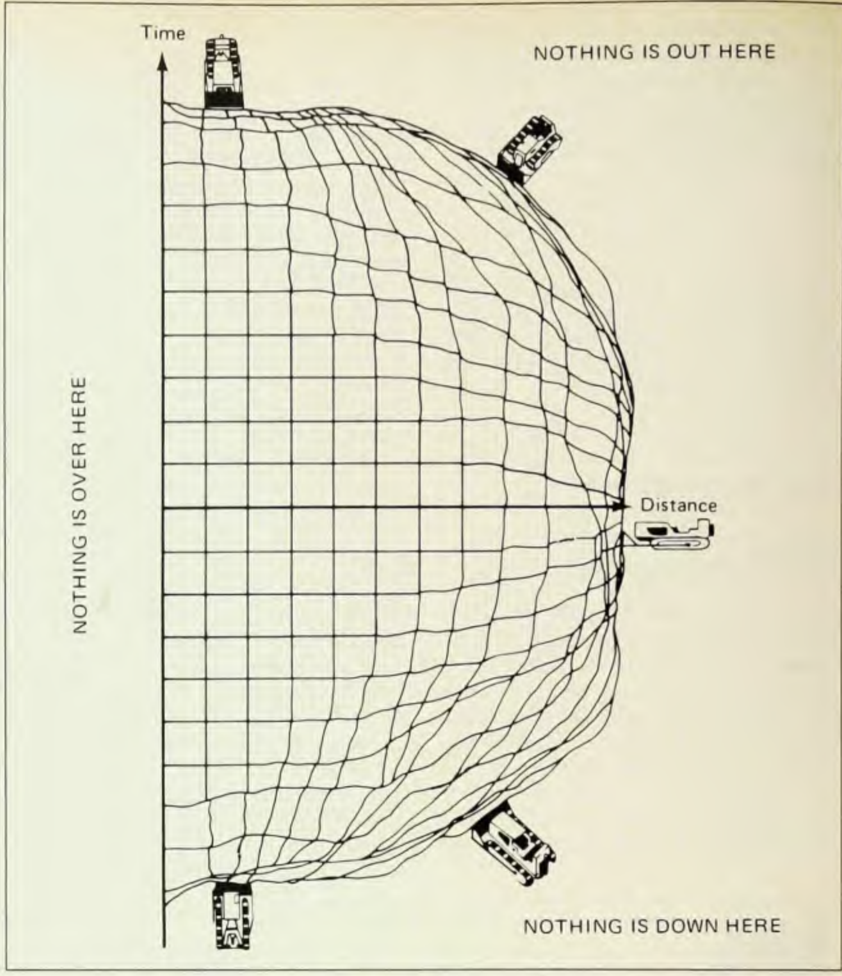
The treatment is highly mathematical and not for the casual reader. The physics sometimes gets lost in the math. The book must be read from page one, and the reading is not made easier by occasionally imprecise language and an inadequate index. Experimental results are rarely mentioned. The book's strength is the detailed mathematical exposition; it is an ideal book for a graduate student or researcher who wants to learn the mathematical treatment of successive atomic jumps in medium-complicated systems.

Stark's book is close to John Manning's *Diffusion Kinetics for Atoms in Crystals* in content. Stark's treatment is more detailed; Manning ranges somewhat wider and deeper. The choice between the two is really a matter of taste. Neither is suitable as a text in an advanced-undergraduate or beginning-graduate materials-science course on diffusion (and how badly such a text is needed!). Both could be used in advanced graduate seminars.

STEVEN J. ROTHMAN
Materials Science Division
Argonne National Laboratory
Argonne, Ill.



Squeezing in the infinite reaches of space-time. In Kaufmann's book bulldozers provide an analogy to the mathematical technique of conformal mapping that provides a "handle" on remote regions.

The Cosmic Frontiers of General Relativity

W. J. Kaufmann III
306 pp. Little, Brown, Boston, 1977.
$12.95 clothbound, $6.95 paperbound

Our culture no longer presumes that Man's immediate fate is tied to the stars, and so we spend incomparably less effort in studying them—as a fraction of our total effort—than did, for example, the neolithic people who built Stonehenge. William Kaufmann points out that the annual cost of even the Apollo project was less than one-third of what Americans spend on cigarettes and about equal to what they spend on dog food. Yet the day may not be far off when we shall use outer space again—to travel, to work, perhaps to survive. Kaufmann's new book is therefore timely: It vividly attempts to familiarize poets and liberal-arts students with some of the more arcane aspects of the modern cosmos.

The first two-fifths of the book contains an elementary introduction of the usual kind to special and general relativity and to the physics of stars. But the rest is quite unusual; it is devoted almost entirely to black holes. These come in Schwarzschild, Reissner–Nordstrφm, Kerr and Kerr–Newman varieties (having mass, mass and charge, mass and rotation, or mass and charge and rotation respectively). The book concentrates on Kerr holes, which are by far the most important in practice. A Kerr black hole is a spacetime warp with an incredibly complicated topology. It is connected smoothly to infinitely many universes similar to ours, rather like a branch point of an infinite-sheeted Riemann surface. Part of a Kerr hole could be realized when a rotating star collapses through its horizon under its own gravity, but the complete (theoretical) Kerr hole would have to be created from scratch, like a miniature universe—and perhaps even concurrently with the universe in which we live.

Kaufmann undertakes to discuss these complicated matters entirely without the help of mathematics. Not a single equation contaminates the text. For example, the invariant interval of special relativity is not defined here as $dx^2 + dy^2 + dz^2 - c^2dt^2$ but is, rather, described thus: "Three of the pieces that comprise the interval come from measurements of the distances (up–down, left–right, forward–back) . . . the fourth piece comes from the amount of time . . ." Again, in the description of the Penrose diagrams so useful for the understanding of black holes, we are told to think of bulldozers (and a figure illustrates this) bringing the infinite portions of spacetime to finite positions where they can be looked at and studied. The simple transformation $x = \tan x'$, which pulls distances in from infinity and which would clarify the matter at once to anyone having even the rudiments of a mathematical education, is barred by the self-imposed rules of the game. And, of course, there are no references to the literature.

Kaufmann's method is largely graphical. Over 200 well-conceived and finely executed diagrams guide the reader's intuition. The two main devices are Penrose diagrams and a long series of illustrations (rather too long, for my taste) showing what astronauts (always carefully designated as "he or she") would see on approaching—or passing through—a black hole along various paths. As for the Penrose diagrams, we are told how to fit the various blocks together and what they mean physically. Of course, no justification for all this can be made without recourse to the mathematics of the Kerr solution, and so everything must be taken on trust. Nevertheless, by playing with these diagrams the reader should come to understand—at a certain level—how one can move through the horizons from one universe to another, how one can pass through the ring singularity to a negative-gravity universe, how a star collapsing to a black hole can emerge as a white hole in another universe, how the Kerr solution permits journeys into the past (closed timelike lines), how "naked singularities" and "blue sheets" arise and other such esoterica.

I enjoyed reading this book. But I kept wondering how the poets for whom it was written, those who have no inkling of the Kerr mathematics nor, perhaps, the spatial intuition to grasp a complicated topology, will fare. I also wondered if they are not told here more than they ever wanted to know about black holes. On the other hand, I would recommend the book—at least in part—with confidence to the serious student who has a playful turn of mind. Although such a student can find all he needs in, for example, Stephen Hawking's and George Ellis's beautiful and rigorous book *The Large-scale Structure of Space–Time*, he will find in Kaufmann's book an amusing and stimulating supplement.

WOLFGANG RINDLER
University of Texas at Dallas
Richardson

Spectra of Finite Systems

H. P. Baltes, E. R. Hilf
116 pp. Bibliographisches Institut, Zürich, 1976. Dm 24.00

A famous problem in mathematical physics is the determination of the eigenvalues for the Laplace operator on a suitable bounded open region in Euclidean space with various boundary conditions (Dirichlet, Neumann or mixed); generally the eigenvalues are non-negative, increasing without finite accumulation and having finite multiplicity. This same problem arises for the wave equation after Fourier-transforming the time variable (Helmholtz equation). In 1911 Hermann Weyl initiated a general study of the eigenvalue distribution by giving an asymptotic expansion for large eigenvalues in which the first term depended only on the volume of the region and not the shape of the boundary. Richard Courant, using minimax techniques, (1920) gave remainder estimates. In 1934 T. Carleman opened a new chapter by employing Tauberian methods to estimate the asymptotic behavior of the corresponding eigenfunctions as well as recovering Weyl's results. These methods have been used in the modern mathematical theory for more general classes of elliptic operators, as reviewed by Colin Clark (1967).

The monograph by Heinrich Baltes and Eberhard Hilf gives another review of these questions, spanning some sixty years, and includes not only the Laplace operator (scalar case) but also similar questions for electromagnetic fields in bounded cavities and deformations of elastic media. Work in the last decade has centered on refining Weyl's asymptotic expansion by the use of averaging techniques to sort out various boundary dependences in higher-order terms. The authors give an overview of this in their fourth chapter, with the cases of a square and a cube detailed in the next chapter.

General two- and three-dimensional regions constitute the content of Chapter 6. For the two-dimensional scalar problem with suitable boundary constraints the higher-order terms depend upon boundary length and curvature. The discussion draws on results of Frank H. Brownell (1957). For further reading, the fine article by Marc Kac (1966) entitled "Can One Hear the Shape of a Drum" is recommended. The authors conjecture that one can, provided the overtones have a lattice-type spectrum given by a symmetric quadratic form on the integers (pages 42 and 64). Remaining chapters deal with remarks on acoustics, perfect gases, models of the nucleus, black-body radiation, correlation functions, con-