

suffice to yield the statistics of phenomena, while the quantum state does so, the latter is the prime candidate for characterizing the atomic object in Folse's reconstruction. The trouble with this reading, however, is that the dynamical development of the quantum state is governed by the Schrödinger equation, which is linear—and from this linearity stems the notorious problem of the reduction of the wavepacket. This problem cannot be solved simply by the strategy of considering the experimental arrangement of the measurement, because the composite system consisting of object plus apparatus is presumably also characterized in reality by a quantum state that propagates linearly—as is dramatically illustrated by Schrödinger's cat. There is no mention of these difficulties in Folse's book, because he resolutely abstains from the evaluation of rival interpretations of the quantum mechanical formalism, and he never writes down any part of that formalism.

The book therefore is silent at just the point where the problems become challenging. If Folse has a realistic interpretation of the atomic object that escapes the problem of the reduction of the wavepacket, what is it? Is it a novel, hidden variables theory, a theory that maintains the standard quantum kinematics but replaces the Schrödinger equation by a nonlinear dynamical equation, or what? Perhaps we should seek a different "reconstruction" of Bohr's thought that dispenses with critical realism and does not permit the problem of the reduction of the wavepacket ever to arise. According to Aage Petersen's very interesting book, *Quantum Physics and the Philosophical Tradition* (MIT Press, Cambridge, 1968), Bohr resisted the kind of commitment to a concept of reality that Folse has reconstructed. But how promising is renunciation of ontology? I must confess that after 25 years of attentive—and even reverent—reading of Bohr, I have not found a consistent and comprehensive framework for the interpretation of quantum mechanics. The value of the last chapter of Folse's book lies in the fact that it draws the reader into reviewing the available options.

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Atmospheric Electrodynamics

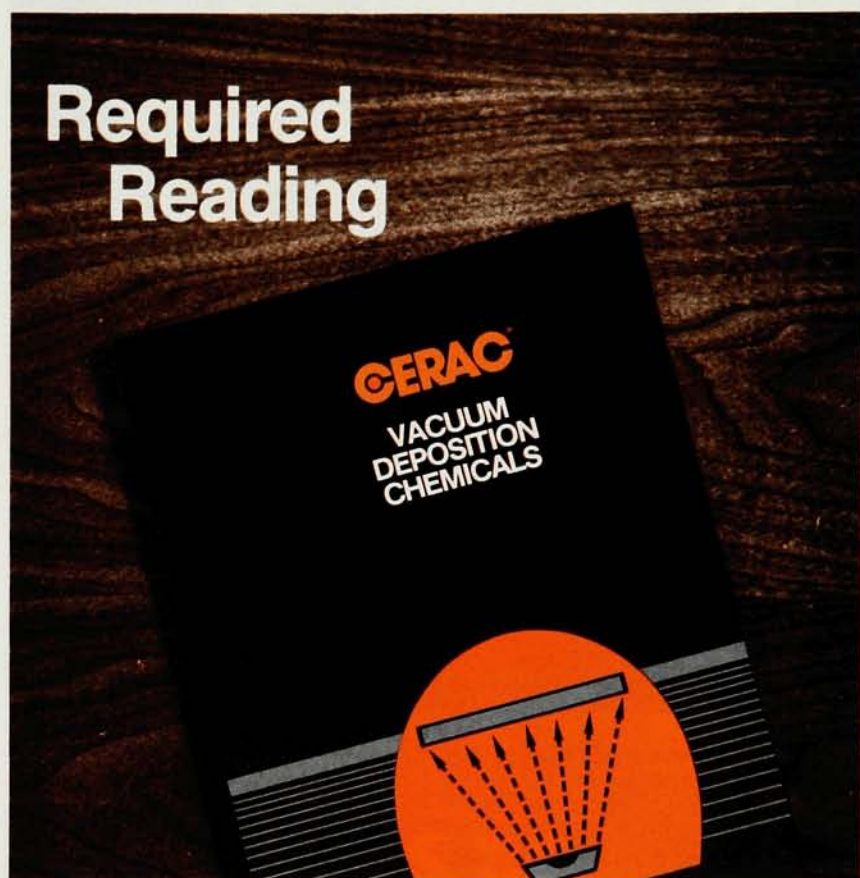
Hans Volland
205 pp. Springer-Verlag, New York, 1984.
\$35.50

Hans Volland's book deals primarily with his specialties: the currents and low-frequency electromagnetic fields that originate in the lower atmosphere,

the upper atmosphere and the magnetosphere. Traditionally these subjects have been treated separately. Thus phenomena originating in the lower atmosphere have been designated as atmospheric electricity, a subfield of meteorology; those originating in the upper atmosphere and magnetosphere, formerly a part of geomagnetism, have been considered subfields of aeronomy and space physics, respectively. Volland stresses that these fields are interconnected and tries with some

success to provide workers in meteorology, aeronomy and space physics with a modern, unified view.

Willis L. Webb, in his book *Geoelectricity* (University of Texas at El Paso, 1980), made a similar effort to unify the treatment of the various kinds of electrical activity taking place above the Earth's surface. The two texts differ markedly in one important respect: Webb concludes that the large currents flowing in the upper atmosphere play a dominant role in tropospheric electri-



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cal phenomena, while Volland, we believe correctly, assumes their effects are of minor importance.

After outlining the sources of ionization in the atmosphere and the consequent variation of conductivity at various levels, Volland deals with the global electric circuit that maintains the negative charge residing on the surface of the Earth. He gives a good outline of our basic knowledge about thunderstorms. His illustration of a typical thundercloud cell, however, leaves much to be desired, for it fails to incorporate recent improvements in our knowledge concerning the air circulation within the cloud and the locations of electric charge. After pointing out that there are two kinds of electrification processes capable of causing lightning, one involving precipitation and the other not, Volland deals only with the former in any detail.

Following the order of increasing altitude in the atmosphere, Volland discusses the interaction of ionospheric plasma with the geomagnetic field and the subsequent induced electric fields and currents. He presents an overview of the solar wind and its impact on the geomagnetic field, leading to the magnetospheric cavity and to geomagnetic activity. He then reviews the global-scale electric-field and current configurations within the magnetosphere and their magnetic manifestations on the ground. Finally he discusses the theory of low-frequency wave propagation through the magnetospheric plasma and observed wave phenomena in the magnetosphere.

In general the topics are well chosen and cover much of the subject matter of contemporary interest. Treatments of these topics are concise and well done within the limited space of a monograph. Simple analytical solutions are often given, and when applicable, their numerical approximations. These are helpful in providing the reader with a physical insight. The book is remarkably free of printing errors.

Nevertheless it has shortcomings. It is uneven in its treatment; sometimes easy, sometimes difficult to read. Occasionally statements are imprecise and could mislead. Specific examples include: "The total space charge induced on the Earth's surface is then $-QA$..." It is impossible to give the Earth a net charge by induction. With regard to the inductive electrification of cloud particles, Volland states, "...the degree of polarization depend[s] on the dielectric constant of the particles involved." However, the electrical conductivity of these particles is so high that electric fields do not exist within the particles. It is not true that "the geomagnetic field at mid and high latitudes is predominantly vertically

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oriented." "On the night side" should be eliminated from the sentence "sudden pulses and sudden commencements are worldwide phenomena occurring nearly simultaneously on the day side and on the night side."

Some readers will be disappointed that this book fails to give adequate attention to interactions between electrical phenomena occurring in the troposphere and the regions above it. For example, no indication is given of the possible effects on the electrification in thunderclouds when solar flares cause increases in the atmospheric electrical conductivity that extend down to levels as low as 15 km. Similarly, little attention is devoted to the effects that radiation from lightning can produce on processes occurring in the upper atmosphere.

Despite these minor limitations, the book should prove a valuable resource for those already working in any of these very active fields of research, or who may be thinking of tackling any of the many fascinating and important problems in atmospheric and magnetospheric physics that remain unsolved.

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Quantum Field Theory

F. Mandl, G. Shaw

Wiley, New York, 1985. \$34.95

Quantum field theory has, in the last two decades, become the natural tool for describing systems with large numbers of degrees of freedom, and it is at this time the only language in which relativistic quantum mechanics can be formulated. Thus some knowledge of field theory is increasingly viewed as part of the general graduate curriculum. This carefully written and, for its length, surprisingly comprehensive book is an excellent candidate for becoming the standard text for a one-semester introductory course in relativistic quantum field theory.

The first part of the book contains a brief, but quite complete, introduction to the quantization of free fields. The discussion of the Dirac equation is perhaps too brief, even though an appendix attempts to remedy an almost complete absence of details in the main text. The problems with the covariant quantization of the radiation field are treated with great efficiency. The quantization of the massive vector-boson field is postponed till the last part of the book, where the topic comes up in a discussion of the weak interactions.

The scattering matrix is introduced in the second part of the book. Feynman-graph rules for electrodynamics are derived and some tree-graph exam-

ples are worked out. I was again impressed with the care the authors have taken to combine brevity with completeness. Thus the reader's attention is drawn to the need for some sort of asymptotic hypothesis; the infrared divergence is discussed in connection with the soft-photon limit of *bremsstrahlung*, and the examples chosen for explicit calculation are compared with experiment. Further, useful examples of tree-graph calculations occur in the last part of the book in connection with

the weak interactions.

The discussion of renormalization is conventional: The various divergent parts are identified, and renormalized. The authors make good use of dimensional regularization. As usual, the discussion of the external line renormalization is awkward in the absence of Lehmann-Symanzik-Zimmermann reduction formulas, but aside from that, everything is clear; and the Schwinger correction to $g - 2$ and the Lamb shift are worked out to order e^2 .

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