

### Uncertainty: The triumphs and defeats of Werner Heisenberg

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**D. C. Cassidy**, *Uncertainty: The Life and Science of Werner Heisenberg*, W. H. Freeman and Co., New York, 1991, 669 pp.

“Not to criticize, not to excuse, only to understand...”

(From the foreword by D. Cassidy)

In December 1990, Leipzig University celebrated the ninetieth anniversary of the birth of Werner Heisenberg. A large conference, entitled “Werner Heisenberg: Physicist and Philosopher in Leipzig,” was dedicated to this event. On the day of the conference, there was a small but interesting exhibition of photographs, documents, and books connected in one way or another with Heisenberg and the university. Among the books was the recently published monograph of the American physics historian, David Cassidy, *Uncertainty: The Life and Science of Werner Heisenberg*. Many episodes in the book are connected with the time Heisenberg spent in Leipzig. Both the conference and the book convincingly demonstrated the importance of Leipzig University in the development of physics in this century.

The life of Heisenberg and his political persona was for many years the subject of intense discussions and debates. Raised in a professorial German family, in his youth Heisenberg actively participated in the youth movement protesting against the conditions of the Weimar world. It was in this period that the young Heisenberg developed the independence of a leader, which became a characteristic feature of his activities in science. However, his irrepressible confidence in himself also had other consequences. At the time of the Second World War his drive for leadership led him to dubious collaboration with Nazi circles.

At the conference in Leipzig, an attempt was made to reconstruct an objective portrait of the man, one of the most radical transformers of natural science in the twentieth century, but at the same time one who stained his later years by participating in attempts to create atomic weapons for Hitler. But as history has shown repeatedly, over time, the image of the genius almost always triumphs over the image of the villain.

Indeed, the time has come to shift the focus of historical studies to the development of science, and not to return to the examination of the same old issues.

From our experience we know how difficult it is to find the necessary compromise between serving science and serving a totalitarian government. Who can put himself in the position of being an impartial judge?

In recent years, several books have been published one

after the other, among them, *The Historical Development of Quantum Theory* by Mehra and Rechenberg,<sup>1</sup> the *Collected Scientific Works* of Heisenberg,<sup>2</sup> and Walker's book on the atomic project in Germany.<sup>3</sup> In Refs. 1 and 3 Heisenberg also has his place. David Cassidy's monograph fittingly completes these serious studies.

Cassidy has put much time and effort into collecting information in archives and in discussions with many people who knew Heisenberg and worked with him. As a result he has portrayed his hero in all his complexity in a book which is written on a highly professional level and which is rare in its completeness and scientific argumentation. The review in *Nature*<sup>4</sup> seems strange because it discusses only the political side of Heisenberg's life. The time has come to stress the appropriate aspects. Cassidy's book is a well balanced biography, and now it is nearly impossible to add anything substantial to it. However, one may find new materials in the archives, especially in those archives which were strictly secret during the war and for many years thereafter. Then one will again be able to return to the past. Cassidy is correct in that he not only discusses Heisenberg's deeds, but also discusses how his life was far from serene. This began in November 1933: Heisenberg refused to participate in a pro-Hitler rally organized by Leipzig professors. In doing this he brought upon himself the wrath of loyal and vindictive professors, who in revenge would not let him be Sommerfeld's successor in the department at Leipzig University. Later the “Heisenberg incident” fell into the hands of SS investigators. The investigation proceeded in a manner which is typical for totalitarian regimes. The investigation was not interested in politics or science; it created a simple criminal case. His mortal enemies, Lenard and Stark, were occupied with battling his scientific views. They were Nobel laureates who were already at this time famous as staunch opponents of the theory of relativity. The SS fabricated a charge of homosexuality, an extremely serious criminal offense in the Third Reich. We will not enter into the details of this ugly story. We present only one citation from the semi-literate article “White Jews in Science” published in the SS weekly “The Black Corps” on 15 July 1937: “If the bearer of this spirit (that is, non-Aryan physics, the physics of Einstein and Bohr-Y.S.) is not a Jew, but a German, then he deserves to be doubly persecuted... This type of contagion-carrier is called a white Jew among the people.” The article was signed by Stark! It is not necessary to explain how dangerous the cloud forming over Heisenberg's head was. But he did not give in, he retained his honor. Cassidy relates in detail examples of this steadfastness. They are evidence that Heisenberg never shared the views or politics of the National

Socialists. It was not the actions of the Nazis, but the fates of scientists and science in Germany that determined his actions.

Heisenberg was spared further persecution by the SS by a random event; chance has frequently played a decisive role in history. Heisenberg's grandfather, his mother's father, Nicolai Weklin, was the rector of the Maximilian high school in Munich. In the hiking club, of which he was a member, he became acquainted with the father of the then unknown Himmler, who would become the head of the Gestapo. Their wives also became acquainted, that is, the mother of Werner and the mother of Himmler. In Werner's difficult days, his mother turned to her friend for help. The discussion of the two mothers about their sons played a significant role in the cessation of investigations.

Complicated interweaving of events makes it very difficult (even impossible) to make an undisputable evaluation of Heisenberg, and the time has certainly come to reach an end. Cassidy has very accurately summed things up by placing the word uncertainty in the title of the book. It very accurately characterizes both the bright and gloomy periods in Heisenberg's life.

In his entire life, his highest achievements were made in the mid 1920s when the twenty-five-year-old professor made his heroic attack on one of the most difficult puzzles of nature, a legacy of the great constellation of physicists of the nineteenth century. This attack achieved a rapid victory, crowned in 1932 with the Nobel Prize. The origin of the new theory was proposed in an article "On a Quantum Mechanical Interpretation of Kinematic Equations" in the September issue of *Zeitschrift für Physik*. The goal of the article was formulated as follows: "...To establish the basis of a theoretical quantum mechanics based on the relationship between only such quantities that are in principle observable." The development of this idea proceeded very intensively and rapidly. A collaboration with Bohr, Pauli, and Born was very fruitful. Only Schrödinger could not accept the matrix idea; having proven the equivalence of his wave mechanics and Heisenberg's quantum mechanics, he lost interest in it. This stage of development was completed by Dirac, who constructed the new science with irreproachable logic and elegance. The patriarch, Einstein, also did not acknowledge the new mechanics (or more accurately, its fundamental nature). The debates of Einstein and Bohr have entered history as one of the most dramatic episodes in this clash of titans. The whole story is related in detail by Cassidy. Can one charge the author with some dryness in the exposition? Cassidy had to solve a difficult (and perhaps insoluble) problem: to write a book about physics which would be interesting and accessible to a wide contemporary range of readers. So it is certainly not warranted to reproach the author; he has done all that he could in the search for a compromise.

It is interesting to note that the appearance of the new mechanics did not meet with too much resistance. Only "Marxist philosophers" found it threatening to their existence, and called the uncertainty principle idealistic gibberish bearing a mortal threat to social order. But the need to gain mastery over nuclear energy saved physics from utter defeat in our country. In recent years, a new generation of physicists educated in the spirit of quantum notions, have turned to a new discussion of the interpretation of quantum theories, but these discussions are about ways of developing

physics, and not of degrading it.

Another interesting, but not so fundamental period described in the book is the work done to develop Heisenberg's old idea, eliminating all unobservable quantities from the theory, leaving only a matrix connecting the preparation of the initial state and the measurement of the final state, a matrix which he called the *S* (scattering) matrix. The new theory was met with enthusiasm by the physics community, but did not lead to new triumphs. The dynamics of the behavior of a quantum system and the details of its development are now accessible not only to theory, but also to experiment.

The idea of nonlinear equations that was perceived by many to be a panacea, turned out to be equally incomplete.

Long periods in the history of science have developed according to the rules of logic: great and lesser scientists, generals of science and its soldiers extract consequences from equations, think up new experiments and discuss their results: what occurs is what is called the analytical development of science. But at some critical moments logic is violated. Someone produces a new idea, someone, according to the comment of Martin Gardner, pronounces the magic word "Aha." The chain of logic breaks, and this break, this catastrophe (its time of occurrence and the post-catastrophic behavior of the system) can hardly be predicted by any algorithm (although some specialists in artificial intelligence believe in the omnipotent computer, I cannot refute this belief). It is these "catastrophes" which determine the global development of science. The life of Heisenberg provides ample food for thought on the source of his idea in 1925, but what compelled him to see the truth in poorly understood, even for the author, mathematical equations of motion? Kuhn's explanation of the change in paradigms reduces everything to a new term which explains little. It could be that Cassidy's book will provoke thought about the role of what some call "subconscious" or "cosmic" intelligence, or the better understood terms "intuition" or "inspiration."

Together with his teacher, Bohr, Heisenberg attempted in many articles to explain the nature of the remarkable property of human thought. Even Pauli thought about this phenomenon for many years.<sup>5</sup> But the solution of the problem is as yet inaccessible to natural scientists and philosophers. Attempts to find an answer to the ever more ontological problems which arise remind one of the processes which occurred in ancient Greece, where the study of nature and philosophy were fused into a single entity. It seems that the end of the twentieth century is also characterized by the fact that the process of uniting natural science and philosophy is occurring, with science playing an increasing role in the dynamic development of society. But at no time has society been so indifferent to the conditions in which science exists in many countries, so to say, they are indifferent to the ecology of science. The ecology of science should attract greater attention. The life of Heisenberg illustrates this problem.

We will not continue the description of the successes and failures of Heisenberg and will limit ourselves only to the good advice to read Cassidy's *Uncertainty* (a good motto for Heisenberg's coat of arms, if it existed).

Unfortunately, it is difficult to take this advice. I do not know how many copies of the book are in the country. But this is a common problem of our science, one of the manifes-

tations of the disastrous situation of the “ecology of science” of which we just spoke.

<sup>1</sup>See review by Ya. A. Smorodinskii in *Usp. Fiz. Nauk* **158**, 742 (1989) [*Sov. Phys. Usp.* **32**, 732 (1989)].

<sup>2</sup>See review by Ya. A. Smorodinskii in *Usp. Fiz. Nauk* **162**, 141 (1992) [*Sov. Phys. Usp.* **34**, 334 (1991)].

<sup>3</sup>See review by Ya. A. Smorodinskii in *Usp. Fiz. Nauk* **162**, 169 (1989)

[*Sov. Phys. Usp.* **34**, 444 (1991)].

<sup>4</sup>M. Walker, *Nature* **354**, 365 (1991).

<sup>5</sup>Compare with K. V. Laurikainen, *Beyond the Atom. The Philosophical Thought of Wolfgang Pauli*, Springer-Verlag, Berlin, 1988; see review by Ya. A. Smorodinskii in *Usp. Fiz. Nauk* **160**, 164 (1990) [*Sov. Phys. Usp.* **33**, 92 (1990)].

Translated by C. Gallant