Introduction to OPTICAL TESTING

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Introduction to the Series

These Tutorial Texts provide an introduction to specific optical technologies for both professionals and students. Based on selected SPIE short courses, they are intended to be accessible to readers with a basic physics or engineering background. Each text presents the fundamental theory to build a basic understanding as well as the information necessary to give the reader practical working knowledge. The included references form an essential part of each text for the reader requiring a more in-depth study.

Many of the books in the series will be aimed at readers looking for a concise tutorial introduction to new technical fields, such as CCDs, sensor fusion, computer vision, or neural networks, where there may be only limited introductory material. Still others will present topics in classical optics tailored to the interests of a specific audience such as mechanical or electrical engineers. In this respect the Tutorial Text serves the function of a textbook. With its focus on a specialized or advanced topic, the Tutorial Text may also serve as a monograph, although with a marked emphasis on fundamentals.

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Donald C. O'Shea
Georgia Institute of Technology

August 1993

Contents

Chapter 3. Interferometric Testing of Optical Systems

Chapter 4. Wavefront Sensors

Chapter 5. General Light Beam Measurements

Chapter 6. Component Measurements

Preface

This tutorial is a practical "how to" course in optical testing. The approach taken is not unlike a guided lab tour. We explain what we are trying to measure and how to go about it. Emphasis is therefore on techniques, procedures, and instrumentation rather than mathematical analysis. The goal is to provide a basic understanding of the measurements made, and the tools used to make those measurements.

Optical testing instrumentation has certainly improved over the decades. Electronics are more compact. Detectors are more sensitive and have better signal to noise. Lasers have made interferometry practical. Computers are ubiquitous. They drive experiments, position components, collect, analyze, and display data. Tests can be conducted which were once prohibitive because of the sheer volume of data required. Such improvements have made optical testing easier. They have not altered the fundamental principles of optical testing.

Optical instruments measure information carried by light. Interest lies either in the light itself, or some modification made by interaction with an object under study. The characteristics of light that are susceptible to measurement are intensity, phase, color, polarization, coherence, and directionality. Among other things, the reader will learn how to measure and characterize imaging systems, perform optical bench measurements to determine first and third order properties of optical systems, set up and operate the Fizeau interferometer and evaluate fringe data, conduct beam diagnostics (such as wavefront sensing), and perform radiometric calibrations.

The level of the text is not taxing. However, any previous exposure to geometric and physical optics, either in the form of an undergraduate course or text (at the level of *Optics* by Hecht and Zajac), or through some practical hands-on experience, would certainly be helpful.

This tutorial had its origins at New Mexico State University. Every May, at the conclusion of the regular semester, the Applied Optics Lab offers a series of short courses in optics. The courses cover a variety of topics, and are open to government, industry, and academic professionals.

When initially asked to prepare this tutorial I hesitated because of the large number of figures involved, and my poor talent as an artist. I therefore owe a debt of gratitude first to Dr. Tom Wilson of Swales & Associates for providing support for the illustrations; and second, to Mike Scriven whose fine artistic talents transformed my crude drawings into professional illustrations.

This tutorial would never have been completed without the substantial help of Rick Hermann and Eric Pepper at SPIE. I must also thank Dr. Don O'Shea (Georgia Institute of Technology) and Dr. John Loomis (University of Dayton) for reviewing the manuscript and providing a wealth of suggestions which have greatly improved the text.

I would like to dedicate this work to two of my mentors in optical testing: Mr. Bill Folger and Dr. Jim Wyant. At the Naval Air Development Center (now Naval Air Warfare Center) Bill patiently taught me the ins and outs, dos and don'ts of photographic testing of aerial cameras. When I was a student at the Optical Sciences Center (University of Arizona), Jim opened up the fascinating world of interferometry for me, and guided my Master's thesis. The knowledge I gained from these gentlemen about optical testing has been of great value in my career.

Joseph Geary
July 1993