stein (here as he was circa 1906) that he (Einstein) and others will write letters to President Roosevelt in 1939 concerning the danger of the development of nuclear weapons by the Germans and of the need for the World War II Allies to beat them to it.

The dialogue form is ideal for convincing a skeptic entrenched in an old point of view of a new and revolutionary idea. Galileo was well aware of that when he wrote his *Dialogue of the Great World Systems*, and Harald Fritzsch learned from him.

The book is enriched by a number of illustrations, from line drawings to photographs. There is also a page of suggested readings and a glossary of technical terms. A detailed index makes it easy to locate particular topics.

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Interpreting the Quantum World

Jeffrey Bub
Cambridge U. P., New York, 1997.
298 pp. $49.95 hc
ISBN 0-521-56082-9

What is the quantum world like, and how can our measurements tell us about it? There was a time when physicists would have dismissed such questions as uninteresting or even meaningless; they were content to advance quantum theory and to apply it successfully to an ever-increasing range of physical phenomena; they felt secure in the conviction that Niels Bohr and the founding fathers of quantum mechanics had honed a satisfactory understanding of the theory and successfully defended it against the challenges of apostates like Albert Einstein and Erwin Schrödinger.

Objections to Copenhagen orthodoxy by David Bohm and other physicists provoked only brief (and, in retrospect, quite inadequate) responses, while those of Karl Popper and other philosophers were either ignored or dismissed as uninformed. But technically minded philosophers of science have continued to worry about the conceptual foundations of quantum mechanics, and a significant minority of physicists has now joined them (especially since the penetrating analyses of John S. Bell), thereby constituting what one recent author has dubbed QUODS, for quantum orthodoxy doubting subculture. For over 30 years, Jeffrey Bub has been a prominent member of QUODS, first as coauthor with Bohm of a hidden-variable theory of wave-packet collapse and then as a professional philosopher of science.

In his powerful new book, Bub clearly lays out the measurement problem faced by P. A. M. Dirac and John von Neumann's interpretation of quantum mechanics. He then constructs a framework for analyzing alternative interpretations that seek to solve this problem without running afoul of "no-go" theorems due to John Bell and the mathematicians Simon Kochen and Ernst Specker, among others. Excluded from this framework are both dynamical collapse theories, in the tradition of Gian Carlo Ghirardi, Alberto Rimini and Tullio Weber, and Hugh Everett's interpretation and its modern variants.

Bub dismisses the former as being a competitor to quantum mechanics rather than an interpretation of that theory, and he presents what he takes to be conclusive objections to the latter. What remains is a class of "no-collapse" accounts, including Bohm's hidden-variable interpretation and Bohr's complementarity interpretation. Although Bub's framework offers a novel way of making sense of Bohr's views, he focuses mainly on realist interpretations: "What we ought to aim for is a description that preserves as much as possible of Einstein's realist intuitions, subject to the constraints of the 'no-go' hidden variable theorems, which limit the applicability of those intuitions in a quantum world in various ways. The uniqueness theorem of chapter 4 characterizes the broad features of such a description" (page 238).

Bub calls this uniqueness theorem (of Bub and Rob Clifton) "the heart of the book." He intends it to show how many determinate properties a quantum system can consistently be taken to have or lack, where the quantum state generates a probability distribution over these determinate properties. Each determinate property state turns out to be defined by both the quantum state and some preferred observable R.

Taking R to correspond to the identity operator, we recover a principle that has come to be known as the eigenvalue–eigenstate link: An observable has a definite value if and only if the quantum state is an eigenvector of the corresponding operator with that eigenvalue. But since it was this link that generated the measurement problem for the standard interpretation, Bub thinks we should instead choose R to be something else, and thereby facilitate an account of the measurement process in terms of the dynamics of property states.

Taking R as position in configuration space, we get Bohm's deterministic hidden-variable interpretation. Bub does not reject this choice because of its well-known nonlocality, since no choice of R can respect Einsteinian locality and separability conditions. But neither does he endorse Bohm's interpretation. Indeed, he regards the choice of R as in part an empirical question: "The choice of a preferred determinate observable R for an observer-free 'no-collapse' interpretation of quantum mechanics that can account for measurements is constrained by the nature of the interaction between open systems and their environments in our universe" (page 163).

Bub suggests an answer to this question—discretized position in configuration space—on the grounds that open systems typically interact with their environments through position-dependent interaction potentials. Although a discrete R gives a stochastic dynamics for property states (here Bub relies on the work of Bell and J. C. Vink), this particular choice would guarantee that anomalous jumps in pointer readings after measurement are highly improbable, especially given environmentally induced decoherence; it would also explain the stability of the system–apparatus correlations produced by an initial measurement interaction.

But if quantum systems have determinate discretized positions, then it is not clear that the resulting interpretation is Lorentz-invariant (despite Bub's brief remarks in his concluding pages), while the extension of this kind of interpretation to relativistic quantum field theories remains a highly problematic task. Still, Bub has presented a strong case for his provocative closing statement: "What is now clear is that this is a task that cannot be avoided without giving up on quantum mechanics."

Interpreting the Quantum World is directed primarily to those scientists, philosophers and mathematicians who have acquired enough familiarity with quantum mechanics to be impressed by its power but puzzled by its conceptual obscurity. The book's first three chapters should be required reading for anyone wishing to get up to speed on contemporary discussions of the conceptual foundations of quantum mechanics. Bub's writing is terse, and the text is enriched by carefully chosen quotations. The book has an appendix that develops the Hilbert space mathematics of the theory so as to make the book self-contained for a reader with some minimal mathematical competence.

After laying out his own positive views, Bub returns to the Copenhagen interpretation. He gives an interesting reconstruction of Bohr's complementarity thesis, but remains dissatisfied with the observer-dependence of the view. The book concludes with a trenchant critique of the "new orthodoxy" that Bub sees condensing around the work of Murray Gell-Mann and Jim Hartle, Roland Omnès, Robert Griffiths and Wojciech Zurek. The orthodox should turn immediately to chapter 8 to test their faith!

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Beyond Star Trek: Physics from Alien Invasions to the End of Time

Lawrence M. Krauss
BasicBooks (Harper Collins), New York, 1997. 190 pp. $21.00 hc
ISBN 0-465-00637-X

Science popularization—the communication of scientific developments to a broad, nonscientist audience—is a double-edged sword. As a community, physicists are concerned about the widespread problem of scientific illiteracy and believe they should help educate the public. On the other hand, those who write popular science books are sometimes looked down upon by their ostensibly more serious-minded peers. Indeed, there are few classics in the genre of physics popularization, although the literature has mushroomed in the last decade.

In *Beyond Star Trek*, Lawrence Krauss has boldly gone where he had successfully gone before (*The Physics of Star Trek*, Basic, 1995). The aim of his most recent book is to exploit the popular fascination with science fiction in order to "set out the ideas that drive the modern scientific enterprise." The flouting of natural laws by such television series as *The X-Files* and blockbuster films as *Independence Day* become foils to illustrate physical principles.

The strategy is certainly entertaining and, for the most part, quite successful. For example, Krauss shows that the gigantic mother ship in *Independence Day* would have exerted huge tidal forces on Earth when it entered geosynchronous orbit, with presumably catastrophic consequences; no need for death rays. However, he misses an opportunity to explain his reasoning—namely, that gravity obeys an inverse-square law.

The first section of the book continues with a lively discussion of rocket propulsion and interstellar travel, making the point that the resources needed for a round-trip to the stars are literally astronomical. Along the way, Krauss works in short discussions of the detection of planets, adaptive optics and the Drake equation for the probability of extraterrestrial life. He builds a solid case against UFOs and does a good job debunking warp drive (faster-than-light travel). Factual errors (such as the assertion that the evolved Sun will end up with an iron core rather than as a carbon–oxygen white dwarf) are mercifully few.

The second half of the book, unfortunately, does not quite match the first in focus and quality of exposition. While ranging over a variety of hot topics, including extrasensory perception, neutrinos, dark matter, long-range forces, time travel, the cosmological constant and computers and consciousness, the treatment at times is too compressed to be genuinely informative for a general reader. (An exception is the longer discussion of quantum mechanics.) The tone also occasionally drifts toward self-congratulation and hyperbole: "I have been championing this once completely heretical idea . . . for over a decade."

Recent news stories have noted the lagging performance in science and mathematics by US high school students; this does not bode well for the continued long-term strength of the scientific enterprise in this country. While the causes of the problem are manifold, lack of exposure to forefront developments in science—as opposed to science fiction—is a contributing factor. Krauss's method of illustrating physical concepts by uncovering the fallacy of much science fiction is therefore a potentially useful antidote to scientific ignorance, and one guaranteed to appeal to an audience raised on television and movies. If, in order to communicate the message, he occasionally adopts the flip tone of TV culture, it is a gesture well worth making.

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Quantum Chaos and Mesoscopic Systems: Mathematical Methods in the Quantum Signatures of Chaos

Norman E. Hurt
Kluwer Academic, Norwell, Mass., 1997. 331 pp. $166.00 hc
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The average reader of PHYSICS TODAY has probably heard the words in the title of Norman Hurt's new book but may not have a precise idea what these terms mean. "Quantum chaos" refers to the manifestations in quantum me-