More Surprises in Theoretical Physics

Rudolf Peierls
Princeton U. P., Princeton, N. J., 1991. 106 pp. $9.95 pb
ISBN 0-691-02522-3

This is not a textbook or monograph, nor is it intended for the layman. It is instead a delightful little book meant as light reading for the professional physicist, graduate student or old-timer, theorist or experimenter. Although it is clearly written and easily read, it is not mainly philosophical or qualitative but contains surprisingly explicit theoretical physics, especially quantum mechanics and condensed matter theory (as well as statistical mechanics and nuclear theory). The topics covered are representative of Rudolf Peierls's distinguished career of almost 60 years and come mostly from the middle of that period (20 to 40 years ago). The treatment of the topics gives the reader an excellent view of Peierls's refreshingly direct and down-to-earth research style.

The book is about "surprises," but not at all in the sense of the unpredictable, as in gambling or sports or politics—or even experimental physics. Some aspects of modern theory, especially quantum mechanics, are still counterintuitive even for professionals, so that some results are not what one predicts at first glance, and certain methods turn out to be easier or harder than expected. It is Rudi's genius to show the reader in concrete terms how to do the predicting after some organized thinking.

The style of the book is quite similar to that of its predecessor, *Surprises in Theoretical Physics*, published in 1979 (Princeton U.P.), and access to both books will help the reader achieve a deeper understanding of modern physics. Like the first book, the sequel starts with general quantum mechanics and shows how to get concrete results in, for instance, the counting of states, the WKB method in three dimensions and perturbation theory. Most of the treatment may seem "lowbrow," but there are enough hints to allow the reader to supply the mathematical rigor as an afterthought. Later chapters bring out unifying themes for seemingly disparate subjects, such as pseudomomentum for crystals, fluids, sound and even light. Some chapters are less detailed and mainly give physical insight into questions such as, What really goes on when one applies an electric field to a piece of palladium that has hydrogen dissolved in it?

This is a refreshing book all the way through, and it is easy reading in the sense that you don't need a battery of reference books in front of you. But you do need to do some concentrated thinking if you want to get some of the book's subtleties.

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Innovation in Maxwell's Electromagnetic Theory: Molecular Vortices, Displacement Current, and Light

Daniel M. Siegel
Cambridge U. P., New York, 1991. 225 pp. $49.50
hc ISBN 0-521-35365-3

The late Richard Feynman once declared that "from a long view of the history of mankind . . . there can be little doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics." The US Civil War, he said, would "pale into provincial insignificance" beside this other event of the 1860s. Feynman may have exaggerated a little, but the formulation of Maxwell's theory certainly ranks as one of the prime events of 19th-century physics, and it is little wonder that Maxwell's steps toward that theory, particularly his use of mechanical models, have attracted close historical scrutiny. The ambiguities and seeming contradictions in Maxwell's electromagnetic writings, especially when viewed from a 20th-century perspective, have helped make them a notorious source of confusion and academic controversy.

Daniel Siegel, in recent years one of the leading students of Maxwell's work, has set out to clear up some of this confusion. The core of his book is in effect a close reading of Maxwell's key 1861–62 paper, "On Physical Lines of Force," and some related documents. Making very effective use of a traditional "internalist" approach, Siegel shows how close attention to the details of Maxwell's writings—including the grouping of terms and the signs in his equations—can illuminate the inner structure of his thinking.

Siegel focuses on Maxwell's famous vortex and idle-wheel model of the ether and its close though complicated relationship to his electromagnetic equations. Maxwell presented himself, Siegel says, as "the mechanical engineer of the magnetoelectric medium," and in Siegel's reconstruction, the vortex model emerges not as a confused or inconsistent auxiliary to the mathematical theory but as a consistent working model of the electromagnetic medium and the basis of Maxwell's thinking on the subject. Siegel shows, for instance, how the displacement current and the "electromagnetic theory of light" emerged from Maxwell's exploration of the workings of his mechanical model and how greatly the original versions of these important ideas differed from their later, purely electromagnetic formulations. Although not all of his conclusions are new, the new level of detail and rigor that Siegel brings to his analysis enables him to settle, apparently conclusively, several long-debated points. There is perhaps still room for dissent on some points, such as his claim that Maxwell regarded electric charge as a real accumulation of idle-wheel particles and his dismissal of the idea that Maxwell ever seriously intended to treat the wheels as acting directly on each other by their mutual pressure. But it is clear that Siegel has greatly advanced our understanding of what Maxwell was up to.

More broadly, Siegel makes a convincing case that Maxwell was a far more committed mechanist than has often been depicted—in particular, that he believed strongly in the existence of ethereal vortices in the early 1860s and that he continued to retain some belief in their reality in later years, even while making a "measured retreat" from his more speculative idle-wheel mechanism. Moreover, Siegel shows how intelligently and productively Maxwell was able to use his model. As Siegel remarks, Maxwell was not a confused and groping 20th-century physicist, but a clear-thinking 19th-century one, for whom imaginary mechanical models were an effective research tool. Siegel has laid the groundwork for a new treatment of Maxwell's work, placing it firmly within the specific 19th-century context from which it grew.

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Quantum Electrodynamics

Edited by T. Kinoshita
World Scientific, River Edge, N. J., 1990. 997 pp. $48.00 pb
ISBN 981-02-0214-8

This collection of specially prepared articles on precision tests of quantum electrodynamics celebrates the triumphant success of the application of theoretical physics to the world of