

treatments of standard topics in the quantum mechanics of atoms and molecules, the Fanos' text is a pedagogical *tour de force* and a delight to read. Excellent physical arguments and inductive reasoning are apparent throughout, and mathematics is brought to bear in a way that best illuminates the physics. Particularly noteworthy in this regard is the masterful discussion of the two-level system, which serves both as basis and as point of departure for the description of more complex systems.

The pace of *Physics of Atoms and Molecules* is leisurely and discursive with the consequence that some traditional modern-physics course topics such as kinetic theory, special relativity and nuclear and particle physics are absent from the book. No matter, for the depth of treatment and insight lavished on the subjects that are covered more than compensate for the often inadequate treatment of the varied topics found in traditional texts.

The Fanos are to be congratulated for having produced a text that should become a standard for the time-honored modern-physics course for undergraduates. Although coverage of the book's contents could be extended over a two-semester course, it is recommended that the material be presented in one semester—a semester that ought to prove most profitable to student and teacher.

PETER G. CABLE

Naval Underwater Systems Center
New London, Connecticut

The Large Scale Structure of Space-Time

S. W. Hawking, G. F. R. Ellis
391 pp. Cambridge U. P., New York, 1973. \$28.50

In principle, nonquantum general relativity is one of the two basic theories in current physics; the other is special relativistic-quantum theory. The empirical evidence for general relativity is comparatively very weak. But there has recently been a considerable increase of interest in general relativity, generated mainly by actual or potential applications in astrophysics.

During the last year or so, three thoroughly modern texts on general relativity have appeared. Steven Weinberg's *Gravitation and Cosmology* emphasizes observations and the relation of general relativity to quantum theory. *Gravitation* by Charles Misner, Kip Thorne and John Wheeler is encyclopedic. This book by S. W. Hawking and G. F. R. Ellis emphasizes the geometric aspects of nonquantum general relativity and its fundamental the-

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oretical content; some applications in astrophysics are also discussed.

The three books supplement each other. For example, Hawking and Ellis say little about perturbation methods but analyze global geometric questions in detail. The perturbation methods are thoroughly covered in the other two books, which are comparatively short on the global results. Taken together, the three books give the student much better access to current theoretical research in the field than has hitherto been available.

Hawking is one of the world's leading authorities on the geometric approach to general relativity and its applications. Ellis has made a variety of important contributions to this field. They have summarized recent developments in this superb book. The canonical reader is a PhD level theoretical physicist with a good mathematical background and perhaps some prior knowledge of general relativity.

The core of the book consists of two chapters. Chapter IV, "the physical significance of curvature," analyzes the general geometric consequences of the fact that gravity always, as far as we know, attracts. Chapter VI studies causal structure. Roughly, causal structure is determined by which spacetime events can influence each other. The work of Roger Penrose, Hawking, R. Geroch and others has shown that many of the most interesting physical and mathematical questions are intimately related to causality.

The other chapters in the first half of the book are primarily concerned with supplying the background needed to understand the two central chapters and the examples needed to elucidate their content. There are also quite useful chapters on the Cauchy problem and on the now famous theorems that show, under rather general assumptions, that nonquantum space-times develop singularities.

The most interesting applications covered are in the penultimate chapter on black holes. For example, the reader will there find a precise version of the statement that a black hole cannot decrease in area or bifurcate, together with a detailed proof. The final chapter discusses recent theoretical results in cosmology.

Parts of the book are quite hard. To avoid undue length, the authors have sometimes been forced to omit steps that a strictly mathematical presentation would include. Thus the reader may either have to spend considerable effort verifying details in some of the more technical proofs or be willing to take some of these details on faith. Fortunately, some of the hardest material is also excellently covered in a somewhat more specialized book by

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Penrose (*Techniques of Differential Topology in Relativity*). The Hawking-Ellis book contains a few minor errors, but none affect the main results. Unfortunately there are no exercises; the book and the reader deserve a carefully thought out set.

On balance, the book is a model presentation of how elegant the interplay between mathematics and nature is. Fortunately, it will be widely studied and will exert a strong influence on research for quite some time to come.

R. K. SACHS
University of California
Berkeley

Astrophysics

W. K. Rose
287 pp. Holt, Rinehart and
Winston, New York, 1973. \$14.00

The past decade has provided sharp advances in astrophysics, with the discovery of the 3K cosmic background radiation, the quasars and above all, pulsars (and therefore neutron stars). *Astrophysics* provides a compact and

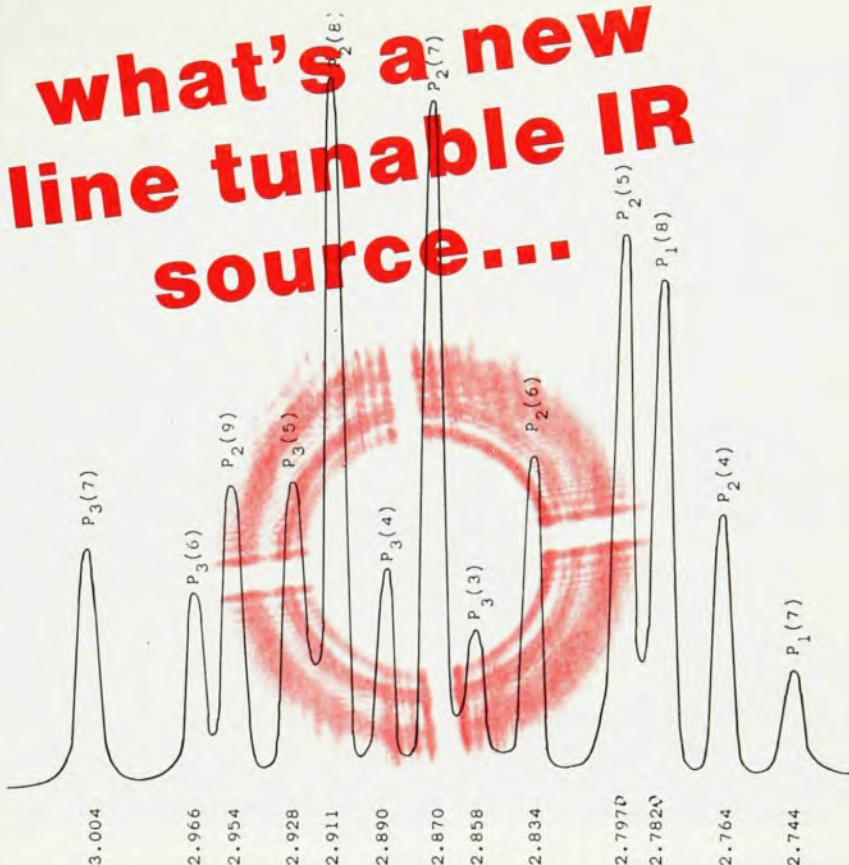
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well written guide to the physics underlying these and many other celestial phenomena. The book does not claim to be a text, and no problems or questions are provided. It is written at about the first-year graduate level, but I will probably use it as a text for my senior undergraduate course in astrophysics, just because of the lack of any really appropriate text at that level.

William K. Rose is a distinguished and able researcher into what is perhaps the most important area of astrophysics today, the evolutionary history of stellar interiors with particular reference to the end points of stellar evolution. Perhaps as a result, the chapters on stellar theory, red giants, white

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