plications in Chemistry and Biology, according to its authors, sets forth "the theory of spin exchange rate constants . . . systematically and comprehensively . . . for the first time." Spin exchange, the exchange of electron quantum numbers when two particles collide in solution, is the simplest possible chemical reaction. It manifests itself in a variety of changes in relaxation parameters, both within the spin system and to the lattice. Spin exchange depends on translational diffusion, on access of interacting species to each other and on overlap of wave functions. It can occur between similar or dissimilar paramagnets. Perhaps half of all esr work being published is in the liquid phase, and spin exchange nearly always contributes to the spectral features. Yet this book is the first systematic treatment. Everyone doing liquid-phase esr should study it.

There are four chapters: a brief introductory chapter, followed by chapters on theory, experimental techniques, and applications. (I suggest reading the last chapter first, since it depends only lightly on the preceding ones and gives a good overview.)

As I read this book, I realized that spin exchange of similar spins in homogeneous fluids is a dull affair. One knows that the exchange frequency will depend on viscosity, diffusion, molecular shape, charge, and so forth, but it is difficult to separate the effects. However, the applications of spin exchange between different species in heterogeneous systems discussed here were exciting, suggesting new opportunities to probe complex systems.

Spin Exchange is at the leading edge of research in esr spectroscopy. It is a primary rather than a secondary source. I predict that it will stimulate significant future research.

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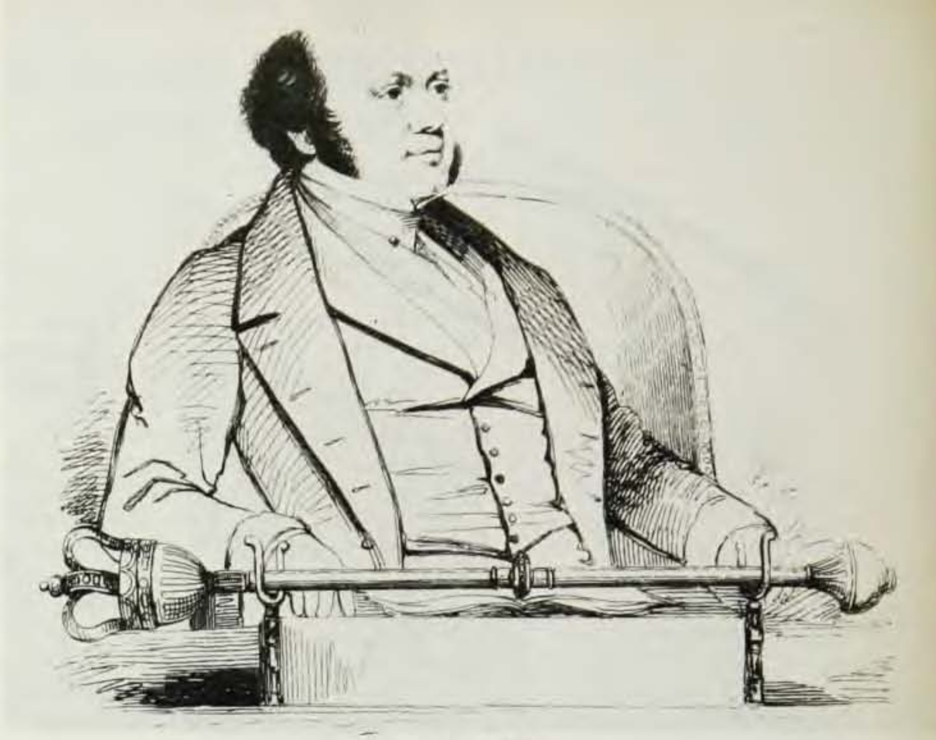

HAMILTON

Sir William Rowan Hamilton

Thomas L. Hankins
474 pp. John Hopkins U. P., Baltimore, 1980. $32.50

Although Sir William Rowan Hamilton, the subject of this biography by Thomas L. Hankins, is known today primarily—if not exclusively—for his share in the Hamilton–Jacobi equations, he made contributions of the first order to many branches of physics and to pure mathematics. Just a few months before his death in 1865, he was deemed to be the leading scientist of the world when he was chosen the first of the foreign associates of the newly founded National Academy of Sciences of the United States. This was quite an honor for a man whose official post was Astronomer Royal of Ireland, and who was not (according to Hankins) "a particulary successful astronomer" at that.

The reputation gained by Hamilton was a result of three great achievements in physics. First, he originated (in 1827) a new theory of optics "that allowed him to describe any optical system in a very general way." Second, and of far greater importance, was his purely theoretical prediction in 1832 of the phenomenon of conical refraction in biaxial crystals. After the experiments of Humphrey Lloyd, Hamilton's colleague at Trinity College, Dublin, had confirmed the prediction, Augustus De Morgan wrote that "opticians had no more imagined the possibility of such a thing, than astronomers had imagined the planet Neptune, which Leverrier and Adams had calculated into existence." To this day, the discovery of conical refraction stands out as one with the great triumphs of prediction in theoretical physics verified by subsequent experiment. Third was the creation in 1834 of the "most general method known for describing the motion of a system of particles." It was here that he developed the "canonical equations" of motion, "Hamilton's principle," and Hamilton's version of the Hamilton–Jacobi equations. While composing his "general method of dynamics," Hamilton wrote to William Whewell at Cambridge that he had "made a revolution" in the science of mechanics. He had indeed, and Hankins shows that "Hamilton was able to achieve such brilliant successes in mechanics precisely because his work was so mathematical."

In fact, it is Hankins's final judgment that Hamilton "was one of the most imaginative mathematicians of the nineteenth century." The field in which he made his greatest contribution was algebra. Here his major innovation was "quaternions," hypercomplex numbers composed of one real part and three complex parts. His discovery (or invention) of quaternions in 1843 set the seal to his world reputation. Although many today tend to think of quaternions as a system that lost out to Gibb's vector analysis, these mathematical entities were of special importance for pure mathematics. As Hankins puts the matter succinctly, "Hamilton's achievement was not just one of finding a new algebra, one that obeys all the rules of ordinary algebra except for the commutative law. More important was his realization that one could sacrifice one or more of the rules with ordinary algebra and still have an algebra that was meaningful. The discovery of quaternions opened the way to much of modern algebra."

Hankin's biography presents Hamilton's life and career in a masterly fashion. Drawing heavily on hitherto unpublished manuscript sources, he has drawn a rich portrait of the person, his times, his science, and his cultural (as well as scientific) milieu. Hamilton was active in British intellectual currents, despite his residence in his native Ireland, and he was in communication with such figures as the poets William Wordsworth and Samuel Taylor Coleridge, and deep in discussions of

"the scientific and aesthetic views of nature, their possible conflicts, and their connection to religious belief." One of the most attractive features of this biography is that the author not only gives admirable critical accounts of Hamilton's individual scientific achievements, but he also provides succinct presentations of the historical backgrounds so that the reader can see the significance of Hamilton's own contributions. In addition, he traces some main topics up to the twentieth century, such as the principle of least action and the development of quantum mechanics. Furthermore, Hankins provides valuable information on such ancillary topics as the organization of science (Hamilton was a founding member of the British Association for the Advancement of Science), scientific education, science and philosophy (and religion), and scientific creativity. All in all, this is a model of a scientific biography.

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Experimental High-Resolution Electron Microscopy

J. C. H. Spence
370 pp. Oxford, U.P., New York, 1981. $74.00

This is a very useful little book that contains a great deal of information concerning the use of conventional electron microscopes at high resolution. It neatly summarizes various theoretical results and gives practical examples. In addition, a considerable fraction of the volume is set aside for practical information on setting up and using the microscope.

The book is not for everyone, however. In spite of the title, the primary focus is upon the use of electron microscopes with thin crystalline specimens where diffraction and interference effects predominate. It is of little value to the biologist.

There is a wealth of information included in this volume, but it is not always correct. In fact, it can sometimes be misleading. To quote a couple of examples, in the chapter on electron optics, one reads:

"It can be seen that the lens shown . . . is very inefficient, since most of the power dissipated supports a field in the z direction which produces no force on the electron entering parallel to the axis. An octopole lens, while far more efficient, appears to have intractable practical problems associated with accurate alignment." It is difficult to make sense of this remark since octupoles have no first-order focusing properties whatsoever.

Then again, when discussing the measurement of ac stray fields, Spence writes: "a field can easily be measured with a coil connected to an oscilloscope which will also indicate the important frequency components of the interference. For maximum sensitivity use the largest possible number of turns of very fine wire." This is certainly misleading since the use of a very large number of turns can increase the inductance to the point where 60 Hz would not be detected at all.

In spite of these deficiencies, I can recommend the book to those interested in crystalline specimens who want to get the most out of their instruments.

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Electrons at the Fermi Surface

M. Springford, ed.
556 pp. Cambridge U. P., New York, 1980. $85.00

This book, written in honor of David Shoenberg of Cambridge University, contains articles on subjects ranging from Shoenberg's specialty, the de Haas–van Alphen effect, to general principles of electrons in metals and provides interesting accounts of the current understanding of properties of metals involving the Fermi surface.

In the part of the book dealing with general principles, the first chapter, I. M. Lifshitz and M. I. Kaganov explain the semiclassical approach to electron motion and describe the different electron orbits used in determining the shape and topology of the Fermi surfaces of metals. It is an excellent review that will be useful to those who feel that there is some mystery involved in the "Fermiology" of metals. The second chapter, by John Wilkins, surveys the understanding of many-body effects in metals and He^3 and demonstrates how fermion excitation can be conceived as nearly independent. It provides a very readable account of many-body effects present in a number of phenomena without overemphasizing formalisms and mathematical detail. This article is highly recommended for required supplementary reading for students learning about formal many-body theory.

The third chapter presents R. G. Chambers' clear treatment of the Boltzmann equation and its application to the path-integral method of calculating transport properties of metals. Unfortunately, no description of recent uses of the theory is included.

The first article dealing primarily with the de Haas–van Alphen effect, by A. B. Pippard, is of general interest to solid-state readers because it discusses the cooperative effect of magnetic interaction, which mean-field theory can explain. (The mean magnetization field in the de Haas–van Alphen effect is not **H** but **B**.)

Three articles on Fermi surface studies of transition metals, itinerant-electron ferromagnets and the effect of strain on the Fermi surface bring theory and experiment together to provide critical reviews; they will serve as excellent references. These articles will be favored by research workers but disappoint those seeking introductory presentations.

The last four articles concern particular aspects of the de Haas–van Alphen effect. Written for experimentalists, they show the wealth of information, on topics from Fermi surface topology to many-body effects, that this effect can yield.

This book will be of value to researchers studying the electron properties of metals experimentally and theoretically. It is useful companion to a 1968 book, *Electrons in Metals*, edited by J. F. Cochran and R. R. Heering, and A. P. Cracknell's monograph *The Fermi Surface of Metals*. Parts of the book also provide good background and excellent supplementary reading for students taking solid-state physics courses.

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new books

Theory and Mathematical Physics

Uniform Numerical Methods for Problems with Initial and Boundary Layers. E. P. Doolan, J. J. H. Miller, W. H. A. Schilders. 324 pp. Boole, Dublin, 1980. $60.00

Mécanique de l'Ingénieur II. Milieux Déformables. Y. Bamberger. 289 pp. Hermann, Paris, 1981. 96F

Theory of Nonlinear Lattices. M. Toda. 203 pp. Springer, New York, 1981. $35.00

Global Lorentzian Geometry. J. K. Beem, P. E. Ehrlich. 460 pp. Dekker, New York. 1981. $45.00

Current Issues in Quantum Logic. Workshop, Erice, 1979. E. Beltrametti, B. C. van Fraassen, eds. 492 pp. Plenum, New York, 1981. $59.50

Lectures on Geometric Methods in Mathematics Physics. J. E. Marsden. 97 pp. Society for Industrial and Applied Mathematics, Philadelphia, 1981. $12.50

Computer Simulation Using Particles. R. W. Hockney, J. W. Eastwood. 540 pp. McGraw-Hill, New York, 1981. $49.50

Selected Papers on Gauge Theory of Weak and Electromagnetic Interactions. C. H. Lai, ed. 450 pp. World Scientific, Singapore, 1981. no price stated