PROBLEMS OF PHYSICAL HYDRODYNAMICS*

Reviewed by I. P. Bazarov

Modern hydrodynamics has the task of solving many problems related to the high velocities of bodies moving through highly rarefied media. Menawhile, the conventional principles of hydrodynamics do not relate to the specific requirements of aviation and rocket engineering. It is necessary here to extend the Navier–Stokes equations. Such a generalization is possible only, however, on a universal molecular-kinetic basis for analyzing the equations of hydrodynamics.

These equations are dealt with in the symposium "Problems of Physical Hydrodynamics" (edited by Academician A. V. Lykov, member of the BSSR Academy of Sciences), published by the Institute of Heat and Mass Transfer at the BSSR Academy of Sciences in honor of Aleksandr Savvich Predvoditelev (Corresponding Member of the USSR Academy of Sciences and recipient of the Lenin Order in 1972 for his great contribution to the development of Soviet science and for his many years of creative pedagogical activity) on the occasion of his 80th birthday.

This symposium contains the classical works by J. C. Maxwell "On the Dynamic Theory of Gases," "Stresses in Rarefied Gases due to Temperature Differences," "On the Boltzmann Theorem of the Mean Distribution of Energy in a System of Material Points" (all translated into Russian by A. S. Predvoditelev in 1919 and revised by S. I. Gribkova in 1965), original works by A. S. Predvoditelev "On the Molecular-Kinetic Basis of the Equations of Hydrodynamics" and "On Turbulent Flows," A. Gugonio's review of his scientific works (with comments by Professor A. A. Pomerantsev), works by N. P. Kasterin "Generalization of the Fundamental Equations of Aerodynamics and Electrodynamics (Part: Aerodynamic Equations)," and the article by V. A. Bubnov "Supplement to N. P. Kasterin's Generalization of the Fundamental Equations of Aerodynamics and Electrodynamics."

All these works had already been published earlier, but they are still as relevant today.

In his "Dynamic Theory of Gases" J. C. Maxwell developed a kinetic theory of diffusion, of internal friction, and of heat conduction in gases; he also refers to R. Clausius, who in his memoirs on the same subject had pointed out several errors in Maxwell's work, thus giving a fine example of proper conduct in scientific criticism by a real scientist.

The main article in this symposium, an understanding one in its coverage of physical aspects, is A. S. Predvoditelev's "Molecular-Kinetic Basis of the Equations of Hydrodynamics" published originally in Izvestiya Akademii Nauk SSSR in 1948. Here the author analyzed the conditions of transition to a continuum and he used the molecular-kinetic theory for generalizing the equations of hydrodynamics.

Problems concerning the generalization of the fundamental equations of hydrodynamics were also the concern of N. P. Kasterin in his work; he was the first to introduce discontinuous solutions to the equations of hydrodynamics. The article by V. A. Bubnov rates high in content, as a supplement to N. P. Kasterin's work.

On the whole, the symposium "Problems of Physical Hydrodynamics" provides a stimulus to further developments in hydrodynamics, for the solution of modern aviation and rocket engineering problems.

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LECTURES ON SYMMETRIES*

Reviewed by B. M. Berkovskii

The book under review here is one in the series of monographs which Gordon and Breach Science Publishers have been issuing under the general title "Documents on Modern Physics." Responsible for the publication of this series is an editorial staff consisting of three members: E. W. Montroll, G. H. Vineyard and M. Levy. So far only one book of the series has been translated into Russian (Izd. Mir, 1972): "The Harmonic Oscillator in Modern Physics: from Atoms to Quasars" by M. Moshinski.

The book of Lopes deals with one aspect of formalism in the relativistic quantum theory, namely with discrete symmetry. It is noteworthy that, besides this book by Lopes, other books in the "Documents on Modern Physics" series deal to some extent with various problems in the quantum field theory: "Dynamical Theory of Groups and Fields" by B. S. Dewitt, "Lagrangian Formalism and Symmetry Laws" by M. Gourdin, and "Symmetries and Elementary Particles" by F. E. Low. The "Lectures on Symmetries" are divided into two parts. The first part is "Classical Symmetries: Basic Survey" and deals with continuous unitary symmetry groups (Poincaré group, reference group). The discussion covers the fundamental observable fields, both local (energy-momentum tensor, moment tensor, current) and global (energy-momentum four-vector, charge).

Chapter One deals with symmetry in the classical mechanics of systems of point particles. It concludes with a formulation of the fundamental theorem: if the Hamiltonian of a mechanical system is invariant with respect to all transformations of a canonical group, then the generators of this group are integrals of motion.

Chapter Two of the first part is devoted to the classical field theory. The Lagrangian formalism for fields of various tensor dimensionalities is considered here, the Neter theorem is formulated and proved, also the algorithm for transition from classical theory to quantum theory is given. All the problems touched upon in the first two chapters of this monograph have been quite adequately covered in Soviet monographs and scientific literature: in "Introduction to the Theory of Quantum Fields" by N. I. Bogolyubov and D. V. Shirokov (Fizmatgiz, 1957), and "Introduction to the Theory of Classical Fields" by A. A. Bogush and L. G. Moroz (Izd. Nauka i Tekhnika, Minsk, 1968). The first of these two books will be reissued by Izd. Nauka in 1973.

Chapter Three "Problem of Conservation of the Energy-Momentum Tensor in the Relativistic Theory of Gravitation" is somewhat set apart, as its results are not referred to any further in the book. Since no significant changes have occurred within recent years in the relativistic theory of gravitation, hence the survey by A. Z. Petrov "Energy Concept in the General Theory of Relativity" (Ucheb. Zapis. Kazansk. Univ., 123, No. 12, 119, 1963) remains to be considered a sufficiently adequate text on the problem of energy-momentum in a gravitational field.

The second part of the book, "Inversion Operators in the Quantum Field Theory," consists of seven chapters. This part covers discrete unitary symmetry groups (space reflection, charge conjugation) and time reversal. Unlike in classical physics, where invariance with respect to such groups does not yield conservation laws, in quantum theory it is well known that these laws follow from the invariance with respect to discrete transformations. We will recall that, according to all modern experiments, both force and electromagnetic interactions are invariant with respect to space reflection P, time reversal T, and to charge conjugation C individually. Weak interactions violate the C-invariance and the P-invariance separately, but in almost all processes resulting from weak interactions the CP-symmetry is retained

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and, by virtue of the CPT-theorem, this indicates a T-symmetry. The CP-symmetry is violated during the decay of a K-meson (under very weak interactions). When a very weak interaction is considered, therefore, then force reflection (according to Pauli's terminology) is the only singularly rigorous symmetry operation – as is pointed out in the concluding chapter of the book.

Chapter One of the second part presents a survey of quantum field-theory fundamentals. Chapter Two is entitled "Space Reflection and Parity: the Bose field." It deals with parity in nonrelativistic quantum mechanics and quantum field theory, the parity of photons, and the selection rule pertaining to a decay of a neutral boson into two photons. Chapter Three, which deals with Fermi fields, covers such probems as the parity of Fermi states, the Wieck–Whiteman–Wigner rules of superselection, and the parity of a neutron and a proton. Chapter Four opens with a definition of the charge conjugation concept. It continues with eigenstates of the C-transformation, charge conjugation of the spinor bilinear covariants, and parity of photon and positron charge conjugation. Neutral Maiorani fields (bilinear covariants of Maiorani fermions, transposed relations) are dealt with in Chapter Five. In Chapter Six is shown the operation of time reversal (time reversal in classical physics, in nonrelativistic quantum mechanics and quantum field theory, antiunitarity of the time reversal operation, principle of piecewise equilibrium). Chapter Seven, the last chapter of the second part, contains the Schwinger–Lüders–Pauli theorem. The problem of the angular momentum of a spinor field and the proof of the superselection rules are relegated to Appendices.

The concise and modern style of writing is successfully combined in this book with simplicity and clarity. For this reason, the book can be recommended to students in advanced courses and to beginning theoretical physicists.