sufficient background to "make the current literature and review articles accessible to the reader." He succeeds admirably in this endeavor. The downside is that there is very little material related to the substructure of the nucleons. The book has numerous references to and illustrations of experimental results. Problems do not appear at the end of each chapter, but rather are scattered throughout, and they are directly related to the development in the text.

Aside from the usual misprints—not excessive—I have few quibbles. A number of facts are presented without adequate explanation. An example is the weak spin-orbit force of the Λ–N interaction, which is mentioned early in the book; this spin-orbit splitting is barely referred to in the description of hypernuclei in the book's last chapter. Also, in the depiction of the double charge exchange of pions, the explanation of the behavior of the cross section at low energies is not given. There are also a very few statements that could be misconstrued, such as blaming isospin nonconservation on the electromagnetic interaction and not mentioning quark mass differences or QCD effects.

However, these are minor reservations. Overall this is an excellent treatment of the basic scattering theory required to understand nuclear physics experiments and their results.

Ernest M. Henley
University of Washington

Space Sailing

Jerome L. Wright
Gordon and Breach, Philadelphia, 1992. 258 pp. $24.00 pb ISBN 2-88124-842-X

The pressure exerted by solar radiation on a perfectly reflecting perpendicular surface is about 9×10^{-6} N/m^2 at 1 AU. A sail made from Kapton film 2 microns thick with a 0.1-micron-thick aluminum coating would weigh about 3 g/m^2. The acceleration of the sail itself from light pressure would then be about 3 mm/sec^2. This is about half the acceleration due to the Sun's gravitational field.

Solar sailing was repeatedly invented in the pre-Sputnik years by, for example, Frederik Tsander, Russell Saunders and Richard Garwin. Among its potential applications are spiralling out from low Earth orbit to geosynchronous orbit in tens of days or to escape in about 100 days. Solar sails can increase the number of satellites that maintain a constant longitude, which could be important when geosynchronous orbits become crowded (as proposed by Robert L. Forward). Transporting freight and passengers between orbits by "sailing ships" could be much cheaper than using chemical rockets. Yet I know of no report of any attempt to deploy solar sails in space.

In the early 1980s Jerome Wright became interested in the possibility of using solar sailing to rendezvous with Halley's Comet during its 1986 passage. This proposal was enthusiastically received by the Jet Propulsion Laboratory. Wright led a group that developed solar sailing technology in considerable detail for this mission. The group settled on the heliogyro design, which looks like a huge helicopter, with 12 rotating blades 7340 meters long held out by centrifugal force. The total surface area of the blades was 0.625 km^2, and the overall weight was estimated to be 4 tonnes (about twice the weight of the simple film sails without the operations module or the payload). The group studied and dealt with the problems of deployment, dynamics and space environment conditions (radiation, micrometeorite damage and so on). In the end, none of these hazards did them in. Space shuttle cost overruns demanded their funds, and NASA cancelled the Halley rendezvous mission.

This book also reflects enthusiasm for even more imaginative applications of space sailing. Wright outlines K. Eric Drexler's design for fabricating by vapor deposition in space aluminum films that are two orders of magnitude lighter than the 2-micron Kapton films. He discusses Forward's designs for sailing to Alpha Centauri with the aid of massive solar-driven lasers.

It is sad that the space shuttle, which has disastrously increased the cost of going into orbit, still has political power enough to displace much imaginative space science and engineering. Wright's book has captured some of the charm and creativity that should be the guiding characteristic of our space program.

Arthur Kantrowitz
Dartmouth College

Surface Science: An Introduction

John B. Hudson
Butterworth–Heinemann, Boston, 1992. 321 pp. $59.95 hc ISBN 0-7506-9159-X

At the 1976 March meeting of the American Physical Society, Robert Schrieffer remarked in an invited talk on surface physics that "if you stay in the field a while, it's a form of masochism to continue." While he soon moved to one-dimensional systems, the field of surface science has thrived, even garnering two entire categories for March meeting abstracts. Nonetheless, remarkably few books have appeared that are suitable introductions to the subject.

Many instructors who offer special-topics courses have adopted Andrew Zangwill's *Physics at Surfaces* (Cambridge U. P., New York, 1988). When Robert L. Park reviewed that text in *Science* (30 September 1988, page 1839) he lamented the short shrift given to many experimental techniques in the book's mere 450 pages. Hence, John Hudson's book—just over 300 pages long—can hardly be expected to cover everything. And, not surprisingly, Hudson, a distinguished experimenter, emphasizes topics on which he did research during his long tenure as a materials engineer at Rensselaer Polytechnic Institute. The book developed from a course Hudson taught variously over two decades to graduate and advanced undergraduate students in physics, chemistry and engineering.

In some sense, because problems appear at the end of each of its 17 chapters, this is the first real *textbook* on surface science. (The questions typically require the student to use the information and formulas to gain a quantitative feel for specific systems.) To hold down the book's price, Hudson himself produced the many figures not taken from other publications. He has put an impressive amount of time, thought and care into this volume.

The book is divided into four parts. The first and longest provides a general introduction and deals in depth with the thermodynamics of surfaces and surface mobility. The acknowledged "special debt" to John Blakely's "pioneering book," *Introduction to the Properties of Crystal Surfaces* (Pergamon, Oxford, UK, 1973) is most evident in this part. (Unfortunately, the book contains little on progress since the early 1970s in the statistical mechanics of surfaces. One can now interpret thermodynamic measurements in terms of microscopic interactions between atoms using powerful tools from statistical mechanics and computational physics.) The second part considers interactions between gases and surfaces, with particular emphasis on beam scattering and chemical rates. In the third section, on energetic-particle probes of surfaces, Hudson deals with the topics that Park found wanting in Zangwill's book. The final part is a chapter on crystal growth, with a cursory paragraph on roughening.

Hudson's approach is avowedly experimental. In contrast to the great algebraic detail on beam processes and reaction kinetics, the book has few specifics on surface densities of states (even in conjunction with experiments), band structures, adsorption-energy calculations, collective effects and other properties of interest to the theoretically inclined. While the book offers a broad introduction to the "alphabet soup" of probes that greets the novice, there are notable omissions. The author has laid all the groundwork in sections on x-ray and electron scattering, but he neglects completely fine-structure absorption probes, most notably surface extended x-ray absorption fine structure, which provide arguably the most precise measurement of interatomic spacings. Likewise, I expected some discussion of Bremsstrahlung isochromat spectroscopy or "inverse photoemission," which complements photoemission by probing unfilled states. It is more excusable, though still unfortunate, that the book does not cover new, powerful techniques such as low-energy electron microscopy and photoemission electron microscopy.

Particle physicists who view condensed matter physics as "squalid state" or *Dreckphysik* will not be disabused by this volume. The book provides little sense of the many exciting and aesthetically appealing aspects of surface physics. Also disappointing are the references at the end of the chapters, half of which are quite dated. Numerous fine reviews have appeared over the last decade. While Hudson does alert students to some in the journal *Surface Science Reports*, he does not mention *Progress in Surface Science*, *Chemistry and Physics of Solid Surfaces* (proceedings of biennial summer schools in Milwaukee, Wisconsin), or several other proceedings and review volumes in Springer-Verlag's series on chemical physics, current physics and modern physics.

This book is particularly valuable for introductory graduate courses in chemistry or chemical physics or for experimenters with little background in solid state theory. For those with stronger theoretical inclinations who opt for Zangwill's text, Hudson's is a useful reference, especially for kinetics. These recessionary times require the comment that paperback editions of Zangwill's book with D. P. Woodruff and T. A. Delcher's *Modern Techniques of Surface Science* (Cambridge U. P., New York, 1986) as an experimental supplement together cost less than Hudson's text alone. Butterworth–Heinemann should follow the laudable lead of Cambridge University Press and produce a paperback soon.

Theodore L. Einstein
University of Maryland

In the Wake of Galileo

Michael Segre
Rutgers U. P., New Brunswick, N. J., 1991. 192 pp. $27.95 hc ISBN 0-8135-1700-1

The historical Galileo Galilei is something like the elephant described by the blind men, each of whom has grasped a different part of the pachyderm's anatomy. Was Galileo a neo-Platonist who eschewed experiment, as portrayed by Alexandre Koyré? Or was he the pioneer of the modern experimental method, as described by Stillman Drake and others? Was he the radical innovator of the scientific method? Or did he derive his procedures from the Jesuit teachers at the Collegio Romano? Or was he perhaps merely elaborating on ideas already proposed in the Middle Ages?

In writing *In the Wake of Galileo*, Michael Segre has taken a new tack in exploring Galileo's attitude toward physical reasoning and experimentation. How, he asks, did Galileo's own disciples view these questions? Segre's book is by no means an in-depth study, but rather an ingenious reconnaissance of a curiously neglected approach to the celebrated "mathematician and philosopher" (the title Galileo insisted upon when he moved to the court of Cosimo de' Medici).

Segre's study concentrates on three distinguished scientists in the generation following Galileo, Evangelista Torricelli, Vincenzio Viviani and Giovanni Alfonso Borelli. He shows that the origins of Galileo's image as an empirical scientist date back to the biography written 12 years after Galileo's death by his young protégé Viviani, but at the same time he points out that Viviani's essay can be interpreted in more than one way. One of the most charming parts of Segre's analysis is the demonstration of how strongly Giorgio Vasari's *Vite* of famous Renaissance artists affected Viviani's own style, including an uncanny parallel to Vasari's treatment of the youth of Giotto di Bondone. Included in Viviani's treatment was even an attempt to make Galileo's birth match the date of Michelangelo's death, to the day and hour.

Segre's analysis at last comes to an altered horoscope for Galileo's birth. As an historian of astronomy, I can point out that the planetary positions recorded in the horoscope make clear that the original birthdate was 15 February 1564, as Segre himself concludes from paleographical evidence. Whether Viviani chose 19 February for Galileo's birthday because that was the day of Copernicus's birth is open to speculation. Segre also places the famous Tower of Pisa experiment, first recorded by Viviani, into the same mythologizing context. All of this demonstrates how early the myth-making began, and how difficult it will ever be to find the true Galileo. In any event, we owe Segre a word of thanks for opening another window onto Galileo, a fresh approach in the ongoing task of sorting out Galileo's role in the birth of modern science.

Owen Gingerich
Harvard–Smithsonian Center for Astrophysics

The Physics of Sports

Edited by Angelo Armenti Jr
AIP, New York, 1992. 333 pp. $35.00 pb ISBN 0-88318-946-1

The Physics of Sports is a collection of 57 reprinted articles on a broad array of sports largely taken from the *American Journal of Physics* and *The Physics Teacher*.

Sports physics is not a mature field, and the articles in this collection range from the ridiculous to the sublime. Roughly half of the articles are in areas where I consider myself knowledgeable, and I judge that half of these are irrelevant or have serious errors. But if there is much in it that is wrong or irrelevant, I shall still value my copy of this book for its classic articles by Paul Kirkpatrick on sports measurements and baseball, the fine essay on archery by Paul Klopsteg and Lyman Briggs's discussion of the aerodynamics of baseballs (although Robert Watts has shown that Briggs's parameterization of the Magnus force is probably in error).

For more recent works, Howard Brody's definitive articles on tennis are enlightening and fun. The inclusion of the description of the knuckleball by Watts and Eric Sawyer allowed me to throw away my old Xerox copy of that paper as well as my copy of Richard Garwin's discussion of the superball, which, if not quite sports, is fine classical physics. I found Peter Brancazio's analysis of kicking a foot-