

HEISENBERG'S SCIENCE AND HIS PERSONAL AND POLITICAL TURMOIL

Uncertainty: The Life and Science of Werner Heisenberg

David C. Cassidy
Freeman, New York, 1992.
554 pp. \$29.95 hc
ISBN 0-7176-2243-7

Reviewed by Max Dresden

During the first 50 to 60 years of this century, theoretical physics was dominated by a very small set of physicists of extraordinary brilliance and power. It is probably not too much of an exaggeration to say that no more than about a dozen physicists were responsible for most of the conceptual innovations and technical advances of that time. Assessments of who made the most seminal contributions may differ, but there can be no doubt that, regardless of the criteria, Heisenberg was one of the major figures in the transition from classical to contemporary physics.

Even though Heisenberg and some of his contributions have been analyzed in a number of contexts, a detailed, comprehensive and scholarly biography of Heisenberg has been lacking. Now David Cassidy has provided such a work, in what is certainly a major contribution to scientific biography.

Writing a scientific biography inevitably involves a number of choices and compromises. Often, barely compatible and even contradictory features have to be accommodated in a book of finite length. In this biography Cassidy treats many aspects of Heisenberg's life—his work, his family, his peers, his social and political environment, and the status of science in his time. Cassidy makes his choices and compromises, producing a book in which these different aspects

are discussed in varying depth and detail.

Cassidy's task was especially difficult. Heisenberg's science was of course monumental, especially in the early phases, between 1920 and 1946. But during this same period Heisenberg experienced political and personal turmoil. His motivation and behavior are not always easy to understand or explain.

As a young man Heisenberg witnessed the dislocation brought about by World War I. He was a witness to one of the most inhumane political upheavals of all time, and he suffered through the disintegration of German culture. Still, he participated, willingly and knowingly, in the investigation of nuclear energy as a possible source of power, weapons not excluded.

Cassidy discusses Heisenberg's somewhat contorted personal and political beliefs—beliefs that enabled Heisenberg to come to terms with a regime he disliked and perhaps detested—and he deserves a great deal of credit for analyzing these controversial and sensitive questions. Although not everyone will agree with his approach or conclusions, there can be no doubt that Cassidy has made a scholarly and compassionate analysis of this difficult subject; he has done so with an objectivity that at times must have been painful to him and at other times might be painful to others. This is a major accomplishment.

The book is divided into 27 chapters each of about 20–25 pages. About half of the chapters are devoted primarily to a detailed examination of the changing social, political and academic climate in Germany between 1910 and 1950 and contain little physics. The first five chapters of this set contain an excellent and evocative description of Heisenberg's family background and his social and political milieu. Heisenberg's close attachment to his youth-group comrades is most instructive for understanding his later attitudes. The remaining

chapters in this set focus on the political events and social upheaval before, during and after World War II. The political infighting for power and recognition in the academic community is beautifully described, with an effective use of primary sources.

Five chapters are devoted primarily to physics. Four of them cover the period from Heisenberg's early efforts in spectroscopy through his discovery and formulation of the uncertainty principle, including his basic paper on matrix mechanics. Another chapter contains Heisenberg's fundamental papers on nuclear structure and the studies (with Wolfgang Pauli) of quantum electrodynamics. It is not entirely surprising that limitations imposed on the level of discussion and on space yield a rather cursory and not always satisfactory treatment.

The remaining chapters contain a mixture of physics and interesting comments on the social and scientific atmosphere between 1915 and 1950. They include an especially illuminating discussion of the many changes and continuing conflicts in the scientific and academic communities. Interspersed in these discussions are occasional descriptions of pure physics and other physicists.

In these chapters Cassidy adheres to a rather strict chronological treatment. Through Cassidy's painstaking research and thorough documentation, Heisenberg emerges as a committed scientist of world-class renown; a strong German nationalist, immersed in the German culture and convinced of German superiority; and a fiercely competitive individual of driving ambition.

It is noteworthy that the three types of chapters—"social," "scientific" and "mixed"—differ not only in content but also in style and even grammar. The social chapters, written with obvious enthusiasm and vigor, include many interesting, novel insights and details. By contrast, the scientific chapters are written in a rather subdued, almost self-conscious

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style, and most of the information they contain is reasonably well known. Often, the scientific discussions are too sketchy, fragmented and at times opaque. Certainly the intellectual ferment that accompanied the creation of quantum theory is hard to find in Cassidy's treatment. This same variation of styles persists within the chapters that contain both science and nonscience.

In this book of 652 pages there are at most 10 formulas, a surprisingly small number for a biography of Heisenberg. The treatment of science is quite uneven. Some portions, although by necessity qualitative, are detailed and excellent; others, such as the discussion of Heisenberg's early spectroscopic studies, are somewhat sketchy and incomplete. The treatments of spin, the density matrix approach and work on positrons are especially weak.

The following remarks are intended to illuminate, clarify and comment on Cassidy's results. It is not at all certain that Cassidy would in fact agree with my conclusions, some of which are given here; he is more tentative (and perhaps wiser) than this reviewer. However, his research provides a solid foundation for the following inferences:

▷ It is important to realize that Heisenberg, in spite of his early recognition and almost instant success, was a rather shy person who was often lonely and deeply troubled, especially in his later life. However, his shyness did not keep him from insisting on public recognition. He could not tolerate being second in anything, be it ping-pong, skiing or physics.

▷ For Heisenberg, the public image he projected was always important, even when the actual issue wasn't that important. For example, Heisenberg, especially in his later life, made a fetish of the importance of Greek (Platonic) philosophy for physics and for himself. It appears that this fixation was primarily for public consumption. His actual background and formal training in philosophy were rather minimal. Although he mentioned it in every public lecture, Heisenberg did very little reading in philosophy.

▷ His personal relationships, outside those with his mother, his wife and a few others, while civil, were guarded and of limited importance. Cordiality was as intense as most of his relationships got. His relationship with his father started out cool and then deteriorated. He didn't care for his brother, and eventually all contact between them ceased. His ties to his two collaborators Pauli and Hendrik

Kramers were pleasant, even cordial, but by no means deep. He did have a deep respect for Bohr, but two bitter confrontations damaged that relationship beyond repair.

Heisenberg's strong emotional attachments were to the comrades of his youth group and to the ideals of those groups—love of Germany and German culture. Even though the various youth organizations with which he was associated, such as *Die Weisse Ritter* (The White Knights), were not explicitly nationalist socialist, their philosophy was uncomfortably close: The organizations were elitist, opposed to the Weimer Republic, willing to submit unquestionably to a leader and fanatically devoted to a romanticized German culture.

▷ Initially Heisenberg vigorously protested the dismissal of Jewish and "politically questionable" professors. In discussions with Planck, he tried to define his position; he decided early that he would not resign and leave Germany (as some did and others had to do). After about two years he made a vigorous effort to replace the dismissed professors by Dutch professors (non-Jewish, of course); they all turned him down. (Max Born was especially angry at Heisenberg over these efforts.) Clearly, to Heisenberg at that juncture, maintaining a strong or at least viable physics establishment took precedence over human rights or dignity.

▷ At first Heisenberg was sympathetic to the Nazi's national aims; later he became increasingly apprehensive about the dismantling of the universities and society by the Nazi regime. Cassidy discovered a manuscript written between 1941 and the fall of 1942 in which Heisenberg arrives at a reluctant accommodation with the Nazi regime. Heisenberg decided or rationalized that he "could live and work as a subject of the system, but not be a part of it." This Faustian bargain enabled him to participate in the German war effort and the propaganda trips to occupied countries. He had reluctantly and tragically become a willing, active participant in Germany's policies and war aims.

▷ A sad byproduct of the calamitous events of World War II was the prolonged and angry confrontation between Samuel Goudsmit and Heisenberg, two one-time friends and colleagues whose youths were devoted to physics in the happy anticipation of exciting new developments. Even though Cassidy devotes a considerable amount of space to this controversy, he does not sufficiently emphasize one of its central issues. Heisen-

berg and a number of other European physicists never gave up their strong belief in the superiority of German and European culture and science. Goudsmit was infuriated by what he saw as perennial German conceit and continued arrogance, even after the American scientific successes in World War II. There was more than a touch of condescension in the German attitude toward US science and a strong tendency to trivialize US scientific accomplishments.

To Goudsmit the decay in the quality of German science was an inevitable consequence of the degeneration of German culture under the Nazi regime. To Heisenberg, if in fact German physics had deteriorated at all, the decay had resulted from administrative obstructions, governmental interference and a severe lack of resources, but certainly not from the diminished quality of German physics itself. That thought was intolerable to Heisenberg. The two men were unable to reach a compromise, and in the end they got tired of arguing. It appears that Heisenberg's post-World War II physics was motivated by his desire to convince the world of the reemergence of the dominance of German physics.

▷ In spite of Heisenberg's genius, power and incredible intuition, not all of his research was important or successful. Nor did he always pursue his own ideas to a successful conclusion. Cassidy does not emphasize this characteristic enough. Heisenberg's work on cosmic-ray showers—his distinction between explosions and cascade showers—did not really lead anywhere. His work on superconductivity, although it caused great excitement and received great publicity, did not have any lasting effect. The ideas of the S matrix initiated by Heisenberg in 1943, were only fully developed years later by Freeman Dyson and Geoffrey Chew.

It is a pity that Cassidy does not discuss in any detail Heisenberg's post-World War II physics and the social and scientific changes of that period. However, it is my understanding that Cassidy is now studying this important and fascinating period for a subsequent volume.

Cassidy remarks in his book that there is no serious scientific and historical study of one of Heisenberg's own postwar preoccupations: the nonlinear spin theory. This theory also caused great excitement, and Heisenberg did nothing to diminish the public's grandiose expectations. But it is not true that this episode has not been studied: Several papers (by this reviewer) on both the technical and

social aspects are currently in press.

All in all this is an important book. It should be read, analyzed, discussed, debated and enjoyed. It is not, nor should it be, the final word on Heisenberg, his science and his times. Many important issues remain to be settled, in particular Heisenberg's relation to Pauli (treated rather cursorily in this biography); the social scientific changes in German and European physics during and after the war; Heisenberg's relations to a new post-war generation of European and US physicists; and the increasing doubt about the inevitability of the Copenhagen interpretation. These studies should be undertaken, but it is Casid's fundamental work that makes such studies possible.

Computational Nuclear Physics 1: Nuclear Structure

Edited by K. Langanke, J. A. Maruhn and S. E. Koonin
Springer-Verlag, New York,
1991. 209 pp. \$55.00 hc
ISBN 0-387-53571-3

Two graduate students were in my office when this book arrived, so I showed it to them. The book, which presents bits of theory together with working computer programs, described in detail, greatly appealed to them. It is obvious that such a text could benefit graduate students.

This compilation covers a rather wide range of subjects in a relatively small number of pages. It is organized into 10 chapters to which 19 experts have contributed; each chapter is devoted to a single topic. The book comes with a PC-compatible floppy disk containing the programs described in the text. The contents of the book reflect the approaches used nowadays to study the properties of atomic nuclei. Important topics include shell model theory, effective mean-field approaches, linear response theory, geometric collective models, the interacting boson approximation, the variational Monte Carlo method for light nuclei, Faddeev equations for three-nucleon systems, the relativistic impulse approximation and electron scattering.

In spirit *Computational Nuclear Physics* is reminiscent of the articles one finds in the journal *Computer Physics Communications*. All the chapters are organized in more or less the same manner, each incorporating a relatively concise theoretical introduction to the topic with a sufficient number of references; a description of

the program and the numerical methods used in it; a flowchart and description of most of the program's subroutines; and the input and output.

The programs themselves represent approximation schemes that are now extensively studied. Because the programs are often simplified, one could hardly use them to carry out original research. On average, the programs are rather long (2000–3000 lines), but the rather frequent comments and the explanations provided in the text should ease the journey through any of them.

Inherent in such a compilation is a certain lack of unity. The programs have mostly been written for specific purposes, and I would not advise someone to try to use them in a library of general-use software or for situations that are obviously different from those described in the book without additional input and effort. For example, if one were to use transition densities obtained from a linear response approximation or a variational Monte Carlo calculation and test them in an electron scattering calculation or a relativistic impulse approximation, besides having a mismatch between the physical assumptions used in the different approaches, one would run into unpleasant programming problems. I believe the best approach might be to run one program first, store the results and maybe work on them by changing the format of, interpolating, smoothing or fitting the data. Only afterwards would I try to use the data in a subsequent calculation.

In fact, I prefer to write my own programs from scratch, rather than to use bits and pieces from disparate programs or to rewrite existing ones to suit my own needs. This is because, in general, physics programs are not canned programs meant to produce results under a wide range of initial input conditions. However, a diligent student will find, after a careful study of the programs described in the book, lots of tricks and methods that may help him or her feel more confident in writing programs.

I am a purist when it comes to using different numerical methods. I found it disturbing that often in the same program numerical approximations having different degrees of accuracy were used. For example, in this book one author suggests computing parts of a wavefunction using higher-order finite difference formulas, only to spoil everything later on with a lower-accuracy formula, often within the same subroutine. Physicists are goal-oriented people, and for us the ends often justify the means. However

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