pendix covers the elements of quantum mechanics, in a form that is unfortunately too brief either for those familiar with the topic or for those meeting quantum theory for the first time.

The author understands that biophysics is a field that is as yet not well defined. He heads his first chapter with a well known statement from Kenneth S. Cole: "Biophysics includes everything that is interesting and excludes everything that is not." For a scientist with a solid background in the physical sciences and an interest in biology, that is not an unreasonable definition. It does suggest the limitations in what can be done in the way of producing a text in biophysics. A reader might want to find a text in biophysics that covers the area in a systematic way, such as would be expected from a text on physical optics, for example. This would be a worthy goal, but the author of the present work has had no more success in this direction than have the authors of several similar books that have appeared over the past five years.

Bearing this limitation in mind, the text has real qualities: The material is clearly presented and the book is reasonably well illustrated. The topics covered include many of interest to biophysicists today. It looks as though it would be easy to use in class, and I think the students would get some idea of the reason "Casey" Cole defines biophysics as "everything that is interesting . . . ."

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Structural Stability, the Theory of Catastrophes, and Applications in the Sciences

P. Hilton, ed.
410 pp. Springer-Verlag, New York, 1976. $14.40

Singularity Theory and an Introduction to Catastrophe Theory

Y.-C. Lu
199 pp. Springer-Verlag, New York, 1976. $12.00

Does "Catastrophe Theory" help us understand Nature? This question is currently the subject of a controversy in the pages of magazines from *Newsweek* to *Science*, from *Scientific American* to *Synthèse*. The books under review originated at a Battelle Conference held in Seattle in 1975 and provide an overview of some of the achievements that proponents of catastrophe theory claim for their work as well as background on the mathematics of the subject.

The essence of catastrophe theory is easy to state: Suppose some discontinuous natural phenomenon is observed; that is, as a function of time, space, magnetic field or some other variable, a property of a system undergoes radical change. Then one accounts for the discontinuity by assuming that some variational principle determines the state of the system and that as an external parameter (time, space, etc.) varies, the minimum that the system occupied initially goes out of existence and the system will change until its properties correspond to those of a distant surviving minimum.

But catastrophe theory goes beyond this. One might have supposed that minima can come and go (as external parameters are varied) in arbitrary ways. They don't. If only four external parameters are varied, then the famous theorem of R. Thom states that generically (meaning, roughly, except for special circumstances such as symmetries) there are only seven different patterns of appearances and disappearances of minima. The upshot is that discontinuous phenomena manifested as functions of space and time can appear in only this limited variety of ways.

To return to the opening question of this review, I think some appreciation of what catastrophe theory does and does not do can be obtained by considering the following questions. What greater understanding of Nature is gained through the use or appreciating of

- vector analysis?
- the abstract concept of "group"?
- Schrödinger's equation?
- the Born–Oppenheimer approximation?
- Feynman diagrams?

This list is intended to suggest that scientific progress can take many forms: the prediction of specific numbers, the simplifying of calculations that could be performed in other ways and the unification of diverse concepts.

I believe that the answer to my opening question is in the affirmative, but that the main contribution of catastrophe theory will be in the conceptual unification of diverse phenomena rather than in the prediction of experimental data. Much of the current conflict revolves about specific applications, but I think everyone agrees that there are *some* topics (such as the study of caustics) where catastrophe theory ideas apply. (For an interesting recent paper on caustics see M. V. Berry and J. F. Nye, *Nature*, **267**, 5 May 1967, page 34.)

How useful catastrophe theory will be for other topics, such as embryology or the propagation of nerve impulses, has yet to be seen. My own experience in applying the theory to phase transitions has been mixed. To describe phase transitions as catastrophes, the best I could do was come up with something resembling mean-field theory, but on the other hand a slightly unexpected prediction for tricritical phase transitions turned out to be correct. However, one should not knock mean-field theory (more than one Nobel Prize has been won for it). For phase transitions mean-field theory was there before catastrophe theory suggested it; however, if the theory inspires the discovery of a useful variational principle in some other area, it will have accomplished a good deal.

The books under review reflect some of the problems of the theory. Although ostensibly devoted to catastrophe theory, P. Hilton's book also includes applications of other mathematical methods (such as bifurcation theory) to various scientific problems. Of the catastrophe theory applications, none in this book falls within the bounds of traditional physics. One paper I found stimulating is that by J. Guckenheimer in which he discusses the Zhabotinsky (chemical) reaction. Strangely, the major qualitative feature of this reaction (connected with wave propagation) does not seem to follow from the exact solution of any equation. Guckenheimer speculates that this feature may only be an asymptotic property and motivates the guess by considering the role of asymptotic expansions in optics. Catastrophe theory lurks off at the sidelines in this paper, and while there is no place in the paper where Guckenheimer could state ". . . and we now use a theorem of Thom to show that . . .", still ideas from this theory play a role in the author's description of his motivations and speculations.

Articles by C. Zeeman and others on buckling beams, on prison riots and on various biological applications are currently the subject of hot debate, and rather than get into the thick of that battle I shall content myself with two remarks. First a scientific comment: Caustics in optics are generally acknowledged to be catastrophes, but in fact they do not represent an application of Thom's theorem because that theorem applies only to finite dimensional "state" spaces. Whether this point is merely technical I do not know; T. Poston's article takes up this question. I'd also like to comment on a human side to the controversy. Zeeman and many of his colleagues sometimes take a playful attitude toward science, and seem to feel that the process of exploration is itself worth reporting. This is reflected in the autobiographical character of some of the articles and the admittedly tentative ideas put forth. Contemporary science often rejects this approach—try to publish in *Physical Review* that you made some discovery on caustics while tilting a glass of milk in the Detroit airport! Nevertheless, I think that if really exciting steps are to be made in science, people have to risk sounding silly. Not only should speculation be encouraged at

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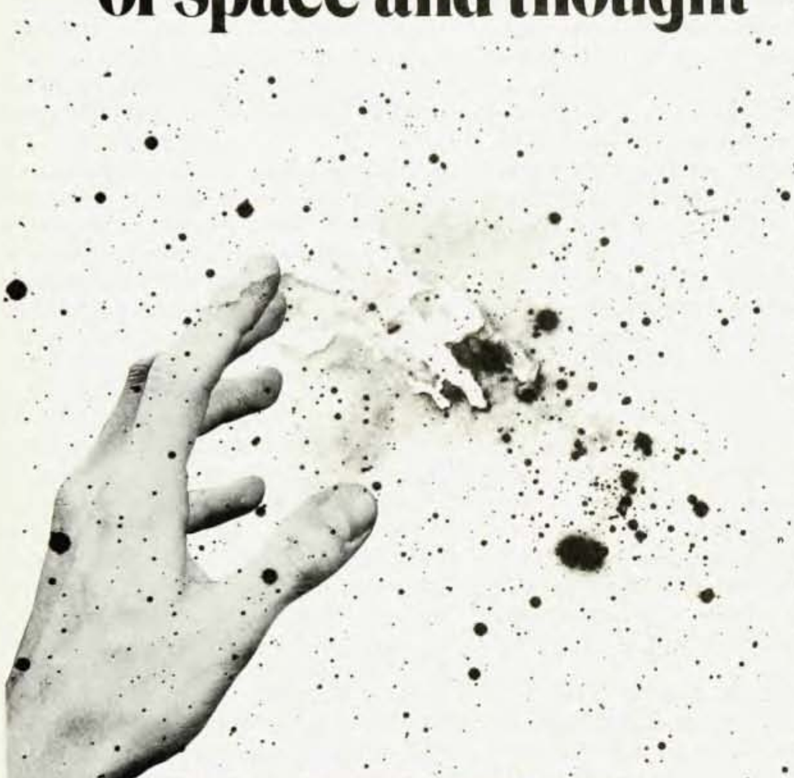

Eighth Texas Symposium On Relativistic Astrophysics

Volume 302. Michael D. Papagiannis, Ed.
Conf. Dec. 13-17, 1976. Pub. Nov. 1977. ISBN 0-89072-048-7
56 papers/**$45.00**

The papers in this book are by physicists and astronomers who were brought together to discuss high-energy and relativistic cosmic phenomena. The fascinating field of astrophysics is explored in the following sections: close binaries; supernovae and stellar collapse; quantum theory in strong gravitational fields; X-ray bursts and globular clusters; X-ray astronomy; cosmology; neutron stars; gravitational theories; quasars; galaxies.

A Festschrift for I. I. Rabi

Lloyd Motz, Ed. Pub. Nov. 1977. ISBN 0-89072-059-2
19 papers/**$25.00**

Following the European tradition of honoring a colleague through publication of papers resulting from his or her work, the New York Academy of Sciences presents its first Festschrift, in recognition of Dr. I. I. Rabi. During the 1930's, Dr. Rabi's brilliant research in theoretical and experimental atomic physics catapulted America to equal standing with the European school of physics. Dr. Rabi's work with molecular beam and magnetic resonance techniques has aided almost every branch of physics, as well as some fields in chemistry and biology. Some of the papers included are: *Physical Interpretation of General-Relativistic Theories*, by Peter G. Bergmann; *Radioactivity's Two Early Puzzles*, by A. Pais; *The Majorana Formula*, by Julian Schwinger; *A Few Specializations of the Generic Local Field in Electromagnetism and Gravitation*, by John Archibald Wheeler.

Five Decades of Weak Interactions

Volume 294. N. P. Chang, Ed. Conf. Jan. 21-22, 1977.
Pub. Nov. 1977. ISBN 0-89072-040-1/ *10 papers*/**$10.00**

This series of papers is the result of an international symposium in honor of Dr. Robert E. Marshak. Some of the work Dr. Marshak is known for includes his theory of weak interactions, and work with white dwarf stars. The following is a sample of the papers submitted to the conference: *Gauge Unification of Basic Forces, Particularly of Gravitation with Strong Interactions*, by Abdus Salam; *Current Problems in the Weak Interactions*, by A. Pais.

Role of Magnetic Fields in Physics and Astrophysics

Volume 257. V. Canuto, Ed. Conf. June 5-7, 1974.
Pub. Aug. 22, 1975. ISBN 0-89072-012-6/ *20 papers*/**$24.00**

The importance of magnetic fields in physics and astrophysics was first suggested in the mid 1960's. This book explores the history of progress from that time and presents current research in the field. Included in the discussion are the importance of magnetic phenomena in astrophysics; summaries of results relevant to quantum effects played by high magnetic fields; the current situation for the solution of the relativistic equation of motion for a classic particle.

Seventh Texas Symposium on Relativistic Astrophysics

Volume 262. P. G. Bergmann, E. J. Fenyves, and L. Motz, Eds.
Conf. Dec. 16-20, 1974. Pub. Oct. 15, 1975.
ISBN 0-89072-015-0/ *56 papers*/**$38.00**

This comprehensive book assesses recent research in astrophysics and relativity, and includes review papers summarizing important theoretical and observational developments. Some of the topics discussed at the conference include: the abundance of elements and density of matter in the universe; supernovae, neutron stars, black holes, and gravitational waves; recent advances in relativity; and recent experimental results and discoveries.

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times, but it is not necessarily immoral for it to be accompanied by fanfare.

Yung-Chen Lu's book is an introduction to mathematical aspects of catastrophe theory and he states that he aims it so that "... even strong undergraduate students should be able to understand most of the contents." Frankly, I don't think he has succeeded. Pedagogically the book is neither better nor worse than most others on the subject. His chapter on catastrophe theory is a bit more clear and down to earth than what Thom is wont to write, but then again it lacks Thom's flights of poetry. For the interested physicist who is willing to devote a few hours to gaining a slight acquaintance with the subject I would recommend M. Golubitsky's "An Introduction to Catastrophe Theory and its Applications" (to appear shortly in *SIAM Review*).

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Fundamental Principles of Heat Transfer

S. Whitaker
556 pp. Pergamon, Elmsford, N.Y., 1977. $50.00

The growing concern about the global energy problem has recently aroused a great number of physicists to take a new, close look at the various elements of energy technology such as energy transformation, energy storage, energy transport and energy conservation. Studies related to any of these elements, however, often require a good knowledge of the subject of heat transfer, which has become a well-developed engineering discipline over the last twenty years. In fact, the recent focus on energy has resulted in a noticeable increase in the interest in heat transfer, accompanied naturally by an outburst of books, specialized monographs or general elementary texts on the subject. In the latter category, indeed, several have come out during the past year, and S. Whitaker's book is one of them.

The book provides a fundamental treatment of various heat transfer processes, namely heat conduction, convection, radiation, and boiling and condensation. It is intended as a textbook for a beginning course in heat transfer in an undergraduate engineering curriculum. The coverage of material, however, is sufficiently extensive that this book can be also used as a general, introductory reference book for non-engineering students. The students are expected to have an elementary background in thermodynamics and fluid mechanics, as well as