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MARTIN J. KLEIN
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A Biographical Memoir by

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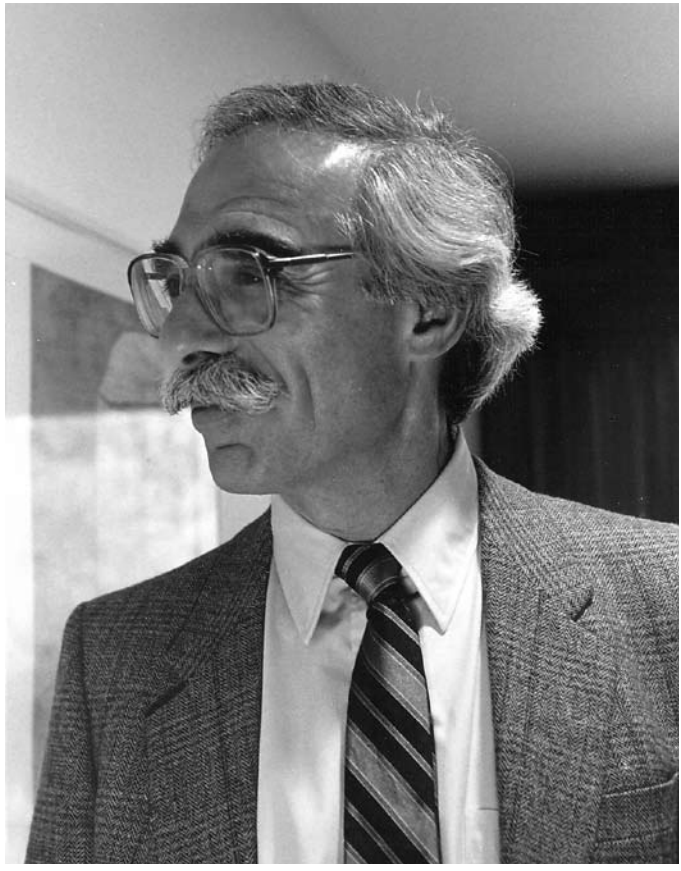
Biographical Memoir



Martin J. Klein

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June 25, 1924–March 28, 2009

BY DIANA KORMOS-BUCHWALD
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MARTIN JESSE KLEIN, PHYSICIST AND HISTORIAN, died on March 28, 2009, at his home in Chapel Hill, North Carolina. Known to many as "Marty," Klein was among the foremost historians of science worldwide, a beloved teacher, colleague, and friend, who in his many writings in the history of physics set an unparalleled model of deep, critical, and empathetic understanding of science and scientists.

Klein was born on June 25, 1924, in New York City, the only child of Adolph and Mary Klein, both schoolteachers. At age 14, Klein graduated from the James Monroe High School in the South Bronx, where he had struck up a lifelong, close friendship with Leon M. Lederman. Both became students at Columbia University, from which Klein graduated with a bachelor's degree in mathematics in 1942 and a master's degree in physics in 1944. "He was way younger than me; it was embarrassing," Lederman remembered. "He won most of the awards at graduation: the chemistry prize, the history prize, English composition. There aren't many like him with a thorough knowledge of physics and the ability to put it into historical context."[1] Klein convinced Lederman of "the splendors of physics during a long evening over many beers."[2]

Toward the end of the war Klein was involved in acoustical research at the Columbia Underwater Sound Reference Laboratory and afterward worked for a year in the Operations Research Group for the U.S. Navy. He continued his studies at MIT and received his Ph.D. in 1948 under the supervision of Laszlo Tisza. Born in Hungary like Klein's grandparents, Tisza had recently immigrated to the United States, and taught theoretical physics, thermodynamics, quantum mechanics, and statistical physics. Tisza, who had worked in Europe with Werner Heisenberg, Fritz London, and Lev Landau, had elaborated the connection between Bose-Einstein statistics and liquid helium into an early version of the two-fluid model of superfluidity. Klein's developing interest in the history of physics may have been furthered by Tisza (who died at the age of 101 only two months before Klein), who during his later years, was interested in the connections between mathematics and physics and in the philosophy of physics. Klein stayed on as a research associate in physics at MIT until 1949, when he joined the Department of Physics at Case Institute of Technology, rising from instructor to professor in 1960.

Although Klein turned primarily to history only after a sojourn in Leiden a decade later, even his earliest papers in physics proper exhibit careful concern with historical background. Klein's first paper, derived from his war research and coauthored with Henry Primakoff, Joseph Keller, and E. L. Carstenen, concerned sound diffraction by a circular disk, a topic of considerable significance for sonar technology. The article was prefaced by a solid historical introduction, reaching back to the origins of the wave theory of light in France. Klein was just 22 years old at the time. Following his appointment at Case Institute, Klein continued his research in physics, authoring or coauthoring nearly two dozen theoretical papers during

the next 12 years on thermodynamics, ferromagnetism, and quantum mechanics.

Klein's interest in the history of physics grew rapidly during these years, particularly following a stay in 1953 at the Institute for Advanced Study in Dublin. It was there that he first encountered the work of Paul Ehrenfest, a student of H. A. Lorentz and one of the central figures in early 20th-century physics. Three years later Klein met Ehrenfest's widow, Tatyana, during his first visit to Leiden, where Ehrenfest had taught as successor to Lorentz. Ehrenfest's perceptive analyses of issues raised by Ludwig Boltzmann's statistical mechanics led Klein in 1956 to publish a paper on the Austrian physicist's "urn model." The model was designed by Ehrenfest and his wife to clarify the proof of Boltzmann's H-theorem, which had raised many questions concerning its foundations. Klein was particularly interested in using the model (which involved a particular way of distributing 2R-numbered balls randomly between a pair of urns over time) to probe the ways the relationship between entropy and fluctuation phenomena can be understood in J. Willard Gibbs's and Boltzmann's distinct formulations of statistical thermodynamics.

Fluctuation processes had interested Klein during his doctoral research, and in 1949 he coauthored a paper on critical fluctuations with his adviser, Laszlo Tisza. Entropy and fluctuations soon became Klein's central focus, together with a growing interest in the early history of the subject, particularly as it developed in Ehrenfest's work. Klein's concern with history developed further during 1958-1959, which he spent at the Lorentz Institute of the University of Leiden on a Guggenheim Fellowship. Encouraged and supported by Mrs. Ehrenfest, Klein undertook to edit the physicist's papers for publication, anticipating the eventual production of a biography. The *Collected Papers* reached

print in 1959, and from then on his research concentrated on physics history, though he continued to publish scientific papers for the next five years.

Although a considerable amount had been written about the origins of quantum mechanics by the late 1950s, the subject was still comparatively young, with many of those who had been instrumental in forging it during the 1920s and early 1930s still alive. Einstein himself died in 1955, while Max Planck lived until 1947. Werner Heisenberg, Paul Dirac, Léon Rosenfeld, and Eugene Wigner were just entering their sixties, Max Born was in his late seventies, and Wolfgang Pauli had only recently died at the age of 58. The younger founders of quantum mechanics certainly had no memory of the subject's earliest period, namely between the publication of Planck's distribution law for blackbody radiation in 1900 and the first Solvay Conference in 1911. Nevertheless, textbooks had for two decades developed a set of canonical accounts of the subject's development. For pedagogical reasons these were based more on retrospective considerations grounded on subsequent events than on what had actually occurred. In his first major paper on the history of quantum theory Klein set out to explain just what did take place.

Klein's first substantial work in history, "Max Planck and the Beginnings of the Quantum Theory," appeared in 1962 in the first volume of the *Archive for History of Exact Sciences,* a journal founded by Clifford Truesdell on whose board Klein would subsequently serve for many years. In this path-breaking paper, communicated to the journal by Rosenfeld (whose historical views were criticized in the article), Klein first of all unpacked the difficult question of precisely what the relationship was between the Rayleigh distribution law for radiation and the novel one that Planck had produced at the turn of the century.

Klein demonstrated that contrary to textbook accounts, the infinite energy implied by the Rayleigh law (the so-called "ultraviolet catastrophe" entailed by classical theory) was not widely discussed or even recognized in the early years, including by Planck. Second, Klein reconstructed precisely how Planck had diverged from Boltzmann's methods in his application of statistics to radiation. And finally, Klein explained why half a decade passed before Planck's new solution was taken up by others in the physics community.

Further papers on Planck and the early history of quantum mechanics appeared in rapid succession during the 1960s, including for the first time ones on Einstein wherein Klein demonstrated that Einstein was the first to develop Planck's hypothesis into a true quantum theory. In 1967 Klein translated letters between Einstein and others on wave mechanics, all the while continuing to work on a biography of Ehrenfest. It was this work on physics history that brought him to Yale that same year as professor of the history of physics.

Klein's biography of Ehrenfest (1970) appeared three years later. The first of an intended two volumes and aptly subtitled "The Making of a Theoretical Physicist," it covered the period through 1920. Surely one of the most insightful and sympathetic scientific biographies ever written, Klein's "Ehrenfest" set a very high standard indeed for historians to follow. In it he described in careful detail Ehrenfest's "single minded concern with questions of fundamental principle." H. B. G. Casimir called Klein's book "an extraordinary and almost unique example of a scientist's biography." In it Klein explained carefully, but with a deft and light hand, the ways Ehrenfest drove to the

heart of contemporary theoretical issues, starting with his dissertation, which concerned Heinrich Hertz's attempt to develop a mechanics that did without the concept of force. Here one finds, for example, Klein's brief but illuminating account of Helmholtz's effort to produce a nonstatistical but mechanical analog of the second law of thermodynamics.

Two years later he expanded this account into a highly influential paper, "Mechanical Explanation at the End of the Nineteenth Century." That work exhibits Klein's fine hand with complex, and now unfamiliar, physics. In it he showed how Helmholtz deftly utilized a model based on a specific kind of cyclic coordinate to generate a function that had the same property as entropy. The result provided, Klein explained, an analogy but not a mechanical foundation for the function (since Helmholtz's restrictions were clearly too narrow for real systems). The analysis fascinated Boltzmann, Klein remarked, even though Boltzmann's own statistics aimed to provide a true mechanical underpinning for thermodynamics.

Throughout the 1970s Klein's historical work expanded as he investigated the earlier development of thermodynamics while continuing to pursue the history of quantum mechanics. Two major papers during this period focused on Sadi Carnot's production of the cycle named after him and on the work of the Yale physicist J. Willard Gibbs, which Klein was among the first to examine in detail. The Carnot paper, short and to the point, nicely exemplifies Klein's ability to uncover and explain the foundational structure of a physical theory. In 1824, when Carnot produced his account of the "Motive Power of Fire," the prevailing consensus treated heat as a conserved quantity, with corresponding thermal relationships. Following William Thomson's (later Lord Kelvin) and Rudolf Clausius's

development of thermodynamics, the Carnot cycle was bound instead to energy conservation and the limited interconversion of heat and work. The cycle was then defined and the work-heat involved in it computed by using the isothermal and adiabatic gas laws. How, Klein asked, did Carnot himself define the cycle when he did not use the adiabatic law to construct it? Emile Clapeyron, a decade later, had also avoided the adiabatic law, though to do so he had relied on heat conservation. Carnot had not. Instead of beginning the cycle at one of its four vertices, where isotherm intersects adiabat, Carnot began the cycle in the middle of the upper isotherm. That, Klein demonstrated, allowed him to define a closed path without reference to either the adiabatic law or to heat conservation, which was becoming a questionable hypothesis even in the early 1820s. This in one fell swoop cleared up questions that had long puzzled those who had perused Carnot's work and enabled one to see just how carefully Carnot built his physics—and Klein his history of it.

Klein continued to write seminal papers in physics history, though he never did produce the anticipated second volume of his Ehrenfest biography. Ehrenfest suffered from depression, to the extent that Einstein, his close friend, had attempted to have his workload decreased. In 1933 Ehrenfest tragically shot himself and his young son, who had Down syndrome. For years Klein had immersed himself in his subject's work and life, and he found it increasingly difficult to come to terms with the way that it ended. Volume two never appeared, and after 1971 Klein concentrated on Einstein and Gibbs.

In 1978 Thomas S. Kuhn published his monograph on the origins of Planck's law. It contained an iconoclastic account in which Kuhn controversially claimed that Planck's mathematics was based on an understanding according to

which the energy element divided phase space but did not apply to the radiating oscillators proper. Klein thought Kuhn had overinterpreted remarks that Planck made years later. The issue remains to some extent unresolved, though much can be said on either side. Ironically, or perhaps understandably, Kuhn and Klein had similar backgrounds. They were both born in the early 1920s to Jewish parents in the Northeast, both were originally trained as physicists (Kuhn under Van Vleck), and both turned in the 1950s to the history of physics, with Kuhn assuming professorships first at Berkeley, then Princeton, and finally at MIT. And both were the only two physicists-turned-historians to have been elected to the National Academy of Sciences. Each in his own way was instrumental in setting new standards for the history of science.

At Yale as Eugene Higgins Professor of History of Physics, Klein and his colleagues developed the newly founded Department of the History of Science and Medicine. Theirs was a unique and new environment for research in the field. Aasger Aaboe, trained by Otto Neugebauer at Brown, taught the history of astronomy together with Bernard Goldstein. Derek de Solla Price ranged over the entire history of science and technology, while Larry Holmes pursued the history of medicine. Visitors to the department remember well the rigor of its research but also the humor and conviviality. In 1974 Klein's historical work was further recognized with his appointment as Van der Waals Visiting Professor at the University of Amsterdam. Unfortunately, fiscal problems led Yale to dissolve the department in 1977, with Klein thereafter joining physics, where he remained until his retirement.

In 1988 Klein undertook the editorship of *The Collected Papers of Albert Einstein.* But his involvement with the project, then located at Boston University, dates to its

early prehistory, when he was asked to serve on the Editorial Advisory Board and Editorial Committee in 1971, at a time when preparations for this edition were in their embryonic stage. His warm and regular correspondence with Helen Dukas, Einstein's secretary and one of the two trustees of Einstein's literary estate, testify to the valuable collaboration that developed until her death in 1982. Klein accepted the part-time appointment as senior editor of the edition, while retaining his professorial obligations at Yale. Four volumes appeared during the decade of his tenure, covering Einstein's writings and correspondence during the years 1909-1914, spent in Switzerland, and a volume of Einstein's writings for the Berlin years (1914-1917). Klein thus shepherded to publication the manuscripts documenting Einstein's most significant work, the path to general relativity. Klein commuted regularly between Boston and New Haven, collaborating with the editorial staff. He was instrumental in putting the project on a solid foundation and keeping it there. It continues now under the editorship of Diana Kormos-Buchwald at the California Institute of Technology.

But the scholarship on which these four volumes of the Einstein Papers were based, as well as that of the earlier and subsequent ones in the series was greatly indebted to Klein's own research. He published 20 articles devoted exclusively to Einstein's work. In his first paper of 1963, "Einstein's First Paper of Quanta," Klein reminded us that although Einstein's work on relativity

> has generated millions of words of comment and exposition on all levels of discourse. Comparatively little has been written about his probings, over a quarter of a century, into the theory of radiation and its significance for our understanding of the physical world. And yet the boldness and clarity of Einstein's insight show forth characteristically in these studies as in his more famous investigations on the nature of space and time.

Indeed, at the time of this article, little careful analysis was available in the history of late 19th-century thermodynamics, electricity, statistical mechanics, or blackbody radiation. By contrast, some 15 years later, when writing about "Einstein and the Development of Quantum Physics," Klein could quote, in addition to his own corpus of articles, the work of many scholars by now distinguished in their own right. There is no doubt that Klein's articles on Einstein between 1963 and 1979, as well as his encouragement and support for the work of younger scholars constituted the foundation on which much of the modern history of physics was constructed. His 1963 paper not only opened up a whole new field but also set the standard of *how* such an investigation should proceed, and which untapped avenues future research might pursue.

Klein served as associate editor for the *American Journal of Physics* in the 1970s, and on the editorial boards of the *Archive for History of Exact Sciences*, *Historical Studies in the Physical Sciences*, and *Sources and Studies in the History of Mathematics and the Physical Sciences*. In 1993 Klein inaugurated the Pieter Zeeman Visiting Chair of History of Physics at the University of Amsterdam. He was a member of the Institute for Advanced Studies and a visiting professor at Rockefeller University and Harvard University. He received many honors, including election to the National Academy of Sciences in 1977, American Academy of Arts and Sciences in 1979, Académie Internationale d'Histoire des Sciences in 1971, and the American Association for the Advancement of Science. He was the first recipient of the Abraham Pais Prize for History of Physics of the American Physical Society, a Guggenheim fellow, a National Research fellow in physics, and he delivered distinguished lecture series at Harvard and Yale.

Klein's first marriages, to Miriam Levin, and to Linda Booz, ended in divorce. He is survived by Rona, Sarah, and Nancy from his first marriage and by a daughter from his second marriage, Abby Klein. His third wife, Joan Blewett, also a historian of science, died in 2006.

Klein was among the first of a cadré of postwar historians who were originally trained as scientists. Their technical expertise combined with a subtle understanding of culture, personality, and environment to produce a new kind of science history. Previous histories, though often interesting and useful, were for the most part retrospective accounts designed to illustrate how the position now accepted as correct emerged from past error. Historians like Klein took a decidedly different approach. Instead of scouring the past for error, they took it on its own terms, seeking to find just how scientists thought and worked with the techniques, tools, and observations that were available to them at the time. Taking past science on its own terms produced wonderfully insightful histories, ones that allow the reader to understand just how difficult it was for investigators to work their way through to new ways of thinking. Today, in the second decade of the 21st century, few historians like Klein have benefitted from the sort of training that produces the willingness to grapple with the details of long-gone systems. Klein was a warm, funny, and gentle teacher and adviser. Many among those who were profoundly influenced by his views and admonitions went on to successful academic careers. As testimony to his lasting influence, a *Festchrift* by his admiring and devoted students and friends appeared in 1995 with a title drawn from a phrase that aptly captures his way with science history: No Truth Except in the Details.[3]

NOTES

1. D. Hevesi. Martin J. Klein, historian of physics, dies at 84. (Obit.) *The New York Times*, Apr. 1, 2009.
2. L. Lederman, with D. Teresi. *The God Particle: If the Universe is the Answer, What is the Question*. Boston: Houghton Mifflin, 1993, p. 5.
3. A. J. Kox and D. M. Siegel, eds. *No Truth Except in the Details: Essays in Honor of Martin J. Klein*. Boston Studies in the Philosophy of Science, vol. 167. Dordrecht/Boston: Kluwer Academic, 1995.

SELECT BIBLIOGRAPHY

1947

With H. Primakoff, J. B. Keller, and E. L. Carstensen. Diffraction of sound around a circular disk. *J. Acoust. Soc. Am.* 19:132-142.

1949

With L. Tisza. Theory of critical fluctuations. *Phys. Rev.* 76:1861-1868.

1956

Entropy and the Ehrenfest urn model. *Physica* 22:569-575.

1959

Ehrenfest's contributions to the development of quantum statistics. I, II. *Proc. Dutch Acad. Sci. B* 62:41-50, 51-62.

Ed. *Collected Scientific Papers of Paul Ehrenfest.* Amsterdam: North-Holland.

1962

Max Planck and the beginnings of the quantum theory. *Arch. Hist. Exact Sci.* 1:459-479.

1963

Einstein's first paper on quanta. *Nat. Philos.* 2:59-86.

1964

Einstein and the wave-particle duality. *Nat. Philos.* 3:1-49.

1967

Introduction. In *Letters on Wave Mechanics by Einstein, Schrodinger, Planck, and Lorentz*, ed. K. Przibram. New York: Philosophical Library.

Thermodynamics in Einstein's thought. *Science* 157:509-516.

1969

Boltzmann, Monocycles, and Mechanical Explanation. George Sarton Memorial Lecture 1969. In *Philosophical Foundations of Science,* Boston Studies in the Philosophy of Science, vol. 11, eds. R. J. Seeger and R. S. Cohen, pp. 155-175. Dordrecht: Reidel, 1974.

1970

Paul Ehrenfest. Volume I: *The Making of a Theoretical Physicist.* Amsterdam: North-Holland.

The first phase of the Bohr-Einstein dialogue. *Hist. Stud. Phys. Sci.* 2:1-39.

Albert Einstein (in part). In *Dictionary of Scientific Biography*, vol. 4, ed. C. C. Gillispie, pp. 312-319, 332-333. New York: Charles Scribner's.

1972

Mechanical explanation at the end of the nineteenth century. *Centaurus* 17:58-82.

1974

The historical origins of the Van der Waals equation. *Physica* 73:28-47.

Carnot's contribution to thermodynamics. *Phys. Today* 27(8):23-28.

1976

Closing the Carnot cycle. In *Sadi Carnot et l'essor de la thermodynamique*, pp. 213-219. Paris: CNRS.

1978

The Early Papers of J. Willard Gibbs: A Transformation of Thermodynamics (presented at the XVth International Congress of the History of Science, Edinburgh, 1977). In *Human Implications of Scientific Advance,* ed. E. G. Forbes. Edinburgh: Edinburgh University Press.

1979

Einstein and the development of quantum physics. In *Einstein: A Centenary Volume,* ed. A. P. French, pp.133-151. Cambridge, Mass.: Harvard University Press.

Review of T. S. Kuhn, *Black-Body Theory and the Quantum Discontinuity, 1894-1912. Isis* 70:429-434.

1982

Fluctuations and statistical physics in Einstein's early work. In *Albert Einstein: Historical and Cultural Perspectives. The Centennial Symposium in Jerusalem,* eds. G. Holton and Y. Elkana, pp. 39-58. Princeton: Princeton University Press.

1993

With A. J. Kox, Jürgen Renn, and Robert Schulmann, eds. *The Collected Papers of Albert Einstein*. Volume 3: *The Swiss Years: Writings, 1909-1911*. Princeton: Princeton University Press.

With A. J. Kox and Robert Schulmann, eds. *The Collected Papers of Albert Einstein*. Volume 5: *The Swiss Years: Correspondence, 1902-1914*. Princeton: Princeton University Press.

1995

With A. J. Kox and Jürgen Renn, eds. *The Collected Papers of Albert Einstein*. Volume 4: *The Swiss Years: Writings, 1912-1914*. Princeton: Princeton University Press.

1996

With A. J. Kox and Robert Schulmann, eds. *The Collected Papers of Albert Einstein*. Volume 6: *The Berlin Years: Writings, 1914-1917*. Princeton: Princeton University Press.