a new unified field theory, was not generally accepted. He could not understand why "all the others" were not willing to cooperate. Wolfgang Pauli, who always spoke his mind, wrote finally, "You're free to go your own way, but I want nothing more to do with it." Heisenberg, as did Albert Einstein and Paul Dirac, spent the later parts of their careers seeking unsuccessfully the ultimate theory, thereby cutting themselves off from the mainstream of physics.

The book includes an introduction by Victor Weisskopf, who describes it as an important human document, as indeed it is. Heisenberg's experience shows, sadly, that all too often life involves the choice between two evils—in his case, to abandon the country he loved or to collaborate, to some extent, with evil. For this story of inner conflict the book could well be read outside the physics community.

Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields

J. Gluckheimer and P. Holmes
453 pp. Springer-Verlag, New York, 1983. $32.00

Until the mid-1970s most of the concepts and tools of dynamical systems were largely the exclusive province of pure mathematicians, although there were a number of applications, such as turbulence and feedback control, available to applied mathematicians and scientists. An explosion of applications has occurred in the past decade in many areas of the physical sciences (fluid flows, solidification of solids, defect formation, atmospherical science, laser physics, optical bistability and chaos, statistical mechanics and phase transitions, chemical reactions and nonlinear diffusion, combustion fronts, and others), biological sciences (genetic transference, embryology, ecological decay, population growth) and social sciences (organizational hierarchy, economical structure).

It cannot be overemphasized that in addition to its many applications, dynamical systems, bifurcations and chaos also provide common structures and common threads for many multidisciplinary endeavors.

In the past decade, widespread interest in dynamical systems, bifurcations, chaos and strange attractors arose in the science and engineering communities. This book is written for the members of these communities who may not have enough mathematical background for the research literature. The authors have not specified the presumed mathematical maturity of the readers; nonetheless I feel that the reader should have had at least a good first course in analysis (advanced calculus) and a solid course in differential equations with a fair amount of geometric interpretations. With these preparations, the authors take the reader through a detailed tour of a veritable garden of rapidly growing knowledge in nonlinear oscillations, dynamical systems, bifurcations and chaos. Of course some exotic and not directly applicable subjects are excluded or merely referenced. The authors exclude those proofs of theorems that do not directly illuminate their applications, and they do not always provide the sharpest or best results in all cases. Rather, they urge the readers to go directly to the literature. I appreciate this approach and consider it wise.

There are three approaches to the study of dynamical systems: the local, the global and the abstract theories. The local theory (also referred to as the

qualitative theory of differential equations) is concerned with the application of topological methods to the qualitative study of differential equations. The general setting is a set of differential equations in R^n, and one is interested in asking: What happens in the neighborhood of a fixed point? Is the system stable? The global theory (smooth dynamical systems) studies the set of vector fields on a differentiable manifold. One is interested in characterizing the structurally stable vector fields and studying the "orbit picture" of the flow associated with a given vector field. The setting for the abstract theory (topological dynamics) is a general transformation group, but the concepts studied are those arising in the local theory. One can show that many of the results in the local theory are also valid in a much broader domain.

The content of this book covers a major part of the qualitative theory of differential equations and some aspects of global theory. It complements well other books on dynamical systems and bifurcation theory. The first chapter provides a concise review of the basic results of the theory of dynamical systems. The second chapter presents a very illuminating and detailed discussion of: van der Pol's equation for a nonlinear damped oscillator, Duffing's equation for a spring with cubic stiffness (the spring-hardening effect), Lorentz's equations for fluid convection in a two-dimensional layer heated from below (to model atmospheric effects), and the equations for a ball bouncing on a massive, sinusoidally vibrating table. The following chapter discusses the methods of local bifurcation theory for flows and maps. The fourth chapter develops the analytical methods of averaging a perturbation theory for studying periodically forced nonlinear oscillators. The fifth chapter treats chaos in detail, including Smale's famous horseshoe map. It is also enlightening that the end of this chapter provides a brief discussion of Liapunov exponents and the invariant measure for strange attractors. The next chapter discusses global homoclinic and heteroclinic bifurcations and illustrates the results with examples from the second chapter. The authors point out the incompleteness of our understanding of even two-dimensional diffeomorphisms and identify the obstructions for further analysis of nonlinear oscillations. The final chapter shows how the global bifurcations reappear in degenerate local bifurcations.

Throughout this book the authors frequently return to specific examples of the second chapter to illustrate the results, thus giving the reader a coherent perspective.

This book is well written and both

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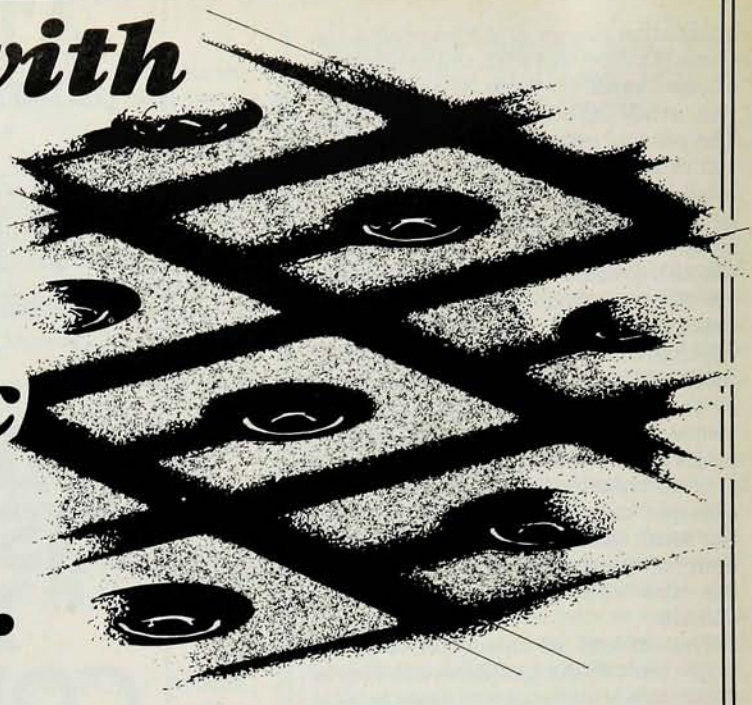

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authors have made substantial contributions to the subjects treated here. They have done an admirable job in explaining the methods for studying dynamical systems, nonlinear oscillations and bifurcations. The book also provides the reader with sufficient ideas and background for reading research literature. Because many details are worked out explicitly, it is most helpful for those who are oriented towards applications. Exercises are an integral part of the book and it is strongly recommended that the reader work them out. Nonetheless, there are some exercises, especially in the seventh chapter, that are quite difficult and could be developed into graduate theses.

The book assumes implicitly that the readers are fully aware of the various applications of the treated subjects. Nonetheless, if the authors were to add a brief discussion of, and references to, current applications such as road maps, then this book could serve as a catalyst for theoretically oriented readers to venture into some concrete applications. It would also provide applications-oriented readers some additional applications. This would result in a more stimulating cross-fertilization, and I hope it will be done in a sequel.

In summary, I recommend this book highly for those who are motiviated to learn and for those who are just curious.

K. K. Lee
General Electric

Physics of Gravitational Systems

A. M. Fridman, V. L. Polyachenko
826 pp. (2 vols.) Springer-Verlag, New York, 1984. $57.00

Students and specialists alike will welcome this splendid monograph. The student who is familiar with the elements of kinetic theory and linear partial differential equations will find here an exceptionally clear and well-organized account of the modern theory of the structure and stability of collisionless gravitating systems. Specialists will be impressed by the authors' success in integrating nearly 500 sources into a coherent mathematical narrative.

The statistical theory of stellar systems was founded early in this century by Arthur Stanley Eddington and James Jeans. They took as their model the kinetic theory of gases developed in the previous century by James Clerk Maxwell, Rudolf Clausius and Ludwig Boltzmann.

Stellar systems behave very differently from ordinary gases, because of the long-range character of gravitation. The motion of a star in a rich cluster or galaxy is determined mainly by the slowly varying gravitational field of distant stars; the rapidly varying part of the field, produced by nearby stars, is much weaker. Consequently, the relaxation time of a rich cluster, calculated in the ordinary way, may be comparable to, or greater than, the age of the universe. The relaxation time of a galaxy is much longer than the age of the universe. If we neglect the weak fluctuating field entirely, we find that there is an infinite number of equilibrium configurations for a rich stellar system of given mass, energy and angular momentum.

Not all equilibrium configurations are stable against small perturbations, however. Methods for investigating stability and small oscillations in collisionless gases were first developed in the context of plasma physics and became the subject of an extensive literature. This literature has provided astrophysicists with their most important mathematical tools for investigating the stability of the equilibrium configurations of rich stellar systems. Volume I of the book under review gives a systematic account of these mathematical tools and their applications to gravitating systems. Each of the five main chapters treats systems having a particular kind of symmetry: nonrotating sheets, cylinders, spheres, ellipsoids and rotating discs. The discussion of each type of system is exhaustive, but the main ideas, methods and results are presented first and in considerable detail, so that students and nonspecialists should have little difficulty extracting what is of interest to them.

Volume II treats nonlinear collective processes: nonlinear waves, solitons, collisionless shocks and turbulence. It also discusses applications of the theory to actual astronomical systems, including globular clusters, spheroidal galaxies, the discs of spiral galaxies and planetary rings. This part of the book is unavoidably less satisfying than the purely theoretical parts, because present theories—powerful though they are—still leave important astronomical phenomena unaccounted for. For example, in all spheroidal stellar systems—including the invisible components of spiral galaxies—the distribution of mass seems to follow the density law appropriate to an isothermal gas sphere. This is the configuration of maximum entropy, so it would seem that spheroidal stellar systems are highly relaxed. Yet, as mentioned above, their relaxation times, calculated in the ordinary way, are much longer than the age of the universe.

The Russian edition of this book was published in 1976. The English version contains a great deal of new and