focus for the sorts of experiment that physicists prefer to do. Phillips's book, by contrast, is much more focused on the interesting, but unpleasant, phenomena that plague real materials, such as how defects determine mechanical properties; nonequilibrium effects, such as microstructure evolution; the role of long-range forces, such as stress fields; and the more complex features of materials phase diagrams. By the time readers have reached page 648, they should have an appreciation of the absolute necessity of being able to handle different scales. Thus, I would be tempted to use selected parts of this book in a first-semester graduate course on solid-state physics, in order to make the readings more relevant to the interesting and crucial materials problems that are the focus of modern research.

In summary, this book has appeared at a useful time—if not slightly too early. Nevertheless, I would recommend it to anyone wishing to get both a broad overview of the intersection of theoretical condensed matter physics with modern materials science, and some good pointers toward future research directions.

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The Physics and Chemistry of Materials

Joel I. Gersten
and Frederick W. Smith
Wiley, New York, 2001. $110.00 (826 pp.). ISBN 0-471-05794-0

As we learn and teach the properties of materials, we clearly need a textbook that combines an authoritative treatment of the issues with broad scope, appropriate journal coverage, clarity, integrated notation, and continuity. Joel I. Gersten and Frederick W. Smith have worked hard on this problem and have solved it in an exemplary and remarkably efficient fashion; their *The Physics and Chemistry of Materials* is, in sum, a wonderful book.

In their preface, the authors discuss the need for a textbook that "emphasizes the physical and chemical origins of the properties of solids while . . . focusing on the technologically important materials that are being developed and used by scientists and engineers." They declare their intent to be "to bring the science of materials closer to technology than is done in most traditional books on 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