A Review Essay on "Lise Meitner and the Dawn of the Nuclear Age" by Patricia Rife

Gary R. Goldstein
Department of Physics
Tufts University
Medford, MA 02155 USA
July 13, 2000

Published in Peace and Change: a Journal of Peace Research, vol.26, 95 (2001).

Abstract

The book "Lise Meitner and the Dawn of the Nuclear Age" by Patricia Rife (Boston: Birkhäuser, 1999) is reviewed in this essay for the lay audience. Meitner was a leading nuclear physicist at the time that the nucleus was the most exciting frontier of science. To establish her career, she had to overcome daunting prejudices against women in science and academia. Being of Jewish origin in Germany in the 1930's, she narrowly escaped certain disaster. Meitner was a crucial participant in the discovery of nuclear fission, yet did not share in the Nobel Prize that her collaborator, Otto Hahn, received in 1945. How these events came about, how they were intertwined with contemporary history and how they fit into the evolution of Meitner's social conscience and her abhorrence of war are some of the fascinating subjects discussed in the book and reviewed in this essay.

Science has contributed immeasurably to the history and character of the twentieth century. Advances in the fundamental understanding of nature raced along at a mindboggling pace. The speedy applications of those advances have led to everything from palm-sized computers and wireless telephones to microwave ovens and nuclear weapons. Consequently, scientists face two important extra-scientific questions: to what extent are they responsible for the applications of your work, and to what extent should they use their expertise and reputation to influence the social uses of their science? We need only think about the many innovations in military technology during the two world wars to realize how important these questions are. Even the most narrowly focused practitioner of "pure research" can be faced with these questions. Consider Albert Einstein, a pacifist, whose extraordinary insights into the nature of space and time ultimately made possible the building of the atomic bomb, the most

destructive single weapon ever used in war. He became an outspoken critic of American nuclear policy after the war, and was labeled a "fellow traveler" by some cold warriors.

Lise Meitner, a contemporary of Einstein's, was a remarkable nuclear physicist whose discovery of nuclear fission paved the way for the Manhattan project, although she was unaware of the project itself. She did not share in the credit for that discovery, in any case, having been passed up by the Nobel Prize committee, while her collaborator, Otto Hahn, did receive the prize in 1945. How these circumstances came about, and how they fit into the evolution of her social conscience and her abhorrence of war are some of the fascinating subjects discussed in the biography by Patricia Rife, "Lise Meitner and the Dawn of the Nuclear Age"(1), here under review.

Lise Meitner's name was hardly known in recent times, until an earlier biography by Ruth Lewin Sime(2) appeared in 1996 that reminded readers - interested scientists, primarily - of her importance. Yet, in the aftermath of World War II, Meitner toured the US and was acclaimed "the Mother of the A-bomb" in the popular press, a dubious honor that she shunned. As that war and its memories have faded from public consciousness, so have the names in a long list of scientists and engineers whose work contributed to weapons research in general, and the development of the nuclear fission bomb in particular. Certainly, everyone recognizes Albert Einstein, whose role in the dawn of the nuclear age was crucial, although he too had nothing to do with the work of bomb project. He is now *Time* magazine's "Person of the Century" and a logo for consumer products. Ironically, even among the cognoscenti, contemporary scientists for whom Einstein's work is part of their life's breath, Meitner's essential role in nuclear research and the details of her extraordinary life are hardly known. Her devotion to scientific discovery was realized amidst an interminable struggle against misogyny, anti-Semitism, economic hardship and indifference. Patricia Rife's biography, which was begun eleven years earlier, further contributes to the understanding of the struggle and achievements of Lise Meitner.

Some of the important milestones discussed by Rife are summarized herein. Lise Meitner was born in 1878 of a middle-class Jewish family in Vienna. Early on it was clear that she had special ability in science and mathematics, although it was very difficult for a young woman to obtain a suitable education. She persisted, struggled against an unsympathetic system and managed to be the first woman ever admitted to the physics department at the University of Vienna. Her subsequent career was exceptional. From her twenties through her sixties she pursued the most vexing and interesting puzzles in nuclear and quantum physics, and she unraveled many of those puzzles in her research.

The times and places in which Meitner lived and worked coincided with some of the century's most important and terrifying events. She was among the first women in Austria and then Germany to be allowed participation in higher education, both as a student, a researcher and finally as a professor. She completed her Ph.D. in Vienna during a time of new discoveries in microscopic physics. The nature of the quantum world was beginning to be

explored, and it was becoming clear that the laws of physics were in need of radical change in order to account for the new phenomena. In 1907, already involved in studies of radioactive material, Lise decided to move to Berlin where Max Planck was leading a group of young physicists and chemists in the first forays into the quantum world. Within a few years some of the leading proponents of the new physics would be there - Einstein, von Baeyer, Franck, Hertz, Stern, and von Laue. Lise soon began to collaborate with a young chemist with interests similar to hers, Otto Hahn, in a partnership that would last through most of her career. For many years, however, she was an unpaid participant in the research at the newly constituted Kaiser Wihelm Institute for Chemistry, since women were not allowed any official status.

Science is not advanced in a vacuum of course, and Rife fills in the historical context throughout. Although Meitner was incredibly focused on her nuclear studies, she was certainly aware of the powerful misogyny that dogged her most pointedly in the early part of her career, but continuing in many forms throughout her life. The turmoil of war - World War I - and its sweep of scientific talent into weapon making or soldiering amidst injuries and death were a sobering experience. She eventually volunteered, seemingly reluctantly, to aid the Austrian war effort as a nurse on the frontlines. She was asked to use her expertise in x-ray properties to aid the diagnosis of severe battlefield injuries and to train others in the fledgling medical technology. She worked to exhaustion.

These war experiences did not turn her into an overt pacifist. In a letter to Hahn, for example, she complained about Einstein's pacifism being out of touch with the reality of the war engulfing Europe. The war did, however, leave her deeply skeptical about political motives for committing lives to furthering grandiose nationalistic goals. She was very unhappy about her peers' participation in research on poison gas, which was led by the distinguished chemist Fritz Haber. Otto Hahn even took part in one of the raids that used gas on the Allied troops, for which Meitner chastised him. In the midst of all this turmoil she longed for the peaceful pursuit of her research, and returned to Berlin hoping for the insanity to "pass over". It eventually did, but was replaced by the post-war deprivations that made everyday life a struggle. Rife emphasizes the point that Lise developed an expectation that in time political and economic chaos would run their course. The best thing to do in the meantime was to focus on her work. One of the people she admired most in Berlin, her friend and mentor Max Planck, advocated the attitude of the scientific internationalists, that science transcends politics and nations and should be pursued for its own sake. Following that philosophy, Meitner maintained the work of the Kaiser Wilhelm Institute for Chemistry Radiological Studies group as the war ended, and she continued on as the director of the Physics Section. Her achievements multiplied and her reputation grew among the increasing number of scientists devoted to nuclear research.

Meitner finally acquired an appointment in 1914, the first for a woman, in the University of Berlin physics department, a separate and more internationally prestigious institution than the Kaiser Wilhelm Institute, but not with a salary commensurate with her status. For many years she had been getting by with

help from her family and a stipend for being Planck's assistant while working at the Institute. Finally in1916, at the age of thirty-eight, she received a salary nearly equal to Hahn's, having been his equal in responsibilities for several years already. As the post-war years were succeeded by the Weimar Republic period, her research progressed unhampered by the forces of political change, but those forces became overwhelming with the collapse of the liberal Weimar government.

The work on nuclear fission, for which Lise Meitner will be remembered most, has a complicated history that is enmeshed with the horrendous policies of Nazi Germany. Clearly presenting the history of the discovery and the ensuing establishment of priority, within the tumultuous events of the times, is a major achievement of the Rife biography. This slice of modern history sharply illustrates how inescapable were the tentacles of fascism, even among the most distinguished scientists. The permanent dislocation of one individual's hitherto exemplary and productive life is a microcosm of the disruptions of the time. What is fascinating from the perspective of the history of science is how inextricably connected are the demands of politics and the military with the directions taken by scientific research. Once Meitner and her colleagues identified fission, the discovery launched an international race to exploit its military potential. To summarize the intertwined issues that Rife disentangles is difficult but essential for appreciating the complexity of her task.

To set the stage, in 1933 the Nazi directorship revoked Meitner's professorship at the university. Despite this great shock, she managed to remain at her beloved Kaiser Wilhelm Institute for Chemistry for five more years during the continuing rise of the fascists and the imposition of their anti-Jewish laws. At the same time as the revocation, Planck, Heisenberg and von Laue nominated Meitner and Hahn for the Nobel Prize for their pioneering work in radiochemistry. These nominations were repeated over many years. Her colleagues hoped that as a side benefit, a Nobel Prize would ease the plight of the non-Aryan Meitner and legitimize her remaining in her research position at the Institute, but to no avail for her. Relying naively on her experience during World War I, Lise tried to "hold center", continuing with her work while political chaos and the deplorable attitudes of many new colleagues (already by 1933 half of the institute staff were Nazi party members) began to engulf her and her colleagues. To protest the dismissal of Jews from the university, Hahn resigned his university position, though not his institute position, which was more significant as the university lapsed into fascist polemics. Planck, however, withdrew from the fray after an initial protest to Hitler over the dismissal of Fritz Haber from the directorship of the Kaiser Wilhelm Institute for Chemistry. Other scientists in Lise's circle advised avoiding direct confrontation with the Nazis. Rife emphasizes that Otto Hahn's choice of "compromise rather than righteous indignation" was symptomatic of many educated German's unwillingness to confront the Nazi hierarchy.

Rife next carefully reconstructs the chronology of the nuclear research. While getting the facts straight, Rife is quite terse with the important scientific developments. A more readable and conventional account of the

science, without the detailed chronology of Meitner's contribution, can be found in the excellent book, *The Making of the Atomic Bomb*, by Richard Rhodes(3). The essentials follow.

In 1934, in the midst of the very threatening political environment throughout Europe, Enrico Fermi and his research group in Rome initiated a new line of nuclear investigations. They used neutrons to bombard a variety of different nuclei and studied the byproducts of the interactions. The transmutation of the elements was underway. Lise Meitner and Otto Hahn resumed their collaboration after a hiatus of 12 years in order to combine their skills in pursuing this new and promising approach. Their "Berlin Group", which added Fritz Strassmann, was immediately a major contributor to the burgeoning research area, competing with Fermi's group and the "Paris Group" of Irene Curie and colleagues, along with several newly constituted US teams. The early results of the Berlin group suggested to Meitner that "transuranic elements", artificially created nuclei heavier than the naturally occurring heaviest element uranium, were sometimes produced when neutrons hit heavy nuclei. By observing the beta radiation from the radioactive nuclear byproducts, Meitner was able to identify many of those nuclei. Hahn and Strassmann, both chemists, did the chemical analyses of the same byproducts. There were, however, some puzzling discrepancies with the results of the Curie experiments. Thinking that they were observing transuranic nuclei, Meitner couldn't accept that the French were finding a lighter element, lanthanum, among the nuclei. Furthermore, issues of priority developed with Curie's group concerning the transuranics. These were very exciting times for science. A new area of exploration, the physics of the nucleus, was yielding new discoveries at a rapid rate and attracting considerable attention. Competition was keen; major discoveries were imminent. There are few periods in the history of modern physics and chemistry that have been as heated. Hahn and Meitner planned a series of experiments to probe further into the byproducts that result when uranium is the bombarded nucleus, but these experiments were slowed and interrupted by the events of 1938, as Rife describes.

The Anschluss, the German takeover of Austria in March 1938, put all Austrians under the German laws and Lise Meitner was classified as a Jew. Rife fails to note that Meitner had actually converted to Protestantism in her 20's (Sime discussed this in her book(2)), although this was irrelevant for the "racial" distinctions that the Nazis made. It was clear to Meitner and her friends, inside and outside of Germany, that she had to leave as soon as possible; "holding center" was no longer viable. Hahn's efforts to allow her to maintain her position at the Institute were half-hearted and ineffectual. She was quite angry with him for not speaking out more forcefully on her behalf.

The subsequent fits and starts arranging Meitner's escape constitute an adventure story that Rife tells well. In brief, Lise managed, with no proper exit visa, but with extraordinary help from the Dutch physicists Coster and Fokker, to get to the Netherlands, where she remained a short time before going to Bohr's institute in Copenhagen and then Stockholm, Sweden. Sweden offered her a modest position in a newly constituted institute for nuclear research. Unfortunately the head, Nobel Laureate Manne Siegbahn,

was never very interested in Meitner's work and provided her with quite inadequate facilities. The Sime book(2) is quite damning of Siegbahn's possible motivation for so ignoring Lise's research needs, while Rife puts more emphasis on his preoccupation with building big machines. In any case, Meitner's research in Sweden was hampered by inadequate equipment and lack of assistants. She was quite frustrated and probably quite depressed, missing her beloved physics research, the Berlin institute, colleagues, friends and even her native German language.

So from July through September 1938 Meitner could do no research, but Hahn and Strassmann continued the project in Berlin to determine the byproducts from the bombardment of uranium by neutrons. Hahn frequently wrote to Meitner about their progress and asked for her advice and interpretation. On December 16 Hahn and Strassmann, by careful measurements, had convinced themselves that one of the byproducts was definitely barium, an element of slightly more than half the mass of the uranium. Hahn wrote Lise asking her to interpret this puzzling result, realizing that this could not be the signature of one of the transuranics. Reluctant to give up the transuranic idea, Lise first tried to find some loophole in the results. While letters were being exchanged, Hahn wrote the article about the work without consulting Strassmann and without Meitner’s name as a co-author. In the meantime Lise spent the Christmas holiday period in western Sweden with friends and her nephew, the young, recently emigrated physicist Otto Frisch. The two, aunt and nephew pondered the meaning of the barium results and, during a walk in the forest, had a breakthrough in understanding. Frisch recalled later that, in classic fashion, Lise sat down by a tree and started doing rough calculations on a scrap of paper. They realized that the barium was appearing as a result of the uranium actually *splitting* into smaller nuclei after being struck by a neutron. And the amount of energy released was just what Einstein’s famous formula, $E = mc^2$ predicted. Fission was discovered!

It is difficult to imagine the emotional turmoil Meitner experienced in that short time from the urgent arrangements being made for her escape from Germany in April 1938 to the quiet Christmas holiday in western Sweden. She had been engaged in some of the most exciting research of her career, while trying to keep the terrifying external situation for non-Aryans away from consciousness. Then in March she was forced to confront the fact that her life was in grave danger. The time for legally obtaining an exit visa had passed. The escape plans were fraught with dangerous uncertainty. She survived the fearful anxiety of crossing the border to safety only to encounter further uncertainty about her livelihood in foreign lands. What distinguishes these emotional upheavals from so many other refugees' experiences is the wrenching removal from her life's work, work that was on a threshold of momentous discovery. She then had to endure reading Hahn's letters about the continuation of that research, while she was unable to do any work herself - she was experimentally mute. But then, when she and Frisch explained the experimental results in terms of *fission*, a term they invented, she was again at the height of scientific creativity. At the age of sixty this creative insight was quite remarkable. Nevertheless, Lise was again in the

doldrums after the holiday when she returned to the isolation of the rudimentary lab she had been assembling in Stockholm. Surely she was depressed, as Rife surmises. A superhuman fortitude sustained her through the war years; she managed to do some interesting research in spite of the obstacles.

After Meitner wrote Hahn about the physical meaning of the experimental results, she and Frisch composed an article whose submission and publication were quite slow. Long before the article appeared in print, a remarkable set of circumstances involving Niels Bohr, brought the news of fission to the US and initiated a race to study the fission process. Meitner was out of the loop from then until to the end of World War II. Her experiments conducted in that period were no longer at the cutting edge. The real developments of nuclear fission became part of the secret rush to build a nuclear bomb by the United States, Germany, and later the Soviet Union.

This history of fission's discovery raises many questions. Why was Meitner not included as a co-author on Hahn and Strassmann's paper? Rife doesn’t consider this point, but the fact that Meitner had been an active partner in this particular research until her escape in July reasonably should have led to her inclusion on the paper. Sime's book(2) speculated that it might have been dangerous for Hahn to include this recently escaped non-Aryan as a co-author. Most of the scientists involved in this line of research knew that Meitner had been an equal partner in the work anyway. Unfortunately, though, after the war Hahn continued to downplay Meitner's role in the research, as Rife shows. During the war "he refused to take a stand on the politics in and out of his Institute: the Third Reich was blinding Hahn and he began to discount Meitner's insights and contributions he had frantically *sought out* months earlier. We witness here appeasement, professional cowardice, and worse." (p.213). Perhaps Hahn's initial lapse is understandable, given that the editor or some other authorities may have rejected the groundbreaking paper for political reasons, although Hahn knew the editor personally. More likely he would have had to stand up to the Nazi directorship of the Institute and the official scientific establishment, thereby jeopardizing his position. And when he finally received recognition for the paper and the acclaim from his German colleagues that followed, he was not about to share credit with Meitner. There is no question that his behavior was scurrilous. He must have constructed a torturous self-justification to assuage his guilt for deserting his decades long collaborator and friend. He never adequately acknowledged her essential role in the discovery, even long after he was awarded the Nobel Prize and was a leading figure in post-war German science.

Another important element of the discovery of nuclear fission for historians of science is how Meitner and Hahn were able to accept the error in their previous thinking about their transmutation research. Rife notes that both shared an initial unwillingness to abandon their interpretation of their previous neutron bombardment work. Here was an archetypal struggle at the beginning of a paradigm shift(4) or creative leap. Hahn remained unsure of his experimental results for a while, but once Meitner, with Frisch, realized

they had seen fission in the data, everything fell into place.

The war years were difficult for Meitner for many reasons. The news of horrendous destruction and turmoil was depressing. She helped friends fleeing Nazi persecution. She kept in touch with family and was able to communicate with some of her Berlin colleagues, but must have felt quite helpless in the sweep of events. Her nephew Frisch got a position in Birmingham, England and continued to experiment with fission. In collaboration with another German-Jewish émigré, Rudolph Peierls, he figured out how the fission of a rare isotope of uranium (U235) could be used to initiate a "chain reaction" and create a "super bomb" of enormous power. The secret Frisch-Peierls memorandum(5) became the impetus for the start of the Manhattan Project. Unbeknownst to Lise, her nephew, Peierls and other physicists working in Britain (including Klaus Fuchs) were sent off to Los Alamos, New Mexico to contribute to the making of the bomb. Had she been given the opportunity to participate in that war work, there is little doubt that Meitner would have declined, as her previous history suggests. In a separate discussion, Rife makes the interesting point that the scale of scientific research would never be the same after the "big science" projects became the rule with the infusion of large government budgets into scientifically innovative weapons development. Siegbahn’s institute in Stockholm had become an example of big science that left Meitner out in the cold although it was not directed toward weapons work.

When the war in Europe ended, Meitner was horrified to learn about the deaths and deprivations of the millions of victims of the Nazi concentration camps. She could not forgive her German colleagues for their lack of active opposition to the regime. Rife quotes a remarkable letter to Hahn (that he never received) in which Meitner excoriates her old friend and research partner: "All of you lost your standards of justice and fairness. … All of you also worked for Nazi Germany, and never even attempted passive resistance. Of course, to save your troubled conscience, you occasionally helped an oppressed person; still, you let millions of innocent people be murdered, and there was never a sound of protest."(p.249). Later she singles out Heisenberg, "They should force a man like Heisenberg, and millions of others with him, to see these camps and the tortured people."(p.250). Heisenberg had come to Bohr’s institute in Copenhagen in 1941 and had delivered a lecture full of propaganda for the regime that had infuriated Meitner. If there remained any doubts about Heisenberg's lack of scruples about his leading Nazi nuclear bomb research, Lise would not have shared them.

Bohr’s efforts to assure the establishment of Lise’s priority for the interpretation of fission were not significant enough to prevent the 1944 Nobel Prize in Chemistry from being awarded (in 1945, after the war) *exclusively* to Otto Hahn for the discovery of nuclear fission. "Lise Meitner keenly felt the injustice of the situation, as did many of her colleagues", Rife recounts (p.258). In his Nobel address to the Royal Academy of Sciences, with Meitner present, Hahn gives credit to Meitner and Frisch for interpreting his and Strassmann’s results. Nevertheless, Hahn did not, in turn, nominate her for the prize once he was on the nominating committee. He gave her part of the monetary award, though, which she then sent on to

an Emergency Committee of Atomic Scientists chaired by Einstein in Princeton.

At war’s end Lise received unexpected attention from the press. She was sought out after the atomic bombing of Japan. Called the "mother of the A-bomb", she quite forcefully tried to make it clear that she was completely removed from any weapon research. Rife quotes a friend of hers who recalls that when Lise first heard about Hiroshima, there were "tears - shock - and then silence"(p.252). With the attention came some welcome invitations for her to visit the United States. She was asked to lecture at Catholic University in Washington, D.C., and was a guest of honor at the Women’s National Press Club. She traveled to many universities giving lectures and being honored. She spoke increasingly about the importance of encouraging women to enter higher education and scientific research. She also found herself among a growing number of scientists who were profoundly worried about the nuclear Pandora’s box that had been opened.

Just days after the bombing of Hiroshima, Lise Meitner took part in a radio interview conducted by Eleanor Roosevelt in which she said: "Women have a great responsibility and they are obliged to try, so far as they can, to prevent another war. I hope that the construction of the atom bomb not only will help to finish this awful war, but that we will be able to also use this great energy that has been released for peaceful work."(p.253). Here she expresses the attitudes that defined the early postwar antinuclear movement among the atomic scientists. It has to be said that history shows, however, that it is doubtful that the atom bomb helped to finish the war or made it less awful(3). The hope that atomic energy should be harnessed for peaceful work has been quixotic because of the enduring safety problems of nuclear reactors. Nonetheless, her words were quite courageous at that time. The plea to women is certainly heartfelt, given her history. Lise felt that even she had abdicated her moral responsibility by staying in Germany as long as she had, in spite of the personal danger, because her work gave legitimacy to the regime. She urged women and scientists to be more aware of the moral consequences of events around them.

Meitner spent the post-war years traveling, giving lectures, advocating arms control and the equal participation of women in science. She wanted to share the lessons that she learned in a lifetime of struggle against the ravages of war and the prejudices toward women and Jews. She lived an active and dedicated life to the age of eighty-nine.

Although Rife gives us a thorough accounting of the facts of Meitner's life, and indicates the concerns she had for family and friends throughout, there is a missing personal connection. For most of Lise's years she lived alone but enjoyed the company of friends. Did she consciously decide to have no intimate, romantic relationships? Did the battle to be accepted in a man's world preclude forming such attachments, or have the biographers missed something? Did physics and her recreations - listening to music and walking - fill her time? We can only infer that she was depressed at particular times when circumstances were quite difficult. What is the core of her personality? Lise was modest and very shy in public, yet unstoppably competitive and

tenacious in her work. She published papers at a high rate, even by today's standards, when the competition for jobs and advancement is unpleasantly keen. Was this her strategy to overcome the prejudices against women in science? Eventually, with all of her achievements, she was accepted by the mostly male community of nuclear scientists. Though she was never given the same level of recognition and reward as her collaborator Hahn, Lise Meitner's single-minded dedication to physics while faced with a myriad of obstacles is proof of an extraordinary person. And with such extraordinary people we want to know how they came to be. We are ultimately left to theorize for ourselves, but Rife has given us much of the data we need in a well-written, thorough, readable and engrossing work. The book is clearly a paean to a great woman scientist.

References

[1] Patricia Rife, "Lise Meitner and the Dawn of the Nuclear Age", Birkhäuser, Boston 1999.

[2] Ruth Lewin Sime, "Lise Meitner:a Life in Physics", University of Cal- ifornia Press, Berkeley 1996.

[3] Richard Rhodes, "The Making of the Atomic Bomb", Simon and Schuster, New York 1995.

[4] Thomas S.Kuhn, "The Structure of Scientific Revolutions", 3rd edition, University of Chicago Press, Chicago 1996.

[5] Otto Robert Frisch and Rudolph Peierls, "The Frisch-Peierls Memorandum", in Robert C.Williams and Philip L.Cantelon, editors, "The American Atom," University of Pennsylvania Press, Philadelphia 1984.