isolate a well-defined mathematical problem, often in the form of a differential equation. An ill-trained researcher may be dismayed to learn that this equation is not discussed in Milton Abramowitz and Irene Segun's *Handbook of Mathematical Functions* (Dover, New York, 1965). For those who have taken typical courses on mathematical methods of physics there is then apparently nothing to do but to spend weeks or months away from the original physics problem, writing and debugging computer code, sifting through copious numerical output, and generating masses of scrap paper.

It is important that students be made aware of the arsenal of techniques for obtaining approximate solutions to problems that are too difficult to solve in closed form. Such techniques are referred to as asymptotic methods. Rather than obscuring the interesting qualitative features of a physical problem, asymptotic techniques often isolate and magnify the most salient physical content of the model. For example, a WKB approximation makes evident the wave-like behavior of a particle in a classically allowed region; boundary-layer theory delineates the abrupt variations that can occur in physical media over very narrow regions. Asymptotic methods often tell us whether the original model is physically realistic. One should postpone numerical studies until the qualitative features of a problem's solution are well understood.

The method of matched asymptotic expansions is the key idea behind most approximation methods. It lies at the core of WKB theory and boundary-layer theory. Unfortunately, it is not easy to teach asymptotic methods, and it is even more difficult to write about them. They are difficult, and sometimes impossible, to justify in rigorous terms. Examples have to be chosen wisely; they must be sufficiently nontrivial that exact solutions are not available, and yet simple enough that a student can learn without getting lost in details. It is only through the study of many examples that a student can develop the intuition needed to attack a tough problem.

Paco Lagerstrom's *Matched Asymptotic Expansions* has dozens of rich examples, which are well explained, well organized and chosen from diverse scientific disciplines. One can find a discussion of the differential equation describing a spherical self-gravitating gas cloud as well as of the differential equation describing the shape of a meniscus.

Lagerstrom's book is organized into three sections: a brief introduction, a 150-page collection of examples using ordinary differential equations and a relatively short discussion of partial differential equations. The style of writing throughout is rather dry and formal, but once past the introduction, the author warms up to the discussion of his examples, which he has evidently been amassing for a lifetime. There are exercises, but no solutions.

There is, however, no dramatic evidence in the book that would convince a novice that asymptotic methods are powerful. Graphs comparing asymptotic approximations with exact solutions would have helped immeasurably. For example, even if one can show that the error is of order ϵ^2, this does not necessarily mean that if $\epsilon = 0.1$, the exact solution and the asymptotic approximation differ by 1%. Comparison plots would demonstrate to the potential user the impressive and often unexpected numerical accuracy of asymptotic approximations.

Asymptotic analysis almost always gives rise to divergent series, but there is no discussion of summation theory in the book. The justification for undertaking asymptotic approximations is that one can sum the resulting divergent series to obtain a sequence of approximants that converge to the exact answer. A book on asymptotics ought to dwell on this point.

Finally, this book should have had a more detailed index.

Despite these shortcomings, *Matched Asymptotic Expansions* would be a useful book for anyone teaching a course on mathematical methods of physics.

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Astrophysics of the Sun

Harold Zirin
Cambridge U. P., New York, 1988. 433 pp. $49.50 hc ISBN 0-521-30268-4; $22.95 pb ISBN 0-521-31607-3

Astrophysics of the Sun by Harold Zirin gives an interesting account of our knowledge of the Sun from an observer's point of view. That knowledge has increased dramatically in the past 30 years through the development of new instrumentation and the capability of observing from space. The Sun can now be observed in electromagnetic radiation at wavelengths ranging impressively from radio down to gamma rays, revealing the Sun to be a natural laboratory

ıere interesting physics can be dis-
vered and learned.

It is magnetic activity that makes e Sun truly fascinating. Differen- ıl rotation and convection in the ın's interior act as a dynamo gener- ing 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 pro- sses in the solar atmosphere. The nsequence is a highly structured mosphere that evolves over all ob- rvable time scales down to sub- conds, and a highly heated upper mosphere, the corona, that expands to the solar wind blowing supersoni- lly past the Earth.

A quarter of Zirin's book describes e hardware used for solar observa- ns and treats elementary radiative ansfer, 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 myster- ıs clumping of the photospheric agnetic field into discrete fibrils, the uilibrium of global and local struc- res, the general phenomenon of ar 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 PHYS- TODAY, July 1987, page 36.]

Zirin writes in a direct, personal le, voicing occasional strong opin- ıs and conveying his excitement out the many beautiful observa- ns 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 ıe observers don't know how to culate and the calculators don't ow what is observed.") Scattered roughout the book are many unde- ed, confused or incorrectly stated eoretical concepts; chapter 3 has veral examples. Zirin's lack of ap- eciation for theory often results in a ıspicuous lack of physical content. ıny of his interpretive analyses ıd as though some of the phenome- logical constructs have acquired a ality independent of physical prin- les. His discussions become bur- ıed by a cumbersome nomencla- e not always adequately explained the book. Solar phenomena are nplex, and more physical consider- ons 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-