Behind the scenes at Solvay

The Quantum Ten
A Story of Passion, Tragedy, Ambition and Science

Sheilla Jones
$24.95 (323 pp.).

Reviewed by Michael Eckert

“Erwin Schrödinger’s second preoccupation was women.” So begins a chapter entitled “Shock Waves” in The Quantum Ten: A Story of Passion, Tragedy, Ambition and Science, by Sheilla Jones. Other chapter titles, for example, “The Quantum Showdown” and “Drawing the Battle Lines,” indicate that such prose is the rule rather than the exception. One would expect that kind of sensationalism in the gossip column of a newspaper rather than in a book published by Oxford University Press. Anyone familiar with the scholarly discourse about the origins of quantum mechanics will approach the kind of popularization offered in The Quantum Ten with some scepticism. As a professional historian of physics asked to review the book, my first reaction was in that vein: I thought I’d either simply deny the offer or suggest that the book does not merit review in PHYSICS TODAY. Given its focus on personal passion and tragedy, how could the book’s readers hope to understand the intellectual turmoil caused by the advent of quantum mechanics in the 1920s?

A closer inspection of The Quantum Ten, however, reveals that Jones’s approach has its virtues. The author, a science journalist with a master’s degree in physics, constructs her narrative around key participants of the 1927 Solvay Conference (the number in the title should not be taken literally), including Albert Einstein, Schrödinger, Niels Bohr, Max Born, and Werner Heisenberg. According to the conventional wisdom of the physics community, disputes about the meaning of quantum mechanics climaxed at the conference. Bohr’s indeterministic Copenhagen interpretation emerged as the winner, and Einstein’s opposing deterministic interpretation of the quantum world, epitomized by the saying “God doesn’t play dice,” came out the loser.

However, biographical and other historical investigations during the past decades have shown that the debates were more than a mere clash between a Copenhagen cohort of Bohr, Heisenberg, Born, and company and a dissenting camp of Einstein, Schrödinger, and Louis de Broglie. For example, later this year Cambridge University Press plans to publish a new book by Guido Bacciagaluppi and Antony Valentini, Quantum Theory at the Crossroads: Reconsidering the 1927 Solvay Conference. Jones cites the work (available at http://arxiv.org/abs/quant-ph/0609184), which concludes that things were not as clear-cut as the spokesmen of the Copenhagen interpretation have made us believe. Bacciagaluppi and Valentini relate that Heisenberg, probably sincerely, proclaimed that “this conference has contributed extraordinarily to the clarification of the physical foundations of the quantum theory.” On the other hand, they quote participant Paul Langevin, who described the conference as an event where “the confusion of ideas reached its peak.” In brief, what has emerged as the Copenhagen interpretation is far from a uniform view shared by Bohr, Heisenberg, and Born, not to mention Wolfgang Pauli, Pascual Jordan, and others who participated in the discourse. Nor have the debates about what quantum mechanics means been settled, as is evident from the post-1927 paradoxes associated with Schrödinger’s cat and the famous Einstein-Podolsky-Rosen paper of 1935.

Based on studies of the recent history of physics and the biographical literature of a number of the participants at the 1927 Solvay Conference, Jones tells an intriguing behind-the-scenes story of the development of quantum physics. She keeps the narrative from being mere gossip, in part because she benefits from excellent sources. The bibliography includes the authoritative biographical literature—Martin Klein’s study of Paul Ehrenfest, a prominent figure throughout Jones’s book; David Cassidy’s biography of Heisenberg; and others—along with more recent work like Quantum Theory at the Crossroads. In view of present quantum experiments that are sparking new interest in the historical debates of 80 years ago, one might have wished for a stronger emphasis on the scientific content of those disputes. The predominance of the personal keeps the physics at a minimum. Where it is unavoidable to delve into the quantum riddles, however, Jones displays an admirable talent for transmitting the essence of the subject without digressing into technical detail.

The Quantum Ten, therefore, should not be dismissed as just another story of scientific heroes. Anyone interested in the emergence of quantum physics and the debates about its foundations will be thrilled by the controversies among its protagonists. So far, no one has portrayed that crucial episode of 20th-century physics in such an easily read, down-to-earth manner as Jones. If one or another aspect is painted too sketchily, the reader can consult the bibliography to find the pertinent expert literature.

Statistical Physics of Particles

Mehran Kardar
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Statistical Physics of Fields

Mehran Kardar
Cambridge U. Press, New York,
2007. $75.00 (359 pp.).

Several years ago while Mehran Kardar and I were sitting outside a coffee shop in Berkeley, California, and discussing the behavior of a system that interested us, he conceived of and sketched a...
derivation of statistical field equations governing the system’s dynamics. Admiring what he was showing me, I asked him how he did it. He shared his logic, and it proved to be a useful lesson. Now, Kardar shares his approach governing the system’s dynamics. Statistical Physics—"that Kardar has written—held some of my competition. The book is the second of two volumes—the other being Statistical Physics of Particles—that Kardar has written based on a two-semester statistical mechanics course he offers at MIT to physics graduate students. Over the past two decades I have admired Kardar’s contributions to theoretical physics, and now I admire his contribution to teaching physics.

Long ago, statistical mechanics was a tangential topic of physics, one that a single graduate textbook could summarize with reasonable completeness. That changed starting in the 1970s, when the importance and breadth of the field began to grow enormously. Statistical mechanics is now indispensable in virtually all of the natural sciences and beyond, from mathematical physics to molecular biology, from economics to social networking. One reason for its growing and unifying role is the development of renormalization group theory, which played out in the 1970s. Another is the ease of numerical simulation, which also began around the same time. Those and related developments changed the sociology of theoretical physics and placed statistical physics at its center.

Nowadays, no one- or two-volume text can cover the entire field. Nevertheless, a good text will provide a foundation for students who can then venture far beyond. I believe that Kardar’s two volumes serve that purpose. The discussions are succinct, focused, often elegant, and almost always demanding. Much of the physics is presented through solutions to exercises appended to all but the second volume’s last two chapters, and in using the books, students will learn by example. The first volume contains roughly 200 pages of standard text and about 100 pages detailing solutions to many, but not all, of the exercises; the second volume has about 250 pages of text plus about 100 pages of problem solutions. Students will not find the books easy going, but they will be substantially rewarded for their hard work. Precocious students might use the texts successfully without an instructor. They will likely need to be comfortable with mathematics typical of a graduate-level quantum mechanics course, and they will need to intuit the meanings of some notations.

Together, the two volumes cover many of the standard topics—ensembles, real gases, Bose–Einstein condensation, equilibrium Landau–Ginzburg theory, the Ising model, and so forth. Nonetheless, there are notable absences. Among the most significant omissions is a systematic treatment of linear response and the connections between measurements and correlation functions. Also, the book does not include a substantive discussion of numerical methods; it has only the briefest mention of the simplest of Monte Carlo schemes.

What Kardar’s text does have—in the first eight chapters of the second volume—is a superb treatment of time-independent statistical field theory that starts with a discussion of elasticity in ordered solids and ends with the two-dimensional Coulomb gas and 2D melting. Several other good texts treat phase transitions by means of scaling, series expansions, and renormalization group theory, but Kardar’s coverage is special. Students getting their first exposure to the topic will obtain an excellent foundation through a remarkably compact yet reasonably complete and understandable presentation of the essentials of symmetries and physical reasoning and also the nuts and bolts of lattice sums, combinatorics, functional integrals, and field-theoretic perturbative calculations. Expert readers will enjoy seeing how Kardar does the job, and they might gain new insights.

The first volume includes cursory discussions of time dependence, but nonequilibrium phenomena are not otherwise discussed until the last two chapters of the second volume. Entitled “Dissipative dynamics” and “Directed paths in random media,” they survey several of the most interesting topics to which Kardar has contributed significantly. The approach taken in those chapters is closer to that of a review article than that of a textbook. Although they are a useful compendium, I prefer something more like the first eight chapters, with an assortment of exercises and illustrative problem solutions.

The first volume, Statistical Physics of Particles, is distinguished by its useful feature of teaching by example, but otherwise its presentations are similar to those in other excellent texts of similar level. On the other hand, the first eight chapters of Statistical Physics of Fields are stunning. With that volume Kardar has produced an excellent and unique textbook that will serve our community well for many years.

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Galactic Dynamics

James Binney and Scott Tremaine

The first edition of James Binney and Scott Tremaine’s Galactic Dynamics is the bible of its field. Written by two of the world’s leading dynamacists, it educated a generation of graduate students and serves as a reference book for researchers of all specialties who work on the subject. Since the book’s publication in 1987, galactic dynamics has witnessed major developments and shifts in perspective, and new dynamical techniques have emerged for modeling and interpreting observations. Nowadays galaxies are not considered in isolation; astrophysicists recognize that their evolution cannot be separated from their formation in the broader cosmological context. Dark matter, an immature concept in 1987, is now seen as the dominant element in the formation and dynamics of galaxies. It is a good time for a second edition.

The new edition incorporates several changes. It expands on the use of Lagrangian and Hamiltonian mechanics and more strongly emphasizes orbit-based methods for constructing stellar systems. In response to increasingly sophisticated N-body simulations, the new edition includes more on numerical methods for evaluating gravitational fields and following orbits. Discussions of dark matter are integrated into the other chapters. Moreover, Galactic Dynamics now has an introductory section to set the cosmological context. The final chapter on galaxy formation and cosmological structure formation includes a short section on star formation and feedback. The topic is far from mature, but it is an appropriate one with which to end the book because it is potentially so important for galactic dynamics. Back in 1987 the community’s understanding of dark matter—