chanics) of very many (on the order of 10^{26}), very small (on the order of 10^{-8} centimeter) billiard balls. As Krylov emphasizes over and over again, the "classical theory" is consistent as long as the following three conditions are met:

1) Initially the system is in local equilibrium. (This is a restriction on the kind of things we find in nature or can prepare in the laboratory.)

2) The dynamics has a sufficiently strong mixing character, a property that expresses in a certain way the tendency to approach thermal equilibrium. This property must be derived from Newton's equation of motion, and one of Krylov's outstanding achievements was to locate what is nowadays believed to be its origin: Phase points that are initially close tend to separate exponentially in the course of time owing to collisions. Krylov even estimated on that basis the time a gas composed of hard spheres needs to establish its local equilibrium.

3) Only a certain class of physical quantities can be observed. (This is a restriction on what we can see and the kind of measurements we can perform.)

Krylov argues that under these conditions hydrodynamics can be derived from microscopic dynamics, a goal still far from being achieved.

After elucidating the "classical theory" Krylov asks the crucial question whether conditions 1 and 3 can be regarded as laws of nature consistent with or even derivable from classical mechanics. This is roughly what Krylov understands by laying the foundations of statistical physics. Going through a large variety of arguments he comes to the radical conclusion that there is no way of constructing statistical physics on the basis of classical mechanics. He reaches the same conclusion regarding quantum mechanics as the fundamental theory.

A sketch of Krylov's arguments would lead too far here. Still I am tempted to present at least one as an example. Under the mechanical evolution initial local equilibrium will not remain so, strictly speaking. Since the initial time is a matter of choice, condition 1 cannot be regarded as a law of nature in a strict sense.

Krylov's book should be read by anyone interested in the foundational and philosophical aspects of physics. It is of more than just historical interest. Krylov raises questions that even now have not really been answered. Why does a microscopically predetermined history appear on a macroscopic level as a sequence of random events? Do we understand, on a dynamical basis, why the statistical approach works so well? Why does the complicated microscopic motion express itself in "simple" macroscopic evolution laws (as for example in hydrodynamics)?

To a great extent the book is nontechnical and uses very few formulas. Nevertheless it is not easy reading. For an introduction it might be useful to consult the article "Modern ergodic theory" by J. L. Lebowitz and O. Penrose in *Physics Today*, February 1973. Krylov's Ph.D. thesis and the sketch by Sinai of the subsequent development of Krylov's ideas are more technical and require some background in dynamical systems.

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Mathematical Physics

Mathematical Problems in Theoretical Physics. Proceedings of a conference, Lausanne, Switzerland, Aug. 1979. K. OSTERWALDER, Ed. Springer-Verlag, New York, 1980. viii, 412 pp. Paper, $27.70. Lecture Notes in Physics, vol. 116.

A few years ago workers in mathematical physics began a series of biennial conferences on their subject (Moscow 1972, Kyoto 1975, Rome 1977, Lausanne 1979, Berlin 1981). Previously, mathematical physics had appeared as a small subsection of conferences on mathematics or high energy physics or as the subject of more specialized conferences. From the book under review, it is clear that the idea of a general conference was a good one. The book, the proceedings of the Lausanne conference, is a smörgasbord of lectures on Schrödinger operators, statistical mechanics, quantum field theory, gauge theory, dynamical systems, supersymmetry and group theory, and C*-algebras, reflecting a series of challenging problems on which interesting progress has been made.

There are 61 contributions, most of which are short (two to four pages) summaries of significant work. There are also roughly a dozen longer reviews, which can serve as introductions to subjects on which progress has recently been made. The book is recommended as a sampler for those who wish to acquaint themselves with what is going on in mathematical physics, as well as as a source book for the specialist. It has been produced in the usual excellent Springer style, photoreproduced from typescript in durable flexible binding.

The first hundred pages of the book are devoted to the theory of the Schrödinger equation, scattering theory, and the properties of bound-state wave functions and eigenvalues. The general theory of scattering has progressed considerably in recent years, and as a result mathematical techniques are much closer to the physical intuition and formal manipulation displayed in the traditional heuristic scattering theory. For example, one of the basic problems of scattering theory is to prove asymptotic completeness, that is, that any state is a superposition of bound states (belonging to the discrete spectrum of the Hamiltonian) and scattering states. As a result of work by D. B. Pearson one now has two systematic methods of finding interaction potentials for which asymptotic completeness fails, which for brevity I will refer to as Pearson's singular spectrum generator and Pearson's wave trap. The singular spectrum generator (described by Pearson in a contribution to this book) causes waves to vacillate; they cannot decide whether to stay localized and be bound states or to run away and become scattering states. On the other hand, in the wave trap a wave traveling in from infinity is made, by multiple reflections, to linger an infinitely long time. Clearly, if asymptotic completeness is to hold for an interaction potential, the potential must not behave like a singular spectrum generator or a wave trap. New geometrical methods in scattering theory, described in a contribution by V. Enss, make it possible to bring out this point very clearly and lead to a beautiful and simple proof of asymptotic completeness for the two-body problem. So far the geometrical method has not been used to produce a similar proof for the n-body problem with $n > 3$, but there has been considerable general progress, which is reviewed by J.-M. Combes.

Most of the remaining contributions in this part of the book deal with properties of eigenvalues and eigenfunctions for special systems. W. Hunziker reviews the recent work on the Schrödinger Hamiltonian in the presence of electric and magnetic fields, which includes the Stark and Zeemann effects. This is one of the oldest applications of quantum mechanics, but it has not been given a mathematically rigorous treatment until recently. In the course of this work on foundations a number of beautiful results have been proved. For example, the ground state energy of a system of spinless Schrödinger particles is always larger in the presence of a static magnetic field than in its absence. Another system discussed early in the history of quantum mechanics is the negative hydrogen ion, H^-. H. A. Bethe first proved that it has a bound state, but until recently how many additional bound states it has was not settled. R. N. Hill gives an account of his proof that there is exactly one singlet bound state below the continuum and no triplet. Another eigenvalue problem, this suggested by the description of charmonium in particle physics, is treated by H. Grosse. Charmonium is a bound system of a charmed quark and a charmed antiquark. It has an interesting excitation spectrum, which can be described by a nonrelativistic model using a potential of the form $V(r) = A/r + Br + C$, where r is the separation and A, B, and C are constants. The problem is to show that the observed order of the levels is a consequence of qualitative properties of the potential and not a freak produced by a special choice. The remaining short contributions, which discuss the Efimov effect, the quasi-classical limit of scattering, the spectrum of a particle in a random potential, and a scattering problem in indefinite metric, are all interesting. The section ends with a review of some open problems about Coulomb systems; here are questions for the strong, ambitious, and patient.

Given the long history of statistical mechanics and the subtlety of its problems, one has a right to expect something intriguing from the 60 pages devoted to statistical mechanics, and I was not disappointed. O. E. Lanford reviews time-dependent phenomena in statistical mechanics, singling out three topics: classical mechanics of an infinity of particles according to Fritz and Dobrushin, the Vlasov limit according to Braun and Hepp, and the Grad limit according to van Beijeren *et al.* The paper can be regarded roughly as part of a program to derive transport theory from first principles—a serious business with many unsolved problems. Jimbo, Miwa, and Sato review an extraordinary family of ideas associated with their names, linking the deformation theory of differential equations with quantum field theory and statistical mechanics. The short contributions include a general proof of the thermodynamic instability of the interface between distinct phases in two dimensions by M. Aizenman and the application of topology to the characterization of defects in ordered media by G. Toulouse, as well as six other papers that it would take too long to describe.

The above should give some idea of the coverage of two of the seven subjects discussed at the conference. In the remaining subjects the talks were just as interesting and nontrivial. If I had to single out one among them, it would be J. Bros's magistral review of the analytic structure of Green's functions in quantum field theory.

This book is a useful tool for all those struggling to keep up with the exploding subject of mathematical physics.

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Geophysics

The Earth's Variable Rotation. Geophysical Causes and Consequences. KURT LAMBECK. Cambridge University Press, New York, 1980. xii, 450 pp., illus. $77.50. Cambridge Monographs on Mechanics and Applied Mathematics.

In the field of geophysics the study of the earth's rotation perhaps illustrates better than any other specialty how scientists can take a relatively innocent-looking topic and turn it into a whole discipline. I am sure no layperson could imagine the breadth and complexity of the discipline that students of this obvious and seemingly regular natural daily occurrence have been able to develop. The subject was first brought together in 1960 in the now classic book of Walter Munk and Gordon J. F. MacDonald titled *The Rotation of the Earth.* It was subtitled "A Geophysical Discussion" in recognition of the broad range of geophysical phenomena that either are reflected in or bear on the earth's rotation.

Two decades later the successor to Munk and MacDonald has been written. Although Lambeck has chosen to call his book *The Earth's Variable Rotation: Geophysical Causes and Consequences* he might, without undue pretension, have called it "The Earth's Rotation: A Textbook on Geophysics." Anyone completing a thorough study of all the topics Lambeck deals with would indeed have a considerable background in the whole of geophysics. He or she would also have gained a more than passing knowledge of positional astronomy and satellite dynamics and picked up some very interesting highlights from the history of science.

Overall Lambeck's book is a worthy successor to Munk and MacDonald's. It reflects well the maturity the subject has gained. Much of the earlier treatise was taken up with introducing the reader to topics through the development of governing equations and simplifications, the description of observations, and the establishment of orders of magnitude. Lambeck is able to move well beyond such introductory material, taking advantage of the many advances in the subject over the last two decades. His treatment of topics such as tides and meteorological effects to the understanding of which he himself has contributed is particularly masterly, although he gives thorough and informed accounts of other difficult topics too.

Geophysical specialists will nonetheless see shortcomings in the treatment of their own subjects. This is to be expected, however, in a treatise that sweeps such a broad portion of the geophysical spectrum, and the breadth of the book is its virtue. Though the subject has progressed considerably since 1960, the Lambeck book is still, like Munk and MacDonald's, a collection of geophysical puzzles. Nearly every topic treated opens doors to further research for both theoreticians and experts in precise measurement. No topic seems complete and absolutely settled, many remain centers of controversy.

In addition, there are some minor disappointments. New observational techniques that hold the promise of providing the stimulus to the next set of major advances in the subject are allotted less than three pages. Presumably this is because they have still not produced a large number of definitive results and Lambeck regards them as essentially unproven. Surprisingly, the deformational equations do not include the Coriolis term even though its importance is mentioned in a far too abbreviated discussion of core dynamics. Specialists will find it curious that a two-term differentiator applied to the polar motion data will not simply turn them into white noise. The more fastidious readers will find occasional blunders, such as an incorrect relation between the bulk modulus and the Lamé constants of elasticity and some problems with vector calculus in the representation of the displacement field in spherical coordinates. Nevertheless, for a first edition the book is relatively free of blunders and seems to have been subjected to reasonably careful proofreading.

Looking to the future, one can hope that, with the deployment of new measurement techniques and the advancement of theory, particularly that of the rotational and dynamical behavior of the