Light Scattering By Small Particles H C Van De Hulst

Reflectance spectroscopy is the investigation of the spectral composi tion of surface-reflected radiation with respect to its angularly dependent intensity and the composition of the incident primary radiation. Two limiting cases are important: The first concerns regular (specular) reflection from a smooth surface, and the second diffuse reflection from an ideal matte surface. All possible variations are found in practice between these two extremes. For the two extreme cases, two fundamentally different methods of reflectance spectroscopy are employed: The first of these consists in evaluating the optical constants n (refractive index) and x (absorption index) from the measured regular reflection by means of the Fresnel equations as a function of the wave A. This rather old and very troublesome procedure, which is length incapable of very accurate results, has recently been modified by Fahren fort by replacing the air-sample phase boundary by the phase boundary between a dielectric of higher refractive index (n) and the sample (n). 1 2 If the sample absorbs no radiation and the angle of incidence exceeds a certain definite value, total reflection occurs. On close optical contact between the two phases, a small amount of energy is transferred into the less dense phase because of diffraction phenomena at the edges of the incident beam. The energy flux in the two directions through the phase boundary caused by this is equal, however, so that 'total reflection takes place.

Individual cell and particle analysis in aquatic sciences is involved in many aspects of oceanography and limnology, including optical physics of particles, phytoplankton physiology and ecology, marine and aquatic microbiology and food web interactions. This book concentrates on the optimal utilization of flow cytometry and image analysis and the ways in which oceanographic and limnological problems can be uniquely or better addressed using these techniques.

Since their inception more than 2.5 years ago, photon correlation techniques for the spatial, temporal or spectral analysis of fluctuating light fields have found an ever-widening range of applications. Using detectors which re spond to single quanta of the radiation field, these methods are intrinsically digital in natnre and in many experimental situations offer a unique degree of accuracy and sensitivity, not only for the study of primary light sources themselves, but most particularly in the use of a laser-beam probe to study light scattering from pure fluids, macromolecular suspensions and laminar or turbulent flowing fluids and gases. Following the earliest developments in laser scattering by dilute macro nl01ecular suspensions, in , ... hich particle sizing was the main aim, and the use of photon correlation techniques for laser-Doppler studies of flow and tnrbuence. both of which areas were the subject of NATO ASIs in Capri, Italy in 19;:3 and 19;6. significant advances have be('n made in recent years in many other areas. These were reflected in the topics covered in this NATO Advanced Research Workshop, which took place from August 2;th to 30th, 1!)!}6, at the Jagiellonian University, Krakow, Poland. These in cluded ('xperimental techniques. statist.ics and data reduction, colloids and aggregation, polymers, gels, liquid crystals and mixtures, protein solutions, critical pllf'nomena and dense media.

This new text offers experienced students a comprehensive review of available techniques for the remote sensing of aerosols. These small particles influence both atmospheric visibility and the thermodynamics of the atmosphere. They are also of great importance in any consideration of climate change problems. Aerosols may also be responsible for the loss of harvests, human health problems and ecological disasters. Thus, this detailed study of aerosol properties on a global scale could not be more timely.

A self-contained, accessible introduction to the basic concepts, formalism and recent advances in electromagnetic scattering, for researchers and graduate students.

Scattering Methods and their Application in Colloid and Interface Science offers an overview of small-angle X-ray and neutron scattering techniques (SAXS & SANS), as well as static and dynamic light scattering (SLS & DLS). These scattering techniques are central to the study of soft matter, such as colloidal dispersions and surfactant self-assembly. The theoretical concepts are followed by an overview of instrumentation and a detailed description of the evaluation techniques in the first part of the book. In the second part, several typical application examples are used to show the strength and limitations of these techniques. Features the latest input from the world-leading expert with personal experience in all the fields covered (SAXS, SANS, SLS and DLS) Includes unified notation throughout the book to enhance its readability Provides—in a single source—scattering theory, evaluation of techniques and a variety of applications

Monograph on multiple scattering of light by small particles; resource for science professionals, engineers, and graduate students.

Particle characterization is an important component in product research and development, manufacture, and quality control of particulate materials and an important tool in the frontier of sciences, such as in biotechnology and nanotechnology. This book systematically describes one major branch of modern particle characterization technology - the light scattering methods. This is the first monograph in particle science and technology covering the principles, instrumentation, data interpretation, applications, and latest experimental development in laser diffraction, optical particle counting, photon correlation spectroscopy, and electrophoretic light scattering. In addition, a summary of all major particle sizing and other characterization methods, basic statistics and sample preparation techniques used in particle characterization, as well as almost 500 latest references are provided. The book is a must for industrial users of light scattering techniques characterizing a variety of particulate systems and for undergraduate or graduate students who want to learn how to use light scattering to study particular materials, in chemical engineering, material sciences, physical chemistry and other related fields.

A thorough and up-to-date treatment of electromagnetic scattering by small particles.

This book presents the separation-of-variables and T-matrix methods of calculating the scattering of electromagnetic waves by particles. Analytical details and computer programs are provided for determining the scattering and absorption characteristics of the finite-thickness slab, infinite circular cylinder (normal incidence), general axisymmetric particle, and sphere.The computer programs are designed to generate data that is easy to graph and visualize, and test cases in the book illustrate the capabilities of the programs. The connection between the theory and the computer programs is reinforced by references in the computer programs to equations in the text. This cross-referencing will help the reader understand the computer programs, and, if necessary, modify them for other purposes.

Liberally sprinkled with humor, these lessons will fascinate beginning physics students and other readers with chapters titled "On a Clear Day You Can't See Forever" and "Physics on a Manure Heap."

There is hardly a field of science or engineering that does not have some interest in light scattering by small particles. For example, this subject is important to climatology because the energy budget for the Earth's atmosphere is strongly affected by scattering of solar radiation by cloud and aerosol particles, and the whole discipline of remote sensing relies largely on analyzing the parameters of radiation scattered by aerosols, clouds, and precipitation. The scattering of light by spherical particles can be easily computed using the conventional Mie theory. However, most small solid particles encountered in natural and laboratory conditions have nonspherical shapes. Examples are soot and mineral aerosols, cirrus cloud particles, snow and frost crystals, ocean hydrosols, interplanetary and cometary dust grains, and microorganisms. It is now well known that scattering properties of nonspherical particles can differ dramatically from those of "equivalent" (e.g., equal-volume or equal-surface-area) spheres. Therefore, the ability to accurately compute or measure light scattering by nonspherical particles in order to clearly understand the effects of particle nonsphericity on light scattering is very important. The rapid improvement of computers and experimental techniques over the past 20 years and the development of efficient numerical approaches have resulted in major advances in this field which have not been systematically summarized. Because of the universal importance of electromagnetic scattering by nonspherical particles, papers on different aspects of this subject are scattered over dozens of diverse research and engineering journals. Often experts in one discipline (e.g., biology) are unaware of potentially useful results obtained in another discipline (e.g., antennas and propagation). This leads to an inefficient use of the accumulated knowledge and unnecessary redundancy in research activities. This book offers the first systematic and unified discussion of light scattering by nonspherical particles and its practical applications and represents the state-of-the-art of this important research field. Individual chapters are written by leading experts in respective areas and cover three major disciplines: theoretical and numerical techniques, laboratory measurements, and practical applications. An overview chapter provides a concise general introduction to the subject of nonspherical scattering and should be especially useful to beginners and those interested in fast practical applications. The audience for this book will include graduate students, scientists, and engineers working on specific aspects of electromagnetic scattering by small particles and its applications in remote sensing, geophysics, astrophysics, biomedical optics, and optical engineering. The first systematic and comprehensive treatment of electromagnetic scattering by nonspherical particles and its applications Individual chapters are written by leading experts in respective areas Includes a survey of all the relevant literature scattered over dozens of basic and applied research journals Consistent use of unified definitions and notation makes the book a coherent volume An overview chapter provides a concise general introduction to the subject of light scattering by nonspherical particles Theoretical chapters describe specific easy-to-use computer codes publicly available on the World Wide Web Extensively illustrated with over 200 figures, 4 in color

Meeting the need for teaching material suitable for students of atmospheric science and courses on atmospheric radiation, this textbook covers the fundamentals of emission, absorption, and scattering of electromagnetic radiation from ultraviolet to infrared and beyond. Much of the contents applies to planetary atmosphere, with graded discussions providing a thorough treatment of subjects, including single scattering by particles at different levels of complexity. The discussion of the simple multiple scattering theory introduces concepts in more advanced theories, such that the more complicated two-stream theory allows readers to progress beyond the pile-of-plates theory. The authors are physicists teaching at the largest meteorology department in the US at Penn State. The problems given in the text come from students, colleagues, and correspondents, and the figures designed especially for this book facilitate comprehension. Ideal for advanced undergraduate and graduate students of atmospheric science. * Free solutions manual available for lecturers at www.wiley-vch.de/supplements/

This book explores generalized Lorenz–Mie theories when the illuminating beam is an electromagnetic arbitrary shaped beam relying on the method of separation of variables. The new edition includes an additional chapter covering the latest advances in both research and applications, which are highly relevant for readers. Although it particularly focuses on the homogeneous sphere, the book also considers other regular particles. It discusses in detail the methods available for evaluating beam shape coefficients describing the illuminating beam. In addition it features applications used in many fields such as optical particle sizing and, more generally, optical particle characterization, morphology-dependent resonances and the mechanical effects of light for optical trapping, optical tweezers and optical stretchers. Furthermore, it provides various computer programs relevant to the content.

This comprehensive introduction to principles underlying laser light scattering focuses on time dependence of fluctuations in fluid systems; also serves as introduction to theory of time correlation functions. 1976 edition.

Light scattering is a very powerful method for characterizing the structure of polymers and nanoparticles in solution. As part of the Springer Laboratory series, this book provides a simple-to-read and illustrative textbook probing the seemingly very complicated topic of light scattering from polymers and nanoparticles in dilute solution, and goes further to cover some of the latest technical developments in experimental light scattering.

An textbook for advanced undergraduate and graduate atmospheric science and meteorology students. Although this book addresses a technically and mathematically demanding subject, the writing style is designed to be engaging and accessible for students requiring a basic foundation in atmospheric physics.

The Scattering of Light and other Electromagnetic Radiation covers the theory of electromagnetic scattering and its practical applications to light scattering. This book is divided into 10 chapters that particularly present examples of practical applications to light scattering from colloidal and macromolecular systems. The opening chapters survey the physical concept of electromagnetic waves and optics. The subsequent chapters deal with the theory of scattering by spheres and infinitely long cylinders. These topics are followed by discussions on the application of light scattering to the determination of the size distribution of colloidal particles. The last chapters are devoted to the Rayleigh-Debye scattering and the scattering by liquids, as well as the concept of anisotropy. These chapters also describe the effect upon light scattering of partial orientation of anisotropic particles in electrical and magnetic fields and in viscous flow. This book is of value to physical chemists and physical chemistry researchers, teachers, and students.

The manipulation of light at the nanometer scale is highly pursued for both fundamental sciences and wide applications. The diffraction limit of light sets the limit for the smallest size of photonic devices to the scale of light wavelength. Fortunately, the peculiar properties of surface plasmons in metal nanostructures make it possible to squeeze light into nanoscale volumes and enable the manipulation of light and light–matter interactions beyond the diffraction limit. Studies on surface plasmons have led to the creation of a booming research field called plasmonics. Because of its various scientific and practical applications, plasmonics attracts researchers from different fields, making it a truly interdisciplinary subject. Nanophotonics: Manipulating Light with Plasmons starts with the general physics of surface plasmons and a brief introduction to the most prominent research topics, followed by a discussion of computational techniques for light scattering by small particles. Then, a few special topics are highlighted, including surfaceenhanced Raman scattering, optical nanoantennas, optical forces, plasmonic waveguides and circuits, and gain-assisted plasmon resonances and propagation. The book discusses the fundamental and representative properties of both localized surface plasmons and propagating surface plasmons. It explains various phenomena and mechanisms using elegant model systems with well-defined structures, is illustrated throughout with excellent figures, and contains an extensive list of references at the end of each chapter. It will help graduate-level students and researchers in nanophotonics, physics, chemistry, materials science, nanoscience and nanotechnology, and electrical and electronic engineering get a quick introduction to this field.

This book deals with a particular class of approximation methods in the context of light scattering by small particles. Soft particles occur in ocean optics, biomedical optics, atmospheric optics and in many industrial applications. This class of approximations has been termed as eikonal or soft particle approximations. The study of these approximations is very important because soft particles occur abundantly in nature.

This is the 3rd volume of a "Light Scattering Reviews" series devoted to current knowledge of light scattering problems and both experimental and theoretical research techniques related to their solution. This volume covers applications in remote sensing, inverse problems and geophysics, with a particular focus on terrestrial clouds. The influence of clouds on climate is poorly understood. The theoretical aspects of this problem constitute the main emphasis of this work.

An Introduction to Dynamic Light Scattering by Macromolecules provides an introduction to the basic concepts of dynamic light scattering (DLS), with an emphasis on the interpretation of DLS data. It presents the appropriate equations used to interpret DLS data. The material is presented in order of increasing complexity of the systems under examination, ranging from dilute solutions of noninteracting particles to concentrated multicomponent solutions of strongly interacting particles and gels. Problems are presented at the end of each chapter to emphasize these concepts. Since a major emphasis of this textbook is the interpretation of DLS data obtained by polarized light scattering studies on macromolecular solutions, the results of complementary experimental techniques are also presented in order to gain insight into the dynamics of these systems. This textbook is intended for (1) advanced undergraduate students and graduate students in the chemical, physical, and biological sciences; (2) scientists who might wish to apply DLS methods to systems of interest to them but who have no formal training in the field of DLS; and (3) those who are simply curious as to the type of information that might be obtained from DLS techniques.

Light scattering has provided an important method for characterizing macro-molecules for at least three decades. Now, through the use of intense, coherent laser light and efficient spectrum analyzers and autocorrelators, experiments in the frequency and time domains can be used to study molecular motion, e.g. diffusion and flow and other dynamic processes, as well as the equilibrium properties of solutions. As a result, laser light scattering has become a powerful form of spectroscopy with applications in physics, biochemistry, and other fields. This volume, which employs a relatively simple approach in order to reach the widest audience, focuses on two main topics: classical light scattering (scattering intensity, concentration dependence, size dependence, and polydispersity) and dynamic light scattering (time and frequency dependence, translational diffusion, directed flow, rotational motion, and more). A series of useful appendixes and a list of references complete this concise, accessible work, a valuable resource for physicists, chemists, and anyone interested in the increasingly important field of laser light scattering.

This fourth volume of Light Scattering Reviews is composed of three parts. The ?rstpartisconcernedwiththeoreticalandexperimentalstudiesofsinglelightsc- tering by small nonspherical particles. Light scattering by small particles such as, for instance, droplets in the terrestrial clouds is a well understood area of physical optics. On the other hand, exact theoretical calculations of light scattering p- terns for most of nonspherical and irregularly shaped particles can be performed only for the restricted values of the size parameter, which is proportional to the ratio of the characteristic size of the particle to the wavelength?. For the large nonspherical particles, approximations are used (e. g. , ray optics). The exact th- retical techniques such as the T-matrix method cannot be used for extremely large particles, such as those in ice clouds, because then the size parameter in the v- iblex=2?a/???,wherea is the characteristic size (radius for spheres), and the associated numerical codes become unstable and produce wrong answers. Yet another problem is due to the fact that particles in many turbid media (e. g. , dust clouds) cannot be characterized by a single shape. Often, refractive indices also vary. Because of problems with theoretical calculations, experimental (i. e. , la- ratory) investigations are important for the characterization and understanding of the optical properties of such types of particles. The ?rst paper in this volume, written by B. Gustafson, is aimed at the descr- tionofscaledanalogueexperimentsinelectromagneticscattering.

Light scattering-based methods are used to characterize small particles suspended in water in a wide range of disciplines ranging from oceanography, through medicine, to industry. The scope and accuracy of these methods steadily increases with the progress in light scattering research. This book focuses on the theoretical and experimental foundations of the study and modeling of light scattering by particles in water and critically evaluates the key constraints of light scattering models. It begins with a brief review of the relevant theoretical fundamentals of the interaction of light with condensed matter, followed by an extended discussion of the basic optical properties of pure water and seawater and the physical principles that explain them. The book continues with a discussion of key optical features of the pure water/seawater and the most common components of natural waters. In order to clarify and put in focus some of the basic physical principles and most important features of the experimental data on light scattering by particles in water, the authors employ simple models. The book concludes with extensive critical reviews of the experimental constraints of light scattering models: results of measurements of light scattering and of the key properties of the particles: size distribution, refractive index (composition), structure, and shape. These reviews guide the reader through literature scattered among more than 210 scientific journals and periodicals which represent a wide range of disciplines. A special emphasis is put on the methods of measuring both light scattering and the relevant properties of the particles, because principles of these methods may affect interpretation and applicability of the results. The book includes extensive guides to literature on light scattering data and instrumentation design, as well as on the data for size distributions, refractive indices, and shapes typical of particles in natural waters. It also features a comprehensive index, numerous cross-references, and a reference list with over 1370 entries. An errata sheet for this work can be found at: http://www.tpdsci.com/Ref/Jonasz_M_2007_LightScatE.php *Extensive reference section provides handy compilations of knowledge on the designs of light scattering meters, sources of experimental data, and more *Worked exercises and examples throughout

This volume outlines the fundamentals and applications of light scattering, absorption and polarization processes involving ice crystals.

Absorption and Scattering of Light by Small Particles Treating absorption and scattering in equal measure, this self-contained, interdisciplinary study examines and illustrates how small particles absorb and scatter light. The authors emphasize that any discussion of the optical behavior of small particles is inseparable from a full understanding of the optical behavior of the parent material-bulk matter. To divorce one concept from the other is to render any study on scattering theory seriously incomplete. Special features and important topics covered in this book include: * Classical theories of optical properties based on idealized models * Measurements for three representative materials: magnesium oxide, aluminum, and water * An extensive discussion of electromagnetic theory * Numerous exact and approximate solutions to various scattering problems * Examples and applications from physics, astrophysics, atmospheric physics, and biophysics * Some 500 references emphasizing work done since Kerker's 1969 work on scattering theory * Computer programs for calculating scattering by spheres, coated spheres, and infinite cylinders

Multiple Light Scattering: Tables, Formulas, and Applications, Volume 1 serves to give concise and handy information related to multiple scattering theory in such a way that the reader would not have to rely on extensive literature on the subject. The book is divided into two parts. Part I: General Theory covers the basic concepts, terms, and notations related to multiple scattering theory; exponential integrals and related functions; reciprocity and detailed balance; different related methods; and homogenous atmospheres with arbitrary phase function and single-scattering albedo. Part II: Isotropic Scattering discusses related concepts such as solutions using the Milne operator; semi-infinite atmospheres; the H-functions; and finite slabs. The text is recommended for practitioners in optics, atmospheric physics, astronomy, and other fields that need a reference book in the subject of multiple light scattering.

Comprehensive treatment of light-scattering properties of small, independent particles, including a full range of useful approximation methods for researchers in chemistry, meteorology, and astronomy. 46 tables. 59 graphs. 44 illustrations.

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