here interesting physics can be discovered and learned.

It is magnetic activity that makes e Sun truly fascinating. Differenal rotation and convection in the n's interior act as a dynamo genering a global field, which reverses elf every 11 years. The magnetic ld gives rise to the 22-year sunspot cle as well as a wealth of nonlinear d nonlocal fluid and plasma prosses in the solar atmosphere. The nsequence is a highly structured mosphere that evolves over all obrvable time scales down to subconds, and a highly heated upper mosphere, the corona, that expands o the solar wind blowing supersonilly past the Earth.

A quarter of Zirin's book describes e hardware used for solar observans and treats elementary radiative nsfer, atomic physics and plasma ysics. The remaining, larger part the book describes the Sun itself. cluded are stimulating discussions the new prospect of seismically obing the solar interior, the mysterus clumping of the photospheric agnetic field into discrete fibrils, the uilibrium of global and local strucres, the general phenomenon of lar activity, and the puzzles posed the solar flare and other eruptive enomena—to name just some of the eoccupations of solar physics. In ch of these topics, there is much we not understand fully, and what we know is physically intriguing. [See e article by Eugene Parker in PHYSICS TODAY, July 1987, page 36.]

Zirin writes in a direct, personal yle, voicing occasional strong opinns and conveying his excitement out the many beautiful observans he describes. He interprets ese observations and evaluates the erpretations critically, using an tirely intuitive approach, but with tle attempt to understand theory. rin holds the extreme opinion that ne observers don't know how to culate and the calculators don't ow what is observed.") Scattered roughout the book are many undeed, confused or incorrectly stated eoretical concepts; chapter 3 has veral examples. Zirin's lack of apciation for theory often results in a nspicuous lack of physical content. ny of his interpretive analyses ad as though some of the phenomelogical constructs have acquired a ality independent of physical prinles. His discussions become burned by a cumbersome nomenclare not always adequately explained the book. Solar phenomena are nplex, and more physical considerons should take over from pure intuition in interpreting observations when enough of the pertinent physics has been identified. Getting at that physics requires that theorists and observers learn from each other rather than avoid the strong coupling of their trades. Otherwise, the awesome images of solar observation easily distract us from the true physical significance of the Sun which has taught us about atomic physics, radiative transfer and a host of fluid, hydromagnetic and plasma processes, among them the dynamo mechanism, magnetic heating, the solar wind, collisionless shocks and particle acceleration. Although Zirin's treatments will be discouraging to readers interested in the physics, his book is still recommended reading: The broad range of descriptive phenomenology covered, the wonderful collection of pictures and the fascination of the Sun are the selling points.

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Principles of Nuclear Magnetic Resonance in One and Two Dimensions

Richard R. Ernst, Geoffrey Bodenhausen and Alexander Wokaun
Clarendon (Oxford U. P.), New York, 1987. 610 pp. $98.00 hc ISBN 0-19-855629-2

Nuclear magnetic resonance has been applied to an astonishing variety of problems and is the foremost analytic tool of the chemist. It has also been developed in truly unexpected and sophisticated ways, and this book documents the theory behind recent developments. The term "nmr in one dimension" refers primarily to pulsed Fourier-transform nmr, in which the transient signal stimulated by a short rf pulse is converted to low frequency, digitized and transformed to get a frequency-domain spectrum. A simple realization of two-dimensional nmr is a set of a few hundred spin-echo sequences in which the time between two stimulating pulses is varied from zero to several tenths of a second, and all the echoes are digitized and saved separately in a computer's memory. Fourier-transform spectra of each echo, transformed a second time with respect to the time between the stimulating pulses, produce a two-dimensional contour map in the spectral domain. In this case the map gives subspectra of pairs of spins in one spectral dimension, ver-

sus their spin–spin coupling in the other dimension. The general method can be extended, almost without foreseeable limits. The single pulses used in this simple example can be elaborated to produce and to selectively read out many forms of coherence or other phenomena such as through-space Overhauser effects. These include coherences that are highly forbidden to direct magnetic detection, such as those between states that differ by more than a single spin flip. Not only are these methods interesting; they are also extremely useful for determining, for example, structure and dynamics of macromolecules.

Richard Ernst and his coworkers have undoubtedly developed a larger variety of two-dimensional nmr methods than anyone else, and they have also been in the forefront of theoretical analysis. Therefore it is a pleasure to welcome this treatise, which covers the theory of these methods in a unified way. The book is primarily concerned with nmr of molecules in solution. This subject lends itself to a unified theoretical approach because such molecules contain finite spin systems, which interact only weakly and for which a single kind of external operation—a short rf pulse—can be used, alone or in combination, to produce all the results described in this book.

Much of the discussion is couched in superoperator formalism, which is necessary for a unified treatment. The book is not written for the casual reader. It starts from elementary spin and statistical theory and carries the reader through the theory to the most sophisticated experiments in a way not hard to follow once the reader abandons trying to read the book through from beginning to end and instead pursues the many internal cross-references. These cross-references, and the literature references as well, are both frequent and excellent.

This is not really a comprehensive textbook of nmr theory or experimental technique, although it does treat a large number of topics outside its main subject of two-dimensional nmr in solution. Many of these, such as nmr in solids, have already been well covered in other treatises and are discussed rather briefly here. The book also does not impart much feeling for experimental strategy; the methods are all here, but you will have to look at the current literature to learn which ones are really used in practice. A beginner would want to read this text in conjunction with other, more experimentally oriented ones on nmr as applied to physics and chemistry, or would want to ask for guidance from an nmr specialist.

Spectroscopists in other high-resolution fields of physics may find some useful ideas here. The book is also worthwhile reading for anyone interested in applications of superoperator theory. It joins the treatises of Anatole Abragam (*Principles of Nuclear Magnetism*; Oxford U. P., New York, 1961) and Charles Slichter (*Principles of Magnetic Resonance*; Springer-Verlag, New York, 1961; third edition in press) as an indispensable classic in nuclear magnetic resonance.

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