Optical Properties of Inhomogeneous Materials

APPLICATIONS TO GEOLOGY, ASTRONOMY, CHEMISTRY, AND ENGINEERING

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ACADEMIC PRESS New York San Francisco London 1979
A Subsidiary of Harcourt Brace Jovanovich, Publishers

ACADEMIC PRESS, INC.
111 Fifth Avenue, New York, New York 10003

United Kingdom Edition published by
ACADEMIC PRESS, INC. (LONDON) LTD.
24/28 Oval Road, London NW1 7DX

Library of Congress Cataloging in Publication Data

Egan, Walter G
Optical properties of inhomogeneous materials.

Bibliography: p.
1. Inhomogeneous materials--Optical properties.
I. Hilgeman, Theodore W., joint author. II. Title.
QC173.4.I53E34 535 78-20043
ISBN 0-12-232650-4

PRINTED IN THE UNITED STATES OF AMERICA

79 80 81 82 9 8 7 6 5 4 3 2 1

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PREFACE

The intent of the authors in writing this book was, first of all, to clarify the newest studies of the optical properties of inhomogeneous materials and then to provide a guide to solve a number of related scientific and engineering problems based on these studies. These problems may come about in research endeavors ranging from remote sensing, aerial reconnaissance, study of the atmosphere, and energy collector design to the study of the surfaces provided by paints and other coatings. The fields of geology, optical mineralogy, astronomy, chemistry, soil mechanics, mechanical engineering, and of course optics are involved. At the same time we have tried to maintain the level of treatment in this book at that of undergraduate optics.

Several reasons account for this approach being taken now. There has been a great advance in the past twenty years in the techniques for experimentally and theoretically analyzing surface scattering by optical methods. A major impetus for this advance came from the Lunar Landing Program. There was a need to obtain as much information about the lunar soil as possible by remote characterization before the landing of a man on the moon. Remote characterization was required in order that the Lunar Module, as well as the lunar roving vehicles, could be designed efficiently. The lunar landing configurations were in great part influenced by terrestrial optical simulation of the lunar surface by spectrophotometric and polarimetric techniques. This work has been extended to the study of the surface and atmosphere of Mars, the earth's atmosphere, and the interstellar medium. Other factors catalyzing the advances in surface modeling were the prevalence of computer facilities having high speed computational capacity and the availability of instruments such as the scanning electron microscope with the ability to reveal surface microstructure.

This book may well be the first to present all the tools necessary for modeling the radiation scattered from diffuse surfaces. Included are the optical complex indices of refraction of a variety of naturally occurring minerals and rocks, appropriate mathematical surface models of varying complexity, and representative computer programs. The plan is a logical development starting with a brief introduction to the formalism for optical properties of inhomogeneous materials. This introduction (Chapter I) assumes that the reader has some familiarity with complex notation and vector algebra and, in particular, with their applications to electromagnetic radiation. This chapter also brings together in a unified formalism, a number of necessary reference formulas such as Snell's law in complex form. There follows a description of surface scattering models in order of increasing complexity and a discussion of atmospheric scattering by particulates (Chapter II). Then, using techniques based on Chapters I and II, the experimental approaches for the determination of the refractive and absorptive components of the optical complex indices of refraction are presented in Chapters III and IV, respectively, with sample indices in Chapter V.

We follow with actual diffuse surface modeling examples in Chapter VI, using complex indices from Chapter V. Retroreflectance, the unique property of a diffuse surface, is treated in Chapter VII. Then applications are discussed in succeeding chapters: remote sensing of planetary surfaces (Chapter VIII); study of the interstellar medium (Chapter IX); research on thermal energy collectors (Chapter X); examination of coatings and paints (Chapter XI); and remote mineral exploration (Chapter XII). The appendixes provide computer codes that may be used for investigations described in this book.

ACKNOWLEDGMENTS

We are indebted to many individuals for their contributions, but we wish to single out the Research Department of the Grumman Aerospace Corporation for providing an excellent intellectual environment in which many of the innovations described in this book were conceived and for providing the laboratory and computer facilities where these ideas could be developed and applied.

We thank the following Grumman Aerospace Corporation and Data Systems personnel: J. Augustine for his help in performing the optical measurements on the rocks and minerals discussed in Chapter V, some of which were previously unpublished; A. Kaercher, T. Mc Givney, and R. Reisch for rendering the graphs of Chapters II and V; A. Cobrin for his cooperation in arranging typing and art services; and especially R. Scheuing and M. D'Agostino for their encouragement and support.

We thank H. Holt, U.S. Geological Survey, Flagstaff, Arizona, for furnishing many of the samples measured for Chapter V.

We are also grateful for the patience shown by our wives during the many hours that we have had to devote to this book.

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