

## Books by and about Werner Heisenberg

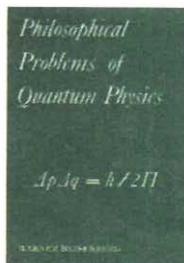
*N Mukunda*

The three principal creators of quantum mechanics made their landmark contributions to the subject in very quick succession between July 1925 and January 1926 in the sequence: Werner Heisenberg, Paul Dirac and Erwin Schrödinger. They received their Nobel Prizes together in December 1933 – Heisenberg for 1932, Dirac and Schrödinger for 1933. The February 1999 and August 2003 issues of Resonance were devoted respectively to Schrödinger and Dirac. The present one celebrates Heisenberg.

The purpose of this article is to present to a younger generation of readers (students and teachers alike) a very brief account of some of Heisenberg's general writings of a historical and philosophical nature. These are accessible both to scientists, even in areas other than physics, and to educated and interested nonscientists. In reading this article, at relevant places one may look at Virendra Singh's Article-in-a-Box on page 3, and Jochen Heisenberg's Personal Reflections on page 90.

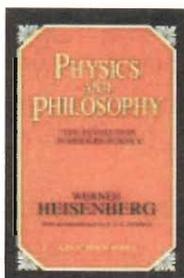
Both Heisenberg and Schrödinger, from Germany and Austria respectively, wrote extensively on general philosophical matters apart from their technical scientific work. In contrast, Dirac has not written much along these lines. The following books by

α



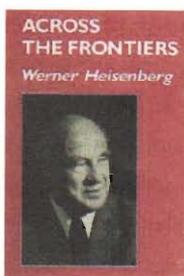
*Philosophical Problems of Quantum Physics*: essays and lectures from 1932 to 1948  
Ox Bow Press, 1979.

β



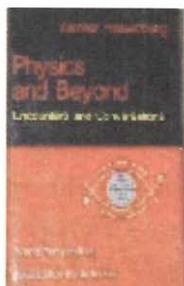
*Physics and Philosophy – the Revolution in Modern Science*: the 1956 Gifford Lectures at the University of St. Andrews  
Harper & Row, 1958.

γ



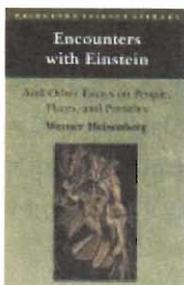
*Across the Frontiers*: essays and lectures from 1948 to 1973  
Ox Bow Press, 1990.

δ



*Physics and Beyond – Encounters and Conversations*  
George Allen & Unwin, 1971.

ε



*Encounters with Einstein And Other Essays on People, Places, and Particles*: essays and lectures from 1972 to 1976  
Princeton University Press, 1983.

Schrödinger should be mentioned: *Nature and the Greeks*; *Mind and Matter*; *My View of the World*; *Science, Theory and Man* (*Science and the Human Temperament*); and *Science and Humanism*. Several of these are currently available either in the Canto Series of Cambridge University Press, or published by Ox Bow Press. Heisenberg's major general writings, more or less in chronological sequence, are listed on page 83 and numbered  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$  and  $\epsilon$ .

Schrödinger's writings have rarely been matched for their clarity, eloquence of expression and persuasive power. 'Heisenberg's nontechnical writings on physics have always been notable for a strong sense of the history of the subject, and for a clear perception of the impact of modern discoveries on time-honored philosophical disputes'. Among his technical books at least two deserve mention: the classic 1929 Chicago lectures on *The Physical Principles of the Quantum Theory* (Dover 1949); and from much later in his life, *Introduction to the Unified Field Theory of Elementary Particles* (Interscience 1966).

The definitive biography of Heisenberg is David C Cassidy's *Uncertainty – The Life and Science of Werner Heisenberg*, W H Freeman 1992. Also of great interest is *Inner Exile – Recollections of a Life with Werner Heisenberg* by his wife Elisabeth, published by Birkhauser in 1984. Michael Frayn's play 'Copenhagen', Anchor Books 2000, has been briefly referred to by Virendra Singh, and is dealt with more extensively by Jochen Heisenberg.

As one would expect, Heisenberg has written frequently about the origins, historical development and difficulties of interpretation of quantum mechanics, the major revolution in thought which he himself initiated. These are extensively dealt with in ( $\beta$ ) as well as in the partly autobiographical ( $\delta$ ). His discovery of matrix mechanics in May-June 1925 has been recounted in Virendra Singh's article. Here is Heisenberg's own description of his intense and dramatic feelings at that time, taken from ( $\delta$ ):

"I had the feeling that, through the surface of atomic phenomena, I was looking at a strangely beautiful interior, and felt almost giddy at the thought that I now had to probe this wealth of mathematical structures nature had so generously spread out before me".

Elsewhere in ( $\delta$ ) he describes his Youth Movement days, his introduction to physics and the atomic concept, his first meeting with Niels Bohr in 1922, and the important conversation with Einstein in 1926 recalled in Virendra Singh's article. (This last appears also in ( $\epsilon$ )). The chapters in ( $\delta$ ) are extremely carefully reconstructed conversations with many different people on a great variety of scientific, philosophical and political topics ranging in time from 1919 upto 1965. They help us see the new physical concepts gradually unfolding with all the attendant suspense, excitement and drama. The evolution of the uncertainty and complementarity principles and of the standard Copenhagen interpretation of quantum mechanics during 1926-27



are all recounted in the first person singular – what more authentic source could one ask for? All these developments are also dealt with in great depth in (β).

Heisenberg's accounts of the growth of ideas over the centuries, starting from early Greek speculations about the nature of matter and natural law, are deeply revealing. In essays in (α) and (γ) titled 'Ideas of the Natural Philosophy of Ancient Times in Modern Physics' and 'Natural Law and the Structure of Matter' there are splendid recapitulations of the ideas of Leucippus, Democritus and Platonic philosophy; and when the comparison to modern day thinking has to be made he says:

"It was an unbelievable achievement of the ancient philosophers to have asked the right questions. But, lacking all knowledge of the empirical details, we could not have expected them to find answers that were correct in detail as well".

Such a finely balanced and refreshingly honest assessment!

At more than one place in these books, in (δ) and (ε) for example, Heisenberg traces the changes that have taken place over time in the concept of elementary particles of matter out of which all matter is composed, and of course also offers his own feelings about how things will develop in the future. In (δ) he says:

"The elementary particle, like the stationary state of an atom, is determined by its

symmetry.... This is the natural consequence of the fact that symmetry is rooted in nature itself".

And in (ε) he suggests that we have reached the end of the usefulness of thinking that one thing consists of others:

"Here the question has obviously been asked, 'What do protons consist of?' But it has been forgotten in the process, that the term *consists of* only has a half way clear meaning if we are able to dissect the particle in question, with a small expenditure of energy, into constituents whose rest mass is very much greater than this energy-cost; otherwise, the term *consist of* has lost its meaning. And that is the situation with protons".

At a couple of places, in (γ) and in (δ), there are discussions of the relation between science and religion. In the chapter titled 'Science and Religion' in (δ), Heisenberg reconstructs superbly from memory what Bohr had said to him on this matter:

"... our attitude to religious questions cannot be separated from our attitude to society... religion helps to make social life more harmonious; its most important task is to remind us, in the language of pictures and parables, of the wider framework within which our life is set".

His accounts of the significance of the works of Albert Einstein, Max Planck and Wolfgang Pauli are contained in three separate essays in (γ).



Virendra Singh refers briefly to Heisenberg's visit to Bohr in Copenhagen in September 1941, when he failed in his attempt to 'reach' Bohr and to effect a reconciliation; and to the controversies surrounding his involvement in the German atomic bomb project. Jochen Heisenberg's feelings on seeing Michael Frayn's play 'Copenhagen' dealing with this episode are expressed in his article in this issue. In this context only two quotations will be recalled here. The first is from Elisabeth Heisenberg's book:

"But they were not communicating; they did not understand each other. The two men who had been such close friends parted deeply disappointed, and there were no further attempts to contact each other. Ultimately, the cause of this misunderstanding must be seen in both of them".

The second is from Victor Weisskopf's Preface to this book:

"Whatever has happened, nobody has the

right to reproach anybody for having avoided a deadly risk. Who can stand up and say he would have taken the risk in the same situation with the same responsibilities? Those who have never been in such situations must be grateful to their fate of being spared such decisions".

And he concludes by saying that this book "will help to improve the bond between those who suffer and those who have been spared".

Heisenberg's writings on many profound subjects are so beautiful that they appear deceptively simple. One enjoys reading him many times over to truly appreciate his thinking. Some of the books described above may be rather difficult to get, but the serious reader must make the effort to find them. She will be very greatly rewarded.

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Heisenberg had a special, intuitive way of getting to the essential point. This, together with an incredible force of persistence and determination, made him the most prolific and successful physicist of the recent past.

– Victor Weisskopf

