but that cannot seem to marshal the economic forces to eradicate the cancerous decay of its cities, to provide quality schools for all its children, adequate housing for all its citizens, and that cannot keep its water fit to drink, its air fit to breathe. We would wish to reëxamine our traditional, largely self-defined, concept of "standard of living," to enlarge its scope to include a measure of the quality of life as well as the quantity of things in it. A nation, like a person, will be judged not by what it can do but by what it actually does.

Coexistence. The "convergence theory" occupies a central role in Sakharov's presentation, and is one of the main arguments supporting his prognosis of a Soviet–American rapprochement. The fact of convergence we cannot doubt, but it could be questioned whether convergence is either a necessary or a sufficient condition for coexistence. Many historical systems that had fought bitterly—religious, ethnic, national groups—have learned to live together in peace, without convergence, when it served their best interest to do so. The US and the Soviet Union must become aware of their own ultimate, and identical, best interest, which is not necessarily to become alike but rather to pursue peace so that each can survive and develop in its own way.

One cannot help but be deeply moved by the sincerity, by the idealism of the Sakharov essay. Yet it is an idealism tempered by the reality of our time: We must learn to live together or we shall perish together. Sakharov is surely aware that Russian–American coöperation is not a panacea but a prerequisite, that a "pax Russo–Americana" would be unacceptable, that all nations must play a role in the crucial years ahead. He makes no claim to having designed a perfect nor even a detailed plan for the future; rather, he sets forth his ideas for discussion, for criticism—so that the dialog—from which such a plan can emerge, and without which it will not—can be kept in motion. Political leaders have largely failed to do this; the hour grows late; others must try. The American scientific community should be grateful to Sakharov for the effort he has given and should accept the challenge to continue it, to enlarge upon it.

* * *

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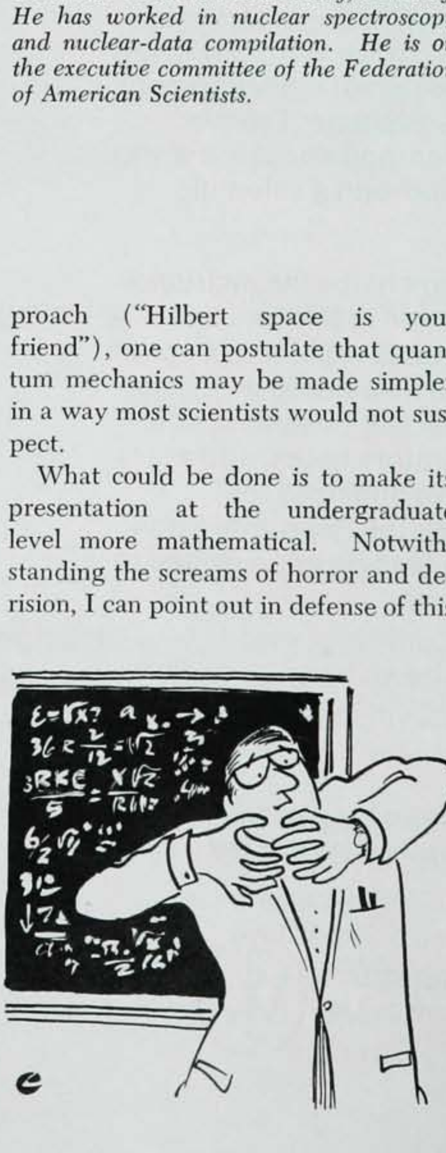
Theory of the microworld

THE MATHEMATICAL PRINCIPLES OF QUANTUM MECHANICS. By Derek F. Lawden. 280 pp. Methuen, London (Barnes & Noble, New York), 1967. $8.00

by GARRISON SPOSITO

Is quantum mechanics really difficult? That is the question put to professors by harried undergraduates and worn-out doctoral candidates as they seek reassurance in their intellectual wrestling matches with the theory of the microworld. It is also the question that professors put to themselves in the quiet privacy of their sanctums and which, unhappily, they tend to answer in the unhesitating affirmative. All right; suppose it is true. Being optimistic about such things, we can ask what can be done to sugar-coat this really difficult subject without loss of precept or content. Besides some rather obvious and probably not very useful suggestions having more or less to do with the Madison-Avenue approach ("Hilbert space is your friend"), one can postulate that quantum mechanics may be made simpler in a way most scientists would not suspect.

What could be done is to make its presentation at the undergraduate level more mathematical. Notwithstanding the screams of horror and derision, I can point out in defense of this

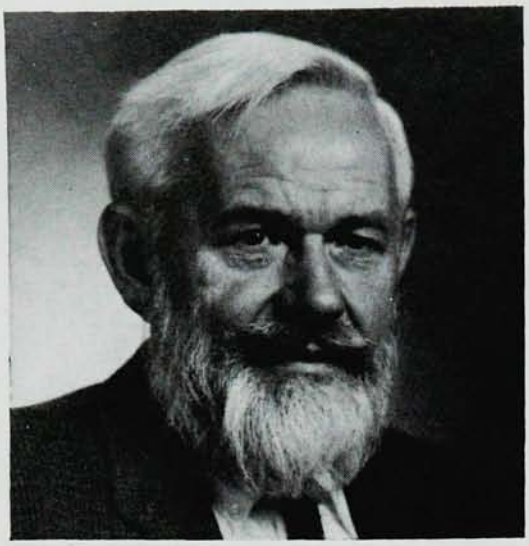


ostensibly treacherous innovation that one of the major difficulties the neophyte quantum theorist has is the assimilation of new concepts in what appears to be a mathematical milieu far different from the one he so painstakingly mastered during his study of classical physics. Why do wave functions have to be square-integrable? Why is there a Principle of Superposition? What does a complete set of states have to do with things? These are mathematical requirements that are difficult to justify on wholly empirical grounds, in the same way that the definitions of the length of a vector in three-space and vector addition are difficult to justify in the classical domain. Why not tell the students the truth: In a very real sense classical and quantum physics are both mathematical children of the same abstract mother—the notion of a normed vector space.

Even if a professor does accept the idea that a first course on quantum theory ought to emphasize the mathematical structure more, he is still faced with the problem of finding a suitable text. One quite feasible possibility is to use a good physics book along with an inexpensive, physically oriented, mathematics supplement. Derek Lawden, professor of mathematics at the University of Canterbury in New Zealand, has supplied us with an adequate candidate for the supplement.

His book, originally written for undergraduate applied mathematicians who wish to know about physics, comprises seven chapters: two on states, three on observables, one on perturbation techniques and one on the Dirac equation. There are also seven appendixes on the properties of special functions and other mathematical details that serve to embellish the main text.

The discussion in the book is generally good, but occasionally lacks the organization and relevance that the rigor-seeking physics student might wish to find. I am not sure just why matrices have to be discussed right along with vector spaces or why a chapter entitled "Observables Having Continuous Spectra" devotes half its pages to observables having discrete spectra. Those students who think they might find out something about the delta "function" will also be disappointed since the rigorous meaning of that artifact is not only highly ignored by the author but is even blighted by his cool introduction of nonentities like



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$\delta^{1/2}(x)$. On the bright side however, it should be pointed out that the chapters on regular momentum, perturbation theory and the Dirac equation are quite good and well worth reading to get the mathematician's slant on those subjects. In fact, this statement can be made about nearly all the physically relevant topics discussed in the book. As an example of the gems to be discovered, consider the startling remark, made in the first chapter, that noncommuting observables may have eigenvectors in common. The author deftly illustrates this fact by exhibiting a pair of Hermitian operators whose respective invariant subspaces are neither equal nor disjoint.

The Mathematical Principles of Quantum Mechanics can be recommended as a worthy supplement to undergraduate courses on quantum physics and as readable rigor to those professionals who are not inclined to go through von Neumann's treatise in search of an understanding of Hilbert space. However, one should be cautioned that this book is not a tome on physics and may deviate from the norm on strictly physical questions. In particular, the author commits a form of the Einstein–Podalsky–Rosen error when he adopts the view that incompatible observables may be supposed to possess definite values at a given instant, even though both are not actually measured simultaneously. He goes on to assert that his view has support in experience because one can demonstrate empirically that the mean value of a sum of incompatible observables is equal to the sum of their mean values. Most physicists would prefer to cite the correspondence principle as basis for this fact, rather than the assumed existence of precise simultaneous values for observables that cannot be simultaneously and precisely measured.

* * *

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Foundations of quantum theory

MATHEMATISCHE GRUNDLAGEN DER QUANTENMECHANIK. By Johann von Neumann. 262 pp. Springer-Verlag, Berlin, 1968. $7.00

PRECIS DE MECANIQUE QUANTIQUE RELATIVISTE. By O. Costa de Beauregard. 202 pp. Dunod, Paris, 1967. 24F.

by PETER G. BERGMANN

This edition of *Mathematische Grundlagen der Quantenmechanik* is a straight reprint of von Neumann's 1932 classic. A translation into English by Robert T. Beyer, which was supervised by von Neumann, and which was published in 1955 by the Princeton University Press, may be preferred by Anglo-Saxon readers, but the typography of the German original is vastly superior.

In some respects the theory of distribution by Laurent Schwartz has superseded von Neumann's mathematical development, and the physical foundations of quantum theory have been explored further during the intervening three and a half decades. Nevertheless, as much of this subsequent work was stimulated by von Neumann's analysis, the renewed availability of the book is to be welcomed.

In *Précis de Mécanique Quantique Relativiste,* O. Costa de Beauregard, of the Institut Henri Poincaré of the Université de Paris, has written a highly condensed summary of relativistic quantum theory. He discusses its foundations and epistemological implications from the point of view of one who is thoroughly familiar with the conventional interpretations (often referred to as the Copenhagen school) as well as with the interpretations of Louis de Broglie, Albert Einstein, Erwin Schrödinger and Alfred Landé.

In the very brief space of not quite

ALAN W. RICHARDS

JOHN VON NEUMANN