Preface

Apart from a number of small corrections and updates, the main change with respect to the first edition is that a set of problems is provided at the end of each chapter, except the last one. The problems deal with numerical computations designed to illustrate the magnitudes of important quantities, and are also meant to reinforce the understanding of the material presented and to test the students' ability to apply theoretical formulas.

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May 2015

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Preface to the First Edition

The invention of the laser in 1960 has brought new ideas and new methods to many areas of science and technology. Starting from the consideration that, in a simplified view, a light beam can be seen as a stream of energy quanta, known as photons, the name "photonics" has been coined, in analogy to electronics, to indicate the generation and use of photon streams for engineering applications. The applications of photonics are everywhere around us from long-distance communications to DVD players, from industrial manufacturing to health-care, from lighting to image formation and display.

Many university programs in electrical engineering and applied physics propose courses on photonics. Our aim is to offer a concise, rigorous, updated book, that can serve as a textbook for an advanced undergraduate course. We believe that the book can be also useful for graduate students, professionals, and researchers who want to understand the principles and the functions of photonic devices.

The description of photonic devices essentially consists in a treatment of the interactions between optical waves and materials. When the interaction is non-resonant, an approach using Maxwell's equations and the macroscopic optical

properties of materials is adequate. The description of optical amplification processes is more complex, because it becomes unavoidable to introduce quantum concepts. Our aim is to make laser action in atomic and semiconductor systems understandable also to an audience that has little background in quantum mechanics. Since photonics is based on a very fruitful interplay between physics and engineering, we have tried to keep the balance between these two aspects in all chapters. In order to give a feeling for the correct order of magnitudes of the discussed phenomena, several numerical examples are given throughout the book.

The book is divided into eight chapters. The first two chapters provide the background in electromagnetism and optics for the entire book. In particular, the second chapter describes the main optical components and methods of linear radiation–matter interactions. The third chapter covers the principles of lasers, and the properties of continuous and pulsed laser sources. Chapters 4 and 7 deal with nonlinear interactions that produce processes such as modulation, switching, and frequency conversion of optical beams. Chapter 5 describes photonic devices based on semiconductors, including not only lasers, but also light-emitting diodes and photodetectors. The properties of optical fibers, and of different fiber-optic components and devices are the subject of Chap. 6. The last chapter discusses the most important applications, emphasizing the main principles, while avoiding detailed technical descriptions that may quickly become obsolete in this rapidly changing field. Introductory information is also given on arguments of particular practical importance, such as solid-state lighting, displays, and photovoltaic cells.

It should be emphasized that the invention of the laser has deeply affected many fields of research, either by putting topics, such as optical spectroscopy, light scattering, and coherence theory on a completely different footing, or by creating entirely new topics, such as the physics of coherent light sources, nonlinear optics and quantum optics. Our text does not touch upon those new topics that generally require a deeper understanding of quantum concepts. The only exception is nonlinear optics, which can be mostly discussed in classical terms.

The book systematically uses the SI metric system with the exception of the use of the electron volt (eV) for the energy of photons and atomic levels. The system of units is summarized in Appendix A, together with a list of values of some fundamental physical constants. Use of acronyms is kept to a minimum, and the list of those used is given in Appendix B.

The book is intended to be self-contained. The prerequisites include a background knowledge from standard courses in general physics, electromagnetic fields, and basic electronics. Some background in quantum physics would be helpful. Considering the level of treatment, we have judged it not useful to provide references to articles that have appeared in scientific journals. Instead, to help an interested reader gain a deeper insight into the fundamentals of photonics or into a particular application, a bibliography containing a selection of a few excellent reference books is given.

We are especially indebted to Lee Carroll for providing us with many suggestions that greatly improved the presentation. We also acknowledge useful conversations with Antoniangelo Agnesi, Cosimo Lacava, Roberto Piazza, and Giancarlo Reali.

Pavia, Italy
February 2014

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http://www.springer.com/978-3-319-20626-4

Photonics
A Short Course
Degiorgio, V.; Cristiani, I.
2016, XII, 253 p. 124 illus., Softcover
ISBN: 978-3-319-20626-4