Wolfgang Pauli

(Scientific Correspondence with Bohr, Einstein, Heisenberg. Part II : 1930—1939)
(Sources in the History of Mathematics and Physical Sciences, Vol. 6)
edited by K Von Meyenn (with the cooperation of A Hermann and V F Weisskopf)

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This is the second volume of W Pauli's scientific correspondence with his contemporaries. Earlier when the first volume was reviewed, we had agreed with the evaluation of the editors on the importance of the subject material as sources in the history of mathematics and physical sciences. We had also remarked on the high quality of scholarship, the great care and thoroughness of the editorial work and the beautiful, flawless production. The high standard has been maintained in this volume as well.

It covers the period 1930-1939. During this time, Pauli had several assistants, Casimir, Peierls, Weisskopf, Ludwig, Kemmer and Fierz—all of them first rate scientists. The volume starts with a summary by Meyenn of their work. A chronology of the important developments in the theoretical physics in the thirties follows. Then we are carried through a year-by-year account from 1930 to 1939. The epilogue in pp 714 to 719 contains useful information and includes a list of eighty most important correspondents of Pauli ; the list includes Bhabha and Salam. The table from page 720 to 732 lists the most important events in Pauli's life. Some of his lecture notes are summarized in two pages (736-737). Finally, a chronological table of the correspondence is given and then later a table is supplied with the correspondents alphabetically arranged. Of course, complete indices of names and topics are supplied at the end.

From 1930 we find Pauli grappling with the developments of quantum field theory. In 1930 his most important work was the prediction of neutrino to explain the continuous beta-ray spectra and other problems in beta decay (an open letter to investigators in radioactivity, p 39). The year 1932 saw some remarkable experimental discoveries—the neutron, the deuteron and the positron. The nuclear theory became simpler with the two constituents of nuclei-proton and nuetron ; the negative energy solutions of the Dirac equation were now well understood. Pauli, however, was not immediately convinced with the resolution of the latter difficulty. His famous Handbuch article on Quantum mechanics appeared in 1933, and the Dirac equation did not yet get the encomium it deserved. From 1934 onward, the relativistic quantum field theory engaged Pauli's attention – the resolution of the negative energy states, the infinite self energy and the development of the Fermi theory of beta decay based on the neutrino hypothesis. Numerous letters were exchanged between Pauli and Heisenberg and their students. These are several lengthy letters in 1935 on the interpretation of quantum mechanics among Schrödinger, Pauli and Heisenberg – the criticism by Einstein was always in the background. Better field theoretical treatment of the Dirac equation emerged slowly. One can see the development of Kemmer equations and Pauli's progress towards the spin-statistics theorem. Then the second world war brokes out and Pauli left Europe. As Meyenn remarked, with his departure a great chapter of European physics ended.

The period 1933 to 1939 was a period of great political unrest. The Nazis came to power in Germany and their strong antisemiticism forced many German scientists of jewish origin to leave the country. They included some of Pauli's great friends – Einstein and Born. One can feel the stresses and strains developing among old friends now unhappily on different sides or at least not having identical political views and convictions. The marches of the troops and the drums of war can be heard through these letters. And one sees with admiration the attempt of scientists to carry on rational discussion in science even when violence is slowly engulfing them. The kind helping hands from America and England are found recorded in these letters.

Occasionally there is a flash of humour. I cannot refrain myself from quoting part of the delightful answer (p 235) by O W Richardson to Schrödinger's enquiry about how to behave when receiving the Nobel Prize. "If you run short of money...you might have to prolong your stay in Stockholm. As a Nobel Laureate your credit is very good for the time being...(you) live in the hotel until the cheque materialized...(Nobel Lecture). One tries to make it intelligible to a lay audience, if possible. My lecture was a minute or two short of the hour. I think perhaps if it had been 45 minutes it might have been more popular. It is well to have this lecture well prepared on account of the exigencies of the table". A very sound advice to any sicentist preparing for any lecture, even if it is not as exalted as the Nobel lecture.

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Quantum Probability and Applications II (Lecture Notes in Mathematics, Vol 1136)

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edited by L Accardi and W von Waldenfels

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This is the second volume in a series of proceedings of conferences devoted to the newly emerging discipline of quantum probability and organised at the universities of Rome II and Heidelberg by L Accardi and W von Waldenfels. Some of the topics covered in this volume are : quantum stochastic calculus, irreversible systems and associated quantum Markov processes, integration of Schrodinger equation using path integrals with respect to ordinary stochastic processes as well as integrals with respect to quantum stochastic processes, quantum chaos, ergodicity and entropy, foundations of quantum mechanics, derivation of classical hydrodynamics starting from Schrödinger equations for systems of Coulomb potentials, etc.

We cite a few examples to convey the spirit and flavour of this volume since it is beyond the capacity of a single reviewer to do justice to all the contributions. Consider a quantum system S whose states and observables are described by density matrices and operators in the Hilbert space H_S. Suppose such a system is coupled to a heat bath or quantum noise N whose states and observables are described in the Hilbert space H_N. The interaction picture of S and N can be described by a total Hamiltonian $H=H_S+H_N+H_I$ where the three successive terms describe the energy of the system, noise and interaction respectively. If ψ_0 is a pure state of N and X is any observable in H_S one can define a transformed observable $T_t(X)$, $t \geqslant 0$ by the relation

$$\langle u, T_t(X)v \rangle = \langle u \otimes \psi_0, e^{itH} X \otimes 1_N e^{-itH} v \otimes \psi_0 \rangle \qquad (*)$$

for all $u, v \epsilon H_S$, $t \geqslant 0$. There are several examples where it turns out that $T_t T_s = T_{t+s}$ for all $s, t \geqslant 0$. Since (*) implies coarse graining T_t is not invertible and thus (T_t) describes irreversible dynamics. Starting from the famous "dog flea" model of Ehrenfest in the classical theory of Markov chains this type of construction has evolved into a subject covering the theory of diffusion through stochastic differential equations in classical probability as well as the theory of quantum diffusion in terms of quantum stochastic differential equations which leads to Markov processes whose generators are described by the Gorini-Kossakowski-Sudarshan-Lindblad theorem. These models arise naturally in the study of Bloch equations, electron shelving effect, Wigner-Weisskopf atom etc. The mathematics behind such a theory is treated in the contributions of Albeveric and Høegh Krohn, Applebaum, Barchielli and Lupieri, Dumcke, Ford, Frigerio, Ghirardi *et al*, Hudson and Lindsay, Kummerer, Maassen and Verbeure. Particularly noteworthy from the didactic point of view are the contributions by D Applebaum and A Verbeure. Verbeure describes beautifully the emergence of the so called K.M.S. condition as a description of detailed balance and approach to equilibrium in quantum statistical mechanics.

There are two articles devoted to the integration of Schrödinger equation for a particle in interaction with a field or a collection of bosons. J Bertrand, B Gaveau and G Kideau present a novel formula in terms of a Poisson point process by considering the kinetic energy and interaction energy as perturbation terms with potential energy as the initial term. Indeed, these authors have pursued this approach much further. A similar formula is arrived at by the reviewer in terms of quantum stochastic processes obeying quantum stochastic differential equations.

C Barnett and I F Wilde and R F Streater deal respectively with extensions of Doob-Meyer decompositions of quantum martingales and Ito's formula for Clifford Brownian motions. W Ochs examines the notion of comparable probabilities in the foundations of quantum mechanics and shows that the curtain has not come down over the conceptual drama of quantum theory. A Paskiewicz looks at the notion of "almost everywhere convergence" for observables whereas C Cecchini investigates the notion of conditional expectation in quantum probability.

Bialynicki-Birula presents an authoritative survey of uncertainty relations in terms of entropies rather than dispersions which may not exist in many examples. Casati, Lindblad, Besson, Ohya and Petz deal with topics like quantum chaos, ergodicity and entropy and show that a lot of work remains to be done. On the whole this volume will be found valuable by those who wish to examine the fundamental role of concepts like probability, events, observables, stochastic processes, conditional expectation, irreversibility, equilibrium, diffusion, tunneling etc., in the framework of quantum theory.

The only drawback is the considerable delay in reviewing this volume and a part of this blame is shared by the reviewer with due apologies to the reader.

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Radiative Transfer in Nontransparent, Dispersed Media (Springer Tracts in Modern Physics, Vol 113)
by Harald Reiss

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ix+205 pages, 72 figures ; price : DM 108 (Hard cover) : ISBN 3-540-18608-5

The illumination and polarization of the sunlit sky had been investigated by Lord Rayleigh as early as 1871 when he specified the radiation field in an atmosphere with well-defined physical laws. Later, in the first decade of the present century Arthur Schuster and Karl Schwarzschild formulated the problem in Radiation Transfer to explain certain astrophysical problems in stellar spectra and stellar atmospheres. S Chandrasekhar's famous book (Dover Publications, 1960) on the subject too has a tilt towards astrophysical applications, although it deals the subject on a wider theoretical level incorporating relevant mathematical devices and techniques. On the other hand, a host of books have been written on the engineering aspects of the subject. There was, thus, a need for a book which paid attention not only to the theoretical aspects but also to their experimental confirmation. The present book fills in that void.

The book has six chapters, first three of which deal with the theory and the rest three, with experiments. The first chapter, as is the custom, gives a general introduction to the determination of heat-flow components defining thermal conductivity, dispersed medium, and, coupling heat transfer modes to temperature profiles. Owing to energy conservation, non-radiative heat transfer cannot be decoupled from the radiative one and hence a discussion on non-radiative transfer modes was warranted in Chapter 2, which also gives the rigorous Mie theory of scattering and calculation of extinction coefficients therefrom. Mie theory has the distinction of predicting reasonably accurate values even though it is applicable only to idealized particle geometries. Chapter 3 gives a good review of approximate solutions of the equation of transfer, such as, Viskanta's solutions for a grey medium for isotropic scattering, linear anisotropic scattering models etc. The diffusion model has also been treated in detail.

Calorimetric and spectroscopic experiments to determine extinction coefficients have been considered in Chapter 4 where a good collection of experimental data (Tables 4.1 and 4.2) has been presented. Chapter 5 is devoted to a discussion of experimental determination of temperature-dependent thermal conductivity and extinction coefficient, while Chapter 6 finally describes a way to achieve optimum radiation extinction.

As the name of the book suggests, the discussion centres on nontransparent media, a great part of which is constituted by thermal insulators. These materials procedure is based on the exact and approximate symmetry properties of an electronic subsystem. A correlation between interatomic interactions in the study of scattering processes have been properly emphasised by the author.

The theory presented in this book is self-contained. Various processes occurring in atomic collisions over a wide energy region from thermal energies to hundred of eV have been properly discussed in the present book. The book is provided with an appendix devoted to the quantum theory of angular momentum, which may be of help to the readers.

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