BOOK REVIEWS

Books on physics and astronomy being published by Mir in 1989

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The publication plan includes the most important books on the fundamental problems of physics and astronomy, particularly those that have a direct bearing on scientific-technical progress. Suitable attention is also paid to books of a pedagogic or a general-education nature intended for a wide circle of readers.

Of great importance for scientific-technological progress is, as before, the development of fields directly associated with solid state physics. The monograph "Fundamentals of Surface and Thin Film Analysis" by L. Feldman and J. Mayer is devoted to the physical foundations and methods of utilization of beams of ions, electrons and x-rays for the analysis of the structure and composition of thin layers of matter. These methods play a very important role in the development of present-day atomic technology and microelectronics. All the topics are presented at a high scientific level. There are no similar books in Russian and specialists who are interested in the problem of analysis of surfaces and thin films, and also undergraduate and graduate students specializing in appropriate fields will find much that is of interest in this book.

The book "Semiconductor Superlattices" by M. Herman in its content is an introduction into a new field of semiconductor physics—the physics of semiconductor superlattices. Multilayer semiconductor microstructures, called superlattices, have important applications in picosecond semiconductor electronics. The book examines problems of electrical conductivity in superlattices and discusses prospects of utilization and technological problems. The presentation of all the problems is complete and at a high scientific level. The material is presented in five chapters: the structure of semiconductor superlattices, the technology of producing superlattice structures, the theory of semiconductor superlattices, elementary results of investigation of superlattice structures, and the practical utilization of superlattice structures. The book is aimed at scientists working in semiconductor physics, at engineers and technologists working in appropriate fields, and also at undergraduate and graduate students.

The book "Dislocation Dynamics and Plasticity" by T. Suzuki, H. Yoshinaga, and S. Takeuchi contains a brief but sufficiently complete presentation of the present state of dislocation physics with particular emphasis on an analysis of the relationship of dislocations to plasticity of crystals. The book consists of 9 chapters. The first two chapters present basic information on and concepts of dislocation theory. The third chapter is devoted to the analysis of expeirmental data on plasticity of crystals under nonstandard conditions. In particular, the change in plasticity of crystals under low-temperature phase transitions is examined. Chapters 4 and 5 present theoretical and experimental data concerning the mechanisms of motion of dislocations, and discuss the connection between dislocations and plasticity in various crystal structures. Chapters 6–9 consider the motion of dislocations in semiconductors and the high-temperature deformation of crystals and composite materials. The most important special feature of this discussion is a departure from the more traditional approach to dislocations confined to the point of view of a macroscopic theory of elasticity, i.e., of a direct effect of dislocations on mechanical properties. Particular attention is devoted to processes at the microscopic level. The interaction of dislocations with the electron subsystem leads to a number of interesting effects (for example the weakening of metals upon transition to the superconducting state, the photoplastic effect). Many of the problems and experiments discussed in this book have been dealt with until now only in the periodical publications, and appear as a monograph for the first time. The manner of presentation makes the book useful as a textbook. It is aimed at scientists, graduate and undergraduate students, who have an interest in problems of crystal physics, dislocation physics, solid state and semiconductors.

The collective monograph "The Quantum Hall Effect" edited by R. Prange and S. Girvin has been written by scientists who have participated directly in the study of the quantum Hall effect. The preface has been written by K. von Klitzing who in 1985 was awarded the Nobel Prize for his discovery of the quantum Hall effect. The book presents results of experimental and theoretical investigations, draws conclusions and makes generalizations, and discusses the problems of the next stage of investigations. The monograph consists of ten chapters forming the two parts of the book devoted respectively to the integral and fractional quantum effect. In discussing the integral quantum Hall effect considerable attention is devoted to special features of observing it experimentally and utilizing it for metrologic purposes. A discussion is given of the basic structures in which the two-dimensional electron-gas is realized, of the design of experiments, the techniques of precision measurements, the use of the Hall resistor as a standard of resistance and for measurement of the fine structure constant. The role played by impurity atoms in a two-dimensional electron gas under the conditions of the quantum Hall effect, and its topological aspects are analyzed. On the basis of scaling theory and quantum field theory the connection is examined between the quantum Hall effect and the problem of Anderson localization. In the discussion of the fractional quantum Hall effect considerable attention is devoted to the experimental aspects of the investigations, the microscopic picture is presented in detail, and a detailed discussion is given of the method of constructing a variational wave function of the ground state of a two-dimensional many-electron system.

Non-variational methods of investigating this state are also presented, and collective excitations under the conditions of the fractional Hall effect are investigated based on the analogy between the system being investigated and superfluid helium. In the concluding section results are summarized, and promising directions for investigations are indicated, the first among them being the possibility of constructing theories of the Landau-Ginzburg type.

Several monographs are devoted to the fundamental problems of physics. The book by J. Nicolis "Dynamics of Hierarchical Systems: An Evolutionary Approach" presents a general approach to the study of the dynamics of complex nonlinear systems. Particular attention is devoted to the analysis of the problem of the formation and dissipation of that new information which arises in the process of development of different physical and biological systems. The book consists of seven chapters and an appendix. In the first introductory chapter a number of problems are discussed which are touched upon in the book and the basic aims of the book are formulated. Here also are discussed the common features of the behavior and development of different physical, biological, and chemical dynamical systems. In Chap. 2 basic information is presented which is necessary for the study of nonlinear dynamical systems. Particular attention is devoted to an analysis of the behavior of dynamical systems with two degrees of freedom near their singular points. Chapter 3 is devoted to a discussion of the role played by spherical electromagnetic waves in the "transfer of information." In Chap. 4 general problems of information theory and encoding are presented. Game theory and its applications are examined in Chap. 5. Chapters 6 and 7 are devoted to the problem of origin of chaos. These chapters examine the formation of chaos in dynamical systems with three and greater number of degrees of freedom. Here also an analysis is given of the problem of chaos in biological and other related systems. The appendix investigates the role played by external influences (noise) on the dynamics of development of different systems. The book is of interest for physicists, mathematicians, chemists and biologists.

The monograph by R. Penrose and W. Rindler "Spinors and Space-Time, V.2: Spinor and Twistor Methods in Space-Time Geometry" develops the subject of the first volume (Spinors and Space-Time, V.1, 1984. Russ. transl., Mir, M., 1987). The book begins with an introductory chapter which contains a list of definitions, formulas and theorems from the first volume which makes it possible to use the book without referring to the first volume (however, the first and the second books have a common numbering of chapters). Chapter 6 introduces the concept of a twistor and analyzes the geometry of twistor space and its relationship to the geometry of the Minkowski space. This chapter presents the most important results associated with twistors (the theory of local twistors, equations and their solutions in the case of fields with zero rest-mass of quanta, etc.). On the basis of a fundamental analysis of isotropic congruences a classification of different spinor fields is made in chapters 7 and 8. The last, ninth chapter is devoted to an analysis of conformal infinity. In it by using spinor and twistor methods a detailed study is made both of the Minkowski space, and also of the space-time of cosmological models and of asymptotically simple spaces. A discussion is given of the problem of energy and of moment of momentum, of the transport of energy (mass) to infinity and the positive nature of mass. The book is of interest for theoretical physicists and mathematicians working in the field of classical and quantum field theory and the theory of elementary particles, and also for undergraduate and graduate students of the appropriate specialties.

The book by P. West "Introduction to Supersymmetry and Supergravity" presents the basic ideas of supersymmetry algebra and its immediate consequences. The presentation includes an analysis of ultraviolet divergences, the calculation of different quantum effects in supersymmetric models in the context of superfield diagram technique, and the theory of supergravity. The monograph reflects the contemporary achievements of expanded supersymmetry and its role in the construction of realistic models of a unified theory of elementary particles, and also of the theory of superstrings. The book is of interest for specialists in theoretical and mathematical physics and also for undergraduate and graduate students.

Progress in physics research is closely connected with availability of apparatus and utilization of achievements of information theory for solution of specific problems. The monograph by H. Harmuth "Information Theory Applied to Space-Time Physics" presents methods of describing events, trajectories, physical fields discrete in space and time, that are typical for experimental measurements and subsequent reduction of data. Also the mathematical apparatus of information theory is introduced which can be used for the analysis of measurements and coordinate fields. The book for the first time investigates with sufficient simplicity and clarity the transition from a continuum space to a discrete one. The book is intended for specialists in the field of theoretical physics, for mathematicians, engineers, and technologists, and also graduate and undergraduate students.

The book by R. Bates and M. McDonnell "Image Restoration and Reconstruction" is devoted to a presentation of the basic procedures of extracting information from images including such questions as the phase problem, the problem of observing images through a distorting medium (speckle-images), transmission computer-assisted tomography as an interferometric problem, etc. A systems approach to the restoration and reconstruction of images (using a technical, mathematical and programming language) is examined. The presentation is based on original material a significant part of which is due to the authors. The book is of interest for specialists in the field of optics, crystallography, astronomy, tomography, information processing and other fields.

The book by H. Kunze "Physikalische Messmethoden" synthesizes information which is usually scattered over courses on theory of measurements, mathematical processing of results of measurements, and methodological instructions for carrying out laboratory work. The book examines systesm of units, questions of design of experiments, similarity laws in mechanics, optics of charged particles, and plasma physics. It is shown how with the aid of electrical and other models it is possible to study processes in complex systems. The foundations of the theory of errors, the special features of different transmissions devices, problems in signal transmission, special features of measuring devices for optical signals, questions concerning the natural limitations on measurements, detectors of charged particles and electro-

magnetic radiation, and also methods of high resolution spectroscopy are briefly outlined. The book is aimed at scientists, engineers, and undergraduate students and other persons involved with physical measurements.

The book by H. Schmidt "Masselektronik in der Kernphysik" is devoted to the techique for automation of experiments and electronic apparatus used in experimental investigations. It discusses detectors of radiation, the principles of construction of preamplifiers, amplifiers, and shaper-amplifiers. The book describes sources of noise and methods of combating them, deals with problems of processing analog information, describes the methodology of selection of events, examines units of auxiliary electronics, different types of counters, scalers, timers, systems of reading off information from different devices, and also different methods of data processing. The formulas included in the book are useful for engineering calculations.

X-ray optics has undergone considerable development in recent years. The monograph by A. Michette "Optical Systems for Soft X-rays" introduces the reader to physics ideas and methods in x-ray optics. The book examines properties of soft x rays, the reflecting optics of soft x rays in range I, the technology of glancing incidence mirrors, the reflecting optics of soft x rays in range II, the production of multilayer mirrors, diffraction optics I and diffraction gratings, the design and technology of diffraction gratings, diffraction optics II, zone plates and their production, the use of x-ray optical systems, and prospects for further development. The book contains material useful for scientists and engineers working in the field of physics of hot plasmas, solid state physics, materials science, laser physics, microanalysis, microscopy, x-ray astronomy, biology, and medicine.

The monograph by S. Solimeno, B. Crosignani, and P. Di Porto "Guiding Diffraction and Confinement of Optical Radiation" examines the propagation of radiation and its interaction with matter, asymptotic methods of solving the wave equation, propagation of light in stratified periodic structures, diffraction phenomena in the propagation of light. The physics of resonators is discussed, Fabri-Perot interferometers are described, and an analysis of propagation of light in optical fibers is presented. Each chapter of the book is provided with problems and contains many useful formulas and information concerning the topics discussed. The book can serve as a textbook or a reference book.

The collective monograph "Physical Principles of Medical Ultrasonics" edited by C. Hill has been written by a group of leading specialists in the field of biomedical acoustics. It presents quite completely and in a clear, rigorous and laconic form the physical bases of all the contemporary areas of application of ultrasound in medicine and biology. Ultrasonic methods developed in recent decades have made it possible to visualize deeply-lying anatomical regions of an organism, to record changes occurring in organs and tissues as a result of some pathology, to exert an active influence on biological tissues, and to invesigate their molecular composition and structure. The book reflects three basic aspects of the problem under consideration: 1) the physical bases of the medical applications of ultrasound; 2) methods of ultrasonic visualization and investigation of biological tissues; 3) the mechanisms of biological action of ultrasound for an active influence on the structure of an organism. The book is written on a high scientific and methodological level and reflects the most modern status of work in this field, including the recent papers of 1985–1986. This makes the book very useful for physicists, engineers, medical scientists and physiologists working in the field of biomedical acoustics.

The collective monograph "Nonequilibrium Vibrational Kinetics" edited by M. Capitelli has been written by leading specialists in the field of molecular spectroscopy, vibrational kinetics, and the physics of gas lasers. It provides a systematic presentation of problems of nonequilibrium vibrational kinetics in molecular systems, with sufficient attention being devoted both to the theoretical and the experimental aspects of the problems. The main emphasis in the book is on the analysis of excitation and relaxation of molecular oscillations in nonequilibrium gas-discharge and gasdynamic systems utilized in producing molecular gas lasers and in organizing selective laser-chemical and plasmachemical processes. In the first three chapters of an introductory nature theoretical and experimental papers of the last two decades are considered, and detailed reference material is presented which is necessary for the description of specific physical systems of vibrationally-excited molecules. Chapters 4–5 provide a concrete description of the cross sections for processes of different classes and give numerical values of constants. The role played by vibational energy in increasing the energy efficiency of chemical reactions is discussed in Chapters 6 and 7. Chapter 8 analyzes the methods of experimental determination of vibrational distributions by means of IR and Raman spectroscopy. Level constants of the rate of vibrational energy exchange for excited states are determined. Chapter 9 is devoted to the problem of isotope separation, and an experiment is discussed on separation of complex sysems. Chapter 10 provides a theoretical examination of nonequilibrium vibrational kinetics of polyatomic molecules. In the final chapter 11 the connection between the occupation of vibrational levels and the distribution function in energy of electrons in a molecular plasma and in an afterglow region is examined. Relaxation data for systems containing nitrogen and carbon monoxide are provided.

The book is intended for scientists and engineers specializing in the field of plasma chemistry, laser chemistry, the physics of gas lasers, and chemistry, and also for undergraduate and graduate students of the corresponding specialties.

Two books in the publication plan are intended specially for use as textbooks. The book by A. Sudbury "Quantum Mechanics and the Particles of Nature. An Outline for Mathematicians." is an original textbook on modern quantum mechanics and simultaneously on the theory of elementary particles. The book is distinguished by a very clear logical presentation, much attention in it is devoted to the world view orientation in the problems being discussed and to an investigation of the ideas, and not to the details of the mathematical apparatus. The discussion is based on a purely algebraic approach using a state-vector space and the algebra of linear Hermitian operators in it, and practically does not contain the formalism of the Schrödinger differential equation. In the first introductory chapter aimed at the unprepared reader basic information from atomic physics and the physics of elementary particles, including the latest developments, is provided at an elementary level but sufficiently rigorously. A presentation of the fundamental assumptions of quantum mechanics is given in Chapters 2–4. Chapter 5

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discusses different interpretations of quantum mechanics. Chapter 6 is devoted to a comprehensive presentation of the theory of elementary particles (the spectroscopy of hadrons, quantum numbers of quarks and gluons, the Zweig rule, the Salam-Weinberg Hamiltonian, experimental confirmation of the Salam-Weinberg theory, and supersymmetry). The last seventh chapter presents the foundations of quantum field theory and relativistic quantum mechanics—second quantization, the principal assumptions of the Yang-Mills gauge theory and quantum chromodynamics, hidden symmetries, Goldstone bosons, and the Higgs mechanism. The book is of interest to scientists who wish to have a compact, but sufficiently rigorous presentation of the modern state of quantum mechanics and theory of elementary particles, and to undergraduate and graduate students of the corresponding specializations.

The book by D. Blanc "Noyaux particules. Reacteurs nucleaires" using only elementary mathematical apparatus presents a wide range of topics in modern physics, i.e., those fields of physics which originated and were developed in the XX century. These topics cannot be presented without using quantum mechanical concepts and basic ideas of quantum mechanics. However the book does not contain a special chapter devoted to quantum mechanics. The necessary quantum mechanical concepts and ideas are explained as they are needed in using them to analyze the physics material. In the mathematical sense this is done at a most elementary level which makes the book accessible to a wide circle of readers. The range of topics touched upon in the book is quite broad. The first chapter is devoted to a review of the basic physics information used in describing the physics of the nucleus. The second chapter is entitled "Particles and interactions: a general overview." It encompasses practically all the main significant results obtained right up to date. The penultimate tenth section of this chapter is entitled "The grand unification. Its consequences accessible to verification," while section 11 is devoted to the theory of supersymmetry. The presentation is brief, nonmathematical, but sufficiently clear. The subsequent chapters have the following titles: "Mass and volume of the nucleus," "Quantization of nucleons and nuclei," "Nuclear models," "Quantization of particles. Laws of invariance," "Radio-activity: experimental aspects," "Electromagnetic interaction," "Strong interaction," "Neutron," "Fission. Nuclear Reactors." At the end of the book there are four appendices containing historical information on a number of questions under discussion, physics constants, tables of elementary particles and bibliography for additional reading, arranged not according to chapters, but to topics. The book is intended for a wide range of educated readers, including students of the early years of institutions of higher learning and students of the upper grades of secondary schools who wish to become acquainted with the present-day state of the physics of the nucleus and of elementary particles in an accessible presentation. The book can also be used as a reference book.

At the present time many of the most important problems of astronomy are problems of physics either in terms of their content, or in terms of the methods of investigation (astrophysics, radiophysics, γ-astronomy, etc.). The publication plan includes a number of books of this nature.

The book "Black Holes: The Membane Paradigm" edited by K. Thorne, R. Price, and D. Macdonald presents in detail a new approach to the analysis of physical properties and astrophysical manifestations of black holes which has been given the name of the "membrane approach." In this approach a black hole is regarded as an ordinary body whose boundary is the horizon of the black hole endowed with such physical properties as electrical conductivity, inductance, etc. As a result it becomes possible to describe phenomena in the strong gravitational field of a black hole in the language used in the rest of physics, and to solve complicated astrophysical problems arising in analyzing the observational manifestations of black holes in real astrophysical objects. The utilization of experience (including also intuitive experience) of specialists in magnetic hydrodynamics and plasma physics is facilitated. The methods presented in the book can be applied not only in construction of models, but also in interpretation of observations of nuclei of galaxies, binary star systems with black holes, etc.

The monograph by W. Saslaw "Gravitational Physics of Stellar and Galactic Systems" examines practically all the problems associated with the gravitational interaction of stars, galaxies and their clusters: the physics of gravitational interactions in homogeneous gravitational systems, the evolution of the large-scale distribution of matter in the universe, the evolution of finite spherical systems—galactic clusters, galactic nuclei and spherical clusters, stellar systems possessing angular momentum. The book is the first bringing together of a broad range of material that has accumulated in the course of the last two decades.

The monograph by A. Thompson, J. Moran and G. Swenson, Jr. "Interferometry and Synthesis in Radioastronomy" is devoted to an examination of a broad range of problems associated with the use of radio-interferometry in order to obtain radio-images of cosmic objects and to solve fundamental problems in astronomy, geodesy, geodynamics and cosmic navigation. In it basic theoretical concepts are presented at a high scientific level and instruments are described based on principles of interferometry. Also another class of apparatus with high angular resolution is examined: intensity interferometer, the method of lunar occultations, modern optical Michelson interferometers. Considerable attention is devoted to methods of processing observational data. The book is of great interest for scientists and specialists in the field of applied astronomy, physics, radiophysics and also for undergraduate and graduate students.

The book by P. Léna, "Methodes physiques de l'observation" describes from a unified methodological point of view the methods and special features of astrophysical observations in the radio, infrared, optical and x-ray ranges (the classical methods of astrophysics either are not considered at all, or just merely mentioned). The book describes problems of information in astrophysics, the influence of the earth's atmosphere, the questions of photometry and apparatus for obtaining information on astronomical objects, the principles of aperture synthesis and active optics; the role played by and the place occupied by spectra in obtaining information on astronomical objects and the methods of obtaining spectral information, etc. are discussed. The book can serve as a textbook.

The current issue of collection of articles "Fizika za rubezhom" (Physics Abroad) Part A (research) contains translations of popular-science articles from the journals "Physics Today" and "La Recherche" which describe the

most recent achievements and the pressing problems of physical science. The presentation is distinguished by a high informational content and scientific rigor. It is intended for readers have some education in physics (including physics students).

Ultrafast phenomena

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Ultrafast Phenomena, Eds. G. R. Fleming and A. E. Siegman, Springer-Verlag, Berlin; Heidelberg; New York; London; Paris; Tokyo, 1986 pp. 551 (Springer Series in Chemical Physics V. 46)

This entire voluminous book is devoted to the application of short and ultrashort intense light pulses to the study of ultrafast phenomena and to the discovery of new nonlinear optical phenomena and their applications.

The first investigations of this kind appeared at the very end of the 1960s and during the last 15 years have led to amazing successes. Investigations of ultrafast processes in molecular, ionic and electronic systems in gases, liquids and solids came in a rushing stream. Special conferences devoted to these problems became necessary.

The book under review represents volume 46 of the "Springer Series in Chemical Physics" containing materials of the conference of the American Optical Society which took place on 16–19 June, 1986 in the USA and was devoted to the application of ultrashort light pulses to the study of different ultrafast processes. The book is entitled "Ultrafast Phenomena." The book containing the materials of the IV conference (1984) has the same title while the preceding three books were entitled "Picosecond Phenomena." The first book appeared in 1978. So far the conference devoted to this subject occur every two years, and in the year of each conference a book appears containing the conference materials. It should be noted that materials related to or coinciding with this subject can be found also in other series published by Springer, for example "Springer Proceedings in Physics" (V.4), "Time Resolved Vibrational Spectroscopy," etc.

The book under review contains 145 articles divided into nine parts. Primarily the research has been carried out by American physicists, Japan and France are represented by 10 papers each, FRG by 9 papers, England by 7 papers, USSR and PRC by 2 papers each. Several investigations have been carried out by western countries jointly.

The materials of the volume are very diverse, and therefore even a brief review of the contents will go beyond the volume of a usual journal review. Therefore we present the titles of the parts of the book from which one can partially draw conclusions concerning its breadth of subject, and we shall speak about the content only very briefly.

Part I. Mode Locking and Ultrashort Pulse Generation

Part II. Ultrafast Optical Generation and Measurement Techniques

Part III. Electrooptic Sampling Techniques

Part IV. Nonlinear Optics and Continuum Generation

Part V. Applications to Semiconductors, Quantum Wells, and solid State Physics

Part VI. Chemical Reaction Dynamics

Part VII. Dynamics of Biological Processes

Part VIII. Energy Transfer and Relaxation

Part IX. Coherent Spectroscopic Techniques

The book devotes considerable attention to the techniques of generating picosecond, subpicosecond and particularly femtosecond light pulses. As a rule, we are dealing with the now conventional generation of light pulses of 100 to 20 femtosecond duration, but in some cases there are now generated and utilized pulses of duration less than 10 fs. Different methods of pulse "compression" and amplification are described, in particular in multiple traversal of the pulse through a jet of dye in a resonator. The possibility of utilizing Raman scattering of light for amplification and production of soliton or quasisoliton lasers utilizing as resonators ring optical fibers is demonstrated. In these cases pulses of ∼60–20 fs duration are generated. Methods are developed for analyzing luminescence of subpicosecond duration.

Electrical circuits based on ordinary electronics turn out to be unsuitable for the technique of picking out subpicosecond and femtosecond pulses, and a new step must be taken, in particular utilizing cryogenic techniques. This in particular is described in several papers of Part III. Devices are described there which enable one to obtain a very steep front of growth of an electrical pulse—several tens of picoseconds, and even such a scheme which produces a time for front growth of 5 ps.

Picosecond, subpicosecond and femtosecond pulses propagating in media have made it possible to observe new phenomena in the case of three-wave and four-wave interaction and generation of a very broad continuous spectrum in the case of passage of short pulses through gases, and to study the problems of absorption spectroscopy.

Various nonlinear optical phenomena and special features of the interaction of ultrashort light pulses with semiconductors are described in Part V of the book. The thermodynamics and kinetics of melting and crystallization under