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VICTOR FREDERICK WEISSKOPF
1908–2002

A Biographical Memoir by

J. DAVID JACKSON AND KURT GOTTFRIED

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Victor F. Weisskopf

VICTOR FREDERICK WEISSKOPF

September 19, 1908–April 22, 2002

BY J. DAVID JACKSON AND KURT GOTTFRIED

VICTOR FREDERICK WEISSKOPF was a major figure in the golden age of quantum mechanics, who made seminal contributions to the quantum theory of radiative transitions, the self-energy of the electron, the electrodynamic properties of the vacuum, and to the theory of nuclear reactions. In the broader arena through his writings and actions he was an effective advocate for international cooperation in science and human affairs. In 1981 he shared the Wolf Prize for physics with Freeman Dyson and Gerhard 't Hooft for "development and application of the quantum theory of fields." In 1991 he was awarded the Public Welfare Medal of the National Academy of Sciences "for a half-century of unflagging effort to humanize the goals of science, acquaint the world with the beneficial potential of nuclear technologies, and to safeguard it from the devastation of nuclear war." As a member of the Pontifical Academy of Sciences he was instrumental in persuading the Pope to speak on the dangers of nuclear weapons.

Weisskopf was born in Vienna, Austria, on September 19, 1908. In his nineties and increasingly frail, he died at home in Newton, Massachusetts, on April 22, 2002. Growing up in Vienna in a well-to-do Jewish family, he had a happy and carefree childhood despite the Great War. In his teens he attended a gymnasium and for two years the University of Vienna. He showed an early interest and ability in science. In 1928, upon the recommendation of Hans Thirring, professor of theoretical physics in Vienna, he moved at age 20 to Göttingen to continue his studies under Max Born. His first important paper, written with Eugene Wigner, was on the quantum theory of the breadth of spectral lines. After completing his Ph.D. thesis in the spring of 1931 he went to Leipzig to work under Werner Heisenberg and then in the spring term of 1932 under Erwin Schrödinger in Berlin. For the academic year 1932-33 he received a Rockefeller Fellowship to work in Copenhagen with Niels Bohr and in Cambridge with Paul Dirac.

In the fall of 1933 Weisskopf came to Zürich for two and a half years as Wolfgang Pauli's assistant. While there he published two important papers. The first was on the self-energy of the electron in the framework of Dirac's hole theory, in which he showed that the self-energy diverged only logarithmically with decreasing size of the electron's charge distribution, in contrast to the linear divergence of classical theory and the quadratic divergence of the one-particle Dirac theory. The second paper, coauthored with Pauli, concerned the quantum field theory of charged *scalar* particles (not the spin 1/2 particles of Dirac). They showed that antiparticles were not unique to the Dirac theory but occurred in general and that electrodynamic processes involving the scalar particles were closely similar to those involving spin 1/2 electrons.

In April 1936 Weisskopf accepted a fellowship at Bohr's institute in Copenhagen. While there he completed an impressive analysis of the properties of the vacuum in the presence of electromagnetic fields, clarifying earlier work, giving physical arguments for the removal of certain infinities, and presciently enunciating the concept of charge renormalization. With the increasing persecution of Jews in Nazi Germany and the prospect of war, he and his wife decided to look for ways to escape Western Europe. To enhance his chances Weisskopf began to work in the increasingly important field of nuclear physics, which occupied many at Bohr's institute, and to publish in English. Although he had job offers from the Soviet Union, after a visit in late 1936 he and his wife decided that he would consider them only as a last resort. With Bohr's help he was offered a lectureship at the University of Rochester beginning in the fall of 1937.

He was on the Rochester faculty for five and one-half years. During that time he continued research in nuclear physics but also on the electrodynamics of the electron. He returned to the self-energy problem and in 1939 established a result little appreciated at the time or now: that in the *n*th order of perturbation theory the self-energy diverges only as the *n*th power of a logarithm.

In early 1943 Weisskopf was invited to Los Alamos, where he soon became Hans Bethe's deputy in the theoretical physics group. Already famous for his physical intuition, he was much sought after by the experimenters to provide estimates of little known or little understood nuclear processes. He served for a time as mayor of Los Alamos, evidence of his humanity and social responsibility.

In early 1946 he joined the physics faculty at the Massachusetts Institute of Technology, where with one substantial break he remained until retirement in 1974. His researches at MIT focused on nuclear reactions, with one major paper with J. Bruce French on a complete calculation of the leading radiative correction to atomic energy levels (the Lamb shift). The nuclear physics work was done mainly in collaboration with Herman Feshbach, sometimes augmented by students and postdocs. These papers are marked by their clarity, the simplicity of the assumptions, and their close connection to experiment. Together with John Blatt he authored an influential text on theoretical nuclear physics, published in 1952. That same year he was elected a member of the National Academy of Sciences.

In 1961 at the apex of his career as an academic researcher Weisskopf was invited to be director general of CERN, the European center for high-energy physics near Geneva, Switzerland. For CERN it was an inspired choice. Weisskopf provided intellectual leadership and a vision of the laboratory as an international research center second to none. He successfully promoted construction of the first proton-proton collider, the intersecting storage rings, and saw to the eventual building of a 300-GeV accelerator. He set CERN on its path to be a preeminent, some would say the preeminent, research center in high-energy physics today.

At the end of his five-year term he returned to MIT, where he was named Institute Professor and chaired the Physics Department for six years (1967-73). During these years he pursued occasional research, but devoted increasing fractions of his time to writing, invited lectures, and public service. He published popular expositions of science, collections of essays on science, science in public affairs and scientific personalities, and his autobiography. After retirement he continued writing and giving informal talks to explain the wonders of science to the lay public.

From near the end of the Second World War Weisskopf was active in discussion of the promise of nuclear energy and the dangers of nuclear weapons. He was among the founders of the Federation of Atomic Scientists, a member of the Emergency Committee of Atomic Scientists chaired by Albert Einstein, and a participant in the early Pugwash meetings.

Weisskopf served as president of the American Physical Society in 1960. He was elected to numerous learned societies in addition to the National Academy of Sciences and received many honorary degrees. He received several prizes and medals, including the Max Planck Medal in 1956, the National Medal of Science in 1980, and the already noted Wolf Prize in 1981 and the Public Welfare Medal in 1991.

EARLY YEARS

Viki (the nickname by which he was universally known) Weisskopf was the second of three children born into a comfortably middle-class Jewish family. His father, Emil, originally from Czechoslovakia, was a successful lawyer; his mother, Martha, was from an upper-middle-class nonobservant Jewish Viennese family. The family saw to it that young Victor and his siblings were exposed to the rich cultural offerings of Vienna—concerts, the opera, theater—with summers at Altaussee. He studied the piano and developed a lifelong love of music. In his late teens he even considered seriously becoming a professional musician. He attended a progressive elementary school and then a gymnasium. There his interest in science, especially astronomy and physics, flourished.

While at their summer home in Altaussee southeast of Salzburg in August 1923, Viki and friend George Winter spent several hours on top of an 1,800-m peak, where they observed a total of 98 shooting stars of the annual Perseid shower, which they classified as to color and appearance. The results of their investigation were published in *Astronomische Nachrichten* (1924). It is not many of us who can claim a first research publication at age 15 and a half!

At the gymnasium participation in youth groups was the norm; Viki joined the young socialists and in 1926 took part in performances of political satire in Vienna cabarets. For two years he attended the University of Vienna, where he found inspiration in Hans Thirring's lectures in classical theoretical physics. Thirring, sensing Weisskopf's exceptional abilities and knowing that Vienna was not in the forefront in modern physics, recommended that he transfer to Göttingen for further studies. Göttingen at that time was the Mecca of theoretical physics, where Heisenberg, Born, and Jordan had invented quantum mechanics in 1925-26.

GÖTTINGEN

At Göttingen Viki became a doctoral student of Max Born, the professor of theoretical physics. In his autobiography[1] Born remembers the young man.

> Another member of my group of research students was Victor Weisskopf, who came from Vienna. He was at first very timid, and several times came near to giving up theoretical physics when he made a blunder in his reasoning. But I encouraged him and succeeded in keeping him on his path.

Viki's insecurity over his potential for mistakes came to the surface from time to time throughout his career, as we note below.

Born's duties and poor health left Viki largely on his own. After learning quantum mechanics from Gerhard Herzberg, Viki embarked on research on the interaction of radiation with matter, a broad subject of central importance and one to which Weisskopf would make major contributions. He attacked his first unsolved problem: the natural width of spectral lines in emission of radiation by atoms. He was able to make progress on a two-level quantum system but not beyond. He sought help from Eugene Wigner, who was then in Berlin but who came back to Göttingen for regular visits. Wigner became Viki's mentor and the collaboration led to two papers. The first, most important paper (1930) treats the exponential decay of excited atomic states and the natural breadth of the associated spectral lines for all types of transitions. In contrast to the semiclassical result where an intense line was necessarily broad and a weak line narrow, the quantum theory accommodates the occasional puzzling broad but weak line.

His doctoral thesis (1931) described the application of the theory to resonance fluorescence, the absorption and re-emission of light by atoms. The thesis has had considerable impact in atomic spectroscopy over the years.[2]

POSTDOCTORAL YEARS

In the years 1931-37 Viki had the most remarkable of postdoc careers, first with Heisenberg in Leipzig, then Schrödinger in Berlin, Bohr in Copenhagen, Pauli in Zürich, and then Bohr again. This history speaks not only to how Viki's talents and promise were judged by the leaders of theoretical physics but also to the scarcity of long-term positions during the Great Depression. The job shortage was greatly compounded for Viki by the exclusion of Jews from numerous academic posts in Germany after the Nazis came to power in 1933. Rockefeller fellowships and Bohr's hospitality in Copenhagen played central roles for temporary opportunity and sustenance for many.

As a new Ph.D. Viki went first to Leipzig, funded by his family, to work with Heisenberg. At Christmas 1931 Schrödinger invited him to Berlin for the spring term to be his *Assistent* in Fritz London's temporary absence. As he told one of us (K.G.) late in life, Schrödinger would sometimes telephone shortly before he was to lecture and ask Viki to substitute, which Viki so many decades later acknowledged with boyish embarrassment as having been occasioned by the professor's assignations. Schrödinger showed another side by arranging a one-year Rockefeller Fellowship for Viki to begin in the fall of 1932. For the long summer period Viki and his current girl friend went to Kharkov in the Soviet Union, where Lev Landau was. This was the first of several trips to the Soviet Union, trips that both opened his eyes to the evils of the regime and made friendships with Soviet scientists that were useful in different ways later in his life.

During his postdoc period Viki developed close friendships with many young colleagues who were rapidly becoming prominent physicists, especially Patrick Blackett, Felix Bloch, Hendrik Casimir, Rudolf Peierls, and George Placzek, as well as Max Delbrück, who left quantum field theory to become a great pioneer in molecular biology. And in 1932 on his second day in Copenhagen Viki met Ellen Tvede, who was soon to be his wife and constant companion until her death in 1989. By this time Viki seemed to have lost the shyness remarked on by Born. In his reminiscences[3] Hendrik Casimir notes that in Copenhagen Viki participated in the entertainments at Bohr Institute conferences by "provid[ing] both poetry and song" and by taking the role of the Dalai Lama.

Three central problems of quantum electrodynamics (QED) were the focus of Viki's research during his postdoctoral period: the role of antiparticles, the self-energy of the electron, and the properties of the vacuum in QED. The puzzling negative energy solutions of Dirac's amazingly successful relativistic wave equation were in 1932 proposed by Dirac to correspond to antiparticles of the same mass as the electron but of opposite charge, an interpretation that was highly controversial. Nevertheless, such particles were discovered in cosmic-ray experiments later that year, but that these objects were indeed Dirac's antiparticles was not clear for some time. Meanwhile the description of the self-energy of the electron using Dirac's electrons alone (positive energy solutions only) led to a badly divergent result.

Understanding of both these problems was greatly advanced in two papers written during Viki's two and a half years as Pauli's *Assistent* in Zürich (fall 1933-spring 1936). At Pauli's suggestion Viki computed the electron's self-energy in perturbation theory, including both electrons and positrons. In doing this calculation Viki made a sign error, which was quickly pointed out by Wendell Furry; when this was taken into account, the result was a self-energy that diverged logarithmically as the electron's radius *a* tended to zero (1934).[4] This was an astonishing result: Classical electrodynamics was long known to produce a linear divergence, and the one-particle version of QED, already mentioned, yielded a quadratically divergent self-energy. The "soft" logarithmic divergence of QED with electrons and positrons was a first indication that QED might be made a tractable theory.

Viki was very discouraged by his error in the self-energy calculation, which exacerbated his lack of mathematical self-confidence. "[I] told Pauli that I wanted to give up physics, that I would never survive this blemish on my professional record." (1991, p. 80). Pauli, like Born before, urged him not to take it too hard, that it would not end his career. And so it proved.

The second Zürich paper, written with Pauli, dealt with the quantization of the charged scalar field (1934).[4] At the time, this work was viewed as a purely theoretical exercise for no "elementary'' spin zero particle was known. It was, however, an exercise that taught an important lesson, because it demonstrated that antiparticles are not a peculiarity of Dirac's theory for spin 1/2 fermions but are also an inevitable feature of a quantum field theory for charged bosons. Furthermore, the Pauli-Weisskopf paper demonstrated that a marriage of relativity and quantum mechanics does not require spin 1/2 as many had incorrectly inferred from Dirac's theory, and that scalar QED gave results for physical processes similar to spin 1/2 QED. And with the advent of Hideki Yukawa's meson theory of nuclear forces, the scalar field theory became more than a setting-up exercise for theoreticians.

COPENHAGEN AGAIN

Viki had been very productive during his first year in Zurich, perhaps in part because he was alone. Ellen and he had agreed to test their love with a one-year separation. The test proved successful, and they were married in Copenhagen on September 4, 1934. During the remainder of his time in Zurich he continued to work on topics in electrodynamics, beginning with an investigation of the properties of the vacuum in QED. This line of study reached full fruition in Copenhagen in 1936, where he held a fellowship with Bohr (April 1936-September 1937). At the Bohr Institute nuclear physics was beginning to be emphasized in addition to basic problems in quantum mechanics and field theory. Of the stimulating atmosphere at the institute Viki says, "Influenced by this remarkable group, I wrote two of my best papers during that time." (1991, p. 95).

The first of these is a classic paper on the polarization of the vacuum caused by the virtual electron-positron pairs under the influence of a uniform electromagnetic field of arbitrary strength (1936).[4] Although this topic had already been studied, the earlier work was very formal and marked by ambiguities. Viki largely cleared these up in this investigation, the technically most sophisticated of his career. Especially noteworthy was his prescient recognition of charge renormalization, in which he exploited the analogy with a charge placed in a polarizable medium to conclude that vacuum polarization produces an unobservable (though infinite) constant factor multiplying all charges and electromagnetic field operators.

It had become clear to Viki by 1936 that an Austrian Jew had better leave Europe for the United States. This was far easier said than done, however, because there were hardly any positions available in the United States, or elsewhere for that matter, and many highly qualified physicists who anticipated a Nazi onslaught were competing for them. To further his chances Viki decided that he should publish something on the new rage (nuclear physics) and do so in English. He carried this off brilliantly with the second of his Copenhagen papers—an original application of statistical mechanics to the evaporation of neutrons from nuclei—and published his results in *Physical Review* (1937).

Viki's first opportunities to leave were a professorship in Kiev and a senior research position in Moscow. In late 1936 he and Ellen visited the Soviet Union and promptly realized that the political climate had deteriorated drastically since Viki's earlier visit to Russia. He would therefore only consider a position there if nothing else were available. In those years Bohr went regularly to England and America to "sell'' the refugees at his institute. In 1937 Bohr convinced the University of Rochester to offer Viki a poorly paid instructorship, which he accepted.

ROCHESTER AND LOS ALAMOS

In the fall of 1937 Viki began a new phase of his career with a new country, a new language, and a largely new field. In his five and a half years at Rochester, nuclear physics became a major focus of his research, with studies of Coulomb excitation[5] and radiative transitions (1941) being especially noteworthy. He continued to work on QED and published a remarkable paper addressing the self-energy problem in greater detail, but more significantly proving that the self-energy diverges logarithmically to all orders in perturbation theory (1939). This paper strengthened his result of 1934.

Fission was discovered in Berlin in December 1938, and on September 1, 1939, Germany invaded Poland. Nuclear physics was suddenly transformed from an esoteric intellectual pursuit into a potentially decisive factor in the war. Not being a citizen—indeed, an enemy alien until he and Ellen became U.S. citizens in 1943—Viki did not participate in secret war-related work until early 1943, when Robert Oppenheimer asked him to come to Los Alamos, where he remained until late in 1945.

No data were then available for many of the processes involved in producing a nuclear explosion or the ensuing effects. The bomb project had to rely on theorists for guidance on many fronts. Viki became a prominent member of the theoretical physics division: His office was known as "the seat of the oracle" in recognition of his ability to quickly devise qualitative solutions to physics problems. Hans Bethe, the division head, eventually needed support in running his expanding team and appointed Viki as his deputy. Because he had been in charge of the calculations about the effects of the bomb, Viki was one of the few theorists to witness the Trinity test at Alamogordo.

MIT AND QED AGAIN

In early 1946 Viki joined the faculty at MIT and during that fall began teaching and research again. With his student Bruce French he revisited the electron self-energy problem to explore an earlier suggestion of Hendrik Kramers that one might make sense of the higher-order radiative corrections in electrodynamics in spite of the infinity in the self-energy of the electron. Kramers had pointed out that what is actually observable is the energy difference between free and bound states of electrons. Viki's demonstration that the divergence is only logarithmic made it plausible that *differences* would be finite and meaningful. French and Weisskopf had not completed their calculation when, in June 1947, Willis Lamb announced the results of his microwave experiments on hydrogen, showing a tiny disagreement with existing theory, with a very small energy difference between two levels supposedly degenerate. Many theorists pounced on this result, which became known as the "Lamb shift." Bethe quickly showed in a nonrelativistic calculation with a cutoff that Kramer's idea led to a level shift close to that measured by Lamb. His work depended, however, on the plausible but unproven assumption that the logarithmic divergences at high energy exactly canceled.

By early 1948 French and Weisskopf completed the first consistent calculation of the Lamb shift, but Viki would not publish because they had a very small disagreement with the independent calculations of Richard Feynman and Julian Schwinger, who agreed with each other. Viki could not believe that his work with French was correct. Surely the two young geniuses who were using their new and much more powerful techniques had not made the same mistake. But they had! The upshot was that French and Weisskopf published their year-old result (1949) only after a paper by Kroll and Lamb appeared with essentially the same calculation.[6]

The Kroll-Lamb theory paper contains a succinct statement about Viki's place in the firmament of theoretical physics: "[Our] calculation," they wrote, "[is] based on the 1927-34 formulation of quantum electrodynamics due to Dirac, Heisenberg, Pauli, and Weisskopf." Despite or perhaps because of such praise, in his autobiography Viki indulges in self-criticism. He laments that he had not had the insight to pursue more diligently his 1936 work in which he realized that just the charge and mass of the electron were affected by the short-distance (high-frequency) divergences, that he and French did not work hard or fast enough to have made a *prediction* of the Lamb shift before its experimental observation, and that his fear of publishing a wrong result caused them to miss being the first to publish the correct result. His wistful "I might even have shared the Nobel Prize with Lamb" (1991, p. 169) sums up his view of what might have been. Such regrets aside, Weisskopf stands among the leaders of twentieth-century theoretical physics and a key player in the development of quantum electrodynamics and field theory in the 1930s and 1940s, as was recognized by the Wolf Prize in 1981.

NUCLEAR PHYSICS

Viki often derided his own technical abilities in theoretical physics. He once said he was contributing his "don't know how" to a collaborative effort. But he was justifiably proud of his remarkable ability to arrive at results by intuition, by exploiting basic principles and making educated guesses. In this regard he would express his gratitude to Paul Ehrenfest, who had been a charismatic visitor to Göttingen when Viki was a student. But as is true of other masters of the intuitive argument, Viki acquired his magical ability by having devoted his youth to technically difficult calculations. As with the great pianist who can improvise so effortlessly, an enormous amount of hard, tedious work lies behind the magic.

Nothing illustrates better his talent of focusing on the essential physics with simple intuitive descriptions than his work in nuclear physics, his primary interest in the postwar period. In this research he found the perfect collaborator in Herman Feshbach. Together and with students and postdocs they published a series of papers on nuclear reactions that are noteworthy for the clarity, plausibility, and simplicity of their assumptions (1947, 1949). In addition to his own research he produced his *magnum opus*, the treatise on nuclear physics written in collaboration with John Blatt (1952). This became the bible for several generations of nuclear theorists.

The most influential paper of this period was with Feshbach and Charles Porter (1954). It describes the total and elastic scattering cross section of neutrons (averaged over individual resonances) through a seemingly incompatible blend of the single-particle shell model and Bohr's concept of the compound nucleus. A vast amount of data is described remarkably well with this approach. In a little known paper Francis Friedman and Viki explored the compatibility of the single-particle and compound nucleus pictures with a masterful mixture of qualitative and quantitative arguments (1955).

DIRECTOR GENERAL OF CERN

By the late 1950s Viki was at the apex of his research career. He was elected president of the American Physical Society for 1960. In 1961 his appointment as director general of the European Organization for Nuclear Research (CERN) near Geneva suddenly transformed Viki from an academic research scientist heading a handful of colleagues and students into the chief executive of a young, large, and burgeoning multinational enterprise. Having seen Oppenheimer succeed in a similar if much more dramatic metamorphosis, Viki saw fit to tell the CERN Council in his "job interview" that not only did he have no administrative experience but "I consider this my strength." Apparently it was, for he proved to be an inspiring and imaginative leader of the laboratory, and a skillful diplomat in the complex political setting in which CERN is governed and funded.

When Viki took over as director general, CERN had a successful research program in nuclear physics with its synchrocyclotron, but only the beginnings of a high-energy physics program. Envisioning CERN as a world-class high-energy physics laboratory, Viki in his first address to the CERN Council at the end of 1961 outlined plans for the innovative intersecting storage rings (ISR) to be fed by the new 20-GeV proton synchrotron, and also spoke of a future 300-GeV accelerator. During his tenure as director general the number of staff and participants more than doubled to 2,500. The laboratory began to make major discoveries. The proposals for the ISR and a 300-GeV machine led to the formation of an internal committee to assess priorities and costs, which grew by 1966 into the European Committee on Future Accelerators. By the end of Viki's term in December 1965 the ISR had become a reality, as the CERN Council funded its construction and also R&D for a 300-GeV accelerator.

At CERN Viki is also remembered for his nighttime visits to the experimental halls and his down-to-earth seminars on particle theory for experimental physicists. A significant factor in Viki's decision to seek the CERN position had been his desire to learn particle physics—a rather extravagant measure for satisfying so modest a wish, but quite typical of him. This motive charged his many educational activities at CERN with an inspiring enthusiasm.

Viki's controversial championing of the ISR, the world's first proton-proton collider, and also of the 300-GeV machine set the tone and spirit of European high-energy physics as a serious competitor to the United States, until then the dominant player in the field, with long-lasting significance for physics everywhere. After returning from Europe

Viki recommended the formation of the influential High Energy Physics Advisory Panel to the Atomic Energy Commission (later the Department of Energy), and was the first HEPAP chair.

RETURN TO MIT

On returning to MIT Viki served as department chair for six years and engaged in intermittent research on particle physics with junior colleagues. Numerous honors came his way—the Max Planck Medal (1956), MIT Institute Professor (1966), Pontifical Academy of Sciences (1975), Ordens Pour le mérite für Wissenschaften und Künste (1978), the National Medal of Science (1980), the Wolf Prize (1981), the Enrico Fermi Award (1988), the Public Welfare Medal of the National Academy of Sciences (1991), as well as many honorary degrees and foreign memberships to prestigious academies. He served for four years as president of the American Academy of Arts and Sciences during a crucial period of consolidation. Along the way he authored a number of books and collection of essays, including his autobiography and coauthored (with one of the present authors, K.G.) a two-volume work *Concepts of Particle Physics* (1984, 1986) that had its origins in popular lectures to summer students at CERN. He reached mandatory retirement in 1974 and became professor emeritus.

CONCERNED SCIENTIST

The threat to humanity posed by nuclear weapons was a preoccupation of Viki's ever since he participated in the discussions initiated by Niels Bohr at Los Alamos before the Trinity test. After the war Viki was among the Manhattan Project scientists who organized what became the Federation of American Scientists. At that time he was also a member of the small committee chaired by Einstein that sought to inform the public about the bomb. In the 1950s Viki participated in the first Pugwash meetings between Western and Soviet nuclear scientists, and continued thereafter to reach out to influential Soviet scientists in pursuit of nuclear arms control. His friendships from the 1930s were of great advantage. Viki joined the Union of Concerned Scientists when it was founded in the MIT physics department, which he then chaired, and he later became a member of its Board of Directors. After his election in 1975 to the Pontifical Academy of Sciences Viki played a central role in convincing Pope John Paul II to speak out repeatedly against the nuclear arms race.

Viki worked incessantly for control and reduction of nuclear weapons and for international cooperation in science. At CERN he encouraged the reciprocal participation of CERN and Soviet-block physicists in each other's high-energy physics programs. He believed deeply in the role of science and scientists in making the world a more peaceful and safer place.

> Science is a truly human concern; its concepts and language are the same for all human beings. It transcends any cultural and political boundaries. Scientists understand each other immediately when they talk about their scientific problems; it is therefore easier for them to speak to each other on political or cultural questions and problems about which they may have divergent opinions. The scientific community serves as a bridge across boundaries, as a spearhead of international understanding (1989, pp. 7-8).

TEACHING AND STUDENTS

Not only was Viki a research scientist, administrator, humanist and internationalist, he was also a wonderful teacher and mentor to aspiring physicists. His deep understanding of fundamental principles and his intuition as to what was essential made his formal lecture courses inspirational, despite his well-known cavalier attitude about pedagogic precision (4π was often approximated by unity, for example). During his summers at CERN after being director general he initiated immensely popular introductory lectures on particle physics for the summer students, also attended by many CERN staff. The authors and others continued the tradition; a two-volume work (1984, 1986), already mentioned, was an outgrowth.

Teaching also included direction of research, of course. Among students at Rochester formally under Viki's supervision were Esther M. Conwell (M.S., 1944) and Ernest D. Courant (M.S., 1942; Ph.D., 1943); Robert Dicke and John Marshall, Jr., acknowledge their indebtedness to him in their theses. At MIT Viki had 21 Ph.D. students, among them the present authors, a Nobel laureate, and MIT faculty colleagues.[7]

MUSIC

Viki's love affair with the piano and classical music persisted through his whole life. In his autobiography half of the final chapter ("Mozart, Quantum Mechanics, and a Better World") is devoted to discussion of his loves in music, both as a listener and a participant. His musical companions recognized him as an enthusiastic pianist with a deep appreciation for Beethoven, Mozart, Schubert, and other classical composers. That music was an integral part of his being is illustrated by a story told by Maurice Jacob of Viki at a public scientific lecture in Paris.[8] Trouble with the sound system caused a few minutes delay. As he waited to begin Viki noticed a grand piano in the corner of the stage, went over to it, sat down, and began to play. The audience was enchanted.

CODA

A sketch of Viki that is confined to his career, even though it was so complex and productive, would only paint the palest shadow of the man. What was really unique about Viki was his vibrant personality. He conveyed an infectious happiness—as he put it, "I have lived a happy life in a dreadful century!"—for had he not seen Hitler and Stalin in action and witnessed the first engineered nuclear explosion? He maintained this happy disposition even under difficult circumstances, as when he spent his early months as CERN director in a Boston hospital suspended in an orthopedic contraption following an auto accident in Geneva.

Viki's almost tangible happiness was not just a signature of his own personality but was in large measure due to his good fortune in having found two wonderful women to accompany him through life: Ellen Tvede, his wife for 55 years until her death in 1989, and Duscha Scott, his second wife, who gave him joy and vital support in his final decade. Ellen and Viki had two children after coming to the United States: Thomas E. Weisskopf, professor of economics at the University of Michigan, Ann Arbor, and Karen Worth, senior scientist, Center for Science Education at Education Development Center, Inc., Newton, Massachusetts.

Victor Weisskopf combined in himself two traits that are often in conflict and rarely coexist so harmoniously: On one side the sentimental and the romantic, on the other the rigorous intellectual discipline and judgment. As he liked to say, his favorite occupations were Mozart and quantum mechanics. He called his popular and wide-ranging exposition of science *Knowledge and Wonder* (1962). In giving talks to lay audiences about cosmology he often played the part of Haydn's *Creation* that accompanies the words "And there was light." Viki exemplified the vitality and imagination that produced one of history's great intellectual revolutions, and gave it a human face.

NOTES

We acknowledge our debt to Viki's autobiography for many factual details. On technical and other matters we have lifted unashamedly (with official or tacit permission) from our own writings about Viki in other venues.[9] We thank the departments of physics at the Massachusetts Institute of Technology and the University or Rochester for assistance concerning Viki's students and other matters.

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7. In chronological order the Ph.D. students at MIT are David Henry Frisch (1947), George J. Yevick (1947), James Bruce French (1948), William Gartland Guindon (1948), David Chase Peaslee (1948), Francis Lee Friedman (1949), John David Jackson (1949), Joseph James Devaney (1950), Edward Joseph Kelly (1950), Murray Gell-Mann (1951), Kerson Huang (1953), Arthur Kent Kerman (1953), Charles Edwin Porter (1953), Harvey Jerome Amster (1954), Charles Leon Schwartz (1954), Kurt Gottfried (1955), Raymond Stora (1958), John Dirk Walecka (1958), Austin Lowrey (1960), and Gottfried T. Schappert (1961).
8. M. Jacob. Knowledge and wonder. In *Victor F. Weisskopf 1908-2002,* CERN Courier Commemorative Issue, December 2002, pp. 18-21.

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