theory and other fields. The mix is almost always satisfactory, and sometimes it is much more. The benefit of this approach more than justifies (and perhaps, requires) a scientific perspective that is clearly personal and of admittedly limited scope.

Burlaga's accounts of the basic physics of the interplanetary medium provide the reader with accessible discussions of the theoretical principles that organize the data. The tangible satisfaction of coming to an understanding of the observational results is frequently balanced by an appreciation of the still-outstanding questions. The reader learns, for example, that pressure-balance structures are frequently observed in the solar wind plasma, and even that a "principle of pressure balance" is sometimes useful. But Burlaga also makes it clear that questions still exist as to why magnetohydrodynamics (or perhaps kinetic physics) tends to produce this balance in the solar wind plasma. The description of magnetic clouds is equally lucid and important, but perhaps somewhat more satisfying because Burlaga supplements the evidence for their detection and structure with an account of the coronal ejection processes that produce them.

Some of the ideas summarized in the book, such as the corotation, interaction and merger of streams, are critical to an understanding of the physics of the outer heliosphere and observed effects on cosmic rays. On the other hand, a few sections of the book, such as the one dealing with the application of catastrophe theory to shocks, seem to lack motivation and are not well explained. Topics such as the application of fractal and multifractal analysis to solar wind observations are more speculative. The book would be better balanced if these more advanced concepts from turbulence theory were introduced by a discussion of magnetohydrodynamic turbulence in a more basic form. However, the multifractal presentation is clear and may be useful to nonlinear-dynamics theorists in developing more detailed models.

On balance, this book will be a valuable and stimulating guide for advanced graduate students and researchers who want to enter space physics or who want a concise discussion of the highly relevant topics that the book covers. Space plasma physics is not yet a mature enough branch of physics to produce greatly refined pedagogical accounts, but Burlaga's blend of concept and experimental reality is a needed step along the way.

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The Collected Works of P. A. M. Dirac, 1924–1948

Edited by Richard H. Dalitz
Cambridge U. P., New York, 1995.
1310 pp. $250.00 hc
ISBN 0-521-36231-8

General Theory of Relativity

P. A. M. Dirac
Princeton U. P., Princeton, N.J., 1996 [Wiley, New York, 1975].
71 pp. $10.95 pb
ISBN 0-691-01146-X

Paul Dirac is widely revered as one of the pioneers of quantum mechanics and one of the great theoretical physicists of this century. Beginning with his days as a graduate student, he spent most of his career at Cambridge University, where he served for 37 years as Lucasian Professor of Mathematics, in the prestigious chair once held by Isaac Newton. After his retirement from Cambridge in 1969, Dirac moved to Florida, where he accepted a post as research professor at Florida State University and remained active in physics until shortly before his death in 1984, at the age of 82.

The Collected Works of P. A. M. Dirac, 1924–1948, edited by Richard Dalitz, is introduced as "the first of two volumes which bring together for the first time all of Dirac's scientific publications, with the exception of his books." Of Dirac's nearly 200 research and expository papers, 84 are reprinted in this first volume.

Almost all of Dirac's major contributions to physics originated during a short period of youthful creativity between 1925 and 1933, his "golden years," at the end of which, at age 31, he was awarded the Nobel Prize in Physics for his innovations in quantum mechanics. *The Collected Works* contains all of the seminal papers for which he will be remembered, including:

▷ "On the Theory of Quantum Mechanics" (1926), in which he elucidated Schrödinger's wave mechanics and Fermi–Dirac quantum statistics;

▷ "The Physical Interpretation of the Quantum Dynamics" (1927), in which he presented his "transformation theory," unifying the different quantum mechanical schemes of matrix mechanics, wave mechanics and q-number algebra, and in which he introduced the famous "delta function" that became associated with his name;

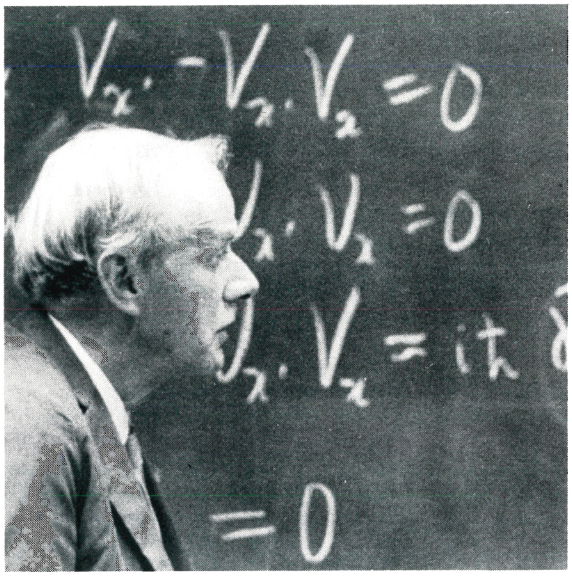
▷ "The Quantum Theory of the Emission and Absorption of Radiation" (1927), in which he developed a primitive but important version of quantum electrodynamics;

▷ "The Quantum Theory of the Electron" (1928), in which he derived his fully relativistic wave equation of the electron;

▷ "A Theory of Electrons and Protons" (1930), in which he presented his theory of "holes" (in the distribution of negative-energy electrons), at first identifying the "hole" incorrectly with the proton;

▷ "Quantised Singularities in the Electromagnetic Field" (1931), in which he introduced into theoretical physics the antielectron (or positron)—the correct hole candidate—and the antiproton, as well as the magnetic monopole; and

▷ "A New Notation for Quantum Mechanics" (1939), in which he introduced his "bra–ket" formalism for quantum



P. A. M. Dirac at Clemson University in 1971. (Photo Courtesy of AIP Emilio Segrè Visual Archives.)

mechanics.

Several other inclusions in *The Collected Works* are also worth noting here. One section traces the evolution of Dirac's famous textbook *The Principles of Quantum Mechanics*, first published by Clarendon Press, Oxford, in 1930. Following an "editor's note" outlining the revisions Dirac made to the book over time, there are reprints of the author's preface and the table of contents for each of the four English editions. Then the editor turns to the three influential Russian editions of the book, outlining their history and interspersing translations of the editors' and publishers' prefaces. Appended to this discussion is a typeset version of the English-language manuscript for a chapter that Dirac wrote especially for the first Russian edition, on "approximate methods" for applying quantum mechanics to practical problems.

Another section of *The Collected Works* reprints the preface, table of contents and introductory section of Dirac's Cambridge University PhD dissertation. Entitled simply "Quantum Mechanics" and submitted in May 1926, it was the first doctoral thesis ever written on the subject. Another section includes reset versions of several previously unpublished reports (several others have apparently been lost) from Dirac's war-related research on neutron multiplication in solids and on isotope separation. Through his service as a consultant to the British atomic-bomb project during World War II, he produced important work on the theory of isotope separation by diffusion methods and on the theory of the countercurrent centrifuge.

Because Dirac's published papers originally appeared in a wide range of scientific journals, books and conference proceedings, *The Collected Works* will be an especially valuable compilation for anyone interested in tracing in detail the progress of Dirac's research. Besides offering convenient access to previously published pieces, the volume makes several papers available for the first time and gives English translations of Dirac's foreign-language papers. The volume has been prepared with care. The selections are arranged in chronological order, and most are reproduced photographically as they originally appeared. Translations of papers that were originally published in Russian, French or German are printed side-by-side with the original texts. The editor has supplied helpful, brief notes on some of the selections, as well as a chronology of Dirac's life and a complete bibliography of his works.

Besides his classic *Principles of Quantum Mechanics*, Dirac authored five other books, all records of lectures he presented on different occasions. *General Theory of Relativity*, first published in 1975, represents a lecture course he gave after he moved to Florida State University. Dirac was a man of few words, and this little book—with 35 sections spanning 69 pages—exhibits the concise, direct style that was his trademark. Seasoned physicists will appreciate the book as an elegant, well-organized introduction to the basic mathematics and physics of curved space, but students approaching the subject for the first time—the intended audience for the book—will probably have their needs met better by one of the more detailed standard introductory texts. Dirac is not necessarily for the beginner in any of the subjects on which he wrote. As Schrödinger once said of his own problems in reading Dirac, "[H]e has no idea how *difficult* his papers are for the normal human being."

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Interfaces in Crystalline Materials

Adrian P. Sutton
and Robert W. Balluffi
Oxford U. P., New York, 1995.
819 pp. $165.00 hc
ISBN 0-19-851385-2

Surfaces and Interfaces of Solid Materials

Hans Lüth
Springer-Verlag, New York, 1995.
$49.00 pb ISBN 3540-585-761

According to the *Oxford English Dictionary*, an interface is "a surface lying between two portions of matter or space and forming their common boundary." *Interfaces in Crystalline Materials*, and *Surfaces and Interfaces of Solid Materials*—two valuable but different texts—cover generally different portions of the science of solid interfaces and are aimed at two different communities. Hans Lüth aims at the surface scientist, who studies the vacuum–solid interface; Robert Balluffi and Adrian Sutton aim at the interface materials scientist, who looks at internal solid interfaces.

In my opinion, surfaces have been studied in more detail because they are easier to approach experimentally, but internal interfaces are more important for practical reasons. I can claim to be one of the small number of people who have published in both fields. Thus I have an interest in both books, but I find that Sutton and Balluffi's fills a more pressing need.

Besides their different emphases, the books also have different aspirations. Lüth provides a broad, well-crafted overview of a field in which there are already several other—although more specifically course-related—books. Sutton and Balluffi provide one of the few detailed expositions of a complex and important field.

Sutton and Balluffi are both highly regarded scientists in the field of grain boundaries, the former an experimentalist and the latter a theorist. In writing their book, they have used their experience well and have covered the extensive and challenging field of internal interfaces as well as we could hope, producing a wonderful addition to the literature of internal interfaces. But it is not light reading! Its 800 exhaustive pages contain hundreds of references and logical and detailed coverage of all the essential material. It will be useful not only for students, but also for scientists in any field who need a better understanding of strained-layer epitaxy, for instance.

Sutton and Balluffi also cover the general complex crystallography of interfaces, known as bicrystallography, which is particularly important in understanding interfacial dislocations. They describe in detail the methods by which theorists calculate the structure and properties of internal interfaces. They discuss both heterophase and homophase (grain boundary) interfaces. They cover interface thermodynamics (such as faceting and phase transitions as well as segregation), along with kinetics (such as diffusion and interface motion). The book concludes with a broad description of interface properties, including electrical and mechanical, with many examples.

Lüth's book comes from the complementary direction of surface science—the study of the vacuum–solid interface. It provides a very good introduction to this subject but is not as exhaustive as the Sutton and Balluffi book. Lüth covers ultrahigh-vacuum technology, surface structure (including electronic and vibrational), diffraction and scattering from surfaces, adsorption and metal–semiconductor interfaces. His book is well annotated for use as a student text. It focuses on the complex techniques used to examine surfaces, whereas Sutton and Balluffi focus on the underlying science of internal interfaces, using experimental data only as illustrative evidence.

This reinforces my original prejudice: Whereas the elegant techniques to probe surfaces are driving surface science, internal interfaces are a more challenging and important problem. Lüth's book, extensively revised in 1992, is certainly not without merit. But the obviously great efforts of Sutton and Balluffi in preparing their book have enormously aided the materials community.

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Atom Optics with Laser Light

Victor I. Balykin and Vladilen S. Letokhov
Harwood, Newark, N.J., 1995.
115 pp. $45.00 pb
ISBN 3-7186-5697-3

During the last 20 years there has been enormous growth in the science concerned with the manipulation of matter with light. An important subfield is atom optics, which investigates "atom-optical" elements that focus, reflect, split and polarize atoms just as conventional lenses, mirrors, beam splitters and polarizers affect light. Atom–field interactions can also extend beyond the possibilities of conventional optics. For example, laser cooling can compress the atomic phase space in apparent violation of Liouville's theorem, and there is no limit to the lowest temperature that can be achieved by laser cooling. Ideas that were once confined to thought experiments have become routine laboratory exercises. Nanokelvin temperatures have already been achieved, as have Bose–Einstein condensation and the confinement of atoms in traps much smaller than an optical wavelength. Cold atoms are now used for rotation sensing and nanolithography, as well as for such more traditional applications as clocks and frequency standards. This appears to be only the beginning: I believe that atom optics is now at the same stage as conventional optics was in the early 1960s, when lasers were just becoming common.

In *Atom Optics with Laser Light*, Victor Balykin and Vladilen Letokhov have written a wonderfully clear book that presents an overview of all but the most recent results in the field.

They establish the context for atom optics right in the first chapter, with comparisons to neutron and electron optics as well as the conventional optics of photons. The first chapter also includes a nice short discussion of atom–matter and atom–static-field interactions.

The second chapter explains the basic forces that permit light to control atoms. It begins with a discussion of the validity of the classical approximation, which may be a bit off-putting to