

The Devil is in the details

The Demon and the Quantum

From the Pythagorean Mystics to Maxwell's Demon and Quantum Mystery

Robert J. Scully, with endnotes by Marlan O. Scully
Wiley-VCH, Weinheim, Germany,
2007. \$45.00 (271 pp.).
ISBN 978-3-527-40688-3

Reviewed by Gian Paolo Beretta

Notable physicist Marlan Scully has contributed to the discovery, design, and interpretation of many quantum effects, devices, and puzzles. In *The Demon and the Quantum: From the Pythagorean Mystics to Maxwell's Demon and Quantum Mystery*, he contributes endnotes to a book principally penned by his son, Robert. Written with the goal of explaining the secrets of the quantum in layman's terms, the book ends up painting a lively, readable portrait of the genesis of modern physics. A diesel mechanic, Robert Scully gains readers' sympathy and attention by declaring at the outset that he is not a physicist. He also disarmingly explains the fortuitous reasons for his unusual familiarity with many famous physicists, including several Nobel laureates, who attended barbecues at his father's ranch during his childhood.

In the first half of the book, the reader is guided step by step along a wonderful journey across the highest physical concepts. Before each step, Scully gives a thoughtful, brief introduction not only to the physics that motivates the theories but also to the human sides of the ancient mathematicians, philosophers, and modern pioneers of classical or quantum theory who contributed to shaping the next concept he will intro-

duce. The smart introductory epistemological essays set a novel-like rhythm, dilute the difficult concepts, and stimulate the reader's curiosity.

The second half, with its extensive set of endnotes, can be disregarded by the nontechnical reader. But those who have some mathematical background will find well-written, concise mini-lectures that translate the descriptions, ideas, and inferences of the first part into the proper technical language of mathematical physics. The consistency of the main chapters with the rigorous material of the endnotes allows for discussions in the first part that are never oversimplified and makes *The Demon and the Quantum* satisfying also to readers who have a strong physics background.

The Scullys successfully explain counterintuitive quantum effects, such as wave-particle complementarity and delayed-choice and which-path information erasure in two-slit interference experiments. Less clearly outlined and convincing are the discussions of Maxwell-demon aspects of Stern-Gerlach experiments and quantum heat engines. Yet that flaw is not the authors' fault: It is a fair representation of the status quo. The role of thermodynamic concepts in quantum theory is still far from fully understood. No definitive word has been written about which exorcism prevents the demon from threatening the validity of the second law of thermodynamics. It is actually very exciting to see the strong revival of thermodynamics in today's scientific literature. About three decades ago, almost every physicist was convinced that thermodynamics was a dead subject and that the final word about it had been said by statistical mechanics. Pioneers who dared to reveal the demons of statistical mechanics and who worked at more consistent theories aimed at unifying quantum mechanics and thermodynamics lost their jobs.

Today, perhaps because of the impressive recent advances in single-particle experimental techniques, one might say that the quantum is finally

becoming thermal. After having been kicked out of the front door 30 years ago, thermodynamics has now reentered through the back window and is once again permeating the physics literature as a source of inspiration. Scully's book shows how historic contributions in physics are not made by those who publish papers by the hundreds or who get funding by the millions, but by the few thinkers and independent minds who have the strength to step out of the race, and quietly identify and address the big questions.

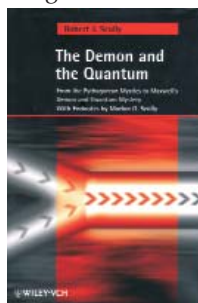
Perhaps in the next edition, Scully could complete the picture with a selection of the physicists, chemists, and engineers who long ago broached the key questions being addressed today by those who study quantum demons and heat engines. Some of those issues are covered in, for example, *Meeting the Entropy Challenge: An International Thermodynamics Symposium in Honor and Memory of Professor Joseph H. Keenan* (AIP, 2008), which I coedited with Ahmed Ghoniem and George Hatsopoulos. Overall, *The Demon and the Quantum* is accessible to a large spectrum of readers of PHYSICS TODAY; it is worthwhile reading even though, in the end, the book turns out to be more convincing in explaining the quantum effects than in clarifying the demon conundrum.

Group Theory

Application to the Physics of Condensed Matter

Mildred S. Dresselhaus, Gene Dresselhaus, and Ado Jorio
Springer, New York, 2008. \$89.95
(582 pp.). ISBN 978-3-540-32897-1

In my experience, there is no ideal way to teach the application of group theory to the quantum mechanics of atoms, molecules, and solids; the reason is the inherent nature of the subject. Students have to invest a large amount of intellectual capital before they reap the benefits in applications that often fall out almost trivially. Moreover, the mathematics of group representations is quite sophisticated and unfamiliar to most physics and electrical engineering graduate students, and that is rather off-putting for many if they do not



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