for the third instrument, the Diffuse Infrared Background Experiment. The DIRBE data, full-sky maps from 1.25 to 240 μm, are difficult to analyze, but they will bear fruit for years to come.

Mather takes great care to show that COBE's success is rooted in the dedication and insights of many engineers, scientists and technicians. The book does more than just associate names with events; it explicates the seminal concepts and visions behind COBE. This is an extremely difficult task. As Mather notes in the epilogue, although referring to a grander scale, "One may never be able to trace the ripples engendered by one small individual action among the many millions in the great human drama."

Although Mather's book contains some minor factual errors and omissions, a more thoughtful and accurate account would be difficult to imagine. Also, no doubt due to his modesty, we do not hear of many of Mather's contributions to COBE.

At times it seems as though the authors view their book as a counter to Smoot's version, centered on the DMR experiment (*Wrinkles in Time* by Smoot and Keay Davidson, Morrow, 1993; reviewed in PHYSICS TODAY, September 1994). For instance, the subtitle bills the book as "The True Inside Story," not just "The Story." This is unnecessary; the thoughtful prose and care taken in giving proper credit speak for themselves. For the outsider, the beautiful and important science from this very complex mission overwhelms the internal skirmishes. It is a triumph that so many could work together for so long to give us such wonderful results.

LYMAN ALEXANDER PAGE
Princeton University
Princeton, New Jersey

The Life and Legacy of G. I. Taylor

George Batchelor
Cambridge U. P., New York, 1996.
285 pp. $75.00 hc
ISBN 0-521-46121-9

As a graduate student in Cecil T. Lane and Lars Onsager's group in low-temperature physics at Yale University in the early 1950s, I had occasion to read an Onsager paper, from a conference in Kyoto in 1953, in which he stated: "In hydrodynamics generally, stability conditions are determined by the Reynolds number $R = vl/\nu$ where v stands for the velocity and l for the significant linear dimension of the flow and ν is the kinematic viscosity . . . ." Knowing nothing about either hydrodynamic stability or kinematic viscosity, I trotted over to Lars's office to be enlightened. He informed me that hydrodynamic stability was a small field of physics being carried on by "a rare crew." The crew members were identified as Chia-Chiao Lin (at MIT), Subrahmanyan Chandrasekhar (at the University of Chicago) and Geoffrey Ingram Taylor (at the University of Cambridge). I had never heard of any of them; Lars undertook to introduce me to all three at meetings in New York City in early 1955. This was the beginning of my long acquaintance with these remarkable men. Thanks to George Batchelor, a research student of Taylor's who spent his career at Cambridge, we now have a satisfying biography of "GI," as his friends called him, in *The Life and Legacy of G. I. Taylor*.

GI was one of the greatest physical scientists who ever lived. He made monumental contributions to the fields of solid and fluid mechanics, meteorology, physical oceanography, fracture mechanics, plasticity, hydrodynamic stability, turbulence and much more. GI's forebears were themselves remarkable people. His father, Edward, was a noted artist, and his mother, Margaret, was the second daughter of George Boole, the founder of Boolean algebra. Margaret's mother was Mary Everest, niece of George Everest, one of the founders of geodesy and the man for whom the mountain was named.

Batchelor organized a memorable symposium in 1986, the 100th anniversary of GI's birth. He called it "Fluid Mechanics in the Spirit of G. I. Taylor." I doubt that any of us who spoke there could remotely fulfill the "spirit." GI did highly original and insightful research over many subjects and many years (1909–72). He had no secretary, never applied for a research grant and never took a sabbatical leave. He had an uncanny ability to select fundamental problems, to invent simple but powerful solutions to them and to do experiments on them, working by himself or with a single technician. Added to that, he had a sunny and generous personality that won him staunch and grateful friends all over the world.

To give an example of GI's style: He published a paper in 1923 entitled "Stability of a Viscous Liquid Contained between Two Rotating Cylinders." It is a theoretical analysis of the breakdown of laminar flow as the cylinders rotate ever more rapidly. The paper predicts the existence of what are now called Taylor vortices, which succeed the laminar flow, and reports a sophisticated experiment to illustrate, and photograph, the vortices described by the theory. The subject continues today to be of interest: There is a biannual workshop on Taylor vortices, now in its tenth iteration, and the intellectual legacy of this single paper easily surpasses 2000 references. (I discussed the early history of this subject in an article in PHYSICS TODAY, November 1991, page 32.)

Batchelor's book contains an illuminating note by the late Nevill Mott on the origin of the study of dislocations in crystalline solids, which is an important branch of solid state physics, and the role played by GI's pioneering ideas. (The article was written in 1976 as a contribution to the Royal Society biographical memoir of G. I. Taylor.) A chapter on turbulence, to which Batchelor himself has made many important contributions, examines the influence of GI's early investigations on this subject and in particular the relationship of his ideas to the later work of Andrei Kolmogorov, Werner Heisenberg, Carl von Weizsäcker and Onsager.

The rest of the book details the incredible contributions GI made as a consultant in the UK and at Los Alamos during World War II, his equally incredible second "golden" period of research after his "retirement" in 1951, and finally an assessment of GI's scientific legacy. It will come as no surprise to anyone remotely acquainted with that legacy that Taylor is quoted as saying, ". . . in general it seems to me that it is through particular problems which can be subjected to experimental verification or compared with natural phenomena that most advances are made."

RUSSELL J. DONNELLY
University of Oregon
Eugene, Oregon

Symmetries in Quantum Physics

Ugo Fano and A. R. P. Rau
Academic, San Diego, 1996.
333 pp. $59.95 hc
ISBN 0-12-248455-X

Traditionally the theory of angular momentum has played an important role in the education of physicists—offering a simple but nontrivial example of a continuous symmetry—and provided them with the requisite tools to sort out the spectroscopy and collision dynamics of atoms, nuclei and simple molecules. Toward this end, the late 1950s and early 1960s saw the appearance of many excellent, now-classic texts, such as those by M. E. Rose (*Elementary Theory of Angular Momentum*, Wiley, 1957), Allen R. Edmonds (*Angular Momentum in Quantum Mechanics*, Princeton U. P., 1957, 1960), Ugo Fano and Guilio Racah (*Irreducible Tensorial Sets*, Academic, 1959), Brian R. Judd (*Operator Techniques in Atomic Spectroscopy*, McGraw-Hill, 1963) and, more recently Richard N. Zare (*Angular Momentum*, Wiley, 1988). These have served to educate several generations of physicists and chemists.

The basic goal of these books is threefold: 1) to establish the nature of the operators and wavefunctions as necessitated by rotational invariance; 2) to introduce the Clebsch–Gordan machinery of angular momentum coupling, the algebra of angular momentum "recouplings" associated with the names of Eugene Wigner and Racah; and finally, 3) to define (spherical) tensor operators and to then prove the justly celebrated Wigner–Eckart theorem allowing expression of the matrix elements of spherical tensors in terms of an irreducible tensorial part and a Clebsch–Gordan coefficient.

These form the canon of angular momentum theory. These texts not only introduce the canonical materials but also carry out detailed analysis of elementary applications, so that the novice learns the fundamentals and the beginnings of applications as well. Later developments, in particular the introduction of diagrammatic techniques and the recognition of the isomorphism of Feynman and angular-momentum diagrams, have also resulted in excellent and comprehensive texts. These are texts that highlight the work of A. P. Yutsis, J. B. Levinson and V. V. Vanagas (*Mathematical Apparatus of the Theory of Angular Momentum*, Israel Program for Scientific Translation, 1962) and Judd (*Second Quantization and Atomic Spectroscopy*, Johns Hopkins U. P., 1967).

Symmetries in Quantum Physics, by the distinguished University of Chicago emeritus professor of physics and Enrico Fermi protégé, Ugo Fano, and one of his own highly successful students, Ravi Rau, of Louisiana State University, clearly comes out of the traditions set by these earlier texts. But it attempts to fill a rather different and timely need: to embed the above canon into a rather broader and more general framework of continuous symmetry and representations of tensorial operators. Thus, representations of the special unitary group SU(2) are introduced early on and are consistently used and developed as "being central to the study of all symmetries under rotations and reflections."

Rather than being simply an abstract development of Lie groups, *Symmetries in Quantum Physics* is also an introduction to the angular-momentum canon itself. As this is done at a rather higher level than is the case in the more traditional texts, and with many fewer detailed physical examples, my suspicion is that it will appeal most to students who have at least seen, albeit briefly, the basic elements of the canon in a first-year graduate course in quantum mechanics. The advantage of this high road is that, by the end of the text, not only are applications of representations of the group SO(4) to the hydrogen atom placed in a familiar framework, but modern uses of noncompact and noninvariance groups are also introduced as an outgrowth of the canonical concepts. Applications of the latter have allowed development of novel classification schemes for strongly coupled states of two-electron systems.

The broader view taken by this clearly written and well-organized book is a welcome development, but one which, perhaps necessarily, still falls short of being an introduction to "symmetries in quantum physics." Thus, for example, the general idea that invariances always imply conservation laws (Noether's theorem) is not made explicit in the text. Nor is there discussion of gauge and broken symmetries, or even of modern applications of symmetry to polyatomic molecular rotational spectra. Thus, atomic theorists and experimenters, who will probably form the major audience for the book, will still need to look to the condensed matter physics literature to find discussions of symmetry issues essential to understanding of the newly exhibited gaseous Bose condensate.

William P. Reinhardt
University of Washington
Seattle, Washington

Principles of Lightwave Communications

Göran Einarsson
Wiley, New York, 1996. 355 pp.
$79.65 hc ($39.95 pb)
ISBN 0-471-95297-4
(0-471-95298-2 pb)

The principles of optical fiber transmission are so well established and books on lightwave communications are so abundant that there seems little room for further texts. *Principles of Lightwave Communications*, however, adds value by its focus on analysis and theory relevant to an area of continuing research interest, namely system optimization. It is particularly interesting for its use of a modern communication-theory approach in its coverage of optical fiber communications. It is thus appropriate for its intended audience of postgraduates and practicing engineers. Göran Einarsson's book is a timely addition to the literature, providing a reference for those working on the modeling of lightwave systems, particularly in the areas of detector and receiver analysis.

Einarsson's first chapter is an interesting and readable review of fiber development. Paradoxically, it seems out of place when seen within the book as a whole, and I cannot help but feel that it will be little read by the intended audience. Chapters two and three touch briefly on the propagation of light within fibers, and are presumably included for completeness, to set the scene or to remind readers of areas with which they should already be familiar.

The fourth chapter marks the beginning of the major focus of the book. It addresses lucidly the area of dispersion, which is key to future high-speed, long-distance communications. There is a brief mention of solitons and fiber attenuation, but it is to be assumed that fuller coverage would have made the book too long.

The next three chapters take the reader into the author's areas of expertise: optical detection, optical receivers and optical amplifiers. These presentations soon surpass the standard levels of background information concerning, for example, quantum limits, and deal with such key topics as intersymbol interference and mean-square error receivers. It is within this section's many pages, packed with useful techniques not often found in one place, that this book comes into its own. The introduction to methods such as the saddlepoint approximation for moment-generating functions, and the use of numerous examples backed up by a good selection of references, make an excellent starting point for those interested in the analysis of optical receivers and amplifiers. There is also specific coverage of the limits to the gaussian approximation, in particular for the setting of optimum decision levels.

Although the framework of these chapters is intensity modulation direct detection, as befits this major area of application consideration is also given to other specialized or up-and-coming areas. These include analog communications and subjects linked to optical preamplification, such as pulse position modulation and shift keying techniques, which have been the focus of concentrated activity in recent years. Coherent communication merits—and gets—a chapter of its own, covering heterodyne systems and providing a balanced view of the field at present.

Overall, I would recommend this