

solid-state physics . . . [stressing] properties and their interpretation and [avoiding] the development of formalism for its own sake." And they designed their book so that, "the range of topics covered is comprehensive but not exhaustive . . . much more material is presented than can be covered in a one semester course." All of these statements of intent are borne out by the text. In its 826 pages, the book does a remarkable job of covering five major topics: structure, physical properties, classes, synthesis, and processing of materials; surfaces; thin films; interfaces; and multilayers. The text is divided into 22 chapters that present clearly and authoritatively the appropriate qualitative descriptions, mathematical developments, conceptual notions, notations, and formulas.

The book contains all the resources that an excellent textbook should have but many modern ones do not. These resources include extensive tables and data, two excellent indices that make the book useful as a reference as well as a text, clear illustrations, and a set of problems that focus on fundamentals rather than simple mathematics or plug-in exercises.

A Web site associated with the book contains further extended discussions of some major points, including the description of additional materials properties and examples of current applications. The Web site also offers experimental techniques and appendices on thermodynamics, statistical mechanics, and quantum mechanics.

Although *The Physics and Chemistry of Materials* is intended as a textbook, it is one of the few books that I will actually make space for on my desk, because of its very broad coverage and remarkably focused discussion of so many topics. The next time I need to be reminded of what the Poole-Frenkel effect is, or what the fundamental microscopic basis for plasticity is, or which polymers are piezoelectric, this book is the place to find the description at the right level, along with some physical examples and leading references.

There are a few things missing even in this exemplary treatment. As the authors themselves point out, the treatment of biomaterials and composites is quite short. Indeed, of the classical aspects of materials science, ceramics clearly gets less emphasis here than do metals and polymers. Some modern topics that one might have expected to find, such as organic light-emitting diodes and conductive polymers, are absent. The book does not point to answers to the problems.

These, though, are minor quibbles. I find this book a delight: its clarity is matched only by its broad scope and remarkable utility. While the cost is high, elementary textbooks for first-year students are roughly in the same cost range. And this book (unlike many classroom texts) will remain very useful long after the course ends.

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Time Travel in Einstein's Universe: The Physical Possibilities of Travel through Time

▶ J. Richard Gott III
Houghton Mifflin, New York,
2001. \$25.00 (291 pp.).
ISBN 0-395-95563-7

Nothing in the world is easier than traveling in time. Just wait five minutes, and you will have moved that far into the future. It is even possible to get there faster; according to special relativity, observers undergoing acceleration experience the passage of less time between two events than do observers in free fall.

The true excitement arises, however, with the possibility of traveling backward in time, a staple of science fiction. It is worth asking if such a journey is consistent with the laws of physics. In the absolute space-time of Newtonian mechanics, the answer is a definitive "No." Newtonian time marches relentlessly forward.

In special relativity, however, the notion of time is somewhat more flexible; clocks carried along different paths can measure different elapsed time intervals. Even in such circumstances, however, travelers are still moving locally more slowly than light, and consequently moving inevitably into the future.

General relativity preserves this feature—local movement at speeds below that of light—as observers move along timelike paths. The curvature of space-time, however, introduces the possibility of deforming the global geometry to allow what are called "closed timelike curves," paths that intersect themselves in the past. It is straightforward to find solutions to Einstein's equations that contain closed timelike curves. As a simple example, take empty Minkowski space and identify all spatial points at time t_1 with the corresponding points

at time t_2 , to produce a cylindrical space-time in which particles at rest move on timelike loops.

The notion of closed timelike curves in the real world is hard to reconcile with our intuitive understanding of causality. Perhaps one can find global solutions to general relativity incorporating closed timelike curves. These, in effect, would be time machines. But it may be impossible to construct such a system in a local region of space. Theorems along these lines were proved by Frank Tipler in the 1970s. Tipler assumed that the energy density was never negative and showed that closed timelike curves could never arise in a local region without also creating a singularity. This was reassuring, as we could hope that both the singularity and the closed timelike curves were hidden behind an event horizon (although this was not part of the proof).

Interest in time travel was reinvigorated a little over a decade ago by the discovery of new space-times containing closed timelike curves: a wormhole solution discovered by Michael Morris, Kip Thorne, and Ulvi Yurtsever, and a solution with two parallel cosmic strings discovered by J. Richard Gott. The wormhole space-time requires negative energy densities, while the closed timelike curves in the cosmic string space-time do not originate in a local region. Both solutions are therefore consistent with Tipler's results, and these models spurred research into the possibility of time travel under more general conditions.

Gott's new book, *Time Travel in Einstein's Universe*, covers all this material in a readable way and at a popular level. As in recent books by Stephen Hawking, *A Brief History of Time* (Bantam Doubleday, 1988), Kip S. Thorne, *Black Holes and Time Warps* (W. W. Norton, 1994), Alan Guth, *The Inflationary Universe* (Perseus, 1997), and Brian Greene (*The Elegant Universe*, W. W. Norton, 1999), Gott personalizes the narrative by combining scientific exposition with the story of his own research. This approach can (and does) result in an idiosyncratic survey of the material. But it seems perfectly appropriate for a book aimed at general readers, who will gain more from such an honest account of the workings of science than they might from a strictly objective recitation of the facts.

After two introductory sections, Gott devotes three sizable chapters to topics loosely connected by the theme of time travel: 1) the creation of closed timelike curves in general relativity, 2) the possibility that the universe might originate

in closed timelike curves, and 3) prediction of the future through application of the Copernican principle ("We are not special") to our relationship to the universe's current conditions.

A second theme, describing work in cosmology that Gott carried out with Li-Xin Li, is an interesting take on the problem of the universe's initial conditions, although their scenario is hard to evaluate without better knowledge of the early universe than we have. A third section describes an attempt to estimate the likely future duration of current conditions by presuming that we are observing them at a typical moment—neither in the first nor the last 2.5% of their lifetimes. As an example, the fact that the Internet is 33 years old leads us to predict, with 95% confidence, that it will last between another 10 months and another 1320 years. Such a level of precision is of little help to investors and planners; the method does, however, serve as a reality check against the temptation to extrapolate our current situation naively forward in time.

The test of a popular-level book is whether it will excite and educate the lay reader. The ideas discussed in this book are undoubtedly exciting and should appeal to a wide audience. The educational mission is less obviously fulfilled; Gott puts an effort into careful exposition, but he spends a great deal of time on issues unlikely to be of great public interest, such as the nature of various quantum vacuum states. I worry also that the initial explanation of the nature of space-time in special and general relativity was given short shrift; if readers do not fully follow the way time works in well-established contexts, it would be hard for them to understand the more exotic space-times.

Meanwhile, the question of what role closed timelike curves might play in the real universe remains embarrassingly unclear. Very likely it will remain so until we achieve a fuller understanding of quantum gravity—or are visited by tourists from the future.

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Tsunami: The Underrated Hazard

▶ Edward Bryant
Cambridge U. Press, New York,
2001. \$74.95, \$27.95 paper
(320 pp.). ISBN 0-521-77244-3,
ISBN 0-521-77599-X paper

In *Tsunami*, Edward Bryant illustrates the threat of such phenomena with a set of mock docudramas based

on five historical tsunami events. He then proceeds to the science underlying the threat.

The book's mechanics are good; list of symbols, formulas, tables, figures, illustrations, list of references, and index are well presented. References are cited as a subheading in each named section of two or three pages. This does make for easier reading though it may blur the sources.

Bryant is at his best in the fairly extensive sections involving geomorphology, which is clearly his specialty. The features of numerous ocean

coastal areas resulting from both tsunami and storm waves are well developed and interesting. Of necessity, these analyses are based on major geological events and their effects (which he refers to as "mega tsunami") and most are prehistoric. Since even many of the more recent, documented, deadliest tsunamis (Lisbon, Krakatau, Sanriku) occurred more than a hundred years ago, tsunamis may be underrated only by those in areas that do not experience them. Tsunamis are an important public safety problem, but Bryant