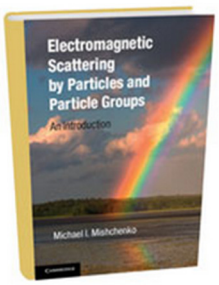
Book Reviews

Electromagnetic Scattering by Particles and Particle Groups: An Introduction

Michael I. Mishchenko

Cambridge, 2014, $70.00 (hardcover).



The author has two goals: first, to present the physical and mathematical principles behind the scattering and absorption of various types of electromagnetic radiation by particles and particle groups (such as the atmosphere, clouds etc.), and second, to unify all these phenomena into a single consistent branch of physical optics. I believe he has shown it can be done. The first third of the book develops electromagnetic theory via Maxwell's equations and their embellishments by Stokes and others in a very concise and elegant way. The rest of the book, using the theory previously developed, considers many real world examples. Although these examples are somewhat idealized, they are still all complex and difficult to analyze.

It is clear that a great deal of thought and care has been given to the organization and presentation of the material in the book. The only annoyance is the constant use of acronyms throughout, although there is a handy table of acronyms included. This book is not light reading, but it is worth the effort.

Review by Albert C. Claus, physics department at Loyola University, Chicago, Ill., USA.

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Electromagnetic Scattering by Particles and Particle Groups: An Introduction, by Michael I. Mishchenko, Cambridge, Cambridge University Press, 2014, 436 pp., £45.00 (hardback), ISBN 978-0-52-15199-22. Scope: monograph, textbook. Level: postgraduate, early career researcher, researcher.

The scattering of light by groups of particles leads to phenomena which are matters of common experience. Dust in the atmosphere leads to the sky appearing blue, refraction by water droplets results in rainbows and so on. These phenomena can be explained at a macroscopic

level without the need to delve too deeply into the equations that govern the propagation of electromagnetic radiation through inhomogeneous media. However, if we want to make quantitative predictions about, say, the amount of solar energy that will be reflected due to changes in the concentration and constituency of particles in the atmosphere or if we would like to use light scattering as a means of remotely ascertaining the physical makeup of a material such as the concentration of bubbles in a liquid, then we need to be rather more sophisticated. One approach, and the one to which this book is devoted, is to write down the full Maxwell equations for the system under consideration and then to see whether these can be appropriately simplified in certain circumstances to allow for direct numerical solutions to be computed. To be a bit more precise, it is assumed that the particles are discrete, isotropic and finite immersed in a homogeneous background medium and only elastic scattering processes are considered, i.e. those in which energy is conserved. This is a configuration which is applicable to many applications in, for example, chemistry, meteorology and astronomy.

The first few chapters of the book outline the general theory. This is unavoidably heavily mathematical in nature and this does not let up throughout the book. This in no way is meant as a criticism, but it is important to understand that this is a book which uses high-powered mathematics to extract interesting information from a complicated set of equations. Subsequent chapters look at approximations that can be made to simplify the equations and under what conditions these might be valid, and also at the sort of quantities that can be measured in practical experiments and how these can be extracted from the theory. After discussing many of the concepts in the context of scattering by a single particle, the book then goes on to examine the effect of groups of particles. In certain circumstances (such as when the particles are far apart), the effect of a group of particles can be calculated simply by treating the scattering by each of them independently and then adding up the results in an appropriate way. This is usually given the name single scattering. Much more interesting and challenging is the case where the mutual interactions between the scattered fields play an integral part in the scattering process, and this case (usually referred to as multiple scattering) is treated extensively utilising a variety of techniques. Another important issue is the random nature of the configuration of the particles, and the author spends considerable time explaining the various different averaging processes that are relevant and the relationship between them.

Overall, this is an excellent graduate-level textbook (there are a number of exercises at the end of each chapter with hints and answers to selected problems) which discusses a challenging set of problems. There are also a number of short sections which discuss the history of the subject and encourage further reading. At times, I felt that the author was trying to claim that the techniques and processes involved are straightforward when in reality they are not. I know from experience that there is a significant lack of understanding when it comes to related problems in acoustics, in which case the technicalities are much reduced. In the context of multiple scattering theory, it is not at all straightforward to assess a priori what the magnitude of the errors will be as a result of using a technique that relies on assumptions which are only valid in an approximate sense. There is a great deal more yet to be discovered about this interesting class of problems.

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