# Book Reviews

## Matter at a Critical Point

**Introduction to Phase Transitions and Critical Phenomena.** H. EUGENE STANLEY. Oxford University Press, New York, 1971. xx, 308 pp., illus. $9.50. International Series of Monographs on Physics.

If heat is applied to a sealed vessel that contains a fixed quantity of water in the form of liquid water in equilibrium with water vapor, then if the quantity is small enough the meniscus that divides the liquid from the vapor will drop toward the bottom of the container (as liquid turns into vapor). If the quantity of water in the vessel is large enough the meniscus will rise toward the top (as vapor turns into liquid). But if the quantity of water is neither too large nor too small (about 0.32 gram of water per cubic centimeter of vessel) then the meniscus will neither rise nor fall, but, as a critical temperature (373°C) is reached, will broaden, fade, and disappear.

Matter at such a critical point is matter at its most perverse: specific heats are anomalously high and bulk moduli are anomalously low; otherwise clear substances become opalescent. For a time it was a matter of dispute whether the conventional fundamental theory of bulk matter was capable, even in principle, of describing matter at a critical point, but in 1944, in one of the great tours de force of mathematical physics, L. Onsager demonstrated that a conventional statistical mechanical analysis of a very special model could yield critical behavior every bit as complicated as that observed. Indeed, the Onsager solution of the Ising model indicated a state of affairs even more complex than many had suggested, and thereby launched a renewed attack on the critical point. Within the last decade the attack has become a massive assault, as a result of highly precise measurements and highly sophisticated numerical analysis of model systems together with (perhaps too occasional) striking theoretical advances and (perhaps too frequent) conjectures.

This volume is intended to help ease the beginner into the field, which until now has been accessible only through several excellent review articles and summer school proceedings on static critical phenomena and through the original articles on time-dependent critical phenomena. I have my doubts as to the wisdom of producing anything so permanent as a book while the battle is raging at its height. (There have already been two developments of major significance since the manuscript was finished: R. J. Baxter's solution of the eight-vertex model and K. G. Wilson's successful application of the renormalization group.) Still, an informal collection of lecture notes could be of considerable help at this stage, and, in spite of the imposing series in which it finds itself, that is what Stanley's volume is. As such, it performs the valuable service of assembling, in simplified form, a large body of disparate material of high current interest, which is presented in an enthusiastic, at times almost breathless, style.

The value of this service, however, is diminished by the uncritical way in which the material has been brought together, commonplaces, points of great subtlety, and, on occasion, common misconceptions all being presented in the same evenhanded cheerful manner. This can be trying in a book on the level of this one, for the reader is rarely furnished with enough analytical details to judge matters for himself and must often accept on faith what the author tells him. For example, L. P. Kadanoff's "derivation" of B. Widom's scaling hypothesis appears to be taken much more literally than Kadanoff intended it to be, and the reader is asked to swallow some of the more preposterous points with little more guidance than qualifying phrases such as "would seem to be valid."

In short, this is not a book from which one can acquire a secure foundation from which to pursue the subject further. Viewed as providing a guide to the existing literature, however, it is, at the moment, unique, and could still perform the useful role of easing the properly warned and closely watched beginner into this most fascinating subject.

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## First-Person Physics

**Adventures in Experimental Physics.** A Selection of Papers and Personal Discovery Stories Dealing with Innovative, Unconventional and Adventurous Experimentation. Alpha 1972, Jan. 1972. Edited by BOGDAN MAGLICH (Rutgers University). World Science Communications, Princeton, N.J. Single issue: $6; to institutions, $12. Subscription (three issues): $12; to students, $10.80; to institutions, $24.

For at least a century and a half, physics textbooks generally have followed a pattern and have been written in a style intended to pave over all obstructions to a flow of distilled argument that seems to reach toward, perhaps, geometry as the ideal of expressiveness. J. R. Oppenheimer said that physicists are continually purifying their concepts; he might have extended this remark to their textbooks. H. R. Crane uses another metaphor: if a physicist were to write a detective story, it would begin with a chapter on the Origin of Law and proceed through Police Practice and the Administration of Justice; the corpse would be discovered in the final chapter.

This attitude toward instruction is especially visible in the curriculum and the textbooks for the physics major. It is quite inconsistent with imparting any of the enthusiasm a scientist brings to his work. The volume reviewed here is the first of a serial publication intended to supplement the lean fare of the major curriculum with tales of adventure in contemporary physics. Maglich has selected episodes, eight in this issue, which tell of the introduction of an inventive technique, the application of physics to an unusual problem, or an attempt at a far-out observation, or which stimulate the imagination for some other reason. Two issues a year are planned.

The chapters in the first issue are:

"Discovery of first optical pulsar," "Discovery of quantized circulation in superfluid," "Measurement of nuclear reaction time using 'blocking effect,'" "Discovery of muon-induced fusion," "Discovery of two kinds of neutrinos," "Transition radiation from ultrarelativistic particles," "Apollo 11 laser ranging retro-reflector ($LR^3$) experiment," and "Search for hidden chambers in the pyramids using cosmic rays." Each offers explanatory notes for nonspecialists, a personal account of the episode by one of the participants, a reproduction of the original paper or papers with, in some cases, ancillary papers, and, where appropriate, a summary of subsequent developments.

The episodes selected for this issue are varied not only in content and style but also in their significance to the development of physics. Among them are discoveries of the most basic sort and some that are intriguing excursions. Some have the flavor of spontaneous inspiration, others report years of directed, highly organized team effort. One describes an effect discovered with low energy electrons in 1919 and apparently forgotten, suddenly becoming important for the identification of particles produced by the highest energy accelerators of today. Another demonstrates the novel use of a solid state phenomenon to permit the timing of nuclear reactions, a story illustrating the value of being alert to developments that are peripheral to one's focus of interest. The episodes illustrate, as well, the flow of ideas and people back and forth across national borders.

The personal accounts relate in a few pages and with varying degrees of completeness the ups and downs of research, why certain paths were taken and not others, what order-of-magnitude reasoning led to estimates of feasibility and design, and how information passes through the informal channels of acquaintanceship. Some hints of the personal relationships among the workers come through, but nothing to resemble the revelations of *The Double Helix*.

The temptation to flamboyance is kept under good control, although in the quantized circulation episode one is led by the subtitle to expect drama that does not materialize. Moreover, Vinen's long paper and his brief addendum referring to two later experiments that validated his work are followed, with inadequate explanation, by a paper that makes no reference to any of the foregoing.

Teachers often try to enliven their courses with stories such as are told in this compilation. To match the variety and assemble all of the relevant background material offered here is a large task. If Maglich's initial selection distresses some for its omissions, he offers the opportunity to nominate favorites for future issues. He is setting out to perform a unique service for physics students and teachers. His initial effort shows promise of success.

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## Turbulent Flow

**Statistical Fluid Mechanics**. Mechanics of Turbulence. Vol. 1. A. S. MONIN and A. M. YAGLOM. Translated from the Russian edition (Moscow, 1965), as revised by the authors. John L. Lumley, Ed. M.I.T. Press, Cambridge, Mass., 1971. xii, 770 pp., illus. $22.50.

If ever a field needed a definitive book, it is the study of turbulence; if ever a book on turbulence could be called definitive, it is this book by two of Russia's most eminent and productive scientists in turbulence, oceanography, and atmospheric physics. Readers who have struggled to make sense of some previous attempts at translation of this important book will appreciate the great improvement in clarity in the M.I.T. Press version. It seems likely that much of the credit for this clarity should go to John L. Lumley, who did the technical editing.

The authors define their purpose in the preface to the English edition. It is to restore some balance to fluid mechanics, which classically has been devoted to the description of individual laminar flows despite the fact that virtually all of the fluid one encounters in nature or in engineering practice is in a state of turbulent motion. Laminar flows are considered as rather exotic special cases of the general condition of turbulence, and their treatment should be "as an introductory chapter to the theory of real turbulent flows."

To spread this view beyond the circle of turbulence specialists, who probably hold it anyway, the authors have tried to summarize the majority of the fundamental work and ideas of modern turbulence theory. The result is encyclopedic. The list of references is 51 pages long and includes virtually every paper of major significance in the field up to about 1968–1970. The authors even identify the source (discovered at some point between the 1965 and the present versions) and give an additional line of the frequently quoted but never referenced turbulence poem by Richardson (1922) beginning "Big whorls have little whorls. . . ."

Despite the length of the book, it is apparent that all the material has been subjected to careful evaluation, and a high standard of scientific merit is consistently maintained in the writing. Critical comment and comparisons are frequent. An attempt at editing is made by relegating some of the lower-priority material, such as description of semiempirical theories of turbulence, characteristic functionals, and details of experimental techniques, to small print. Generally speaking, however, the authors have included in generous detail everything they consider relevant or important. The result is a bit overwhelming, and few will have the persistence or breadth of interest to read all of the book, but few in the field would not benefit from the attempt.

The authors take nothing for granted, and in case the reader doesn't know how to do laminar flow problems examples are given at the beginning of the book. Basic equations are derived and explained, and a very thorough treatment of stability theory is given as the basis for the development of turbulence as the Reynolds number increases and more degrees of freedom of the flow are excited. The style and treatment of the material will be familiar to readers of Landau and Lifshitz's book on fluid mechanics.

In the second chapter, sufficient probability theory is developed to permit an adequate understanding of some of the subtle difficulties which beset the mathematical description of turbulence and to distinguish between the confusing variety of averages used. Reynolds equations for turbulent fluxes of momentum and heat are developed in the usual detail and are exhaustively compared with available data and various semiempirical turbulence theories developed over the years. Effects of compressibility, Coriolis forces, and stratification are introduced.

An extensive treatment of turbulence in a thermally stratified medium is given which demonstrates the physical principles and similarity scaling adequately, but which is somewhat slanted toward atmospheric turbulence over land. Effects of humidity on buoyancy