Acoustic Systems in Biology

Neville H. Fletcher
Oxford U. P., New York, 1992. 333 pp. $65.00 hc
ISBN 0-19-506940-4

In the preface, Neville Fletcher, a well regarded and broadly published physicist, assigns two purposes to this work: It should function as an introductory textbook in acoustics for physics or engineering majors, and it should be suitable as a textbook for those graduate students in the biological sciences interested in auditory and vocal systems. While I am not sure of its potential utility as a standalone text for either of these populations, I am very confident that both would benefit immensely from *Acoustic Systems in Biology*.

Indeed, the more I read this book the more I wished that it had been available as a supplemental text the last time I taught acoustics. Its strength for physics and engineering majors is its physical analysis of the problems that it poses. The author does a superb job of making his readers feel the physics underlying the mathematics of acoustics. However, the book is much less mathematical and has less depth across the range of topics than standard acoustics texts such as *Fundamentals of Acoustics* by Lawrence Kinsler, Austin Frey, Alan Coppens and James Sand (Wiley, New York, 1982). The biological examples used throughout the book are both clear and likely to be interesting to most physics and engineering majors. But to work as a text, it would require supplementing with nonbiological examples. However, I strongly recommend that this book be available (in the library or elsewhere) to physical science students taking acoustics courses. The book schools students well in the vocabulary of thought and expression in acoustics.

I am not sure that this text is well suited to students in the biological sciences for, in my experience, there is not enough biology in the first ten chapters to keep students of biology motivated. I can guarantee, however, that acquaintance with and study of this book will prove of exceptional value to biologists and audiologists active in hearing and sound-production research. These researchers must both communicate with colleagues from the physical sciences and have a good understanding of the various transformations of sound energy from its production to its detection and analysis. The author's effective communication of the vocabulary of acoustics is likely to be of exceptional use to these biologists.

Acoustic Systems in Biology is implicitly divided into three parts. The first ten chapters are basically a one-semester acoustics course where the applications come from the biology of sound detection and generation. The focus of these chapters is more acoustics than biology. The next four chapters focus more on the biology than on the physics. The eleventh chapter, on high-frequency auditory models, is an excellent application of the previous chapters to the biology of sound detection. Students and professionals in the field will benefit from studying the clear-headed analysis presented here. The next three chapters analyze in some detail several interesting topics in bioacoustics. I found chapters 11 to 14 to be well thought out and well written and a pleasure to study under the author's guidance. Indeed, for those interested in either acoustics applications or the biology of sound, I highly recommend the book for these chapters alone. The third part, consisting of only the last chapter, is on signals, noise and information. With the exception of a nice discussion on the degradation of acoustic information with distance and in noise, this chapter seemed a bit outside the theme of the book.

Acoustic Systems in Biology will certainly work as the text for a one-semester undergraduate course in introductory acoustics. However, I would rather recommend it as a supplement to the more mathematical texts used in introductory acoustics courses at the advanced undergraduate or graduate level. Furthermore, this book is likely to be of considerable value to biological and audiological researchers of sound generation and detection.

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Supermanifolds

Bryce DeWitt
Cambridge U. P., New York, 1992 [1984]. Second edition, 407 pp.
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$37.95 pb ISBN 0-521-42377-5

Supersymmetry, a symmetry relating fermions and bosons, may or may not exist in nature; but it surely is all over the place in current theoretical attempts to describe matter. Even if no partners of the known particles show up in experiment—as supersymmetry implies they should—there is a point to understanding supersymmetry. The reason (if this reviewer has diagnosed the current atmosphere in theoretical physics correctly) is that the existing schemes for a unified description of elementary particles leave most people dissatisfied. Although superstring theory represents an important step forward, it is currently valued more for the hints it may give about a future grand synthesis than for its intrinsic worth. Nevertheless, for those who aspire to an understanding of the laws governing matter, the road currently leads through superstring theory and supergravity. To follow this path, a command of the basic descriptive machinery of supersymmetry is indispensable. Thus, one must welcome the second edition of a book on supermanifolds that, in its first edition, has been tried and found useful.

As the author remarked in the introduction to the first edition, this book was originally intended to be an appendix to a book on supergravity. Then it evolved into the first volume of a planned two-volume work on supermanifolds and supersymmetry. The second volume has not yet appeared; in the meantime, here is a second edition of the first volume. Compared with the first edition, it contains an essential addition: a chapter on applications involving topology. The first five chapters are essentially the same.

One feature of the material covered in the book should be mentioned: its mathematical character. The theory of supermanifolds originated in physics but the ideas were taken up by a number of mathematicians. The author offered the following statement in the preface to the first edition: "Mathematicians will find much of this book incomplete and expressed in language that nowadays they have passed beyond, but it is probably pitched about right for the average physicist." The reviewer agrees with this statement, but ventures the following additional opinion: The work on the mathematical theory of supermanifolds has not reached consensus on the basic definitions. Thus, the reader who wishes to supplement the account in DeWitt's book with a mathematically rigorous treatment of the basic ideas faces a bewildering variety of choices. This is regrettable but appears to be the state of the art.

The starting point of DeWitt's account is the replacement of a real or complex variable by an element of a Grassmann algebra. Recall that to define the Grassmann algebra of a vector space V, one first forms monomials v, $w \wedge x$, $y \wedge z \wedge b$ and so on, where v, w, x, y, z, b and so on are vectors in V and $\wedge$ denotes an antisymmetric multiplication. One then takes linear combinations

$$a_0 + a_1 v + a_2 w \wedge x + a_3 y \wedge z \wedge b \ldots$$

where a_0, a_1, a_2, a_3 and so on are real or complex depending on whether V is a real or complex vector space. These sums are the elements of the Grassmann algebra; Dewitt calls them "supernumbers." The multiplication law under the operation $\wedge$ makes them into an algebra. Ever since Herman Grassmann, the resulting algebraic calculus has been used to treat questions involving relations between subspaces of V. More than 30 years ago Felix Berezin developed a systematic theory of functions whose independent variables are supernumbers, and this theory has been used effectively in the quantum mechanical discussion of fermions ever since.

The next step in the theory is to define vector spaces in which the coordinates are supernumbers, the supernumbers themselves forming the one dimensional vector space. Using the Berezin calculus, one can then imitate the usual construction of manifolds (coordinate patches, consistency of coordinates in the overlap of patches, atlases and so on) to define the notion of a supermanifold. All this is done in chapters 1 and 2.

Chapter 3 deals with super Lie groups. They differ from Lie groups in having the group manifold generalized to be a supermanifold. Chapter 4 discusses examples of super Lie groups. Chapter 5 contains applications of supermanifold theory to the quantization of dynamical systems in which the configuration space is based on euclidean space. The new Chapter 6 concentrates on the additional wrinkles that arise when the configuration space has a non-trivial topological structure.

I recommend the book to those hardy souls who wish to venture out into the stormy waters of current particle theory.

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Statistical Mechanics of Phase Transitions

J. M. Yeomans
Oxford U. P., New York, 1992. 153 pp. $24.95 pb
ISBN 0-19-851730-0

This book provides a brief, accessible introduction to phase transitions, critical phenomena and the renormalization group. Proficiency in the study of phase transitions is not a prerequisite for writing a book such as this one, given the large number of review articles, monographs and texts at various levels of sophistication that are now in the literature. However, an intimate acquaintance with front-line research enables one to distinguish what is essential from what is dispensable in preparing an introduction to the field. The author, Julia Yeomans of Oxford University, has the competence and accomplishments that prepare one to exercise this kind of judgment. She has, for example, performed some of the best and most influential research on the antiferromagnetic next-nearest neighbor interaction model, which describes a magnetic system that, because of competition between ferromagnetic and antiferromagnetic order, can exhibit an extraordinary diversity of magnetic phases.

Yeomans starts, appropriately enough, with a definition of phase transition and follows with a description of some of the systems exhibiting the thermodynamic singularities that betoken phase transitions. Then, after a compressed discussion of relevant notions in statistical mechanics, she embarks upon a review of models, concepts and theoretical techniques that have been applied to the study of critical phenomena. The reader will find mention of almost every theoretical approach to phase transitions that has influenced the evolution of our understanding of this remarkable set of phenomena over the past three decades.

I am not a neophyte in the field, so finishing the book in two sittings as I did is not a particularly noteworthy feat, especially given the fact that I attempted none of the problems at the end of each chapter. However, I did keep an eye open for the kind of writing that leads the reader into logical dead-ends simply because he or she hasn't managed to extract the author's meaning from a jumble of ambiguously worded sentences. I was well pleased with the clarity and coherence of the exposition. I did, however, find much to criticize in the quality of the prose. About three-quarters of the sentences in *Statistical Mechanics of Phase Transitions* use passive, rather than active sentence construction. The best technical books breathe life into a topic by conveying the author's enthusiasm for and delight in the subject; this book fails in that regard. Fortunately, there is enough mystery and elegance to be found in the subject of critical phenomena to seduce the reader, even in the absence of a compelling prose style.

On the whole, this book will prove useful to the beginning graduate or advanced undergraduate student who wants to start learning about phase transitions and critical phenomena, and to the instructor who would like to teach the subject to such a student.

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Exotic Properties of Superfluid ^{3}He

G. E. Volovik
Series in Modern Condensed Matter Physics, Vol. 1.
World Scientific, River Edge, N. J., 1992. 215 pp. $48.00 hc
ISBN 981-02-0705-0

The "exotic properties" in the book's title are essentially the phenomena arising when the internal order parameter of one or the other of the superfluid phases of ^{3}He—which reflects the orientation of the "diatomic molecules" (Cooper pairs)—varies in space and/or time. Grigor E. Volovik of the Landau Institute in Moscow has been a leading theoretical player in this area, and this book is in large part a compendium of his contributions and related work. Apart from some review material that introduces the language of broken symmetry and a fairly brief final chapter on quasi-two-dimensional films, one can pick out three main themes: the bulk orbital statics and dynamics, analogies with phenomena in particle physics and the properties of various topological singularities, particularly vortices in ^{3}He-B. The last topic is likely to be of somewhat limited interest to those not actively engaged in the relevant theory and experiment, and it is at times presented in an unnecessarily mystifying way. (For example, the author makes much of an A-phase singularity, which is described as "a combination of the half-wounded disgyration with the half-quantum vortex" and illustrated in fairly abstract terminology in a figure. I wonder how many readers will grasp that this superficially exotic beast is nothing but a simple (^{4}He-type) vortex of the up-spin Cooper pairs, with the down-spin order parameter remaining constant.)

As to the correspondences with particle physics, being the kind of philistine who does not feel that, for example, his understanding of the Bloch equations of nmr is particularly improved by being told that they are a consequence of Berry's phase, I have to confess to greeting the news that the "spin-orbit waves" of ^{3}He-A are