

Ion spins in crystals

SPIN-LATTICE RELAXATION IN IONIC SOLIDS. A. A. Manenkov, R. Orbach, eds. 453 pp. Harper & Row, New York, 1966. Paper \$5.00

by Ralph P. Hudson

Theoretical and experimental investigation of the factors governing equilibrium between a system of magnetic ions and the crystal-lattice environment extends over the last 30 to 40 years. The interest of researchers and concomitant significant advances have fluctuated widely, stimulus coming at intervals from such varied sources as general investigations into magnetism below room temperature, development of magnetic cooling for very low temperatures, application of ac methods and, later, microwave techniques to research into paramagnetism and invention of the solid-state maser. Blending of quantum mechanical descriptions of paramagnetism and radiation with thermodynamics, lattice dynamics and crystal field theory has resulted in the present fairly thorough understanding of spin-lattice relaxation in ionic solids. The theory, model-based rather than microscopic, is qualitatively very strongly upheld, and quite well substantiated quantitatively, by experiment.

The book under review is a paper-bound collection of reprints comprising, in the compilers' words, "a cohesive unit rather than every major paper on the subject." The editors are themselves notable contributors to the subject as their own papers that appear in this volume attest. A useful pedagogical feature is the annotation of each title in the table of contents. Quite appropriately, the first item is the pioneer article by I. Waller (*Z. Physik* 79, 370, 1932), who suggested as the mechanism for relaxation of the spin system the modulation by the lattice vibrations of the dipolar interaction between ions. This, however, is quite inadequate to account for the observed relaxation rates. The correct explanation—modulation of the spin-orbit interaction by the fluctuating electric field of the lattice—was furnished by R. de L. Kronig (*Physica* 6, 33, 1939) whose paper is second in this collection.

No one has contributed more to the development of the field than John H. Van Vleck, whose major pertinent papers (four in number) are included together with fairly obvious choices of articles by N. Bloembergen, S. A. Altshuler, R. Kubo, A. G. Redfield, M. W. P. Strandberg, P. E. Wagner, C. D. Jeffries, R. Orbach, A. A. Manenkov, A. M. Prokhorov, and their col-

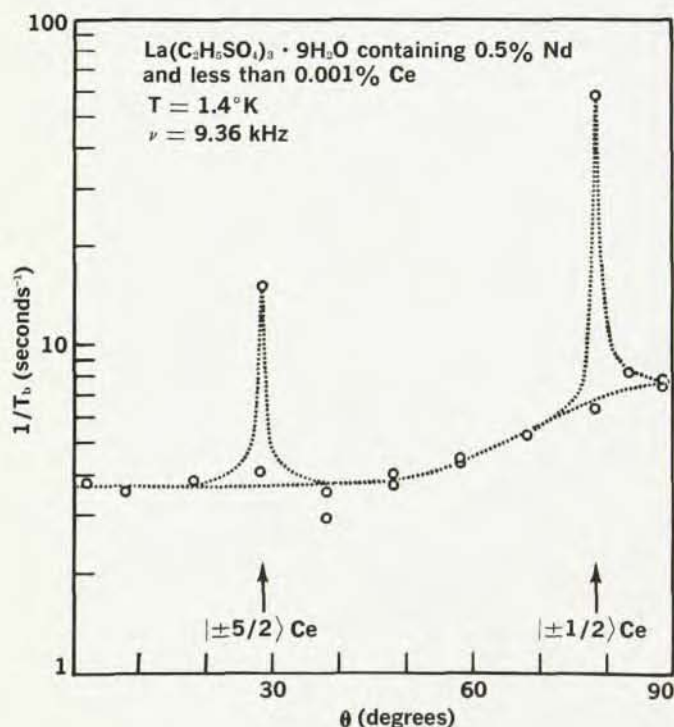
leagues, together with numerous others totaling almost 50. Many of the selections are from the Russian literature, all except one in English translation. In five groups they cover the topics of relaxation process theory (19), phonon bottleneck (4), cross relaxation (4), exchange reservoir (5) and relaxation experiments (13).

Most of the quite substantial Leiden and Oxford contributions to the field have been in experimentation with the nonresonant audiofrequency technique, an area that the editors have excluded, save for two fairly recent Oxford papers, on the grounds of being adequately covered by C. J. Gorter's book *Paramagnetic Relaxation* (Elsevier, 1947). Nor have they attempted to cover other related areas, for example conduction-electron relaxation and impurity relaxation in semiconductors.

The editors' selection would necessarily be duplicated, in the main, by anyone undertaking a compilation of this title, and one may assert without qualification that this is a most attractive and useful collection for students, teachers and research workers alike. At the published price it is within reach of everyone interested.

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The reviewer, who in pursuit of his general interest in magnetism at very low temperatures has dabbled in the field of spin-lattice relaxation, is currently chief of the Heat Division at the National Bureau of Standards.



RELAXATION RATE T_b^{-1} for Nd in a crystal of lanthanum ethyl sulfate, as a function of the angle between crystal z axis and field H. (From *Spin-Lattice Relaxation in Ionic Solids*.)

Introducing plasmas

PLASMA PHYSICS IN THEORY AND APPLICATION. Wulf B. Kunkel, ed. 494 pp., McGraw-Hill, New York, 1966. \$15.50

by Sanborn C. Brown

In 1961 the University Extension of the University of California organized a lecture series with the same title as this book. During the last five years the attempt has been made to bring together the various lectures given at that time, and the present volume is the result of this effort. The contributors are well chosen, and the elapsed time between their presentations and the publication date has not detracted from the value of the collection. It

should, however, be read not as a book, but as individual papers by the various authors. Although occasionally there is a parenthetical comment (see chapter 2 and chapter 5), I could not find any detailed correlation between the various chapters. Thus each author refers to his own equations, but never to similar equations in other chapters. Also the units and the nomenclature from chapter to chapter are different, although the units are carefully stated and definitions for the terms are included, so that there is no question about the meaning of the terms in a given chapter. It does, however, set the tone of the collection as contributed by particular people without correlation or homogeneity.

The volume is divided into three areas: After what is called an "Introduction of Plasma Physics" by Wulf B. Kunkel and Marshall N. Rosenbluth, there are chapters on adiabatic charged-particle motion by Theodore G. Northrop, statistical mechanics by Burton D. Fried, and dissipative effects by Allan N. Kaufman. The volume then moves on to discussing the plasma state as a continuum with chapters by Norman Rostoker on stability; MHD characteristics, shock waves, and hydromagnetic flow by Arthur Kantrowitz, Harry E. Petschek, and Julian Cole. There is a section on waves and radiation by Charles B. Wharton, Alvin W. Trivelpiece, and Hans R. Griem. The last third of the book is taken up with practical discharges, energy conversion, propulsion for space vehicles and controlled thermonuclear fusion by appropriate experts in these fields.

The effort was made to ask working experts in the various fields to present the material, and although some of the more practical applications of the plasma state are somewhat out-of-date because of the length of time taken to produce the volume, it is still an excellent summary of the basic material. The bibliography includes considerably more modern material than the original set of lectures could have embraced.

The editor says that the material is "intended to provide, for active research workers and other scientists desiring a general knowledge of plasma physics, a comprehensive introduction to this . . . field." I believe this is

a statement that accurately reflects the tone of the book, and the editor has achieved his goal in a successful and readable manner.

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The reviewer is the author of Basic Data of Plasma Physics, 1966, a revision of his earlier book that has just appeared from the MIT Press.

No longer an art?

THE GROWTH OF CRYSTALS FROM THE MELT. By J. C. Brice. 192 pp. North-Holland, Amsterdam (Interscience, New York), 1965. \$7.00

by Martin S. Straumanis

The author, who is associated with Mullard Research Laboratories, Redhill, Surrey (England), writes in the preface of the book: "Crystal growth is slowly changing from an art to a science. At the present time, it is probably best described as a craft. The aim of this monograph is to give a simple account of the scientific principles which underlie the various processes associated with the growth from the melt. For details of the other methods used for growing crystals the books of J. W. Mullin (1961), W. D. Lawson and S. Nielsen (1959), Buckley (1951), M. H. Francombe and H. Sato (1964), and J. J. Gilman (1963) should be consulted."

Accordingly, in chapter 1 the kinetic theory of gases, the binding forces in solids, crystal lattices, intrinsic and grown-in defects, impure solids, the melting process, properties of liquids, phase diagrams and evaporation are discussed very briefly using a minimum of mathematics. The increase of vacancies that one finds when approaching the melting point of elements that may be important in crystal growth is also mentioned (but not the names of Simmons and Balluffi).

Chapter 2 deals with the kinetics of growth from the melt, starting with the equilibrium shape of crystals (according to I. N. Stranski) and continuing with nucleation, nucleation theories, and the growth of perfect, imperfect, and rough interfaces and the dendritic growth. The next paragraphs on constitutional supercooling and interface distribution coefficients are more elaborate.

Although the distribution of impurities in a growing crystal is treated from various aspects in chapter 3, very little is said about the distribution of admixtures soluble in the liquid melt but nearly insoluble in the solid (for example, distribution of Cd in a Zn crystal). More detail is provided for semiconductor single crystals.

In the last four chapters the experimental conditions for crystal growth are summarized, such as the growth methods, furnaces, temperature and

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