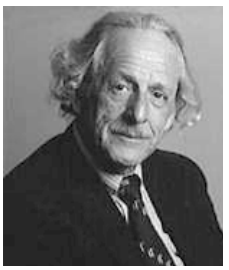
Essays of an Information Scientist: Science Reviews, Journalism Inventiveness and Other Essays, Vol:14, p.186, 1991 Current Contents, #47, p.3-10, November 25, 1991



Current Comments®

EUGENE GARFIELD
INSTITUTE FOR SCIENTIFIC INFORMATION®
3501 MARKET ST., PHILADELPHIA, PA 19104

David Cassidy's Biography of Werner Heisenberg—the Quantum Mechanic. Part 1. The Path to Uncertainty

Number 47 To Reprint November 25, 1991

The uncertainty principle is known to most scientists and widely used metaphorically. In David C. Cassidy's new book *Uncertainty: The Life and Science of Werner Heisenberg*,[1] we learn the history of this concept and something of the personality of its controversial progenitor. While Heisenberg was considered an opportunist by many, Cassidy concludes that he was a staunch nationalist, but not a card-carrying Nazi. He also believes the Germans were capable of making an atomic bomb. He attributes their failure to do so to the lack of confidence in Heisenberg's team by the German high command. Indeed, Cassidy asserts that the Nobel laureate was eager to build the bomb. At one point he pressed Albert Speer to convince Hitler of the merits of such a project.

Courtesy of David C. Cassidy

Werner Heisenberg

The Nobel Prize

Werner Karl Heisenberg received the Nobel Prize in physics in 1932 at the age of 31, although the award ceremony took place the following year when he was 32. W.L. Bragg was the youngest Nobel laureate in physics, receiving the award at the age of 25. Heisenberg was the second youngest to receive the award in his field, along with two others—Carl Anderson and P.A.M. Dirac. The average age of a Nobelist is about 55.[2]

Heisenberg was born in 1901 at Sanderau, a suburb of Würzburg, Germany, and died in 1976. He is one of the principal founders of modern quantum physics. We have excerpted materials from throughout his biography and present them below to give readers a flavor for the book, which is quite lengthy (669 pages). So we have split our verbatim excerpts into two parts.

Heisenberg received the Nobel for his work on the spectra of atoms and molecules. He provided the groundwork for solutions to some of the problems relating to the rotations of atoms by successfully predicting that hydrogen molecules would appear in two forms.

His uncertainty principle led to significant advances in the then new field of quantum mechanics. The chairman of the Nobel committee for physics, H. Pleijel, of the Royal Swedish Academy of Sciences, described Heisenberg's uncertainty principle:

"According to quantum mechanics it is unconceivable to determine, at a given instant of time, both the position taken up by a particle and its velocity. Closer study of quantum mechanics shows in fact that the more one attempts to fix exactly the position of a particle, the more uncertain the determination of its velocity becomes, and vice versa."[3]

Incidentally, 17 of Heisenberg's articles listed in the *Science Citation Index* ® (*SCI* ®) have been cited more than 100 times each. These articles were cited in more than 2,500 publications, based on data for 1945-1990 alone, ranking him in the top 1 percent of cited authors. His most-cited paper was published in 1948 on a statistical theory of turbulence.[4] It was cited more than 265 times.

A more complete citation analysis of his work awaits the compilation of a prewar *SCI*, although we did a 1920s *Physics Citation Index* as a National Science Foundation project. In this index, Heisenberg's work is cited more than 750 times during the 10-year period.

Implications Beyond Science

As indicated above, Heisenberg's work had implications far beyond the confines of science. The uncertainty principle permeated art and literature after World War II, fostering a sense of cultural insecurity. To many, especially artists and intellectuals, the notion that it was impossible to measure unlimitedly both the position and velocity of a subatomic particle translated to an admission that nothing could be considered certain in this world, except, "death and taxes."

As Harriet Zuckerman has noted,[2] many Nobelists tend to become philosophers late in life. Heisenberg was no exception. In 1971, he published *Physics and Beyond: Encounters and Conversations.*[5]

We learn in Cassidy's work that while the Nazis valued Heisenberg as a brilliant scientist, they nevertheless distrusted him. He was subjected to a year-long investigation by the Gestapo for suspected disloyalty. And there were accusations that the physicist, the eventual father of seven children, was a homosexual, presumably because of his numerous friendships with younger men. All charges were eventually dropped, but his position remained precarious during the Third Reich.

The "Bugs" at Farm Hall

An interesting account of what top German scientists were thinking during their interment immediately after the war is contained in a book called *The Griffin* by Arnold Kramish.[6] Heisenberg, along with nine other members of the so-called "Uranium Club," were held at Farm Hall, a lovely country estate in England used for intelligence purposes.

The book implies that the German scientists during this period fabricated an account of their wartime atomic research that is still being recounted today. According to the book, the Germans were unaware that Farm Hall was extensively bugged, including the surrounding grounds.

The British Foreign Office, the book notes, is expected to make a decision in 1992 on whether to release the full transcripts of the Farm Hall conversations. Some parts of the tapes have already found their way into print over the years. If the full transcripts are released, it could shed considerable light on Heisenberg's role in these matters.

Another book of historical interest that documents Heisenberg's activities during this period is Mark Walker's 1989 *German*

National Socialism and the Quest for Nuclear Power, 1939-49.[7] And a recent review by physicist Jeremy Bernstein[8] of Victor Weisskopf's book *The Joy of Insight. Passions of a Physicist*[9] discusses in some detail the Farm Hall days.

Copenhagen and Neils Bohr

Heisenberg studied physics between the two world wars at Munich, Göttingen, and Copenhagen. His mentors were Arnold Sommerfield, Max Born (Nobel Prize in physics—1954), and Niels Bohr (1922), all considered giants in modern physics. In addition, his friendships, intellectual collaboration, and correspondence include the names of Einstein (1921), Planck (1918), Schrodinger (1933), Pauli (1945), Dirac (1933), Kramers, Ehrenfest, Franck (1925), Oppenheimer, and others. All of these scientists are woven into the fabric of *Uncertainty.* In making our selections, we have chosen to highlight the relationship with Einstein because of Cassidy's expertise as an editor in this area.

There are, of course, many books on Einstein. One that comes to mind was edited by Harvard physicist/science historian Gerry Holton, in conjunction with Yehuda Elkana.[10] Another is a biography by Ronald Clark.[11]

Another important book on the Heisenberg era appeared recently—*Niels Bohr's Times, Philosophy and Polity*[12] by Abraham Pais of Rockefeller University. Heisenberg's relationship to Bohr is explored in detail. This book was also reviewed by Bernstein.[13] Another review of the book by John Ziman appeared recently in *Nature.*[14]

Cassidy's Background

David Cassidy spent 6 years in Germany during the 15 years he worked on the Heisenberg biography. He is the only historian who has been granted, by Heisenberg's widow, full access to all of her husband's papers. Cassidy received his undergraduate and master's degrees in physics from Rutgers University (1967 and 1970) and a PhD in the history of physics from Purdue University (1976).

Since 1983, he also has been on the editorial staff of *The Collected Papers of Albert Einstein,* published by Princeton University Press.

The excerpts of Heisenberg's biography that follow have been selected with an eye toward giving you a brief glimpse into the controversial scientist's life.

* * * * *

My thanks to Paul R. Ryan for his help in preparing this introduction and for selecting the following passages.

REFERENCES

1. **Cassidy D C.** *Uncertainty: the life and science of Werner Heisenberg.* New York: Freeman, 1991. 669 p.
2. **Zuckerman H.** *Scientific elite.* New York: Free Press, 1977. 335 p.
3. **Magill F N,** ed. *The Nobel Prize winners: physics.* Englewood Cliffs, NJ: Salem Press, 1989. 470 p.
4. **Heisenberg W.** Zur statistischen theorie der turbulenze (Towards a statistical theory of turbulence). *Z. Phys.* 124:628-57, 1948. (Cited 265 times.)
5. ---------. *Physics and beyond: encounters and conversations.* New York: Harper & Row, 1971. 247 p.
6. **Kramish A.** *The griffin.* Boston, MA: Houghton Mifflin, 1986. 294 p.
7. **Walker M.** *German national socialism and the quest for nuclear power, 1939-49.* New York: Cambridge University Press, 1989. 290 p.
8. **Bernstein J.** The charms of a physicist. (Book review.) *New York Review of Books* 11 April 1991. p. 47-50.
9. **Weisskopf V.** *The joy of insight. Passions of a physicist.* New York: Basic Books, 1991. 328 p.
10. **Holton G & Elkana Y,** eds. *Einstein: historical and cultural perspectives.* Princeton, NJ: Princeton University Press, 1984. 439 p.

11. **Clark R W.** *Einstein: the life & times.* New York: Avon, 1982.
12. **Pais A.** *Niels Bohr's times, philosophy and polity.* Oxford, UK: Clarendon Press, 1991. 552 p.
13. **Bernstein J.** King of quantum. *New York Review of Books* 26 September 1991. p. 61-3.
14. **Zlman J.** Deep truths and trivialities. (Book review.) *Nature* 353:511-2, 1991.

Uncertainty: The Life and Science of Werner Heisenberg

Back to Introduction

by
David C. Cassidy

ABSTRACT

Heisenberg's family background; his gymnasium days and first encounters with atoms—disagreements with his high school textbook and passages from Plato's *Timaeus*; his participation in the German youth movement.

Werner Heisenberg, born at the dawn of the twentieth century, became one of its greatest physicists. He is also among its most controversial. While still in his early twenties, he was among the handful of bright young men who created quantum mechanics, the basic physics of the atom, and he became a leader of nuclear physics and elementary particle research. He is best known for the uncertainty principle, a component of the so-called Copenhagen interpretation of the meaning and uses of quantum mechanics.

Heisenberg was also a man who chose to reside in Germany throughout his life. Born into an academic German family, Heisenberg experienced all the upheavals of the cultural elite in Germany: two lost world wars, a Soviet revolution, military occupation, two republics, and Hitler's Third Reich. As the leading non-Jewish theoretical nuclear physicist to remain in Germany after Hitler came to power in 1933, Heisenberg, although not a Nazi, played a prominent role in German nuclear research during World War II, traveled frequently to German occupied territories, and helped to establish West German science after the war. He died in 1976....

✔

In approaching the life of this man, several questions immediately present themselves. How did this child, born in 1901, climb so quickly to the top of his profession, attaining a full professorship in theoretical physics at the age of 25 and the Nobel prize at the age of 32? What impact did the most turbulent period of his life, the events surrounding the end of World War I—the lost war, soviet revolution, and the German youth movement—have upon his mature political and scientific views? What impact did his private and professional lives have upon his scientific achievements? Why did this brilliant young man, this product of the

David C. Cassidy

best that Germany could offer, hold a prominent professorship under Hitler's Third Reich and perform nuclear fission research for Germany throughout World War II, working feverishly right up to end of the war?... [From the preface to *Uncertainty: The Life and Science of Werner Heisenberg*.]

✔

Family Matters

The Heisenberg family's social mobility is evident in a carefully constructed family tree preserved in Werner Heisenberg's private papers. The tree, rather a typed pedigree replete with certificates of birth and baptism, owes its origin to the search by Nazi authorities for a Jewish ancestor in the scientist's past. It traces the Heisenbergs back five generations to one Heissenberg in Heidenoldendorf, a village in the northern state of Westphalia. The eighteenth-century ancestor is succeeded by a brandy burner, a master cooper, and a locksmith. The locksmith, Wilhelm August Heisenberg (1831-1913), dropped the second *s* in his name and moved north to Osnabruck, then in the state of Hanover, where he raised three daughters and two sons, one of whom was Werner's father [August].

After Werner's grandfather learned the locksmith trade, he set out on a "wander year," a common rite of passage in those days. He obviously did well: on his return he purchased his master's business, barn, and house. With business, property, and title (master locksmith), he easily rose to the rank of official Burger of Osnabruck, a voting member of the town's middle class. In 1858 he ensured his status by marrying the daughter of a prosperous local farmer. The two complemented each other well. Wilhelm Heisenberg is remembered as a quiet, cerebral man, an impression confirmed in a surviving photograph. His wife, Anne Marie, is remembered for her strong will and keen intelligence....

Two years out of gymnasium, August [Werner's father] abruptly headed for Bavaria, attracted to the southern province by the imperial Wagnerian music of the Bavarian capital, Munich, and by its enthusiasm for the glories of ancient Greece. Even more attractive were the efforts of Bavarian state officials to raise the cultural level of the rural province through generous funding of education and the importation of famous Prussian scholars, the so-called northern lights. August was drawn to one of the these beacons at the University of Munich, Karl Krumbacher, a lecturer who soon founded Germany's only chair for Byzantine studies (middle and modern Greek philology). Heisenberg immediately converted to the promising yet nearly untouched field, assured of bright career prospects in the rural southern province.

In 1893, August Heisenberg completed his doctorate under Krumbacher, passed the difficult teacher-qualifying examination, and soon became a teacher trainee at the prestigious Maximilians-Gymnasium in Munich under its learned and powerful rector, Nikolaus Wecklein....

✔

Little is known of Werner's mother, Annie [Wecklein]. Neither she nor her sister received a university education: German universities were closed to women, as a rule, until 1895, and Munich did not admit female students until 1903. Nor are there informative state personnel files on which to rely: German civil careers were only open to men. Both Wecklein girls no doubt attended one of the segregated girls' middle schools, which typically offered training in the fundamentals—math, history, and literature—and prepared its pupils for their future roles as genteel wives and cultivated mothers of educated sons....

✔

After Heisenberg completed his annual six weeks of military exercises in the sum-

mer of 1901, he and his family moved to Würzburg, about 400 kilometers (250 miles) northwest of Munich. August began teaching in September, while his wife prepared to give birth to her second child [Werner]....

✔

August Heisenberg is remembered by his family, superiors, and pupils as a rather stiff, tightly controlled, authoritarian figure. A former student recalled that the schoolmaster demanded "unbending fulfillment of duty, absolute self-control, and meticulous precision." "He treats his pupils with propriety but tolerates no lazy boys in his class," his Lindau rector noted. August must have applied the same standards in raising his own two boys, who grew up in a family structure typical of Burger families at the turn of the century: father centered, authoritarian, hierarchical....

✔

By the same token, a German woman of that era, no matter what her interests or talents, regarded as her obligation being an obedient wife and a self-sacrificing mother. As the wife of a gymnasium teacher and the daughter of a gymnasium rector, Annie's duties were self-evident. When Annie married August, she knew that self-realization or recognition could be achieved only in ensuring the success of her husband and the well-being of their children. She excelled brilliantly.... She even learned Russian in order to translate research papers for her husband's use—all this, of course, in addition to caring, no doubt without help, for the two growing boys....

✔

Children, on the other hand, were at the bottom of the Heisenberg family hierarchy. As Werner grew into adolescence, what he saw and felt from that position must have increasingly distressed him. Like any other turn-of-the-century Burger family, the Heisenbergs cherished the appearance of genteel respectability, social grace, and allegiance to nationalist trappings....

✔

The bourgeois ambivalence of Werner's childhood may have played a role in his own adult ambivalence toward the sweeping claims of every system of thought and belief, including science. At middle age and again near the end of his life, Werner declared science and religion to be "complementary" aspects of reality, each with its own language and symbolism and each with its own limited realm of validity. Different religiously or intuitively apprehended truths should be viewed as different sides of the same truth, while rational science—his own profession—should be viewed as just one among a variety of ways of perceiving reality....

✔

In his seventh-grade class, 1917-1918, Werner received a dose of trigonometry and his official introduction to physics. The sole textbook for the three years of physics (1917-1920) was surprisingly good, though rather elementary. It covered, without calculus, such subjects as elementary mechanics, electricity, magnetism, heat, kinetic theory of gases, optics, and energy conservation. Save for mathematics, it was comparable to a sophomore physics text at a modern American college. Contemporary physics—the relativity and quantum theories—did not exist for the author of Werner's gymnasium text. But, heeding the urgings of the ministry, he did provide material on other physical sciences, such as meteorology, astronomy, and geography, and offered explanations of such technical devices as the steam engine, water pump, telescope, and telegraph. The 500-page book was crammed with nearly 700 carefully detailed realistic drawings. Yet Heisenberg, although

supposedly enthralled with technical apparatus, insisted that he had little interest in physics until his last two years at the gymnasium, beginning in 1918. And even then, he maintained, his curiosity was piqued by his philosophical ponderings on the problem of atoms, rather than by any specific desire to study physics.

Werner's pondering, so he frequently claimed late in life, derived from two encounters with atoms at about that time. One involved a drawing of multiatomic gas molecules in his physics textbook. In it atoms were joined into molecules with little "hooks and eyes." Accustomed to the realistic drawings of technical devices elsewhere in the book, the demanding adolescent was disturbed to find molecules portrayed in what was to him such a superficial, utilitarian manner. "To my mind, hooks and eyes were quite arbitrary structures whose shape could be altered at will to adapt them to different technical tasks, whereas atoms and their combination into molecules were supposed to be governed by strict natural laws. This, I felt, left no room for such human inventions as hooks and eyes."

Heisenberg's second remembered encounter with atoms occurred when he read Plato's *Timaeus* while freed from school by military duty in May and June 1919. The relevant passage involved a fictional attempt by Timaeus to explain to Socrates that the observable properties of the four elements—earth, air, fire and water—can be attributed to the transcendent properties of ideal geometric "atoms." To each of the four elements, Plato assigned one of the so-called Platonic solids. Plato, or a member of his school, had proven that there exist in nature only five solid bodies composed of equal-sided, two-dimensional geometric shapes. Timaeus used the properties of four of these solids—cube, tetrahedron (pyramid), octahedron, and icosahedron—in assigning each to one of the elements:

> Let us assign the cube to earth; for it is the most immobile of the four bodies and the most retentive of shape, and these are characteristics that must belong to the figure with the most stable faces.... And again we assign the smallest figure to fire, the largest to water, the intermediate to air.... Logic and likelihood thus both require us to regard the pyramid as a solid figure that is the basic unit or seed of fire; and we may regard the second of the figures we constructed [octahedron] as the basic unit of air, the third [icosahedron] of water. We must, of course, think of the individual units of all four bodies as being far too small to be visible, and only becoming visible when massed together in large numbers.

Purist Werner reacted to this passage with astonishment and dismay, as he had to the drawing in his textbook. How could the sagacious Plato believe that atoms are cubes and pyramids? More important, "The whole thing seemed to be wild speculation, pardonable perhaps on the ground that the Greeks lacked the necessary empirical knowledge." Atoms were not to be so rudely treated as objects either of pure speculation or of superficial utility. Certainly, Plato's atoms bore no relevance to modern science. Or did they?

In his 1969 memoir *Der Teil und das Ganze* (English: *Physics and Beyond*), Heisenberg recalled turning to two close friends from the gymnasium Military Preparedness Association and the postwar youth movement, Kurt Pflugel and Robert Honsell. As recounted in his memoir, the three young men entered into a neo-Galilean *discorsi* on Plato's *Timaeus* soon after Werner's encounter with the puzzling passage. In Heisenberg's scenario, Kurt, a budding engineer, is cast as the crude pragmatist and Werner the perplexed seeker of enlightenment, while Robert, the deep thinker, is given the role of Platonist—atoms are not things but mental constructs, mathematical ideals or forms as transcendent yet reality-bound as mathematics itself. Werner's two friends argue their positions as though in a chess match, until Robert finally wins, convincing Werner of the validity of Platonism and helping him to comprehend Plato's Timaean atoms.

In another account of this encounter with Plato's atoms, delivered in defense of classical studies to the old Max-Gymnasium in 1949, Heisenberg went so far as to claim that his reading enlightened him to basic notions of atomic physics and that from then on "I was gaining the growing conviction that one could hardly make progress in modern atomic physics without a knowledge of Greek natural philosophy...."

✔

Pathfinding

"It must have been in the spring of 1920. The end of the First World War had thrown Germany's youth into great turmoil. The reins of power had fallen from the hands of a deeply disillusioned older generation, and the younger one drew together in larger and smaller groups in an attempt to blaze new paths, or at least to discover a new star to steer by."

With these opening words Heisenberg set the stage for his 1969 reminiscences, *Der Teil und das Ganze* (English title: *Physics and Beyond*). He began not with childhood or adolescence but with the period that most profoundly influenced him as both scientist and citizen—the chaotic years immediately following World War I. And he focused neither on family nor on formal education but rather on his participation in the postwar German youth movement, the experience that most directly affected the formation of his adult values....

✔

For Heisenberg...the youth movement became a vehicle for his adolescent rebellion, adventurous impulses, and budding leadership qualities. It spurred his intellectual independence, taught him how his primary interests—science and music—could transcend the chaos of daily life, and gave him close and secure friendships with his comrades, with whom he formed valuable lifelong relationships....

✔

Certainly Werner's relationships with his followers and comrades went far beyond mere friendship, even involving a type of love for one another, but it seems more the love of comrades in arms. Though perhaps not devoid of sexual overtones, it expressed itself most extensively as a nonphysical Platonic love of kindred souls that excludes the outside world while uplifting and strengthening those privy to such feelings. Women, of course, could not participate in such bonding; in fact, Werner and his fellows never had much to do with women....

(To be continued)

Editorial Schedule Change

With the first issue of 1991, ISI ® implemented a schedule change in the front matter for *Current Contents.* ® *Citation Classics* ® and the *ISI* ® *Press Digest*, including *Hot Topics*, now appear every other week. They alternate with either an essay by Eugene Garfield, a reprint with an appropriate introduction, or an essay by an invited guest.