牛津大学研究生教材系列

Modern Classical Optics

现代经典光学

G. Brooker

科学出版社
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科学出版社
北京

图字:01-2007-2794号

图书在版编目(CIP)数据

现代经典光学=Modern Classical Optics:英文/(英)布鲁克(Brooker, G.)著.—注释本.—北京:科学出版社,2009

(牛津大学研究生教材系列)

ISBN 978-7-03-023623-4

Ⅰ.现… Ⅱ.布… Ⅲ.光学-研究生-教材-英文 Ⅳ.043

中国版本图书馆CIP数据核字(2008)第201618号

责任编辑:胡凯 王飞龙/责任印制:钱玉芬/封面设计:王浩

科学出版社 出版

北京东黄城根北街16号

邮政编码:100717

http://www.sciencep.com

新蕾印刷厂 印刷

科学出版社发行 各地新华书店经销

*

2009年1月第一版 开本:787×1092 1/16

2009年1月第一次印刷 印张:26

印数:1~3 000 字数:501 000

定价:78.00元

(如有印装质量问题,我社负责调换<长虹>)

Preface

The level of treatment in this book is that of the fourth year of an M. Phys. undergraduate course in the UK. However, I have tried to give descriptions that are simple enough to be followed by someone at an earlier stage who seeks a 'different' account of the more basic material. And graduates may find that some 'well-understood' ideas offer unexpected challenges. The topics included here are more than could be covered in the time available in any one undergraduate course, but different courses will, quite properly, make different selections of material.

I concentrate on 'physical' optics (light as a wave), and describe only as much geometrical optics as is really necessary. A thick lens is mentioned only three times. Lens design and optical aberrations are hardly mentioned at all, and then in terms of an optical transfer function rather than Seidel sums. I justify this exclusion on the ground that lens design is now wholly done by computer-aided optimization, description of which would require a very different style of presentation.

This book might better have been called 'semi-classical optics', since the photon nature of light is not ignored. Indeed, photon emission and detection are inherently quantum-mechanical. However, our main concern, the passage of light between emission and detection, can usually be treated classically. Those phenomena, such as entanglement or antibunching, that require 'quantum optics' proper lie outside our remit. Even so, I have tried, in Chapter 10, to explain where the interface lies between the (semi-)classical and quantum regimes.

In a book of this length, some selection of topics is unavoidable, even within physical optics. In particular I regret the omission of interference microscopes (too large a digression) and of adaptive optics applied to Earth-bound astronomical telescopes (too computational).

A book is a linear structure: from beginning to end. Understanding is not like that. It's achieved by reading interactively: checking calculations; cross-linking new information with old; asking 'what if'; thinking of implications and possible objections. Why is μ_r always assumed to be 1 at optical frequencies? Why is an electromagnetic wave always discussed in terms of its $\boldsymbol{E}$-field when $\boldsymbol{B}$ is equally significant in the Maxwell equations? A Fabry–Perot and a thin film are very similar structures; why then are the methods of analysis so different? Can we trust the Kirchhoff-assumption boundary conditions used in diffraction, and how could we find out? Why are the fields inside a laser cavity mathematically similar to the wave functions for a simple harmonic oscillator? The bright student will want answers to such questions, and if a full answer can't be given at this level then at least s/he wants to be given reassurance that the questions are not regarded as troublemaking. The less imaginative should be encouraged by example to see that these are the kind of questions that ought to be asked.

Critical questions shouldn't be allowed to clutter the exegesis, yet a place must be found for them. I have therefore put much exploratory material into 'problems'. A 'problem' is not necessarily an exercise set (though it may be) by the author or at his suggestion by a teacher; it is often an opportunity to make statements (to be checked) about special cases, to point out a link to a similar idea elsewhere, or to encourage discrimination by challenging the 'well-known'. In short, problems are meant to be read, as a commentary integral to the material; the reader can decide which ought to be worked through in detail as well. Most problems are referenced at an appropriate point in the text, to indicate that additional information or critical discussion is available. Solutions are given where mathematical steps are not all obvious or where the physics needs (even more!) discussion.

Problems are graded on a three-point scale from the most basic (a), usually easy, to the most challenging (c). A few 'entertainment' problems, labelled (e), are opportunities to take a wider view. Whatever its classification, each problem is intended to draw attention to some insight, technique or order of magnitude.

This book has grown out of lecture courses that I have given, over a number of years and at different levels. (The author sometimes complains that the Oxford Physics Department has type-cast him as an optician.) The content and attitude have been strongly influenced by frequent interaction with students, one or two at a time, in tutorial discussions that range over most areas of degree-level physics. To those students who asked searching questions or insisted on clearer explanations, I owe a great debt.

Several colleagues have contributed to this book, not always knowingly, by reading it in draft or via a number of discussions. I am particularly indebted to Professor D. N. Stacey and Professor C. E. Webb for their patience in the discussion of a number of tricky points. Dr S. J. Blundell is responsible for an improvement in the clarity of Chapter 5. Mr C. Goodwin very kindly supplied the practical detail on thin-film deposition in Chapter 6. Dr J. Halliday was most helpful in providing information on CD and DVD technology. Dr R. A. Taylor gave valuable help with the description of LEDs in Chapter 11.

I thank Springer-Verlag for permission to reproduce Figs 3.8, 3.9 and 3.12 from the *Atlas of Optical Phenomena*. I thank the IEEE and Dr H. Kogelnik for permission to reproduce Fig. 8.3. I thank Lucent Technology and Drs Fox, Li, Boyd and Gordon for permission to base Fig. 8.7 on a diagram that originally appeared in the *Bell System Technical Journal*. All other diagrams were prepared by the author.

Finally, I thank Marlene, who in her last three years shared less time with me than we both would have wished because this book was in preparation.

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