example, the electron is first discussed in the context of the question "How can we assert that the electron is *really* elementary?" and the discussion then turns to the self-energy of the electron. These nonstandard issues arise so naturally in Wichmann's development that it becomes hard to see how other treatments avoid facing up to them.

On the other hand, again considering the electron, Thomson's measurement of e/m and the Millikan oil-drop experiment are alluded to in about two sentences each, supplemented by footnote references to the original papers. This is typical; Wichmann favors fresh gems, not old chestnuts. But old chestnuts usually gain their status from their intrinsic interest and importance, and familiarity with them is part of the cultural literacy of a physicist. Thus there is something incomplete about a treatment that virtually omits them, as in the cases cited, or disdains treating them in a routine, compact way, as in the case of Wichmann's coverage of the Bohr model of the hydrogen atom. Fortunately, it is relatively easy for the instructor to remedy this sort of omission.

It would be harder for most instructors independently to supply some of Wichmann's gems. One of the more exotic is the discussion of the fact that the same Planck's constant applies to photons and electrons. Less exotic and more characteristic are brief treatments of typical magnitudes in atomic physics and a demonstration that there are only about seven truly fundamental constants of nature. The value of such discussions is not that they represent *tours de force* of sound simplification (which they do); it is that they keep the student's attention focussed on broad and fundamental questions. This is the strength of the book, and it is a strength that far outweighs the omissions mentioned above.

Many of the derivations are done with conventional completeness, and there is frequent appeal to experimental results. However, in some instances arguments are carried out with reliance on enlightened handwaving. While this succeeds splendidly in displaying the power of simple physical reasoning as practiced by a sophisticated professional, it conceivably could discourage some students who might be at a loss to see how they could safely generate similar arguments themselves. However, Wichmann does not rely on this method to excess, and, as already indicated, there are strong benefits in watching a maestro wave his hands.

A few scattered specific remarks: The book covers virtually no solid-state physics or special relativity; it has an array of imaginative and stimulating problems, but most instructors will want to accept Wichmann's invitation to make up their own "substitution" type problems; a section on theory of measurements is uncharacteristically difficult to comprehend; there are very good bibliographies at the end of each chapter.

In overall summary, this book is an enthusiastic exposition by an author who makes good use of a profound perspective on quantum physics, and who has a gift for very lively and lucid explanation. It is not encyclopaedic in coverage or style, but fastens upon fundamental concepts in quantum physics and succeeds imaginatively in conveying their spirit and content in a form understandable to an intelligent sophomore.

David Bodansky
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Spin Temperature and Nuclear Magnetic Resonance in Solids

By M. Goodman
246 pp. Oxford U. P., New York, 1970. $13.75

It was in 1957, I believe, that I was approached by a fellow worker in nuclear magnetic resonance with some puzzling results on some experiment in a solid. He summarized his mystification for me by lamenting that "it looks as if it is a case of spin temperature." That was an era in which it was also not difficult to find otherwise rational scientists who did not believe in the concept at all, usually on the grounds that a spin system could easily be made so hot that the "temperature" was negative, an obviously ridiculous result. But even people who had faith that the concept would have some role in the explanation of mysterious experimental results seemed to think of it more as a disease than as a beautifully simple, clarifying concept. Now, some 20 years after R. V. Pound's and E. M. Purcell's initial experiments in lithium floride, 15 years after A. G. Redfield's extension of the concept to the rotating frame, and after some ten years of very active development, Maurice Goldman has producd a unified description of the many theoretical and experimental applications of spin temperature to nuclear magnetic resonance in solids.

Goldman is a member of the magnetic-resonance group at Saclay, which, under Anatole Abragam, has made many of the major contributions to this subject. It should surprise no one, then, if this book bears considerable resemblance to Abragam's *Principles of Nuclear Magnetism* in style, level of presentation, notation and (as the publisher is the same) general appearance. Indeed, it can be regarded an an updating and expansion of chapters 6 and 12 in that book. It follows that the potential

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readers and users of this book are the professionals of nuclear magnetic resonance who do not shrink from density matrix calculations, and who are at home in all rotating reference frames.

The author's major emphasis is on the behavior of spin systems in isolation from the lattice, and the book begins with a discussion of the establishment and evolution of spin temperature in an isolated system. After a brief chapter on the effects of spin lattice relaxation on spin temperature, Goldman presents the Provotorov technique of calculating the effects of a saturating rf field on the spin system.

Chapter 5, on the applications of the Provotorov theory, is one chapter whose contents should be known to all working in magnetic resonance in solids, even those not consciously interested in exploiting the techniques and theory of this book. Almost everyone uses lock-in detection, many use adiabatic fast passage, some use both simultaneously, and some do so without realizing it. If not the cure, then certainly the detailed diagnosis of the "spin temperature disease" is to be found here. Everyone using the standard experimental methods of nuclear magnetic resonance in solids will eventually encounter signals that behave strangely, or do not appear when they should, or are found with the "wrong" phase of the lock-in reference. Goldman uses the machinery of his earlier chapters to calculate many of the practical consequences of the spin-temperature hypothesis.

The remaining chapters are devoted to the establishment of spin temperature, particularly in the presence of more than one spin system (that is, problems involving cross-relaxation), and to dynamic polarization experiments. Throughout, the author cites and discusses with care the major experiments (many of them his own) that provide the justification of the spin-temperature hypothesis.

As I suppose must be true about any book, there are some disappointments. Some readers might feel more at home with the calculations if they were accompanied by more diagrams of the sort that aid the reader in keeping track of the various thermodynamic systems and the relaxation process between them. Qualitative previews of what to expect and what the results will be could have preceded many of the lengthier expositions. The figures from experimental papers cited are essential and were judiciously selected, however.

On questions of substance rather than style, there are two small areas of disappointment. One is the rather offhand treatment of the expansion of the density matrix in the high-temperature approximation. The reader with doubts should see Appendix E of the well known text by C. P. Slichter, *Principles of Magnetic Resonance*. The other is the brevity of the discussion of the fundamental assumption, the spin-temperature hypothesis, which occupies barely half a page. In a book of this size on so narrow a subject the reader expects in general to find a careful and complete discussion of the foundations. Such a discussion would be useful (and not just as an academic exercise) in order to prepare the reader for recent experiments such as those by John Waugh and his group at MIT, which point out quite explicitly the need for care in the use of the spin-temperature concept.

In summary, this book is one for specialists in nuclear magnetic resonance working in solid-state physics. Detailed knowledge of its contents is essential for workers who want to play tricks with spin systems. Those who regard NMR in solids as mainly a branch of spectroscopy will ignore the material presented here at their own risk. The cure is probably not worse than the disease.

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Underwater Acoustics

By L. W. Camp
308 pp. Wiley, New York, 1970. $17.50

Underwater acoustics as a branch of science and engineering implies many things to many people. To some it is marine bioacoustics, to others it is a tool in marine geology and oceanography, and to still others it is the oceanic eyes and ears of our naval forces. Common to all these facets of underwater acoustics is the topic of underwater-sound projectors and receivers. Basically, this is the subject matter of *Underwater Acoustics* by Leon Camp with contributions from Richard Stern and Bob M. Brown. The purpose of the book is to present those fundamentals and principles of underwater acoustics that bear on transducer design engineering. In doing this the principal author, who has had wide experience in transducer research and development, has brought together material that is not normally found under one cover.

This book, which is an outgrowth of a "short course" offered for many years at the University of California, Los Angeles, can be divided into three broad sections. The first four chapters contain review and summary material on vibrations, uniform bars, simple transmission problems, wave acoustics and ray acoustics. Most of this material can be found in the popular texts on acoustics such as *Fundamentals of Acoustics* by Lawrence E. Kinsler and Austin R. Frey.