

them and pass over the less happy discussion of fundamentals. To do so, however, would run counter to the book's explicit purpose. The authors provide applications, valuable as they may be, to explicate certain general principles that they adopt as fundamental to statistical mechanics. It is really these principles that are being expounded; and we owe it to the authors to examine the work in that light.

Indeed, the useful applications of statistical mechanics are connected rather loosely to those fundamentals the authors proposed. In any particular application, the important and undoubtedly correct results usually turn out to be derivable from many different viewpoints. The danger of a too-narrow viewpoint is not so much that it will lead to a wrong prediction, but rather that it will suggest that the validity of a result depends on extraneous assumptions. Therefore, instead of asking which viewpoint is "correct"—a matter of personal opinion—it is better to ask which viewpoint leads to the most general results with the fewest assumptions—a matter of demonstrable fact.

The authors expound three general principles: the "contraction of distribution functions," the "attenuation of correlations," and the "ergodic relation." According to the first, after a short initial "kinetic phase" a joint probability distribution for the positions and momenta of n particles becomes a functional of (that is, is determined by) the Boltzmann single-particle distribution $f(x, p, t)$. Bogoliubov advanced the principle in 1947 as a tentative conjecture; the intervening years seem to have brought, if not proof, at least confidence; for Akhiezer and Peletminskii it has become a general principle. (However, I do not intend this as a criticism; for generally by a "principle" of statistical mechanics is meant some proposition that one wants to adopt but cannot prove—for once it is proved, it becomes a result, not a principle. Of course, this strategy necessarily entails the risk that one's principles will be disproved.)

The second principle is that as the separation between particles increases, their probability distributions become independent (in particular, uncorrelated). The authors also seem to assume, at first glance quite plausibly, that the range of correlations is short, of the order of the range of forces or at most a few times the mean free path. However, some caution is needed in making this assumption. For example, from the theory of response functions given in Chapter 4, the acoustic Green's function is $(kT)^{-1}$ times the space-time correlation function of the air pressure fluctuations, $\langle \delta P(x, t) \delta P(x', t') \rangle$. It follows that a student in the back of a

lecture hall is able to hear the teacher's voice only because thermal pressure fluctuations at the student's ear and the teacher's mouth are correlated, over a distance of perhaps 10^9 mean free paths. If the distance required for attenuation of correlations is larger than the size of the macroscopic system under study, then the principle does not seem to have much content.

The third principle seeks to deal with a dilemma of interpretation that haunts us throughout the work, starting on page 1. Over and over again we find the statement that a system "makes a transition into a state of statistical equilibrium." Its quantum-mechanical version is easier to describe notationally. Given an initial "statistical operator" or density matrix $\rho(0)$, common teaching holds that its time development is given by the Schrödinger equation of motion:

$$\rho(t) = e^{-iHt} \rho(0) e^{iHt} \quad (1)$$

On the other hand, equally common teaching holds that a system in thermal equilibrium at temperature T is described by a Gibbsian canonical distribution:

$$\rho_c \propto e^{-H/kT} \quad (2)$$

Suppose, then, that a system with Hamiltonian H , in an initial nonequilibrium state described by $\rho(0)$, is left to itself and comes eventually to thermal equilibrium. Believing both of those common teachings, one seems forced to the conclusion that dynamical evolution of equation 1 must in the course of time lead to the "state of statistical equilibrium":

$$\rho(t) \rightarrow \rho_c \quad (3)$$

But it is trivial to prove that this cannot, in general, be true. For equation 1 is a unitary transformation, and so not only is the information entropy $S_I = -k \text{tr}(\rho \ln \rho)$ a constant, but also each individual eigenvalue of $\rho(t)$ is a constant of the motion. If the eigenvalues of the initial $\rho(0)$ are not the same as those of ρ_c , then no unitary transformation can carry $\rho(0)$ into ρ_c .

The difficulty was not seen so clearly in equilibrium theory, which simply postulated the canonical form and never paid much attention to the dynamical development. But any attempt to explain how a system manages to get into the equilibrium state presents the basic dilemma of irreversible statistical mechanics. Denying the validity of equation 1 denies that the system obeys the Schrödinger equation. Denying the validity of equation 2 denies experimental facts. Yet it is a mathematical theorem that in general equations 1 and 2 are incompatible. Each writer on the subject must find some way around this difficulty; most try simply to obscure it. Akhiezer and Peletminskii

are refreshingly clear and forthright on this point; they simply ignore the mathematical theorem and assert the validity of equation 3 as an "ergodic relation." Equilibrium is achieved by fiat.

A point of understanding is missed here, one that was recognized clearly by Aleksandr Y. Khinchin about 40 years ago. In trying to bridge the dichotomy between equations 1 and 2, it would be far stronger than necessary and almost always untrue to assert that the distributions themselves become the same. It is sufficient to show that their physical predictions, for the particular macroscopic quantities of interest, become the same. It may well be that the authors' principles of contracted distributions and of attenuation of correlations would have helped in demonstrating this identity, but for intervention of their extraneous "ergodic relation."

In summary, the work has a beautiful and impressive collection of applications, which teachers of advanced statistical mechanics will want to use. The discussion of fundamentals is dated, however, and needs much revision before it would be suitable to use as a modern textbook.

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Bound for the Stars

S. J. Adelman, B. Adelman

335 pp. Prentice-Hall, Englewood Cliffs, N. J., 1981. \$17.95 cloth, \$8.95 paper

Bound for the Stars is an interesting book devoted, as the title indicates, to the feasibility of manned exploration of nearby stars. It contains essentially one equation (the so-called Drake equation, which simply estimates the unknown number of civilizations as a product of several equally unknown factors, such as L , the average lifetime of these civilizations) and a few versions of the coordinate sphere. I suspect it provides too little detail to satisfy readers of *PHYSICS TODAY*. My guess is that it is intended as general reading accessible to anyone having a high-school education. It might possibly serve as one of several books supporting a popular general course on space and space travel.

Bound for the Stars has a few nuggets for most everyone. The authors have done a good job of pulling together a wide variety of information, much of which the interested reader would find hard to locate in a library in such a coherent form. I personally enjoyed the critical assessment of the now-defunct President's Science Advisory Council's wishy-washy deliberations over what NASA should do after Apol-

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lo. The authors have relieved the obvious organization (past origins, present status, future possibilities) with variety: Some chapters are expository; some are historical; some are imaginary scenarios of what a day on a starship might be like: "The public address system, in that curious flat tone that no advance in technology seems able to cure, announces that the Lunar Space Ship is ready for boarding. Follow the guide, please." Some chapters introduce elementary astronomy (coordinates without tears); some are evangelical. Material has even been gleaned from committee reports of one kind or another (like the above public address system, committee prose seems to be refractory against improvement).

While this book is not your colorful coffee table ornament, it is attractively presented. Figures and reproductions are black and white. Tables unfortunately rarely turn up to summarize even abundant data contained in the text. The prose reads a bit telegraphic but not objectionably so; the authors move from point to point geodesically. Structurally, the book becomes somewhat rushed toward the end, where it jumps from discussing the feasibility of stellar travel *per se* to discussing direct manned exploration, as if the authors suddenly decided that they had spent too much time getting to the point. I find it difficult not to believe that high-speed automatic probes (in effect, the topic of the missing chapter) would precede direct human exploration; individuals might volunteer for a one-way trip to what might be a barren star, but who would finance a mission on that basis? More likely we would have ascertained atmospheric composition, conducted aerial surveys and biochemical profiles, and signed a mutual defense pact with any inhabitants before setting off, if even then. Another of the few lacunae concerns the probability of nearby habitable bodies. The authors discuss mainly the feasibility of detecting planets about other stars, and quite justly so, for such data would certainly help spur interest in sending off probes to investigate. But there has also been some interesting theoretical work on what kind of stars might be inhabitable that has moved beyond just looking under our own stellar class G2 streetlamp for the keys to life. For example, most of the nearby stars are M and K dwarves, runty little warm poker tips compared to the Sun, albeit indifferent to our own prejudices regarding where to look for life. Oddly enough, Alpha Centauri is not only the closest star (excluding possibly a few cinderlike neutron stars—long-dead pulsars—idly turning in the sky) but quite like the Sun. Alpha Centauri is one of a triple star system, but it remains far enough apart from the

others (named Beta and Gamma, of course) that an "Earth" as well as much of the rest of the solar system could orbit quite unperturbedly about it or either of the others.

What this pleasant book tells us—that we might be at the technological edge of a brute-force effort to reach the nearest stars—is important, but one can't help but hope we will be more imaginative when the time comes than to shove off in a monster ark in some direction.

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Topics in Classical Biophysics

H. J. Metcalf

300 pp. Prentice-Hall, Englewood Cliffs, N. J., 1980. \$9.95

Biophysics and biophysical methods not only have contributed to modern research at the cellular and molecular levels, but also have begun to provide a new level of understanding of seemingly complex relationships in biology and medicine by describing larger-scale biological phenomena (involving muscles, circulation systems, or the whole organism). Considering basic physical laws, effects of scale, and relations between energy production and transduction can often lead to simple answers. Harold Metcalf, a member of the physics faculty at SUNY, Stony Brook, has written a short book about these "classical" areas, including biomechanics, thermodynamics of metabolism, blood circulation, biological feedback, nerve cells, and hearing. In a book that requires little knowledge beyond a first course in physics, some knowledge of simple differential equations, and a minimum acquaintance with biology, Metcalf deals with subjects sometimes classified as "medical physics" and "bioengineering."

The first four chapters deal with mechanics and biomechanics; heat, thermodynamics and energy; and the viscous flow of fluids. Metcalf chooses examples from a wide variety of biological topics, including kinesiology and blood circulation. In the next chapter Metcalf treats basic ideas of feedback and control—but without the depth usually found in elementary electronics treatments; his description of the principle of operational amplifiers is sparse and limited. A chapter entitled "Nerve Cells" presents the biophysics of nerve action potentials and neural transmission up to and including the Hodgkin-Huxley equations. The most convincing chapter in the book, it should provide an elementary understanding of this important process. A chapter on sound and hearing restates many of the traditional conceptions of

this process based largely on the work of George von Békésy. More modern work is not discussed, and this section would not provide a basis for the understanding of a beginning student. The last two chapters deal with "Light, Color, and Vision" and "Experimental Techniques." Both seem rather hodgepodge collections of physics and some biology, with little coherent relation between them. The discussion of geometrical and physical optics and its relation to vision is particularly dated and uninformative. Too often, Metcalf has chosen to state qualitatively some theory or idea and leave a careful description or comment to others. The experimental chapter lists a number of techniques (esr, nmr, electron microscopy, and ultrasound, to name a few) without developing this material enough to permit a reader to become very knowledgeable.

Problems selected from biological physics are appended to each chapter, and supplementary material—on such diverse topics as countercurrent exchange distribution, the moment of inertia of the human leg, diffusion and random walk, lateral inhibition and painting (an outmoded argument), and photodetectors—appears in the appendices. A bibliography contains many references for further reading.

In summary, the first two-thirds of the book would be a useful supplementary text in, or after, a first course in college or university physics for students intending to major in the biological sciences or for those planning a career in the health sciences. It would not replace a standard introductory physics text or provide enough material for a course in biophysics at the junior-senior level.

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Information Processing: Fundamentals

S. H. Lee, ed.

308 pp., Springer-Verlag, New York, 1981. \$49.50

This book, the 48th volume of the series *Topics in Applied Physics*, is a companion of an earlier volume in the same series, *Optical Data Processing: Applications*, edited by D. Casasent. The present book contains seven chapters, each with a comprehensive list of references to the literature, and a subject index at the end. On the whole, the book gives an excellent treatment of the fundamental principles and experimental techniques of the various subject areas of optical information processing.

Editor S. H. Lee wrote the first chapter on basic principles. Following a brief historical overview on the devel-