BOOK REVIEW

Mehra, Jagdish and Rechenberg, Helmut, *The Historical Development of Quantum Theory* ; Vol. 5. Part 1 : Erwin Schroedinger and the Rise of Wave Mechanics. Part 2 : The Creation of Wave Mechanics : Early response and applications 1925-26. Springer Verlag, New York, Berlin and Heidelberg, 1987.

In a few magical months in 1925-26 Erwin Schroedinger created wave mechnics. It was a formulation of quantum mechanics that made attack on atomic and molecular problems possible by physicists traditionally trained to deal with waves. That was a glorious achievement. In their work on the historical development of the quantum theory, Mehra and Rechenberg devote Vol 5, in two parts, to this episode. The level of scholarship, care and thoroughness shown in earlier volumes is maintained. Very few mistakes can be found in printing or scientific content [one mistake occurs on p232 where equations (2a), (2b) should be ordinary and not partial differential equations]. *Anybody who has contributed to the story and has to be introduced is given some space with his or her biographical details and a short account of the scientific work. The volumes are very useful for general information about a* large number of scientists. The long list of references pp.869-964 is exhaustive.

I

The book is divided into two parts ; each part has two chapters. Chapter I (part 1) entitled 'Schroedinger in Vienna' describes his early life in Wien or Vienna, capital of the Austro-Hungarian empire. Chapter II entitled 'Prelude to Wave Mechanics' deals with his early scientific work, his participation in the World War I and his move to the Eidgenoessische Technische Hochschule (ETH : The Federal Institute of Technology) at Zurich. Chapter III (Part 2) describes the creation of Wave Mechanics, undoubtedly the piece de resistance of the work. Chapter IV is concerned with 'Early Response and Applications' but also the development of the full time-dependent wave equation.

Chapter I starts with an elaborate discussion on the city of Vienna. The author's state, "The reconstruction of the origin of wave mechanics demands a detailed and careful analysis of Schroedinger's development as a person and as a scientist whose interests extended far beyond the borders of physics and science in general" (p. xiii). In his well known lectures which ushered in molecular biology as a scientific discipline in the forties Schroedinger showed a deep understanding of the ancient Indian philosophy. Vienna founded in Roman times was situated at the most convenient East-West connection and has felt the influence of the orient more than other centres of west European civilization. It has also been an imperial city, the capital of one of Europe's most enduring empires, and the urban sophistication of its inhabitants (Pauli and Schroedinger) was only to be expected. The university of Vienna was founded in 1384. It had been a pioneering institution in the fields of medicine, biology, physiology and psychoanalysis. At the end of the last century it had two very good physicists—E. Mach and L. Boltzmann. Mach was an original philosopher scientist. Boltzmann's contribution to statistical mechanics was recognized all over Europe. When radioactivity was being investigated elsewhere, the Vienna school had contributed in a new direction—that of cosmic radiation—through the work of Kolhoerster and Hess. Exner and Hasenoehrl, whom Schroedinger had as teachers, were good physicists with a broad spectrum of interest. In fact, Schroedinger did some experimental work in his early days. But his power in theoretical work was also evident in the analysis of fluctuations in Smoluchowski's work on Brownian motion.

Schroedinger participated in World War I "without getting wounded and without illness and with little distinction" (p 182). He observed that dehumanisation was rapid in war and got homesick for scientific work. After two years of war service he managed to get back to science.

Chapter II deals with his Zurich period. He moved to Zurich in 1921 and soon became an independent and careful observer of the development in atomic physics. He worked on Bohr-Sommerfeld orbits in the atom but soon concerned himself with the question of consistency of quantum theoretical description of identical microscopic particles. Incidentally the authors give a very nice account of ETH at Zurich and its most famous student A. Einstein ; it is more complete than A. Pais's account in "Subtle is the Lord".

II

In the creation of wave mechanics there is some evidence that the final push came from some remark of P. Debye during a seminar of Schroedinger on de Broglie waves. Debye said that the thing to seek was a wave equation for these waves. The exact date of the seminar cannot be ascertained. Certainly neither Debye nor anybody else anticipated what followed. First the relativistic equation (the Klein-Gordon equation) was found and rejected as the solution did not agree with the experimental results. Working then from variational principles, optical analogy and the Hamilton-Jacobi theory, Schroedinger wrote down the time-independent hydrogen atom equation and solved it to find the correct eigenvalues. Experience and intuition played their parts. But the hydrogen atom equation was the first step. The second step was to develop a systematic scheme for wave motion analogous to the Hamilton-Jacobi theory in classical mechanics. Just as wave optics was more general than geometrical optics the new scheme must be more general than classical mechanics but should reduce to it in the appropriate limiting condition. This generalised scheme constitutes the second paper of Schroedinger. Mehra and Rechenberg also describe sommerfeld's very elegant route to the Schroedinger equation (p 522).

When he had the general scheme Schroedinger tried to apply it to many problems. Here the book of Courant and Hilbert 'Methoden der mathematischen Physik' came in handy, and their mathematics merely required minor transcriptions in several cases. The perturbation theory was worked out and some of the triumphs of the old quantum theory—the Stark effect, for instance—were repeated.

Wien and Sommerfeld were delighted ; Hilbert recovering from pernicious anaemia received the news of the wave mechanics with joy and started lecturing on it. But Wien and Lorentz also pointed to unresolved questions—the radiation problem and the connection of the eigenvalues with the Ritz combination principle.

Very soon the two schemes—the matrix scheme and the wave equation scheme—were shown to be equivalent by Pauli, Eckart and Schroedinger. All three found the easier route from the partial differential equation to the matrices via the orthogonal eigenfunctions of the boundary value problem. Weyl failed to reach the equation from the matrices ; the operator techniques were not so well developed. But Lanczos proposed an integral equation formulation based on the Fredholm theory described in Courant-Hilbert.

Applications were being made fast. Fues, Schroedinger's student, worked on the band spectra ; Pauli calculated the line intensities. Born considered collision problems and made the momentous statement that "it was necessary to give up the deterministic description of the scattering process". This is the beginning of the Born probabilistic interpretation and the authors promise that Volume 6 will take up the story.

Heisenberg now solved the helium problem. The symmetry properties of the wave function for many electrons came into focus. Fermi and Dirac formulated a completely new statistics for electrons, which was different from the other known quantum statistics due to Bose and Einstein for photons.

By June 1926, about six months after he embarked on the search, Schroedinger found the time dependent wave equation. It was first order in time so that its coefficients were free from special dynamical quantities and depended on fundamental constants like Planck's constant and the electron mass. Clearly the equation was non-relativistic. But Schroedinger went ahead and worked out the time dependent perturbation theory.

Two Indians appear in this book with some prominence. S. N. Bose's work influenced Schroedinger's statistical work before he plunged into wave mechanics. C. V. Raman's discovery of the Raman effect confirmed the quantum calculations of the dispersion phenomena.

The book ends with Schroedinger well settled in Berlin amidst a galaxy of famous German scientists. The best summary of the work can be given in Einstein's words : "...this theory contains without doubt a piece of the ultimate truth..". How it was done is well described in this volume. But will any narrative, however detailed, ever fully explain the mysteries of the working of a great mind ?

Satyendra Nath Bose National Centre for Baisc Sciences. C. K. MAJUMDAR
DB 17, Sector I,
Salt Lake City,
Calcutta-700 064.