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At first sight, nothing could be simpler than nuclear emulsions, those thin strips of film designed to trap the tracks of passing charged entities—nuclei, protons, electrons and the other objects that inaugurated the field of particle physics. But the method's seeming simplicity hides a complex history. Scientifically, emulsions posed myriad problems and required years of effort by a dedicated corps of emulsion physicists and chemists, who had to learn how to make the film sensitive to minimally ionizing particles, and how to store, process, dry and ultimately analyze the ramified skein of tracks. Developed in the 1930s by Marietta Blau, an Austrian physicist who fled her homeland following the Anschluss *in March 1938, the nuclear emulsion method was taken over by Cecil Powell, who transformed it during the 1940s into a cottage industry, with female "scanners" and an international team of physicists and chemists. From Powell's laboratory in Bristol, England, the method migrated to the burgeoning, industrial-scale accelerator centers at Berkeley and Brookhaven, until even there, emulsions were displaced by the mammoth bubble chambers of the 1950s and 1960s.*

In the following excerpt from Image and Logic, *I address the early moments of this trajectory, moments in which the fate of Marietta Blau signifies what it meant to be a woman, a Jew and a solitary physicist fleeing the convulsing world of Nazi Austria.*

Born in Vienna in 1894, Blau grew up in a prosperous Jewish family that had made its mark in Viennese high culture by founding the foremost music publishing company in Europe. Blau received her PhD in 1919 with a thesis on ray physics—on the absorption of gamma rays. Following her doctorate, she moved to Berlin in 1921, taking a position with a company that manufactured x-ray tubes—her tasks involved electrotechnical and spectral analysis. This job was followed by a stint as an *Assistentin* at the Institute for Medical Physics at the University of Frankfurt (am Main), where she worked and published papers on x-ray physics. Primarily, however, her assignment was to instruct doctors in the theoretical and practical bases of radiology. This border zone between medicine and physics brought Blau much nearer the realm of nuclear physics than it may at first appear. For not only did she carry over a deep knowledge of ray physics and film from medicine to physics (at times even exploiting standard dental x-ray film to do nuclear physics), she took with her a lasting commitment to the persuasive power of the image and the concomitant close analysis of artifacts that accompanied the establishment of real effects amid the visual noise.

The tradition of radiology had carried over directly from the invisible rays of Röntgenology to those of the subatomic domain. Marietta Blau's career trajectory underscores that link. Not only did she publish extensively in journals of photography, she contributed to joint projects such as a multiauthored 1931 volume on the physical–medical border area.[1] In that volume, after summarizing her own research, she emphasized the continuity of the long history of photography as an aid to the study of radioactivity; less obviously, she insisted that the examination of radioactivity would contribute reciprocally to the development of the photographic process itself.

For a decade and a half, between 1923 and 1938, Blau's investigations were centered at the Institut für Radiumforschung in Vienna and at the Second Physical Institute. Despite these solid surroundings, she was always peripheral (and by and large unpaid). When the issue of her getting a *Dozent* position arose, her brother later recalled, a professor told her that to be a woman and a Jew was just too much. To make ends meet, in the years before 1937 she taught *Praktikumsunterrichten* and occasionally worked for other institutes, including the oceanographical institute in Göteborg (where her mentor, Hans Pettersson, was based), the Röntgentechnische Versuchsanstalt in Vienna and a variety of photographic and precious metal enterprises.

In the interstitial zone between scientific and commercial ventures, her work in physics continued. At Pettersson's suggestion, Blau began to explore the possibility of finding protons and smashed atoms using photographic emulsions. Finally, in 1925, she succeeded in detecting the fragments of atoms hit by alpha particles, including the thinner, harder-to-find tracks of protons.[2] These experiments were followed in 1926 and 1927 by a series of experiments in which Blau bombarded aluminum

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with alpha particles in order to measure the nuclear fragments that would emerge. Unfortunately, with a weak radioactive source (the only kind available to her), she had to settle for the very lowest energy particles.[3] It was clear that if she was going to make fast protons visible (as opposed to the much more heavily ionizing nuclear fragments or slow-moving protons), she would have to improve both the emulsion and the development process that would bring out the narrow tracks.

The Blau-Wambacher collaboration

For a variety of reasons, perhaps in part because of the encouragement offered by Stefan Meyer, the head of the institute, and in part because the boundary between physics and chemistry had, as a field, been more open to women physicists, the Institut für Radiumforschung became a mecca for women exploring the complex of fields surrounding nuclear physics, radiochemistry and radiophysics. Meyer brought in, among others, Blau and Berta Karlik; Blau was then able to coauthor papers with or supervise the dissertations of at least five other women in the years 1930–37 alone: Elizabeth Rona, Elisabeth Kara-Michailowa, Hertha Wambacher, Stefanie Zila and Elvira Steppan.

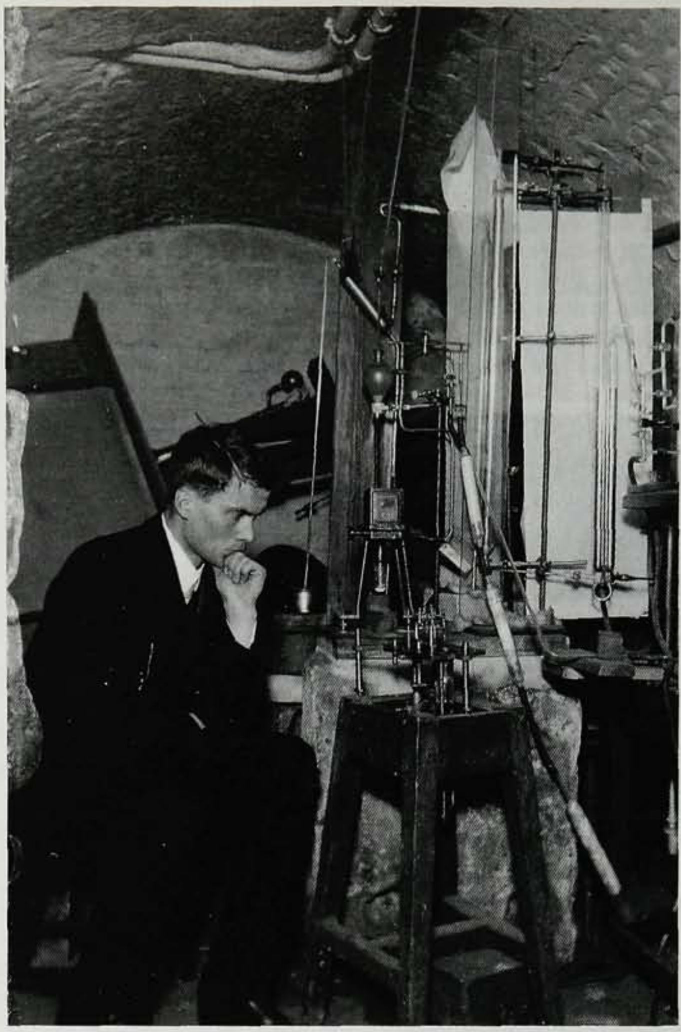
In mid-1932, Blau began a longer collaboration with Wambacher, continuing Wambacher's thesis topic on desensitizers in an effort to improve the photographic method. Their first important success occurred in the fall of that year, when they were able to exhibit the recoil protons from unseen neutrons (neutrons having just been discovered by James Chadwick).[4] Blau and Wambacher's result was, on the face of things, bizarre and counterintuitive. When the photographic plates were soaked in a photographic *de*sensitizer, the organic dye pinakryptol yellow, beta rays and gamma rays were clearly less able to leave an imprint. But plates so desensitized seemed to register the same number of alpha tracks, and the size of the blackened grains *increased*—at least in large-grained emulsions. Indeed, for protons and alpha particles, Blau noted a marked increase in recognizable series of grains. To secure their results, Blau and Wambacher compared their recoil tracks with those registered under neutron bombardment both in the Wilson chamber and in scintillation experiments. The striking similarity in outcomes among the methods legitimated (in their view) the new method. They then directly compared, on the same plate, the result of a neutron source placed at one end and a proton source on the other. Recoil protons could be observed beginning at a variety of distances from the neutron source, whereas in the proton case they began directly in front of the source. Compiling the range of the recoil protons, Blau and Wambacher could then find at least a rough energy distribution for the initial neutrons. In Blau and Wambacher's hands, the photographic plate promised both a new quantitative and a new qualitative way to explore the emission of neutrons.

MARIETTA BLAU, in a rare photo, probably taken during the 1950s. (Courtesy of Leopold Halpern, Florida State University, and Contributions of 20th Century Women to Physics Web site.)

With a grant from the Federation of Women Academics of Austria, Blau went first to Göttingen. But when, in April 1933, Marie Curie offered Blau the use of strong radioactive sources at the Institut du Radium in Paris, it was an offer Blau could not refuse. Making quick use of the concentrated polonium that she received, Blau continued her emulsion studies, now on a neutron beam produced by alpha particles hitting beryllium.[5] By this time, it was quite clear, Blau emphasized, that the choice of plates was a subtle matter. Choose too sensitive a film and the observer will be overwhelmed with "parasitic" effects. Fine grains might be an advantage, but *too* fine a grain made individual grains indistinguishable under the microscope, which lowered the precision of range and ionization measurements. Moreover, it appeared to Blau that the very fine grains simply would not register the passage of a single alpha particle: Lippmann plates, for example, often failed to register a single hit by an alpha. While the *Röntgenzahnfilm* Agfa may have been superb at recording the insults of a decaying tooth, it was less good at seizing the relativistic proton. And as the energy of the incident protons increased—and their ionizing power decreased—they became harder and harder to detect. Only the mysterious effects of pinakryptol yellow could materialize the image, and there, as Blau put it, "we are totally in the dark as to how to explain the apparent sensitivization by a desensitizer."[5]

In 1934, Blau returned to Austria to push forward her neutron studies with Wambacher but confronted the thinness of the emulsions—tracks simply up and left the plate before they had deposited enough of a track to allow a full measurement. The photographic giant Ilford obligingly began to thicken the plates so that more of the inclined tracks could be traced in their entirety. But now difficulties arose as the thicker plates created new problems in the dark room: problems of homogeneity in drying, sensitivity and processing that would haunt the method for many years. Nor was this all. Since 1931, Blau had sought to understand why the latent image of the tracks themselves seemed to fade; that is, between the time of the exposure and the time of development, the image spontaneously vanished into the chemicals. And despite Ilford's help, the thinness of the films continued to put geometric constraints on film capture of particle motion.

When it came time to apply the method to the specific problem of determining neutron energies, other challenges to the photograph's legitimacy arose. In 1935, specifically targeting Blau, H. J. Taylor rejected the very possibility of using a photographic emulsion to estimate the energy distribution of neutrons and protons freed in nuclear disintegrations: "[T]he uncertainties introduced by this method of investigation are considered, and the conclusion is reached that the method is unsuitable for determining



HANS PETTERSSON, shown here in about 1930, was a Swedish physicist working in Austria who wanted a reliable means of counting nuclear particles. He assigned the problem to Marietta Blau: to create more stable, sensitive photographic emulsions for detecting protons and smashed atoms. (Courtesy of Central Library for Physics in Vienna.)

the detailed distribution of neutron energies." Using the radioactive material thorium-C′ (ThC′), Taylor measured 60 alpha tracks and found a 20% spread between the shortest and longest alpha tracks. From this determination, and the fact that perfectly registered tracks should all be the same length, he concluded that tracks in general would carry a 20% error in length, catastrophically high for the quantitative legitimacy of the new method.[6] Blau and Wambacher shot back that the size of the error Taylor reported reflected his use of low energy alpha rays, which produced shorter tracks. The error in the emulsion method was associated with the variation in the length of track missing near the end of the trajectory. If alpha tracks were longer (as the paths of the high energy protons in disintegration experiments generally were), then the percentage error was much smaller than Taylor had reckoned.

The Nazi circle

With a budget near zero, Blau struggled with a handful of students and her ex-student Wambacher to stabilize a deeply insecure method, one with fading images, inconsistent tracks, distorted trajectories and published opposition to its validity. But instability in the emulsion was nothing compared to the political precariousness of the world outside (and sometimes within) the institute walls.

Blau's collaboration with Wambacher must have been fraught; for in Wambacher Blau had chosen an ardent Nazi as her laboratory partner. Indeed, the entire circle of institute experimenters working on and around emulsions had formed an alliance with the still-secret fascist movement. Throughout Blau's collaboration with Wambacher during the 1930s, it appears to have been no great mystery to those in the laboratory that Wambacher was extremely close personally to Georg Stetter, an active Nazi and powerful figure in the Austrian scientific community after the *Anschluss*; at the same time she was collaborating with a second Nazi, Gerhard Kirsch, on emulsions. Kirsch had been a leader of a *Keimzelle* (roughly "seed group") of the National Socialist Teachers League at the University of Vienna from 1933 to 1937,[7] and Stetter had joined the National Socialist Teachers League in 1932, taking up (secret) membership in the NSDAP during June 1933.[8] Rounding out the leading Nazi triumvirate in the laboratory, Stetter worked with Gustav Ortner.[9] Together, Stetter and Ortner had shown that the photographic method was picking up "all" the alpha tracks by comparing the results obtained to those found under similar conditions using the better established electrical method.[10] This scientific legitimation of her new method (by her political enemies) was clearly important to Blau—she cited it, almost as a touchstone, throughout the thirties. So it was, that while Blau never worked personally with Kirsch, Stetter and Ortner, she was tied pedagogically and then collaboratively to Wambacher, and through her to a set of affiliated colleagues whose political dedication to Nazism was early, deep and enduring. With scientific reference to those who threatened her own existence, she hoped to ensure the survival of the images delicately engraved in silver on photographic plates.

Amid the threats to both her and her method's existence, Blau had a break. With the help of the man usually credited with discovering cosmic rays, Victor F. Hess, Blau and Wambacher were able to send their new emulsions to the 2300-meter peak on Hafelekar (near Innsbruck) for a five-month exposure, ending in June 1937. On first examination, they found proton tracks of a length (and therefore an energy) far in excess of what anyone else had observed, some extending as far as the equivalent of 6.5 meters of penetration through air. Considering that Japanese and American teams had recently launched emulsion-bearing balloons into the stratosphere showing tracks of about 1 meter (air equivalent), the two women's results were astounding. But Blau and Wambacher's more salient result was what I consider to be the first emulsion golden event, which bore little resemblance to anything previously seen. The phenomenon was this: On the emulsion there appeared several "contamination stars" (several tracks emanating from a point) with tracks leading from them that were longer than any Blau and Wambacher had ever seen in the laboratory. Could this, they wondered, be a new radioactive decay? Or was it merely a lessening of the braking power of the emulsion? The method was not yet secure enough a base on which to erect, by way of a single golden event, a major scientific claim. A week later, they found another star that was unambiguously clear of any irregularity in the emulsion and that manifestly could not be associated with any known decay. With four such events in their collection, Blau and Wambacher sent a 25 August 1937 paper to *Nature*.[11]

Blau and Wambacher's golden event "star" consisted of nine branches, of which only one could be identified as an alpha particle. Two others were protons with ranges of 11 and 30 centimeters, and the rest were protons with

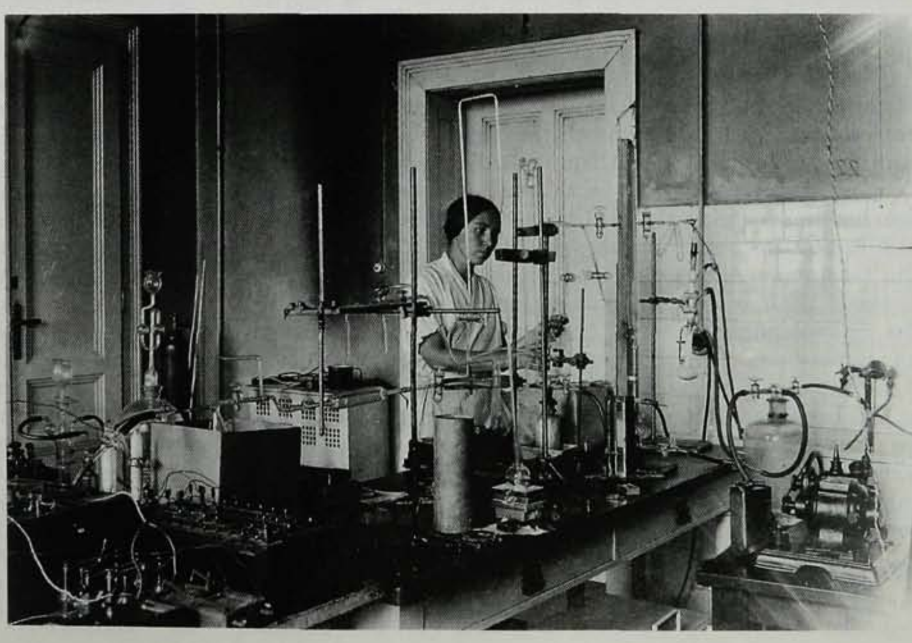
STEFAN MEYER, head of the Institut für Radiumforschung in Vienna from 1910 to 1938, encouraged many women physicists, including Blau and several of her students and collaborators. Meyer lost his position after the Germans occupied Vienna. (Courtesy of Central Library for Physics in Vienna.)

larger energies that penetrated the emulsion. Interpreting the event was difficult, but two features were clear. First, the particle causing the star had to be from the cosmic rays because its energy far exceeded those from known radioactive decays. Second, the destroyed nucleus must have been one of the heavier elements of the emulsion because it had to have begun with a charge of at least 9; the most likely candidates were bromine and silver. Third, the authors pointed out that other physicists had found a single case of disintegration in a cloud chamber, but no one previously had ever actually seen the center of disintegration. Immediately, Blau and Wambacher began trying new experiments, adding thin layers of different materials above the emulsion to see whether stars formed differently when other nuclei were the targets, exposing film at different altitudes to probe the effects of cosmic radiation at varied heights, and sending emulsion samples high into the atmosphere with balloons.

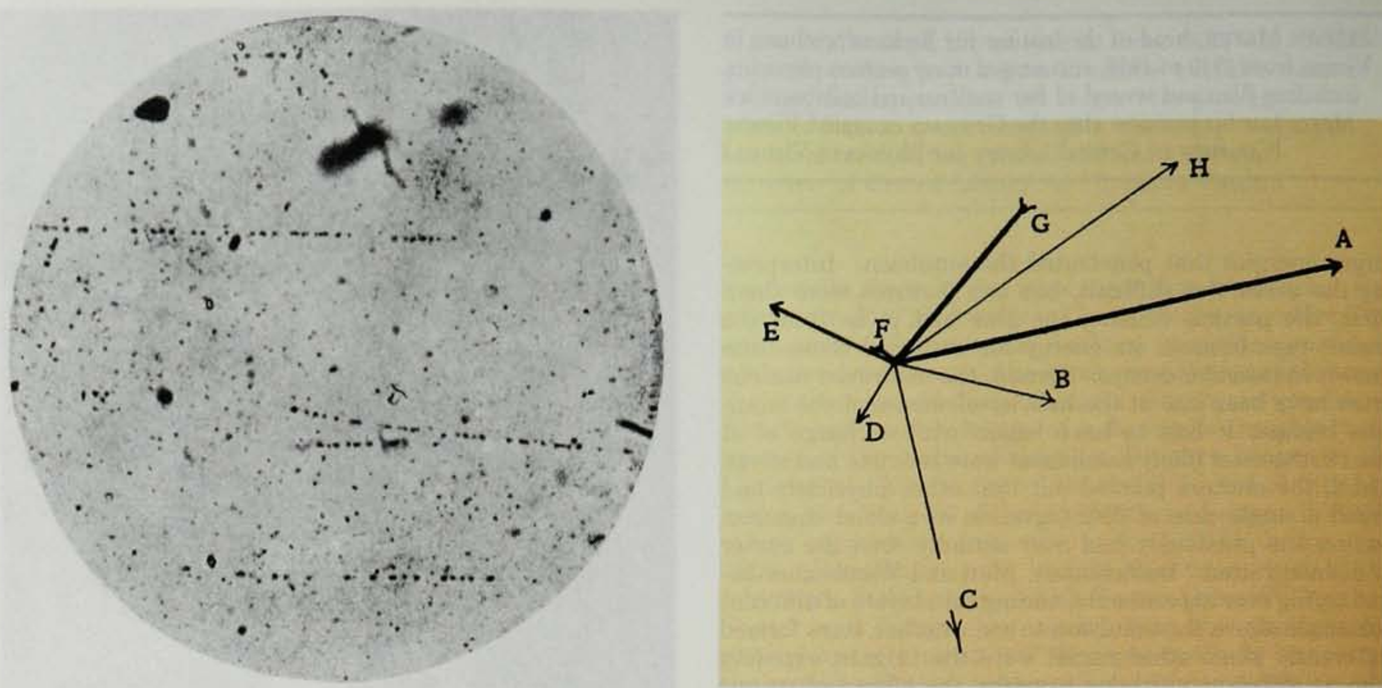
After the *Anschluss*

For one brief moment Blau was at the peak of her career. She had a film prepared in such a way and exposed at such a height as to give her an advantage over virtually all competitors. The golden moment ended abruptly with the rapidly deteriorating political situation. Suddenly Wambacher, one-time student and subordinate, had the upper hand over her former advisor.

On Friday, 11 March 1938, the Germans entered Vienna. Blau fled first to Oslo, at the invitation of Ellen Gleditsch (to work at the Institute for Organic Chemistry). Then, desperate to find another home and to rescue her mother from Vienna,[12] she began exploring the possibility of getting to Mexico. She was, as she wrote in one only partly preserved letter, "obviously ready to do not only scientific work, but whatever is needed for the country"—which might include, for example, geological work, spectral studies of ores or even further work on x rays. With the recommendation of Einstein,[13] Blau moved (in November 1938) to Mexico City, where she became a professor of physics at the Polytechnic School. From there, as she told Einstein, she gave a series of successful lectures at a provincial university (in Morelia). There, it seems, she deeply impressed the rector of the school, whose pride in the institution had been manifest when he went to the United States to purchase the makings of a laboratory. For want of a scientist, the equipment still stood in cases, and the rector was pleased to invite Blau to set it up. Excited by the prospect of working again, Blau had first to finish a stint teaching in Mexico City, no trivial matter since each week she had some 24 hours of lectures to deliver. Unfortunately, by the time she finished, the apparatus in Morelia had vanished, only to reappear shortly thereafter in a pawn shop. Stymied by events and frustrated by three years of isolation from physics, she pleaded for an intervention from Einstein so that she might at least do something in geophysics or a related field. "If one would simply let me work," she pleaded, "I could prove, at least to the best of my abilities, that an emigrant can be more than a useless burden." Einstein did oblige in a letter of 24 June 1941 to the Mexican ambassador to the United States.[14]



HERTHA WAMBACHER worked with Blau on perfecting the emulsion technique. The collaboration, between an ardent Nazi and a Jew, must have been an uneasy one. (Courtesy of Central Library for Physics in Vienna.)



A NUCLEAR 'STAR' (left) captured by Blau and Wambacher in 70 μm thick emulsion that was exposed on a mountain peak near Innsbruck. Because of the angles of the tracks, only some are in focus in the image. The diagram at right shows the star's eight tracks; thick lines indicate a large number of grains per unit length of the track, and the interrupted line means that the track is too long to be reproduced on the same scale. The arrows indicate the direction from the surface of the emulsion to the glass. (From ref. 11.)

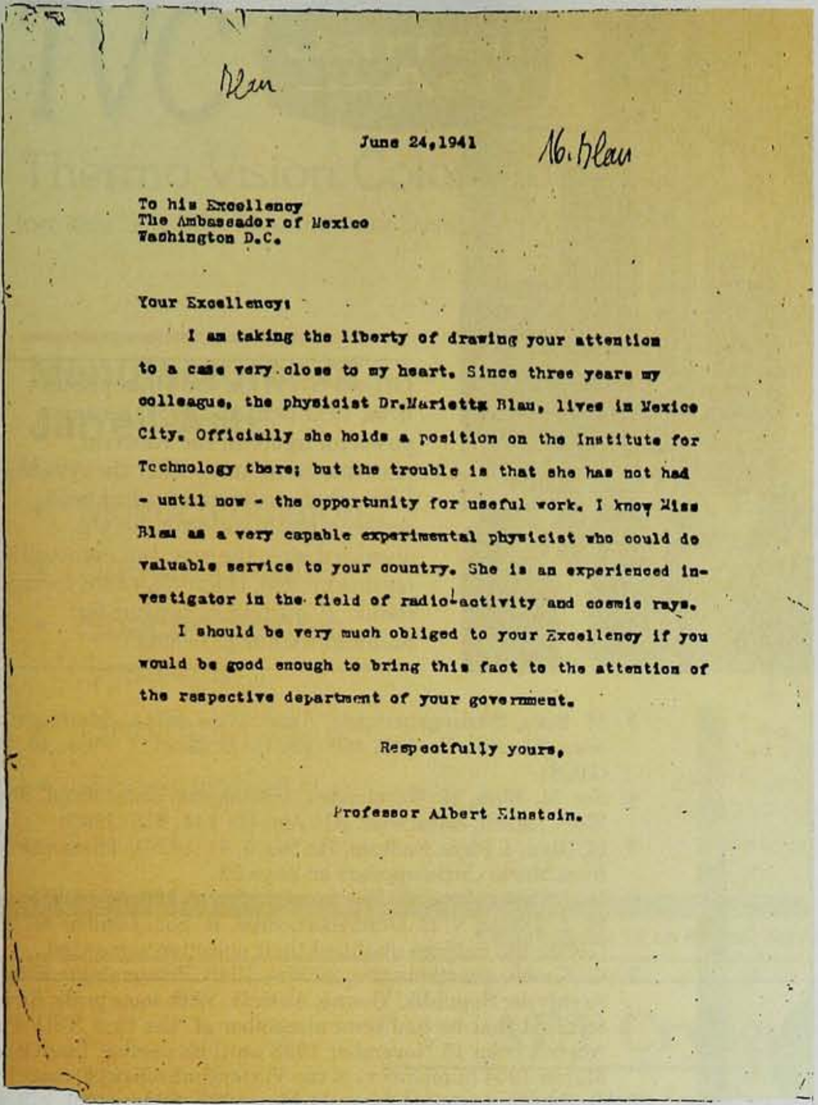
In May 1944, Blau moved north to New York City, where she took a position with the Canadian Radium and Uranium Corporation and the International Rare Metals Refinery.[15] With the war over, the newly established Atomic Energy Commission (AEC) set Blau up at Columbia University as a research physicist; the AEC then moved her in 1950 to its Brookhaven National Laboratory, which was just then turning to high energy work. Among other results that Blau obtained there with her emulsions was the first demonstration that accelerator-produced mesons could produce more mesons.[16] In further work, she contributed to the design of scintillation counters, while her main research continued to be with emulsions.[17] Although Brookhaven initially seemed congenial, even that resting spot did not last, as personal friction with some staff members, coupled with dire financial difficulties and health problems, led Blau back to Vienna in 1960. Constantly on the move, Blau was nowhere long enough to become fully visible to the world of physics.

The fate of the Nazis

Wambacher and Stetter did well indeed during the war and continued to publish in the field of photographic emulsions. According to a friend and colleague of Blau's, Leopold Halpern, after the war Blau told him that as she was leaving Germany from Hamburg in 1938, her zeppelin was forced down and all her scientific notebooks stolen by the Gestapo. Apparently the Nazis knew precisely the object of their search, dismissing her once they had found the crucial papers. What happened to those notebooks has never been clear. Blau, according to Halpern, believed that they ended up back in the hands of her old colleagues at the Institut für Radiumforschung in Vienna. Although we may never be able to confirm this, we can know something of Wambacher's attitudes in the years of Nazi rule. Writing to the Nazi membership division, Wambacher was incensed:

> I have been an applicant for party membership since June 1934. . . . [A]s you can tell by inquiring to Circle IX, my status as party applicant has been in good order even when it was illegal [to join the party]. . . .
>
> In May 1940 I suddenly received a form according to which my application request had been refused! The form consisted of a printed slip, evidently used for many cases, and contained no indication of the grounds for my refusal; I was "free" then in 1940, once again to apply that is to say together with all those characterless, previously hostile riffraff who exploited the economic "boom" of 1940!
>
> According to word of mouth in the *Ortsgruppe* there is a large number of upstanding illegal Nazis being subjected to this shocking and totally unnational-socialistic treatment. Obviously I have not let myself be subjected to this *Schweinerei* and turned first to the bureau for membership in Vienna; there I received the verbal information that my case was in no way unique. . . .
>
> I intend to pursue these matters through all stages of appeal right up to the chancellery of the Führer, especially since I see that I am not alone. . . . Heil Hitler![18]

With the Nazis' many successes, right-thinking National Socialist physicists had two ordinary and two extraordinary chairs to fill in Vienna, positions freed, as one report put it delicately, "by the departure of the Jewish professors Meyer, Ehrenhaft, Przibram and Kottler."[19] (Blau's departure from her minor position left few spoils.) It was a bit awkward bureaucratically to appoint docents from the same university to such major positions, and Ortner, for example, had hardly been a rising star. Ranked as "extraordinary assistant" since 1924, Ortner's docentship was renewed periodically through 1934, a long enough span that some explanation was demanded: He was, as one official explained it, in "full mastery of complicated radioactive measurement methods," while Professors Przibram and Jaeger had been overburdened. Faint praise. Stetter likewise had been an "extraordinary assistant" for quite some time; at the Second Physical



Blau

June 24,1941 M. Blau

To his Excellency
The Ambassador of Mexico
Washington D.C.

Your Excellency:

I am taking the liberty of drawing your attention to a case very close to my heart. Since three years my colleague, the physicist Dr.Marietta Blau, lives in Mexico City. Officially she holds a position on the Institute for Technology there; but the trouble is that she has not had - until now - the opportunity for useful work. I know Miss Blau as a very capable experimental physicist who could do valuable service to your country. She is an experienced investigator in the field of radio-activity and cosmic rays.

I should be very much obliged to your Excellency if you would be good enough to bring this fact to the attention of the respective department of your government.

Respectfully yours,

Professor Albert Einstein.

ALBERT EINSTEIN helped Blau find a position in Mexico in 1938, after she fled Vienna. Later, he wrote to the Mexican ambassador to the US, to ask that Blau be given more suitable work as a scientist. (Courtesy of Albert Einstein Archives, Hebrew University of Jerusalem, Israel.)

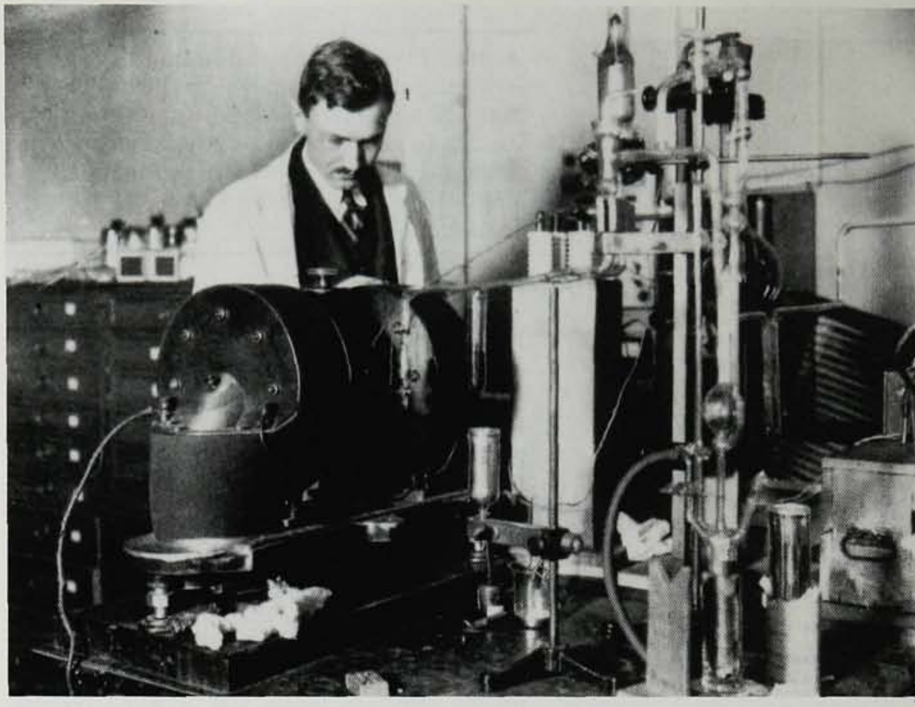
Institute since November 1922, he was renewed for the next 15 years or so. Kirsch too had been professionally slow to advance before the German army entered Vienna. After some discussion back and forth, Stetter was proposed for *Ordinarius*, Kirsch for *Ordinarius* and Ortner for *Extraordinarius* professorships. The Academy resolved simultaneously to name Ortner chair of the Institut für Radiumforschung . . . .

[The end of the war had predictable consequences for Stetter, Wambacher, Ortner and Kirsch: As members of the Nazi Party, they were booted unceremoniously from office. Then the wheels of rehabilitation began turning. Stetter's prior protestations of having been an early and avid supporter of the party dissipated, and he recycled himself into a casual Nazi who had protected Stefan Meyer and H. Thirring (though even after the war, Stetter still reckoned there was a "Jewish style" in physics). Using a technicality, the district captaincy demonstrated that Stetter was not actually a Nazi at all, allowing him, in 1953, to advance to a professorship. Ortner too protested his dismissal on the grounds that he had not understood where his party dues had been going. Rehabilitated, he rose through the Austrian system and was welcomed into the international atomic energy establishment, gaining access to Harwell, Argonne, Batelle Memorial Laboratory, Brookhaven, Berkeley and General Atomics. By 1960, he was head of a new institute and an *Ordinarius* Professor of Technical Physics at the Technische Hochschule. In Kirsch's case, it took just 26 months for his dismissal to be commuted to a retirement. Of the four physicists, the sole casualty of the peace was Hertha Wambacher. The only woman in the group, and its least powerful member, she was 42 when the war ended, and unlike her male colleagues, she was not brought back up through the ranks. Wambacher published a single article between 1946 and her death in 1950.]

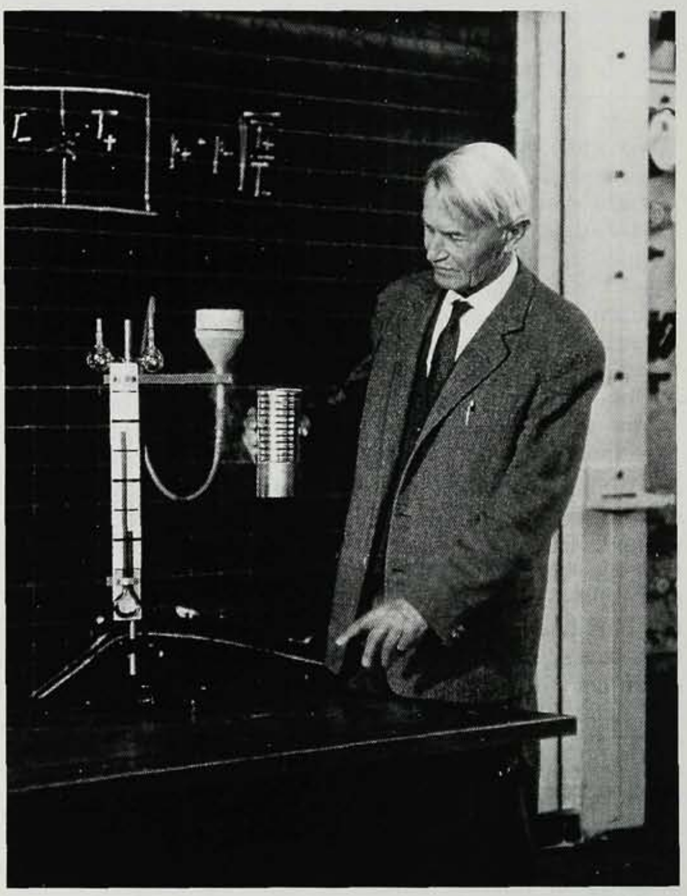
The final years in Vienna

By the end of the war, Marietta Blau had moved some ten times, lost all her scientific papers and notebooks and still had no clear path to a permanent position. Wherever she went, the relatively inexpensive emulsions gave her a kind of replaceable laboratory, from the mountains of Austria to the halls of the Institut für Radiumforschung, from Mexico City to Brookhaven. Unlike a cyclotron or even an electronic apparatus, the emulsion was an instrument well suited, however awkward its images, to those on the margin. With a box of Ilford halftone photographic plates, the use of a microscope and some desktop chemicals, atomic disintegrations, neutron dynamics and radioactive decays could be studied and brought to the pages of *Nature*, *Zeitschrift für Physik* or the *Mitteilungen aus dem Institut für Radiumforschung*. But while the method worked (to a certain extent) for the nomad, institutions still held the power to locate evidence amid the noise, and to orchestrate the cross-checking of novelties among different observers. Cut off from her former colleagues in Vienna, Blau was not part of a network of collaborators in film production, film testing and interpretation of events. Isolated, she spun ever farther from the center.

After Blau's return to Vienna in 1960, several physicists tried to gather funds for her. Erwin Schrödinger put her up for the Schrödinger Prize (which she won), and twice for the Nobel Prize, to no avail.[20] And Halpern, through Otto Frisch, tried to convince the big film companies to grant her a sinecure in recognition of the minor industry of nuclear emulsions that she helped create. Ilford responded this way: "[O]n the assumption that from all sources a worthwhile contribution to her future welfare will be forthcoming[,] Kodak Limited and ourselves would each be willing to contribute £100 per annum." Her pride still with her, Blau thanked Frisch in 1964 for his kind efforts and reiterated her gratitude to Ilford. But in the end she declined despite her poverty: "[F]or various reasons I believe that it [the consulting job with no real duties] could not be done in this way. I also want to thank all colle[a]g[u]es who have thought about, how to help me. In this connection I wish to tell you that I do not suffer any material hardship because one of my brothers is well situated and very willing to help me, if I can not manage



GEORG STETTER, shown in photos from 1933 (left) and 1958, became a powerful figure in the Austrian scientific community after the *Anschluss*. Like other scientists who had been active in the Nazi Party, he was dismissed after the war, but eventually regained much, if not all, of his former status. (Courtesy of Institut für Radiumforschung, Vienna.)



alone." Blau died five years after her last letter to Frisch, poor and virtually unknown outside the small world of the first-generation emulsion physicists.

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14. Letter from M. Blau to A. Einstein, Albert Einstein Papers, documents 54-835-1 and 2, Princeton U. Libraries, Princeton, N. J. Letter from A. Einstein to the Mexican ambassador to the US, Albert Einstein Papers, document 54-837, Princeton U. Libraries, Princeton, N. J.
15. M. Blau, B. Dreyfus, Rev. Sci. Instrum. **16**, 245 (1945). M. Blau, I. Feuer, J. Opt. Soc. Am. **36**, 576 (1946).
16. See, for example, M. Blau, M. Caulton, J. Smith, Phys. Rev. **92**, 516 (1953).
17. M. Blau, Phys. Rev. **75**, 279 (1949). M. Blau, M. Caulton, Phys. Rev. **96**, 150 (1954).
18. Letter from H. Wambacher to NSDAP, Reichsleitung München, Amt für Mitgliedschaftswesen, 24 January 1942, Archiv der Republik, Vienna, Austria.
19. An excellent secondary source for information on the fate of academics dismissed from the Institut für Radiumforschung and other Austrian institutions of higher learning can be found in F. Stadler, *Vertriebene Vernunft II: Emigration und Exil Österreichischer Wissenschaft*, Jugend und Volk, Vienna, Austria (1988).
20. W. J. Moore, *Schrödinger, Life and Thought*, Cambridge U. P., Cambridge, England (1988), pp. 479–80. ■