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Light Scattering by Nonspherical Particles: Theory, Measurements, and Applications

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Almost all solid particles and very many liquid drops are not spherical. In addition, particles may have internal structure, both homogeneous and heterogeneous, and there may be agglomeration.

It has long been recognized that the well-known Mie theory for homogeneous spheres, and similar theories for simple shapes such as the infinite cylinder, are not adequate representations of the scattering by more complex shapes and structures. There may be significant differences in the calculated phase function to that in reality, and a theory for homogeneous spheres will completely fail to predict polarization effects.

In the absence of rigorous analytical solutions for particles of general shape and structure, recourse is made to numerical techniques. The development of powerful computers has enabled these calculations to be performed rapidly and accurately for a wide range of particle types and sizes. The growth in numerical techniques has been exponential. For these reasons this book has come at a very opportune time, and is a welcome review of a large field of expertise. Authors who are recognized masters review each subject, and all the major methods are covered. For completeness there are also sections dealing with examples of practical applications of the calculations to nature.

The book opens with a foreword by the renowned H C van de Hulst, who provides an interesting historical review and perspective. An introductory section of three chapters follows, dealing with fundamental concepts and definitions. The first of these deals with scattering by single particles and moves on to multiple scattering and radiative transfer. The second chapter is concerned with methods for nonspherical particles. It briefly reviews the limited exact theories available and then covers numerical and approximate methods. Finally, there is a chapter covering the basic properties of the scattering matrix for small particles. Overall, this section provides a most welcome review and grounding in the necessary basics of the subject.

The next two sections form the backbone of the book and are concerned with reviewing developments in numerical techniques. The first of these has chapters covering the method of separation of variables, the discrete dipole approximation, the T-matrix method and the finite difference time domain (FDTD) technique. The second section pursues inhomogeneous particles with refractive index profiles, heterogeneous particles with inclusions, multiple interacting particles and aggregates. At the end of this section is a chapter reviewing developments to date in the theory of scattering by statistically irregular particles. This is very welcome in light of the fact that the bulk of natural particles are not regular in the sense that their shapes can be predicted.

The latter part of the book is the province of measurements and applications. Here it is slightly less satisfactory, being perhaps a little narrower in scope. Under measurements there is a description of one experimental method for the determination of the elements of the Stokes

matrix and a description of one microwave facility for large scale modelling of particles. The final section is a review of applications. This is largely concerned with environmental situations, covering LIDAR and radiative transfer methods for studies of clouds, microwave measurements of precipitation, scattering in marine environments and interplanetary dust. The book ends with a short chapter of biological applications. These are all interesting and useful illustrative examples, but I wonder whether a wider view may have been appropriate. Applications in industrial situations come to mind.

In summary this is a very worthwhile research publication. It is attractively presented and comprehensive. It will prove to be a most useful addition to the literature in the ever-expanding field of light scattering.

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Light scattering by nonspherical particles

Academic Press, San Diego, CA, USA 2000. XXX/690 pp., numerous figs., hardbound. US$ 125.00. ISBN 0-12-498660-9.

Dealing comprehensively with optical (and electromagnetic) scattering by paricles, this volume follows in the tradition of the venerable *Light Scattering by Small Particles* (van de Hulst HC, Wiley, New York 1957: Dover Press, New York 1981) and the equally famous *Absorption and Scattering of Light by Small Particles* (Bohren CH, Huffman DR, Wiley, New York 1983), as well as Mileslone Volumes of seminal papers reprinted by the SPIE Optical Engineering Press. The great merit of this volume over its predecessors is that it handles scattering by nonspherical panicles – a topic of enormous interest in many diverse disciplines and therefore possessed with a widely scattered scientific literature. In 5 parts together comprising 20 chapters, 31 authors present an excellent survey that will enormously benefit novice and non-specialist researchers and constitute a useful reference source for experienced specialist researchers.

Chapters 1–3 establish basic definitions and terminology, provide an excellent overview of the topic, and derive significant mathematical relationships pertaining to scattering by nonspherical particles. The next four chapters review the application of spheroidal wavefunctions, the coupled dipole approximation method, the T-matrix method, and the finite difference time domain method. Any researcher of note must have tolerable familiarity with at least one of the last three numerical methods. Ensembles of particles are treated in Chapters 8–11, out of which the reviewer must single out Chapter 8 for its mathematically elegant analysis of scattering by compounded spherical particles. The following two chapters, being the fourth part of the book, present laboratory techniques for optical measurements and their microwave analogs. The fifth part comprises the last seven chapters and takes the reader on a tour of various relevant applications: aerosols and hydrometeors, marine environment, interplanetary dust, and biological cells. After going through this volume, the reviewer, who was heavily involved in particulate scattering during the 1980s, became somewhat nostalgic and – more importantly – very aware of the major advances computational science has taken during the past decade.