Are new windows revolutionizing our view of the universe?

The Invisible Universe: Probing the Frontiers of Astrophysics

George B. Field, Eric J. Chaisson
195 pp. Birkhäuser, Boston, 1984. $19.95
Reviewed by Jay M. Pasachoff

Hercules cluster. This photograph is a three-color image obtained with a charge-coupled device and is recorded on Polaroid Polacolor ER Land Film Type 809.

"In all of history," the authors write, "there have been only two periods in which our perception of the Universe has been so revolutionized within a single human lifetime. The first occurred nearly four centuries ago at the time of Galileo; the second is now under way." Few scientists are as well qualified to write about this revolution in our knowledge as George Field and Eric Chaisson. Field was chairman of a profession-wide survey committee, reporting to the National Academy of Sciences, that assembled the report *Astronomy and Astrophysics for the 1980s* (see PHYSICS TODAY, April 1982, p. 46 and November 1982, p. 25). The final report not only discussed the entire possible range of astronomical advance, but also ranked the instrumental possibilities and set priorities for funding. This "Field Report" has had, and will continue to have, a major influence on the progress of astronomy. Chaisson, as a professor first at Harvard and now at Haverford, has long been interested in, and has taught and written about, a wide range of astronomical topics, including the search for life elsewhere in the universe.

Field and Chaisson, in this nontechnical book, provide an overview of astronomy's present and future for educated readers. They divide the field into eight major parts, quite far from the traditional division. Only half of them would have been major divisions in earlier times: radiation, Sun and stars, planets, and galaxies. And even here there are deviations from the astronomy of the past: The study of life and intelligence is mixed in with the discussion of planets, and most of the discussion of radiation is of radiation invisible to our eyes. The other half of the topics are much newer as major divisions: interstellar space, cosmic violence, universe, and forces of nature. Showing the book's origin in the Field Report, each section ends with a few pages on "prospects for the future," including mainly space missions now definitely planned or at least on the drawing board. A set of appendices gives more details about eight such projects. A glossary provides basic definitions and an index increases the usefulness of the book.

Between each of the sections, one of the authors has written (and initialed) a personal story of one to three pages. My personal favorite is one of Chaisson's, about the time that Cygnus X-3 flared brightly, giving the potential of being a nearby supernova that could harm the Earth's atmosphere and thus the life below it. On this holiday weekend, Chaisson's radio observations were plagued by interference. After his request through Lincoln Lab for radio silence "rapidly filtered up the chain of command to some unnamed person or persons in Washington," he and his colleagues were told that they would have eight minutes without interference. "At exactly the appointed time, nearly all the electromagnetic interference disappeared; even the underlying static that had plagued every radio observation I had ever made until that moment (or since) became less. . . . I often wonder what might have happened if the Soviets had initiated a first strike during those eight minutes, when, apparently, much of the American military radar systems had been turned off (or at least greatly decreased in transmission power)." Another favorite of mine is Field's self-effacing report of how he calculated for Charles Townes that it would be hopeless to search for NH_3 in interstellar space before Townes "fortunately. . . ignored my advice and, not long afterward, discovered NH_3 in space."

The book also contains three color sections with images provided and described by Thomas P. Stephenson, formerly head of the image-processing facility at the Harvard–Smithsonian

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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 SIRTF 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