Preface

Since the invention of the laser in 1960 there has been an enormous increase in the number of applications of this newly available light and its spectacular properties, and there is no end to this development in sight. In many fields of science, technology and medicine laser photons are the driving force of progress. In the near future we will probably experience a further rapid development in this field as a result of the widespread industrial production of semiconductor diode lasers and new nonlinear optical materials. Light from the new lasers may become even cheaper than that from light bulbs. Thus, laser optic devices will influence all sectors of private and public life.

The high power, high brightness, narrow bandwidth, good coherence, special polarization and/or short pulses of laser light beams enable new applications. Many of these processes will be based on nonlinear optical interactions of the laser light with suitable optical material. In these interactions the material is modified by the incident light. The light is then in turn modified by the modified matter. Finally, the nonlinear modification of light as a function of other light becomes possible. Light is modified by light.

To use laser light in this sense in science, technology and medicine, knowledge from different fields of physics, chemistry and engineering is necessary. Besides conventional optics, which is essential in all laser light applications, a large field of new physical phenomena has to be considered. This book assembles the necessary knowledge ranging from the basic principles of quantum physics to the methods describing light and its linear and nonlinear interactions with matter, to practical hints on how the different types of lasers and spectroscopic and other measuring techniques can be applied. So that the book remains handy and readable, the description focuses on newer concepts in a compressed form. Nevertheless, many examples, tables and figures allow direct access for answering practical questions.

In this book, nonlinear physical processes in which laser photons are used as a tool will be summarized under the term *photonics*. This term was introduced by engineers at the Bell Laboratories to describe the optical analogy of electronic devices in electronic communication technologies; here, photons are the information-carrying particles. But the word is used today to cover nonlinear optics and quantum optics, too.

Thus, photonics will become more and more fundamental in the key technologies of the future. Communication and data processing, transportation and traffic, medicine and biotechnologies, new materials and material processing, environmental pollution detection and conservation and power production will be promoted by photonics. As a consequence of this rapid development, scientists and engineers in many fields of research and technology need some basic knowledge in photonics.

Therefore, fundamental laws from the different fields of the large area of photonics are described in this book in a more or less phenomenological way. As far as possible the basic equations are given and the principles of their derivation are mentioned. Exemplary material constants and calculated results are collected in tables to aid direct use of the information. Examples illustrate the physical relations. Thus, this book may be used as a guide to the basics of photonics on the one hand, and as a laboratory manual for designing new experiments and estimating wanted or unwanted laser light effects on the other hand.

The different topics of photonics are described at graduate level. Thus, the book should be useful for students and graduates of physics, electrical engineering, chemistry and biology for learning purposes and as a reference. The articles and textbooks cited should enable extended studies of related topics to be undertaken. Interested non-specialists from other fields may learn at least the basic of photonics by skipping details of the description.

Therefore, the subject is described in combination with practical questions such as: How can I measure this? How do I have to set up this apparatus? What are the physical limits of this application? The representation is based on more than 20 years' experience in laser research and nonlinear spectroscopy as taught in many lectures for physicists and chemists. Of course the description is not complete, and rapid further progress is expected in this area. Nevertheless, it will serve as an introduction to this field.

Photonics uses knowledge from conventional optics, electromagnetism and quantum mechanics. Essential information from these fields is described with respect to their importance. In the first chapter different topics of photonics are described in an overview. The subsequent analysis of the properties and the description of light in the second chapter are essential for the understanding of nonlinear phenomena. Although photonics deals mostly with nonlinear optics, in Chap. 3 some linear interactions of light with matter are treated first. Then the description of nonlinear interactions of light with matter follows in Chap. 4 for transparent matter, and in Chap. 5 for absorbing matter. These two chapters provide basic knowledge for all kinds of photonic applications. Because the laser as a light source is the fundamental tool for almost all photonics, a brief description of the main principles and their consequences is given in Chap. 6. This includes a short description of the main parameters of common laser systems and the principles of generating light with special properties such as short pulses or high brightness. As

applications of those subjects, on the one hand, and as a precondition for examining applications, on the other hand, some fundamentals of nonlinear spectroscopy are described in Chap. 7.

A large number of references allows direct access to the detailed scientific research results in the field. The selected articles are cited with all authors, the full title and the number of pages, and are arranged in descending year order per topic. Considering this information and the title of the journal may help to select the most useful articles from the list for the reader's purpose. In addition, the related section is cited as {Sect. ...} and thus the references of a section can be read almost separately. In these references also additional effects and their applications are described. The descriptions in this book allow a general understanding of these specialized articles. It may be worth searching for a special reference in the chapters describing the basics as well as in the applications part of the book because the references are cited usually only once. These references represent mostly current research topics. The pioneering work, if not explicitly given, can be traced back from these articles. Many of the measured material parameters have slightly different values. In the sense used in this book the most probable or averaged values are given without a detailed discussion. For details the references with their cited literature shall be used.

For further general reading some selected textbooks are given (cited as monographs [M...]). The titles and publications years may be used for guidance.

Questions, comments and corrections are welcome and can be sent to the author via the e-mail address: photonics_menzel@springer.de.

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The list of people I would like to express my thanks to is much too long for the space available. Therefore, I would first like to thank all those people who have contributed to the text in a more or less indirect way and are not quoted here. There is no harm intended if someone is not explicitly mentioned or referred to. I am aware that the overwhelming part of this text has been developed by the common activities of the scientific community in this field and has been published in other textbooks or articles. In some cases it may even be difficult to identify the originator of the ideas and descriptions directly. Therefore, I would like to thank all those open-minded colleagues in science and industry for the possibility of being involved in discussions about these topics over the years.

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Contents