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!

Richard Healey
University of Arizona, Tucson

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.

Joshua A. Frieman
Fermi National Accelerator Laboratory
Batavia, Illinois

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
ISBN 0-7923-4459-6

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 mechanics of chaotic behavior in the corresponding classical systems. For example: certain features in the spectrum of the hydrogen atom when it is exposed to a strong magnetic field. "Mesoscopic systems"—for example, two-dimensional metals of various shapes with wires attached, the whole thing less than 1 μm in diameter—are the hottest items in the miniaturization of electronic circuits. The inelastic mean free paths of the electrons are several times the diameter of the sample, but their wavelengths are much smaller: say, tens of nanometers.

These two areas of research have mushroomed in the past ten years, with significant input from theoreticians, numerical analysts and experimentalists in nuclear, atomic, molecular and solid-state physics as well as optics and acoustics. It would be foolish to expect all this work to be organized in any systematic way, and Hurt was wise to add the subtitle "Mathematical Methods in the Quantum Signatures of Chaos." Many different approaches and interpretations have been proposed and investigated, but there is no single principle, like the perturbation expansion in quantum field theory, to guide the perplexed. The author is at home with many important concepts that are related to the main problem in some qualitative and intuitive way.

Among the basic ideas, we find the statistics and the correlation of energy levels, the connection between the classical periodic orbits and quantum-mechanical energy levels, the fluctuations of the conductivity and the localization of the wavefunctions near periodic orbits. Some of these phenomena have found a precise expression in mathematical formulas, but only under certain conditions. The reader would do well to distinguish between the ideas that can be good or bad and the formulas that can be right or wrong. Thus, the trace formula can be generalized to include diffraction effects and ray splitting among the classical trajectories, and the random-matrix theory for the statistical properties of the spectrum depends on the existence of additional symmetries like time-reversal, and so on.

The book functions more as a reference work than as a text, a reference that informs the reader about the mathematical justification for some of the intuitive connections that physicists have found in this area. Hurt has produced a remarkable collection of results from various fields, such as the theory of differential equations, the mechanics inside cavities and curved surfaces and the theory of fluctuations and correlation functions in disordered systems. All of them are relevant to recent work in physics that is related to the title of the book. The ideas lead the reader to many unexpected places, always with the purpose of looking at situations in which simple mechanical systems show unexpectedly complicated behavior.

The author is obviously very widely read, and he provides 30 pages of references from all walks of mathematics as well as theoretical and experimental physics. But Hurt seems not to be an active participant; at least he does not give a single reference to his own work. He has also chosen to live without diagrams or tables, although his mathematics is quite readable for somebody who, as I did, grew up before the abstract-algebraic trend took hold in mathematics teaching.

This book may serve as an introduction that encourages contact between mathematicians and physicists. It may even inspire new theorems, models and numerical explorations in an area where definitive results seem particularly elusive.

Martin C. Gutzwiller
IBM Research Center
Yorktown Heights, New York

Experimental Innovations in Surface Science: A Guide to Practical Laboratory Methods and Instruments

John T. Yates Jr
AIP Press (Springer-Verlag), New York, 1998. 904 pp. $89.95 hc
ISBN 0-387-98332-5

The title of John Yates's new book is suitably descriptive and seems to promise a lot; he has delivered on that promise. His goal in writing *Experimental Innovations in Surface Science* was to describe those practical laboratory methods used throughout the burgeoning field of surface science, a field rich in a wide variety of new physical and chemical measurement methods.

Yates, who is director of the Surface Science Center at the University of Pittsburgh, has concentrated here on covering methods of design, construction and measurement, of which almost 240 are described. The entries are mostly two or four pages in length, with some running to six pages. Every one features exemplary drawings. (I agree with the author's view that "the core ideas from published and unpublished accounts of research in easy-to-comprehend pictorial form . . . are the most effective mode for communication of information of this type.") The published research he alludes to spans a period of about 30 years, and, not surprisingly, most of the references come from the *Review of Scientific Instruments* and the *Journal of Vacuum Science and Technology*.

The entries are grouped under nine topical headings, the first six of which—Vacuum System Technology, Mechanical Fabrication Techniques, Measurement Methods, Thermal Control, Delivery of Adsorbates to Surfaces and Ultrahigh Vacuum Windows—account for some 80% of the book's contents. Because such a listing alone cannot convey the breadth of the book's contents and the thoroughness of the author's approach, I have selected a half-dozen entries to attempt to give the flavor of that approach.

▷ By cleaving a crystal in UHV (ultrahigh vacuum), one can produce an atomically clean surface. Details are given for how to make a UHV crystal cleaver that will operate at low temperatures (page 144).

▷ Many of us are familiar with the copper gaskets used with Conflat flanges in UHV systems for demountable seals. But how do you remove the gasket? Three useful tools for accomplishing that often-frustrating task are described (page 156).

▷ A 50-year history of the development of the methods of single-crystal orientation, grinding and polishing is presented. Three pages of text (including 16 references) and three pages of illustrations offer several good solutions (page 230).

▷ Spot welding seems easy to do until you have to deal with difficult junctions. Six examples are presented, with clear pictures of how those junctions should be handled (page 260).

▷ Planning to generate some low-energy ions and then form a beam source? A simple way to focus magnetically is to use a 2 kG samarium-cobalt permanent magnet at the proper location. The details are given, along with a typical result of its efficacy (page 324).

▷ Suppose you would like to take advantage of the powerful oxidizing properties of ozone. How is the tricky stuff produced, stored and used? The answer: 1) read the entry (page 702), and 2) be careful.

There are two appendices, one of which lists 50 useful books on experimental surface science methods (in addition to the many books included in the references section of each entry). Among them are two texts that share Yates's philosophy of featuring clever ideas and tricks of the trade: *Building Scientific Apparatus,* by John H. Moore, Christopher C. Davis and Michael A. Coplan (Addison Wesley, 1983) and *Handbook of Electron Tube and Vacuum Techniques*, by Fred Rosebury (AIP Press, 1993). I suggest one other: Gary S. Coyne's *The Laboratory Handbook of Materials, Equipment and Technique* (Prentice Hall, 1992). The second appendix in Yates's book lists manufacturers of materials and components used in the field. While the information is useful, the great majority of the listings appear in the annual PHYSICS TODAY *Buyers' Guide*. The author should have included that reference and also the on-line buyers' guide offered by the American Vacuum Society at www.aip.org/avsguide/.

This is a book from which a great deal of information has to be retrieved efficiently, and so a complete, well-designed index is a must. The author and publisher obviously expended the effort necessary to accomplish that. I sampled a variety of topics in the index; it passed my test.

It is a pleasure for me to recommend this book highly for its outstanding depiction of the importance of instrumentation and measurement to successful research in surface science as well as materials science, physical electronics and semiconductor technology. It will be a valuable reference for both beginning and experienced researchers. Regretfully, I don't believe so brief a review as this can really do it justice. Try to browse through a copy; you can't help but be impressed.

Lawrence G. Rubin
Massachusetts Institute of Technology
Cambridge, Massachusetts

X-Ray Charge Densities and Chemical Bonding

Philip Coppens
Oxford U. P., New York, 1997. 358 pp. $85.00 hc
ISBN 0-19-509823-4

Crystallography is not only a matter of locating atoms. Hardware and software developments and a better understanding of how to correct raw x-ray diffraction data for systematic errors have made the search for chemical bonding information in x-ray data meaningful. The field has developed steadily over the last 30 years, with Philip Coppens as one of its major contributors. His monograph, *X-Ray Charge Densities and Chemical Bonding*, addresses the electron distribution in atoms and molecules, and chemical bonding—or rather, how such information can be obtained from x-ray diffrac-