radium Institute and teaching at a Realgymnasium in Vienna beginning in 1930, when she was listed as the institute's collaborator in the almanac of the Austrian Academy of Sciences.[54]

On the subsequent work with Curie's and Rona's polonium preparations see Pettersson, Report on the investigations regarding artificial disintegration. Rona also instructed Ewald Schmidt in the technique of preparing polonium sources. See Pettersson, Report to the International Education Board (cit. n. 1); and Rona, *How It Came About* (cit. n. 26), p. 28.

[52] Elisabeth Kara-Michailova, "Helligkeit und Zällbarkeit der Scintillationen von magnetische abgelenkten H-Strahlen verschiedener Geschwindigkeit," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1927, *136:*357–368.

[53] *Ibid.,* pp. 359–360. On Stetter's background see Georg Stetter, Kommissionsbericht, Rigorosenakt, no. 059, UW archives. For Aston's mass spectrograph and the other Cambridge techniques adopted in Vienna see Hughes, "Radioactivists" (cit. n. 35), p. 107. See also Pettersson, Report on the investigations regarding artificial disintegration (cit. n. 50); Georg Stetter, "Die Massenbestimung von H-Partikeln," *Z. Phys.,* 1925, *34:*158–177; and Stetter, "Die Bestimmung des Quotienten Ladung/Masse für natürlich H-Strahlen und Atomtrümmer aus Aluminium," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1926, *135:*61–69.

[54] Almanac of the Austrian Academy of Sciences, 1931, p. 285, ÖAW archives. On Karlik see Bischof, "Frauen am Wiener Institute für Radiumforschung" (cit. n. 25), pp. 101–117.

WHAT DID IT MEAN TO BE AN EXPERIMENTER AT VIENNA'S RADIUM INSTITUTE?

What it meant to be a physicist specializing in radioactivity was strongly dependent on the culture within which such an identity was constructed and performed. In Vienna Pettersson initiated a new era of experimentation and transformed the meaning of "experimenter" within the institute. Introducing the research program on artificial disintegration required changes in space arrangements, the use of new experimental techniques, and the reordering of the entire laboratory. Before his arrival physicists had worked either alone or with one collaborator, who was often a practicum student. In the early 1920s, however, the shift to experiments on artificial disintegration, investigating several elements, demanded group research. Both the competition with the Cavendish Laboratory and the nature of the experiments themselves necessitated the changes. To determine the number of protons produced by the disintegration of light nuclei, physicists counted the number of flashes that appeared on the zinc sulfide screens of their scintillation counters. The task was painstaking, and several students were usually recruited to do the counting in addition to the main experimenters themselves. For instance, in one of her experiments Kara-Michailova had employed two groups of observers who simultaneously recorded the scintillations produced by alpha and H-particles.[55]

At the same time, in order to compete with Rutherford's team, each of the Viennese researchers focused on one of the key aspects of the controversy, collaborating with other colleagues either to develop and improve new experimental methods or to probe a variety of different elements. Thus Pettersson introduced research among a cluster of scientists with varying areas of expertise, each of whom was assigned a topic of investigation that contributed to the overall effort. Although Pettersson was the leading experimenter, he encouraged teamwork and exercised minimal control over the pace and direction of research in his group. As he describes its rituals, "The papers are circulated in manuscripts and read by all the co-workers and thoroughly criticized by them before publication."[56] The Viennese chose peer review as a way to construe experimentation in their local context. The result was the development of close collaborations, the exchange of ideas and scientific papers among the researchers, and even the transfer of parts of instruments from one workbench to another. (See Figure 3.)

In contrast, to be a physicist in the British group meant to accept the hierarchical structure that Rutherford's authority imposed and to work on assigned projects that were designed to maintain that authority. Students' training was strictly organized around the accepted research methods of the laboratory and maintained the local experimental culture. As Jeff Hughes explains, "Rutherford introduced a compulsory new training regime for fledgling experimentalists based on the course established at Manchester by Walter Makower and Hans Geiger."[57] Rutherford's reprimand of his student Bates gives us a glimpse of the highly competitive environment at the Cavendish Laboratory.

The shift in emphasis from the individual researcher to the research group definitely improved collegiality at the Radium Institute. In that welcoming and less competitive atmosphere, women were more readily accepted. As the cases of Dagmar Pettersson, Kara-Michailova, and Rona suggest, they exercised the same type of control over their experi-

[55] Kara-Michailova, "Helligkeit und Zällbarkeit der Scintillationen" (cit. n. 52), p. 361.
[56] Pettersson, Report to the International Education Board (cit. n. 1).
[57] Jeff Hughes, " 'Modernists with a Vengeance': Changing Cultures of Theory in Nuclear Science, 1920–1930," *Studies in History and Philosophy of Modern Physics,* 1998, *29:*339–367, on p. 344.

Figure 3. *Elizabeth Rona (sitting), Berta Karlik (in front of her), Elizabeth Kara Michailova (left, behind Rona), and another researcher gathered around a laboratory work table at the Radium Institute, circa 1925. (Courtesy of Artur Svansson.)*

ments, instruments, and theories as their male colleagues. Undoubtedly, the active presence of women scientists at the Radium Institute also points to Meyer's role as a supportive supervisor, mentor, and administrator.

STEFAN MEYER: A SUPPORTIVE AND POLITICALLY COMMITTED DIRECTOR

Meyer played a decisive role in making opportunities in radioactivity research available to a number of women. Of the thirty-two women who published in the *Mitteilungen* between 1920 and 1934, twenty entered the institute as Meyer's students. He kept in touch with some of them even after their departure. On several occasions he used his connections to the international scientific community on behalf of the institute's women. For instance, in 1930 he arranged for Karlik to work at William H. Bragg's laboratory in London. Rona's later account of Meyer's personality and his role as director comes as no surprise: "The atmosphere at the Institute was most pleasant. We were all members of one family. Each took an interest in the research of the others, offering help in the experiments and ready to exchange ideas. Friendships developed that have lasted to the present day. The personality of Meyer and that of the associate director, Karl Przibram, had much to do with creating that pleasant atmosphere." The same collegiality is echoed in Otto Hahn's recollection of Meyer: "As a special characteristic of genuine collegial loyalty toward his many coworkers, I always have felt that he gave every individual far-reaching freedom in his work and allowed him always to publish alone, although for very many investigations he nevertheless was the intellectual stimulus."[58]

Meyer's role was also crucial in supporting women's networks in the wider community of radioactivity researchers. At his invitation, the Norwegian radiochemist Ellen Gleditsch paid several visits to the Radium Institute over the years. Well known in the field and active in feminist politics, Gleditsch functioned as a mentor for many of the younger women scientists, paying attention not only to their scientific work but to their personal lives as well. In 1934, with the perspective of one who was older and more experienced, Gleditsch warned Rona about the hazards of radioactivity. "My dear Elisabeth, pay attention before it is too late," she urged when Rona was suffering from anemia. Karlik, too, appreciated Gleditsch's warm friendship and took care of her when she spent time at the institute in late 1937.[59]

Given the close collaboration between Meyer and Gledistch, exchanges of publications, instruments, and even research students between the two institutes became a common practice.[60] In 1934 Gleditsch arranged for her assistant Ernst Föyn to spend some time in Vienna; the visit led to an important research project on the effects of bombarding radioactive isotopes with neutrons, conducted in collaboration with Rona, Kara-Michailova, and Hans Pettersson. The exchange of researchers was reciprocal: Rona and Karlik paid frequent visits to Gleditsch's laboratory while working at Pettersson's oceanographic station in Bornö, Sweden, over the course of several summers.[61] Moreover, amid the political turmoil that characterized Vienna in the late 1930s, Rona and Blau found shelter at Gleditsch's laboratory.

Meyer was one of the best loved and most respected persons in the international scientific community. The outstanding feature of his personality, as Paneth later recalled, was

[58] Rona, *How It Came About* (cit. n. 26), p. 15; and Reiter, "Stefan Meyer" (cit. n. 6), p. 119 (quoting Hahn). Information about Meyer's students is based on the individual Rigorosenblätter of all the women of the institute, UW archives. For his contact with women after they left the institute see, e.g., Meyer to Dora Kautz, 11 May 1934; and Meyer to Gertrud Wild, 17 June 1946, ÖAW archives. Regarding arrangements made on their behalf see William H. Bragg to Meyer, 29 Aug. 1930; and Meyer to Bragg, 1 Sept. 1930, ÖAW archives.

[59] Ellen Gleditsch to Elisabeth Rona, 19 Aug. 1937; and Gleditsch to Karlik, 4 May 1937, ÖAW archives. Five years younger than Meyer, Gleditsch was one of the first women who entered the field of radioactivity before World War I, collaborating closely with Marie Curie. Her scientific and friendly relationship with Meyer went back to the war, when Gleditsch supplied radioactive materials for the research that Horovitz and Hönigschmid were performing at the institute. Besides spending time at Curie's laboratory in Paris, Gleditsch worked with Bertram Boltwood in his laboratory at Yale University for a short period. The exact determination of the half-life of radium brought Gleditsch to the forefront of radioactivity research and established her as a specialist in the separation of radioactive substances from minerals. In 1916 she was appointed *Dozent* at the University of Oslo. Well aware of the difficulties women faced in their scientific careers, Gleditsch became heavily involved in the International Federation of University Women, established in 1919. See Weidler Kubanek and Grzegorek, "Ellen Gleditsch" (cit. n. 4).

[60] In 1919 Gleditsch thanked Meyer for sending her his valuable papers and expressed hope that she could visit the institute in the future: Gleditsch to Meyer, 27 Apr. 1919, ÖAW archives. In a 1938 letter Karlik assured Gleditch that she sent her a microscope table that should arrive in the mail soon: Karlik to Gleditsch, 7 Apr. 1938, ÖAW archives.

[61] For work that came out of Föyn's visit see Ernst Föyn, Elisabeth Kara-Michailova, and Elisabeth Rona, "Zur Frage der Künstlichen Umwandlung des Thoriums durch Neutronen," *Sitzungsber. Akad. Wiss. Wien Math. Naturwiss. Kl., Abt. IIa,* 1935, *72:*159; and Föyn, Hans Pettersson, and Rona, "Künstliche Umwandlung des Thoriums durch Neutronen," *Naturwissenschaft,* 1935, *23*:391. Föyn remained at the institute for a year and worked closely with Rona: Meyer to Gleditsch, 18 Aug. 1934; Gleditsch to Meyer, 30 Aug. 1934; and Meyer to Rona, 12 Sept. 1934, ÖAW archives. See also Almanac of the Austrian Academy of Sciences, 1935, p. 196, 1936, p. 213, ÖAW archives. He later worked on the radioactivity of seawater with Pettersson, Karlik, and Rona; see Föyn, Berta Karlik, H. Pettersson, and Rona, "Radioactivity of Seawater," *Göteborgs Kungl. Vetenskaps- och Vitterhets-Samhälles Handlingar.,* 1939, *6:*1–44. On Rona's and Karlik's visits to Gleditsch's laboratory see Rona to Meyer, 9 Sept. 1935, ÖAW archives; and H. Pettersson to Karlik, 27 Sept. 1934, GUB archives.

his "never-failing kindness."[62] There is no doubt that he shaped the collegial ethos among his researchers and encouraged women to take active roles in the institute and in the international radioactivity community. Within the general political context of Red Vienna, however, Meyer's role takes on additional dimensions. A few liberal and well-placed men anywhere might have made occasional exceptions so as to incorporate a few women into their own scientific settings, but individual initiative is not enough to explain the more persistent phenomenon of women's participation in the Radium Institute. Changing attitudes about women's fitness to work in science and creating opportunities for them to do so requires more than kindness. It requires political intention.

Although Meyer was not a member of the party, he seems to have held the same progressive ideas about women's role in science and society as the Social Democrats. In his youth, following the lead of important figures in the Viennese physics community such as Exner, Ernst Mach, and Victor von Lang, Meyer contributed immensely to creating an environment friendly for women who wanted to pursue careers in physics. As early as the mid 1890s, Mach, Lang, and Exner founded a committee for the support of women's admission to university studies. As a younger member of their circle, Meyer shared their views. When the Radium Institute was established in 1910, Meyer had a remarkable degree of flexibility in administration and in setting the scope of the research, and he consistently supported women's participation there. Rona writes in her autobiography of the particular effort he made in inviting her to join the institute's research team in the mid 1920s.[63]

Moreover, in a strongly anti-Semitic city the fact that Meyer was Jewish gave him a distinct standpoint. As Helmut Gruber argues, anti-Semitism was deeply rooted in Austrian society even during the years of Red Vienna. "It is the Viennese Jews prominent in professions and arts, in journalism and the rising mass media, in industry and high finance, but especially in SDAP, who were the targets in the hate campaigns which were a permanent fixture of the First Republic." A Jewish woman seeking to be hired and then promoted within the University of Vienna faced very long odds. When Blau attempted to get a position as *Dozentin* at the university she was told, "You are a woman and a Jew and together this is too much." For those women who wished to remain in academia after their student years it was clearly a disadvantage to be Jewish.[64] In Meyer's institute, however, that was not the case. Jews—both men and women—were welcomed and attained

[62] Friedrich Paneth, "Prof. Stefan Meyer," *Nature,* 1950, *165:*548.

[63] On the committee to support women's university admission see Bischof, "Frauen am Wiener Institute für Radiumforschung" (cit. n. 25), p. 23. See also Maria Rentetzi, "The City as Context of Scientific Activity: Creating the Mediziner-Viertel in *Fin-de-siècle* Vienna," *Endeavour,* 2004, *28*(1):39–44. Regarding the offer to Rona see Rona, *How It Came About* (cit. n. 26), p. 25. Annette Vogt first drew attention to a similar case of directorial independence—the role of the so-called Harnack principle in the employment of women in the scientific institutes of the Kaiser Wilhelm Society. This principle, named after the first president of the society, Adolf von Harnack, alludes to the fact that each institute within the society was created in a new scientific discipline and specifically for one individual. Thus the director of the institute was endowed with the absolute power to hire and fire his personnel. When the director was progressive, the "Harnack principle" worked in favor of women's employment. See Annette Vogt, "Von der Ausnahme zur Normalität? Wissenschaftlerinnen in Akademien und in der Kaiser-Wilhelm-Gesellschaft (1912–1945)," in *Zwischen Vorderbühne und Hinterbühne: Beiträge zum Wandel der Geschlechterbeziehungen in der Wissenschaft vom 17. Jahrhundert bis zur Gegenwart,* ed. Theresa Wobbe (Berlin: Berlin-Braderburgischen Akademie der Wissenschaften, 2003), pp. 159–188, esp. p. 171.

[64] Gruber, *Red Vienna* (cit. n. 16), p. 26; Leopold Halpern, "Marietta Blau: Discoverer of the Cosmic Ray Stars," in *Devotion to Their Science,* ed. Rayner-Canham and Rayner-Canham, pp. 196–204, on p. 197; and Harriet Pass Freidenreich, "Gender, Identity, and Community: Jewish University Women in Germany and Austria," in *In Search of Jewish Community: Jewish Identities in Germany and Austria, 1918–1933,* ed. Michael Brenner and Derek Penslar (Bloomington: Indiana Univ. Press, 1998), pp. 154–175, esp. p. 166.

important positions, as the cases of Przibram, Blau, and Rona attest. The gender profile of the Radium Institute's personnel between 1919 and 1934 indicates Meyer's influence in women's careers as well as the interrelation of socialist politics and women's participation in science.

THE GENDER PROFILE OF THE INSTITUTE'S PERSONNEL, 1919–1934

The almanac of the Austrian Academy of Sciences from 1919 to 1934 serves as a first indicator of the gender profile of the institute's personnel. A survey of the director's annual reports published there reveals that over the fifteen years 113 scientists, 43 women and 70 men, conducted research at the institute. During this period 83 of them—73 percent of the total—remained at the institute from one to three years. Because the institute occupied a prominent position within the international scientific community, a few of those researchers were visitors from abroad.

One such visitor was Frances Wick, an associate professor at Vassar College in the United States. Wick graduated from Cornell University in 1908; in 1918 she became the first woman to work on airplane radios and gun sights in the U.S. Army Signal Corps. She came to Vienna twice and spent more than two years at the institute, joining Przibram's research group on radioluminescence. Apart from the visiting researchers, most of the scientists who stayed for a short period at the institute were practicum students taking advantage of the special training—the "radioactivity practicum"—that was offered every spring semester for young physicists.[65] Most of the practicum students published one or two papers related to their dissertation topics in the *Mitteilungen* and then left the institute. Overall, nearly 39 percent of those short-term scientists were women.

Table 2 lists researchers who remained at the institute for more than four years. One third of these were women. In addition to the two assistants and the director, in 1927 the Austrian ministry of education offered 5,000 schillings for the appointment of a *wissenschaftliche Hilfskraft* (scientific assistant) at the Radium Institute. Ewald Schmidt was the first to obtain the position, which he held as a joint appointment with the Second Physics Institute. Attracted by the work on artificial disintegration, he entered the institute during the academic year 1924/1925. Pettersson reported to his sister, "My third assistant, Dr. Schmidt, is a jewel." He was surprised that Schmidt, who was married, could manage on a salary of just 125 sek a month. A few months after his appointment at the Radium Institute, Schmidt quit the position for the prospect of becoming an *ausserordentlicher Assistent* at the Second Physics Institute.[66]

The next scientific assistant was Kara-Michailova. In November 1928 she was offered the position of *wissenschaftliche Hilfskraft,* "with the salary of an *ausserordentlicher Assistent*." By the end of March 1933, however, both Austria and the institute were deeply

[65] On Wick's background see Rossiter, *Women Scientists in America: Struggles and Strategies to 1940* (cit. n. 3), p. 118. Wick was at the Radium Institute during 1929/1930 and 1930/1931 and returned for another year in 1936/1937. During her first visit she suffered a serious infection, as did Franziska Witt and Stefan Wolf, also members of the institute: Almanac of the Austrian Academy of Sciences, 1930, p. 234. In 1926/1927 the institute also hosted R. Hasche from New Jersey and H. Raudnitz from Prague: Almanac of the Austrian Academy of Sciences, 1927, p. 204. On the radioactivity practicum see Stefan Meyer, 28 Nov. 1931, Mitarbeiten/Assistenten, ÖAW archives.

[66] On the funding for the new position see Stefan Meyer, 18 Nov. 1931, Mitarbeiten/Assistenten, ÖAW archives. For Pettersson's enthusiasm for Schmidt see H. Pettersson to Mellbye, 3 Mar. 1926, in Rodhe to Rentetzi, 29 Oct. 2001. On Schmidt's resignation see 6 Nov. 1928, Kara-Michailova file, Mitarbeiten/Assistenten, ÖAW archives.

Table 2. Researchers Who Remained at the Radium Institute for Longer Than Four Years from the Academic Year 1919/20 to 1933/34

Researcher	1919/20	1920/21	1921/22	1922/23	1923/24	1924/25	1925/26	1926/27	1927/28	1928/29	1929/30	1930/31	1931/32	1932/33	1933/34	No. of Years
Baiersdorf, G.												°	°	°	°	4
Belar, Maria		°	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr					10
Blau, Marietta		Dr			Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	12
Czapek, A.										°	°	Dr	Dr			4
Fonovits-Smereker, Hilde	ausA	ausA	ausA	ausA												4
Hernegger, F.												°	°	°	°	4
Holesch, Elsa											°	°	°		Dr	4
Kailan, Anton	Pr	Pr	Pr	Pr												4
Kara-Michailova, Elisabeth		°	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr/wH	Dr/wH	Dr/wH	Dr/wH	Dr/wH	Dr/wH	14
Karl, A.										°	°	°	°			4
Karlik, Berta												Dr	Dr	Dr	Dr/wH	4
Kindinger, Max						°	°	°	°	°	Dr	Dr	Dr	Dr	Dr	10
Kirsch, Gerhard	°	Dr		Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	14
Krafft, P.								Ing	Ing	Ing	Ing	Ing	Ing			6
Kreidl, N.						°	°	°	°							4
Kürti, G.												Dr	Dr	Dr	Dr	4
Mayer, Gertrud									°	°	°	°	Dr			5
Meyer, Stefan	Dir	Dir	Dir	Dir	Dir	Dir	Dir	Dir	Dir	Dir	Dir	Dir	Dir	Dir	Dir	15
Ortner, Gustav					Dr	ausA	ausA	ausA	ausA	ausA	ausA	ausA	ausA	ausA	ausA	11
Pelz, S.										°	°	°	°	°	°	6
Pettersson, Dagmar			Dr	Dr	Dr	Dr	Dr									5
Pettersson, Hans			Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Dr	Pr	Pr	Pr	Pr	13
Przibram, Karl		oA	oA	oA	oA	oA	oA	oA	oA	oA	oA	oA	oA	oA	oA	14
Rona, Elisabeth						Dr	Dr	Dr	Dr	Dr/wH	Dr	Dr	Dr	Dr	Dr	10
Schmidt, Ewald						Dr	Dr		wH	wH	Dr	Dr	Dr			7
Stetter, Georg											Dr	Dr	Dr	Dr	Dr	5
Ulrich, Karl	Dr	Dr	Dr	Dr	Dr	Dr										6
Urbach, Franz				°	°	°	°	Dr	Dr	Dr	Dr	Dr	Dr			10
Weiss-Tessbach, Felicitas								°	°	Dr	Dr	Dr				5
Wolf, S.							°	Dr	Dr	Dr	Dr					5

Abbreviations: Dr = doctor, ausA = ausserordentlicher Assistent, Pr = practicum student, oA = ordentlicher Assistent, Ing = Ingenieur, wH = wissenschaftliche Hilfskraft, Dir = Director. The small circle indicates that the individual was listed as a collaborator of the institute but without a title; most were probably practicum students.

affected by the wider European political crisis. Financial problems prompted Meyer to address the dean of the Faculty of Philosophy on 21 March 1933. He sought to retain the position, even if at only half the former salary. Kara-Michailova, meanwhile, had decided to apply for a Yarrow Scientific Research Fellowship, a grant that aimed to support women scientists. As she informed Meyer from her parents' home in Sofia, she could rely on the financial support of her father, who wanted her to continue her scientific research even if she was unable to extend her stay at the institute after March.[67]

Karlik was the next to obtain the position. When she took up the job on 1 April 1933 her monthly salary was reduced to 150 schillings from the 289.5 schillings that Kara-Michailova had received in 1932. In addition to Fonovits-Smereker, Kara-Michailova, and Karlik, all of whom were paid directly by the Radium Institute, Rona was appointed as an additional *wissenschaftliche Hilfskraft* for the academic year 1928/1929 only. Erwin Zach, the Austrian-Hungarian general consul in Singapore, and the industrialist Ignaz Kreidl, whose son Norbert was working as a research student in Pettersson's group, funded her position.[68]

Given the shortage of archival sources, it is difficult to draw any systematic picture regarding the financial support of those, besides the assistants, who conducted research at the institute. The Institutsverrechnung, a notebook briefly recording monthly revenues and expenses, shows that from 1925 to 1928 Kara-Michailova received monthly checks of 200 schillings. From 1928 to1932 Rona was systematically paid 250 schillings per month, while Blau's monthly checks ranged from 100 to 200 schillings between 1929 and 1932.[69] A few *Bestätigungen,* isolated receipts signed by women scientists, confirm that some of them were paid for chemical and photographic tasks as well as for the preparation of radioactive sources. The same can be said for many of their male colleagues, who appear either to have received monthly paychecks or to have been paid for individual tasks.

A list of those who conducted research at and were paid by the institute indicates the exceptional gender politics of employment and opportunities for research that were offered to women. A survey of the *Mitteilungen* reveals the gender division of labor and the level of participation of men and women in the institute's ongoing scientific research. From 1920 to 1934, 98 individual authors appeared in the *Mitteilungen*; 32 were women and 66 were men. Only 6 of the women and 15 of the men published more than two papers in the *Mitteilungen*. This confirms the pattern found in the almanac of the Austrian academy—namely, that most of the practicum students remained at the institute only for a short period. Table 3 shows the publications of these individuals, using the *Mitteilungen* as the chief source. Surprisingly, women accounted for 29 percent of the total; moreover, if we exclude Pettersson and Przibram from the calculation, the productive women averaged about one more paper each than their male colleagues.

We can safely conclude that women were among the most productive individuals working at the Radium Institute. Given the number of their publications and the time they

[67] On Kara-Michailova's appointment see 6 Nov. 1928, Kara-Michailova file, Mitarbeiten/Assistenten, ÖAW archives. For the request to the dean see Meyer to Dekan, 21 Mar. 1933, Karlik file, Mitarbeiten/Assistenten, ÖAW archives. Regarding her father's support see Kara-Michailova to Meyer, 18 Jan. 1933, ÖAW archives. In 1935 Kara-Michailova moved to Cambridge, where she spent four years working at the Cavendish Laboratory. See Bischof, "Frauen am Wiener Institute für Radiumforschung" (cit. n. 25), p. 95.

[68] For the figures on salary see 10 Jan. 1934, Karlik file, Mitarbeiten/Assistenten, ÖAW archives; and 2 Dec. 1932, Kara-Michailova file, Mitarbeiten/Assistenten, ÖAW archives. On Rona's special appointment see Almanac of the Austrian Academy of Sciences, 1929, p. 202, ÖAW archives.

[69] Institutsverrechnung, 1922–1932, ÖAW archives.

Table 3. Number of Publications of Those Researchers Who Published More Than Two Papers from 1920 to 1934

Researcher	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	No. of Publications
Belar, Maria		1		2			1									4
Blau, Marietta					1	1	1	1	1	1	2	2	3		2	15
Gräven, Heinrich											1		2			3
Haberlandt, Herbert													2	5	5	12
Hoffman, Josef											2	1	1	2	1	7
Kailan, Anton	1	2	1		1		1			1		1			1	9
Kara-Michailova, Elisabeth			2	1	1			1	1	1		1		1	3	12
Karlik, Berta								1	1	1	2			3	4	12
Kirsch, Gerhard	1		1	1	2	2		1	1				4	2		15
Meyer, Stefan	1		1	1	1				2	3	1		1		1	12
Ortner, Gustav					1		1	1	1	1	1	1		3	2	12
Pelz, S.												1		2		3
Pettersson, Hans				2	6	3		2	2	1			1	2	4	23
Przibram, Karl		2	3	2		2	4	4	2	5	3		6	5	5	43
Rieder, Fritz													5	1		6
Rona, Elisabeth							2	1	2	1	1		3	1	1	12
Schintlmeister, Josepf													2	3	4	9
Schmid, Ewald						1		1	2	1	2					7
Stetter, Georg							1	1	1	1	2	1	6	1		14
Urbach, Franz							1		3	3	5					12
Wambacher, Hertha												1	3	1	2	7

SOURCE.—*Mitteilungen aus dem Institut für Radiumforschung.*

stayed at the institute, it is obvious that they were not merely assistants and members of the laboratory support staff, setting up experiments and performing tedious preparatory tasks for their male colleagues. Instead, they made steady contributions to radioactivity research and were as scientifically productive as their male counterparts, publishing not only in the institute's journal but in other periodicals as well. Articles by Blau, Kara-Michailova, Karlik, and Rona often appeared in prestigious journals such as the *Zeitschrift für Physik,* the *Physikalische Zeitschrift, Naturwissenschaften,* the *Journal of the Chemical Society,* and *Nature*.

In large part, women's active participation in laboratory life at the Radium Institute can be credited to Meyer's progressive politics, coupled with and encouraged by the political context of Red Vienna. But because the socialists' power was restricted to the municipal level, people like Meyer had only a limited influence. Thus the employment system of the University of Vienna, controlled by the conservative national government, remained fairly gender segregated. It is indicative that none of the women who were affiliated with the Radium Institute was promoted to the position of *Privatdozentin* at the University of Vienna before 1934. This had a significant impact on women's careers when the controversy over artificial disintegration between Pettersson's and Rutherford's groups was resolved in favor of the British at the end of the 1920s.[70] Soon thereafter Petterson returned to Sweden, and the loss of the key figure of the group led to disarray in the study of atomic disintegration; they also suffered from the ongoing financial crisis, which was already severe and grew steadily worse. Because the women at the institute lacked stable university positions and monthly payments from the state, they were the ones most deeply affected by the dissolution of Pettersson's group. To sustain their positions in science, some of them shifted their research to the border zone of radioactivity and oceanography. Thanks to the establishment of Pettersson's oceanographic research in Sweden, they took up temporary work in his oceanographic station in Bornö, analyzing sea-bottom samples for their radium content. Eventually, the political upheavals of the 1930s dramatically affected the fate not only of the women who had worked in Pettersson's group but of the entire Radium Institute.

FROM *AUSTROFASCISMUS* TO THE *ANSCHLUSS*

In the city elections of April 1932 the National Socialists emerged as a serious political force and a threat to the conservative Christian Socialists. Faced with a strong social democratic party on the left and an emerging Nazi power on the right, Chancellor Engelbert Dollfuss suspended the Austrian parliament in March 1933. After a number of Nazi terrorist acts in Vienna, he banned the party in July. With Mussolini as his ally and protector,

[70] On the resolution of the controversy see Stuewer, "Artificial Disintegration and the Vienna–Cambridge Controversy" (cit. n. 36); Hughes, "Radioactivists" (cit. n. 35); and Andrew Brown, *The Neutron and the Bomb: A Biography of Sir James Chadwick* (Oxford: Oxford Univ. Press, 1997). Among these historians there has been an assumption that women played a secondary role in the controversy. On the basis of James Chadwick's account of women's work in Vienna and a comment that Pettersson was supposed to have made, the women have been considered technical assistants and mere counters of scintillation flashes; see, e.g., Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge Univ. Press, 1998), p. 90. However, on the basis of new archival information and an examination of women's scientific publications related to the artificial disintegration research project, I have argued that they in fact played an important role in the research agenda of the group. See Rentetzi, "Gender Politics and Radioactivity Research in Vienna" (cit. n. 7); and Maria Rentetzi, "From Cambridge to Vienna: The Scintillation Counter in Female Hands," *Nuncius: Annali di Storia della Scienza* (in press).

Dollfuss fought on two fronts, against the Nazis and, more fiercely, against the Social Democrats. In the following months, in the context of the wider European political crisis and Hitler's rise to power in Germany, the political situation in Vienna became increasingly unstable. For three days, from 12 to 14 February 1934, government troops fought with frustrated workers in the streets of the city until socialism was defeated. Dollfuss's assassination in July of the same year brought his fellow Christian Socialist, Kurt von Schuschnigg, to power. Two years later, seeking to resolve the political crisis, Schuschnigg signed an agreement with Hitler giving amnesty to imprisoned Nazis and including several others in the government. This reconciliation advanced Hitler's plans for the annexation of Austria, which took place when German troops marched into Vienna on 13 March 1938.[71]

The changes at the Radium Institute during the early years of the fascist regime did not directly affect its structure. Probably because it was an institute devoted to research rather than to education, the fascists had little interest in transforming its internal hierarchy and in dismissing its undesirable personnel. For strategic reasons, their concern was focused on institutions and educational establishments with direct influence on the public and, especially, the young generation of students. Most of the Radium Institute's personnel continued their research in the same manner as before. Karlik even succeeded in becoming *Dozentin* in 1937, and, despite being Jewish, Blau shared the Ignaz Lieben Prize of the Austrian Academy of Sciences with Hertha Wambacher for their work on photographic emulsions. In addition, Blau directed five dissertation projects during 1935 and 1936, four of them conducted by women.[72]

A systematic examination of the gender profile of the institute's personnel from 1934/1935 to 1937/1938 reveals that the percentage of women remained fairly high, 37 percent—barely less than it had been during Red Vienna. This fact reflects both the lasting influence that socialist politics had on women's education in general and the limited interest the fascists showed in the internal affairs of the institute. The purging and replacement of university and academy members was not yet radical. The fascist regime did, however, thwart Meyer's ambitions to elevate the Radium Institute to a national regulator of radium supplies for medical use and cut it off from any key role it might have had at the municipal level.[73]

[71] On Schuschnigg's agreement with Hitler see Karl Stadler, "Austria," in *European Fascism,* ed. S. J. Woolf (New York: Vintage, 1968), pp. 88–110, on p. 109. On the Austrian history of this period see Rabinbach, *Crisis of Austrian Socialism* (cit. n. 14); Karl Stadler, *Austria* (New York: Praeger, 1971); Gottfried Kindermann, *Hitler's Defeat in Austria, 1933–1934: Europe's First Containment of Nazi Expansionism* (Boulder, Col.: Westview, 1988); and Gordon Brook-Shepherd, *Dollfuss* (Westport, Conn.: Greenwood, 1978).

[72] In a self-description written around 1963, Blau mentioned that she received the Haitinger Prize of the academy in 1936: Blau, Curriculum Vitae (cit. n. 46). According to the records of the academy, however, Blau received the Ignaz Lieben Prize in 1937: Almanac of the Austrian Academy of Sciences, 1939, p. 136, ÖAW archives. See also Bischof, "Frauen am Wiener Institute für Radiumforschung" (cit. n. 25), p. 79; and H. Pettersson to Karlik, 7 June 1937, GUB archives. From 1865 to 1937 Blau and Wambacher were the only women besides Lise Meitner (1925) to be awarded the Ignaz Lieben Prize; from 1905 to 1938 the only women who received the Haitinger Prize of the academy were Rona and Karlik, both in 1933; see Almanac of the Austrian Academy of Sciences, 1939, p. 141, ÖAW archives. On the dissertation projects Blau directed see Rosner and Strohmaier, eds., *Marietta Blau* (cit. n. 4), p. 37. The four women were Elvira Steppan, Stefanie Zila, Hanne Lauda, and Johanna Riedl.

[73] In conjunction with the construction of the radium station at the Lainz hospital, Meyer and the directors of the Vivarium planned to establish a common research laboratory devoted to medical and biological research on radium. They hoped that this laboratory would serve as the regulator of radium supplies in Austria. See Directors of the Vivarium to the Kuratorium of the Vivarium, 2 June 1932, ÖAW archives. I have argued elsewhere that their failure to bring these plans to fruition is largely attributable to political and racial factors. Both institutes hosted a significant number of Jewish and leftist scientists, as well as women; moreover, the proposed director of the new laboratory, Eugen Steinach, was also Jewish. See Rentetzi, "Gender Politics and Radioactivity Research in Vienna" (cit. n. 7), pp. 244–249.

Although the party was technically illegal after 1933, the Nazis in fact faced few difficulties. A number of the scientists at the Radium Institute joined the Nazi party (NSDAP). Kirsch, who had been a member since 1923, became the leader of a *Keimzelle* of the National Socialist Teachers League at the University of Vienna in 1933. As Karlik informed Pettersson on 13 September 1933, "Kirsch has come back [to the institute] and now one has to face politics again. I feel so disgusted!!" Stetter had been a member of the National Socialist Teachers League since 1932 and had joined the NSDAP just a month before Dollfuss banned it.[74] Ortner became a member of the National Socialist Teachers League in 1934.

Given the favorable attitude of the Austrian fascists after 1936, scientists committed to the National Socialist ideology felt increasingly free to express their political views within the Radium Institute as time went on. Thanks to the interventions of the institute's Nazis, patterns and forms of everyday practice changed drastically during the late 1930s. The unfortunate collaboration of Blau and her Nazi colleague Wambacher, well documented by Galison, illustrates some of the difficulties the Jews at the institute had to face.[75] After the *Anschluss,* Austria's annexation to Germany in 1938, Wolfgang Reiter observes, "the Radium Institute lost a quarter of its collaborators, in particular those who had shaped the profile of the Institute with their scientific achievements." Specifically, of the 17 women in the institute during the academic year 1937/1938, only 8 remained during 1938/1939. Meyer rushed to apply for permanent retirement from the philosophical faculty on 18 March 1938 and voluntarily resigned his academy membership in an attempt to avoid a confrontation with the Nazis and the humiliation of a dismissal. Both he and Przibram remained at the institute as "guests" until January 1939, when a hate campaign against them forced Ortner, the new director, to forbid them to work there.[76]

While anti-Semitism in the institute forced the Jews into exile, the Nazi gang enjoyed impressive success after the *Anschluss*. Besides taking over the directorship of the institute, Ortner was named *Extraordinarius Professor*. Stetter and Kirsch were both promoted to the position of *Ordinarius Professor* and assumed the responsibilities of those who had left or been dismissed. The Nazis not only continued the institute's research but planned to expand it. Supported by the German ministry for financial development in Berlin, Stetter played an instrumental role in establishing an institute for nuclear research as a joint program between the Second Physics Institute and the Radium Institute.[77] The

[74] Karlik to H. Pettersson, 13 Sept. 1933, GUB archives. On the ease with which the NSDAP continued to exist despite being banned see Elisabeth Barker, *Austria, 1918–1972* (London: Macmillan, 1973), p. 74; on Kirsch and Stetter see Galison, *Image and Logic* (cit. n. 37), p. 153.

[75] Blau and her former student Wambacher worked together on the development of photographic emulsions, a method for tracing the tracks of charged particles. In 1937, in the course of an experiment, they observed nuclear disintegration caused by cosmic rays in photographic emulsions, something Galison has characterized as a "golden" event in the history of emulsions. The collaboration of the two women was deeply influenced by the political upheavals of 1938. The Nazis at the institute, including Wambacher, made it clear that Blau, a Jew, was no longer welcome there. Her career came to an abrupt halt, she was forced to flee Austria, and all her scientific notebooks were confiscated by the Gestapo. Meanwhile, Wambacher continued to use Blau's earlier work and to publish on photographic emulsions with Nazi colleagues such as Stetter. See Galison, "Marietta Blau" (cit. n. 12).

[76] Reiter, "The Year 1938" (cit. n. 25), p. 195. On Meyer's retirement see Reiter, "Stefan Meyer" (cit. n. 6), p. 122; and Sime, *Lise Meitner* (cit. n. 4), pp. 287–288. For events up to January 1939 see Berta Karlik, "1938 bis 1950," in *Festschrift des Institutes für Radiumforschung Anlässlich seines 40jährigen Bestandes (1910–1950)* (cit. n. 8), pp. 35–41, on p. 35.

[77] On Ortner's promotions see Galison, *Image and Logic* (cit. n. 37), p. 159; on Ortner and Stetter see Karlik to H. Pettersson, 1 May 1938 [in English], GUB archives. The new institute is discussed in Karlik, "1938 bis 1950," p. 36. As Galison points out, Stetter was a member of the commission that met in May 1938 to consider the restructuring of physics in Vienna; see Galison, *Image and Logic,* p. 158n.

Vierjahresplan-Instituts für Neutronenforschung was directed by Stetter, with Ortner as his second in command.

At the same time that the Jews of the institute were cut off from their research, the Nazi circle—including Max Kindinger, Josef Schintlmeister, Willibald Jentschke, Stetter, Ortner, Kirsch, and Wambacher—secured the support of the Third Reich for a role in the development of nuclear physics. The fate of the Radium Institute was entirely in the hands of those who saw that politics offered them a chance to rise in the scientific ranks and to impose their worldviews on their colleagues and the work they pursued. In front of the building, a long banner with the slogan "One nation, one Reich, one leader" made tangible the dramatic changes in the city and, especially, in the institute itself. Even more expressive was the slogan that hung in the Physics Institute: "Juden sind hier unerwünscht [Jews are unwelcome here]."[78]

CONCLUSION

What did it mean, after all, to be a woman experimenter specializing in radioactivity in Vienna? The very question presupposes that to be a woman experimenter differed within the various laboratories and recognizes that research on radioactivity was contingent on the local setting. As we saw, the handling of scintillation counters and of radium preparations was indeed different in the Cambridge and the Vienna groups. There were differences not only in techniques and materials but also with regard to modes of collaboration, gender politics, and power relations within the laboratory. The myriad studies of "the laboratory" have shown that it does not stand in isolation from the broader cultural and political context in which it functions. On the contrary, the individual experimenter embodies meanings, values, and symbols, all the essential components of his or her interaction with the society and its dominant discourse. In this essay I have taken this interaction seriously, arguing that both the politics of Red Vienna and the specific experimental culture of the Viennese contributed to the exceptional gender relations at the Radium Institute.

Vienna's cultural, political, and intellectual life at the beginning of the twentieth century provided opportunities for women's emancipation and their pursuit of professional careers. The route of women to the Radium Institute in particular was eased by the fact that Exner and Meyer actively supported their participation in the field. Later on, the careers of these women were shaped in good part by the shifting meanings and the politics attached to being a woman experimenter at that time. With the Social Democrats having control of the city from 1919 to 1934, women became a political category. The party's discourse and its projects of educational reform created the conditions in which women could envision themselves as socially active, as well as encouraging key figures such as Meyer to implement their progressive gender politics. Specifically, Meyer's political agenda with regard to the institute's sustainability and his alliances with key socialists such as Tandler offered tangible possibilities for both the men and the women of the institute to advance their careers. When the entire range of educational reforms and the social and cultural policies of Red Vienna were destroyed amid the flood of anti-Semitic and anti–Social Democratic propaganda that succeeded the *Anschluss*, the changes were strongly reflected in the institute's gender and racial profile.

[78] Karlik described the banners in Karlik to H. Pettersson, 9 Apr. 1938, 19 Mar. 1938, GUB archives. She reported to Pettersson that Max Kindinger got involved in the NSDAP with great enthusiasm after the *Anschluss*: Karlik to H. Pettersson, 19 Mar. 1938. On Jentschke and Schintlmeister see Bischof, "Frauen am Wiener Institute für Radiumforschung" (cit. n. 25), p. 140.

Vienna's political context accounts in part for the institute's history. I have argued that the experimental culture of the Radium Institute played a significant role in promoting women's active presence in the field. The record of published works makes it clear that women did not enter the Viennese institute as technicians and laboratory assistants to their male colleagues. Instead, they were involved in the institute's research agenda as experimenters with a deep knowledge of their instruments and materials. The collegial atmosphere and, especially, Pettersson's style of directing his group led to exceptional gender equality within the institute. Moreover, the fact that the instruments used in radioactivity research were table-top devices, portable and easy to construct from scratch, made it easier for women to negotiate their roles and prolong their involvement in the discipline. Being able to transfer a single part of a laboratory technology from one workbench to another or across disciplinary boundaries enabled women to expand their possibilities for work.

Is Vienna's Radium Institute a unique case in the history of radioactivity? To settle this question is not an easy task. Given the lack of comparative studies from an institutional perspective, it is tempting to fall back on general explanations and argue that, independently of local peculiarities, radioactivity was indeed a field that attracted, sustained, and fostered the careers of a considerable number of women. At one level, this essay is concerned with the specifics of one particular institutional setting. At a second level, however, it suggests a shift from the historiography of causes to one concerned with contingencies of place and time.