

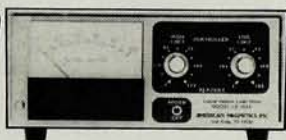
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Center for Astrophysics. These sections give an overview of, and reveal the power and beauty of, the process of digital image-processing now in widespread and increasing use. They show not only finished images but also a wide variety of intermediate stages, to illustrate how the process can be useful. The images show objects in parts of the spectrum that are otherwise invisible to the human eye.

The Invisible Universe is as up to date and wide ranging a survey as can be presented. Only a few changes have occurred since its publication, including the discovery from HEAO-3 that aluminum-26 is widespread in our galaxy and thus that its presence in our solar system need not invoke a supernova trigger to have started its condensation; the statistical work lessening the probability that galactic cannibalism has taken place; and the renaming of SIRT to Space Infrared Telescope Facility with its probable removal from the space shuttle.

Field and Chaisson maintain their identification of our times with Galileo's by quoting extensively from Galileo's writings on the opening page of each section, as well as quoting Kepler to open the epilogue. The material that they present in the book fully justifies their claim. Their book will be of interest to everyone of a scientific bent, and should be widely read.

The Philosophy of Niels Bohr: The Framework of Complementarity

Henry Folse

281 pp. North-Holland, New York, 1985.
\$19.50

Henry Folse is a creative partisan of Niels Bohr. His book aims at "presenting Bohr's philosophy as a consistent and comprehensive framework for the objective description of nature." But because of Bohr's unfamiliarity with philosophical terminology and positions, the author feels that he can achieve this aim only by a "manner of exposition which reconstructs Bohr's viewpoint in what appears to me to be its best possible form." The resulting reconstruction is presented to philosophers, historians and scientists who are interested in Bohr as a natural philosopher, and it presupposes no technical knowledge not readily available to any of its prospective readers.

The book must be judged on two grounds: its utility in illuminating the writing of Bohr—which is often cryptic—and its success in achieving philosophical coherence, independent of fidelity to Bohr's own intentions.

The bulk of the book consists of explications, which I cannot recommend. They are repetitious and for the

most part consist of variants of Bohr's own phraseology. Serious omissions prevent the book from being properly self-contained. For example, without mention of de Broglie's wavenumber-momentum relation and without pictures and descriptions of procedures for measuring linear momentum—both of which Bohr himself presents masterfully—the uninformed reader has no grounds for understanding the incompatibility of experimental arrangements for measuring position and momentum. Although Folse repeatedly emphasizes the importance of unambiguous description and communication, he nowhere mentions Bohr's thesis that the "closure" of a phenomenon in an irreversible registration is essential for unambiguity. The presentation of the debate between Bohr and Albert Einstein is marred by overlooking the field-theoretical ontology preferred by the latter and by attributing to him a reactionary commitment to classical mechanics. The claim that there are no experimental tests bearing on the Bohr-Einstein debate surprisingly neglects the theorem of John Bell and the experiments based on it—whose outcomes favor Bohr.

The "reconstruction" of Bohr's philosophy, mainly in the last chapter, is the essential contribution of the book. A valuable series of quotations supports the position that Bohr cannot be classified philosophically as a positivist, phenomenalist or instrumentalist for whom physical theory is nothing but a tool for ordering and predicting experience. Bohr, as reconstructed by Folse, is a realist, but a *critical* one. A distinction is made between the atomic object and the various phenomenal objects that appear in complementary experimental arrangements. The reality of the atomic object is described "in terms of its power to produce the various different observational interactions described by the theory as providing complementary evidence about the same object." The atomic object would not possess the same properties exhibited by the phenomenal objects, and in this way Bohr's critical realism would differ from the realism of classical mechanics. (In fact, this critical realism seems remarkably close to the position of Einstein!)

If we accept this reconstruction of Bohr, then we are confronted with the crucial question: What are the intrinsic properties of the atomic object? Folse hints repeatedly that they are the properties implicit in the quantum state (in other words, the wavefunction or the state vector), though at one point he quotes with approval Max Born's thesis that the invariants of a system, such as charge and mass, constitute the objective properties lying behind experience. Because the invariants do not

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

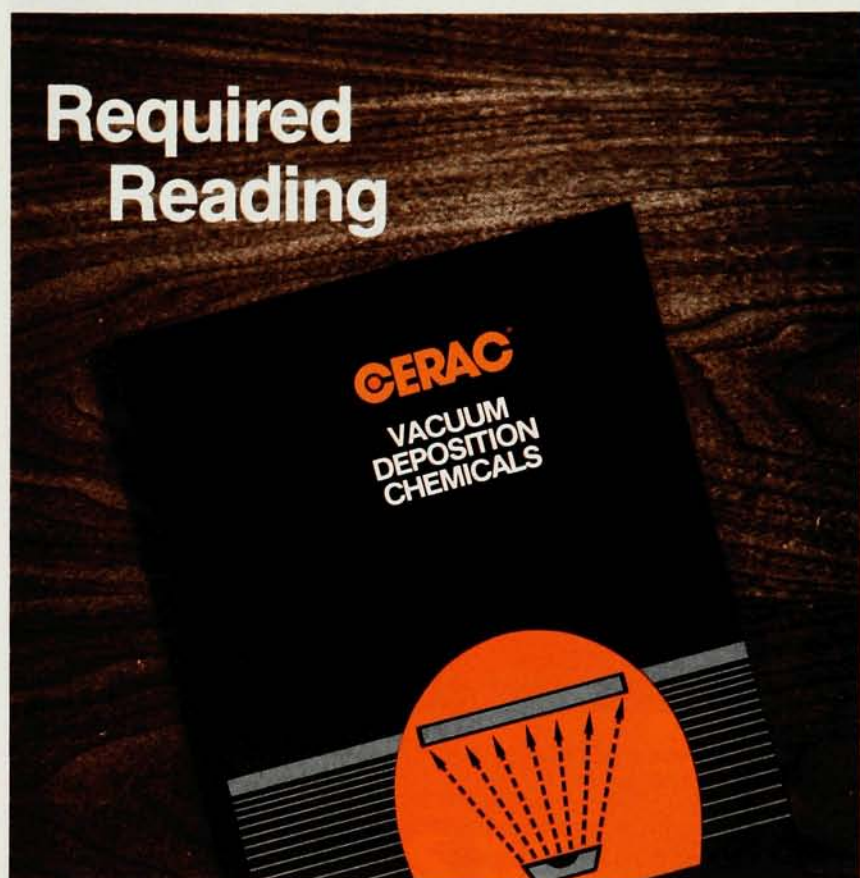
Hans Volland
205 pp. Springer-Verlag, New York, 1984.
\$35.50

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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