An Intimate Look at the Scourge of God

No Time to Be Brief: A Scientific Biography of Wolfgang Pauli

Charles P. Enz
Oxford U. Press, New York, 2002.
$60.00 (573 pp.).
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Reviewed by Valentine. L. Telegdi

Wolfgang Pauli (1900–58) was probably the most colorful personality among the founders of modern theoretical physics. Child prodigy, acerbic but much sought critic by age 20, caustic originator of countless anecdotes throughout his life who signed his letters "the scourge of God," his fame is due to more than his monumental contributions to physics. Were it not for the fact that Pauli revealed himself through his voluminous published correspondence comprising some 2600 letters (published by Springer-Verlag), one might say that the physics community has been waiting for a Pauli biography with bated breath. Many of those letters, though, are in German, and furthermore, they only rarely deal with his personal life. Thus, Charles P. Enz's scholarly opus fills a real gap. The book, whose title should have been *A Man of Principle*, is not easy reading, but it is a must for any physics library.

The book's structure is like that of Abraham Pais's celebrated biography of Albert Einstein, *Subtle is the Lord* (Oxford U. Press, 1982)—a mixture of thorough analysis of the scientific papers and of parallel developments in the subject's personal life. Enz, who was Pauli's last assistant, writes with an intimacy based on day-to-day contact, while Pais is more reserved.

The book analyzes in detail almost all of Pauli's papers, including some that had understandably fallen into oblivion. The discussion, couched in modern notation, of Pauli's works in the "old" quantum mechanics, permits one to understand the birth of the exclusion principle. The evolution of Pauli's thoughts—from neutron to neutrino—about a neutral spin-½ particle makes fascinating reading. Pauli's vision and ultimate rejection of a non-abelian gauge theory, previously accessible only in his published correspondence with Pais, is carefully presented. The topic of Pauli's last paper, "On the Thermodynamics of Dissociated Equilibrium Mixtures in External Force Fields," (*Zeitschrift für Angewandte Mathematik und Physik*, volume 9b, page 496, 1958) shows the breadth of his interest. It was dedicated to a colleague, the aerodynamicist Jakob Ackeret.

AIP EMILIO SEGRÈ VISUAL ARCHIVES

Wolfgang Pauli, in a 1940 passport photograph taken shortly before his trip to the Institute for Advanced Study in Princeton, New Jersey.

The book tells us much about the vicissitudes of Pauli's personal life: his mother's suicide; his short, failed marriage; his second, happy one; his relationship with ETH Zürich, where he was a professor from 1928 until his death. The story of the latter part of that relationship will baffle and rightly shock any reader.

In a nutshell the story is this: In July 1940 Pauli left, with a formal leave of absence from ETH, for a semester at the Institute for Advanced Study (IAS) in Princeton, New Jersey. Subsequently, for lack of proper travel documents, he could not travel back to Switzerland. On the one hand, the ETH authorities threatened to dismiss him unless he returned promptly; on the other, the head of the federal police refused to endorse Pauli's application for naturalization, which had already been filed in 1939. The official correspondence in this matter is full of veiled and even overt anti-Semitic remarks (see Charles P. Enz, Beat Glaus, Gerhard Oberkofler, eds., *Wolfgang Pauli und sein Wirken an der ETH Zürich*, Hochschulverlag ETH, 1997). In July 1943, a motion at the school board for the dismissal or forced retirement of Pauli failed by a single vote, cast by the president of ETH. After Pauli returned to Zürich in 1946, a fresh Nobel laureate who had been offered Einstein's post at the IAS, the earlier history was forgotten and his naturalization ultimately granted.

The section of Enz's biography that readers will find most puzzling is the one that covers Pauli's deep involvement with Zürich psychoanalyst Carl Jung. The breakup of Pauli's first marriage in 1930 led him into a deep depression and he agreed to be analyzed, first by one of Jung's assistants and then by Jung himself. The treatment appears to have been beneficial and Pauli came to embrace many of Jung's mystic conjectures. The embrace was firm enough that Pauli and Jung jointly published a collection of essays. Pauli, the ultimate rationalist in physics, felt a deep interest in what lay "beyond" exact science. Perhaps he was searching for the wellsprings of his own creativity. In his essay on Johannes Kepler's concepts, he traces the origins of those concepts to preconceived

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archetypes, as opposed to geometrical notions. Note that Pauli carefully recorded about 1000 of his dreams and that his depression on the breakup of his marriage did not affect his legendary powers of concentration. On his deathbed, Pauli named Jung as the one person he wanted to see.

While Enz's book is a monument of painstaking scholarship, its narrative does not flow well. It is constantly being interrupted by thumbnail sketches of people who crossed Pauli's path. The discussion of life in Zürich has so much detail that one needs a map to appreciate it. The space used up by such minutiae would have served better by including more Pauli anecdotes. Finally, much of Pauli's depth and wit, originally expressed in most elegant German, gets lost in the often stilted translations that are given.

Cohesion: A Scientific History of Intermolecular Forces

J. S. Rowlinson
Cambridge U. Press, New York, 2002. $90.00 (333 pp.).
ISBN 0-521-81008-6

Why does matter stick together? Why do gases condense to liquids, and liquids freeze to solids? *Cohesion* traces how those and kindred questions have been "tackled in the Western world in the last three hundred years." The book is an intricate and intriguing saga, ably presented by John Rowlinson, emeritus professor of physical and theoretical chemistry at Oxford University and a distinguished contributor to the analysis of intermolecular forces. His avowed "wider aim" is to exemplify the fitful development of a "branch of normal science," a field that did not endure Kuhnian revolutions but nonetheless is replete with periods of confusion, excitement, and stagnation.

The saga has many strands, some stretching back to antiquity. Rowlinson weaves a Brueghel-like tapestry that amply depicts both the tangled, contending notions about cohesive forces and the erratic, messy evolution of a science toward a coherent perspective. He portrays three broad periods of chaotic advances in chapters named after Isaac Newton, Pierre-Simon Laplace, and Johannes Diderik van der Waals.

In a final chapter, titled "Resolution," Rowlinson describes how quantum mechanics at last solved major conceptual puzzles, particularly about dispersion and retardation forces. However, he also shows that progress was significantly handicapped by an arrogant "reluctance to believe that anything of importance could have happened before the great days of quantum theory." He emphasizes as well that, despite the essential role of intermolecular forces in a host of current applications to biophysical dynamics and material sciences, there remain "fundamental limitations on our abilities to make accurate calculations, which no one yet knows how to overcome, and which few are willing to tackle."

The book admirably fulfills its stated aim of serving historians of science and also physicists or physical chemists curious about the roots of modern approaches to intermolecular forces. In its style and level of detail, *Cohesion* bears comparison with the epic story of intra-atomic and intranuclear forces given by Abraham Pais in his *Inward Bound* (Oxford U. Press, 1986). There is also apt contrast, in that *Cohesion* is much wider in historical scope; for the most part less technical; and, rather than celebrating abrupt paradigm shifts, chronicles a more gradual progress. Rowlinson's historical scholarship is extensive; he provides about 1200 notes and references, chiefly to primary printed sources, as well as a name index with 850 entries. For the 20th century, however, the huge expansion of pertinent work forces him to offer only impressionistic coverage of some selected topics.

Cohesion includes many episodes that are enhanced by historical context but deserving of wider attention as instructive or cautionary scientific parables. I note a few choice items. Newton envisaged matter as corpuscular and cohesion as due to short-range forces of attraction but refrained from publishing most of his speculations "lest I should be accounted an extravagant freak and so prejudice my readers against all those things which were [my] main design." Throughout the 18th century, metaphysical doubts about action at a distance in a vacuum and about elastic collisions of rigid spheres were great impediments. In the 19th century and beyond, ignoring such doubts became, as Rowlinson says, "one of the features of normal science."

More generally, Rowlinson illustrates "that scientists have a well-developed defensive mechanism when faced with theoretical obstacles. They ignore them, hope that what they are doing will turn out to be justified, and leave it to their deeper brethren or to their successors to resolve the difficulty." Indeed, the action-at-a-distance enigma was not resolved until the mid-20th century, when intermolecular forces were attributed to exchange of photons and consequently subject to the retardation effect. Rowlinson also demonstrates that scientists may be embarrassingly unaware of antecedent work. He notes, with regard to the hydrodynamic pressure tensor for a viscous fluid, that arguments advanced in the second half of the 20th century about its representation "duplicate, in ignorance, and almost word for word, some of those of a hundred years earlier."

Students of molecular science (and their teachers!) would do well to consult Rowlinson's book to see how discussions of topics such as capillarity, surface tension of liquids, elasticity of solids, and gas imperfection gain uncommon clarity from historical perspective, which brings out underlying assumptions and perplexing aspects often obscured in current texts. Those concerned about science literacy—either for the general public or for the coming generation of professionals—will find much material useful for seasoning their sermons.

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Order and Chaos in Dynamical Astronomy

George Contopoulos
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Imagine two black holes with just enough electric charge to cancel their mutual gravitational attraction. Then consider an uncharged test particle moving under the gravitational influence of those two fixed black holes and sharing a plane with them. In classical dynamics, the motion of the test particle turns out to be regular, but in general relativity it is chaotic.

Your reaction to *Order and Chaos in Dynamical Astronomy* will, I think, be much like your reaction to the two black holes. If you are charmed by the order–chaos dichotomy, you will find much to enjoy in the book. If it bothers you that nothing astronomers know of remotely resembles two fixed black holes, the book is probably not for you.

George Contopoulos has a half-century record of working on unusual but interesting problems. Best known for his work on high-order perturbation theory in stellar dynamics (the third integral), he also contributed—long before most others took any interest—