Preface

It is exactly 50 years since the first laser was realized. Lasers emit coherent electromagnetic radiation, and ever since their invention, they have assumed tremendous importance in the fields of science, engineering, and technology because of their impact in both basic research as well as in various technological applications. Lasers are ubiquitous and can be found in consumer goods such as music players, laser printers, scanners for product identification, in industries like metal cutting, welding, hole drilling, marking, in medical applications in surgery, and in scientific applications like in spectroscopy, interferometry, and testing of foundations of quantum mechanics. The scientific and technological advances have enabled lasers spanning time scales from continuous operation up to as short as a hundred attoseconds, wavelengths spanning almost the entire electromagnetic spectrum up to the X-ray region, power levels into the terawatt region, and sizes ranging from tiny few tens of nanometers to lasers having a length of 270 km. The range of available power, pulse widths, and wavelengths is extremely wide and one can almost always find a laser that can fit into a desired application be it material processing, medical application, or in scientific or engineering discipline. Laser being the fundamental source with such a range of properties and such wide applications, a course on the fundamentals and applications of lasers to both scientists and engineers has become imperative.

The present book attempts to provide a coherent presentation of the basic physics behind the working of the laser along with some of their most important applications and has grown out of the lectures given by the authors to senior undergraduate and graduate students at the Indian Institute of Technology Delhi.

In the first part of the book, after covering basic optics and basic quantum mechanics, the book goes on to discuss the basic physics behind laser operation, some important laser types, and the special properties of laser beams. Fiber lasers and semiconductor lasers which are two of the most important laser types today are discussed in greater detail and so is the parametric oscillator which uses optical nonlinearity for optical amplification and oscillation and is one of the most important tunable lasers. The coverage is from first principles so that the book can also be used for self study. The tutorial coverage of fiber lasers given in the book is unique and should serve as a very good introduction to the subject of fiber amplifiers and lasers.

Toward the end of the first part of the book we discuss quantization of electromagnetic field and develop the concept of photons, which forms the basic foundation of the field of quantum optics.

The second part of the book discusses some of the most important applications of lasers in spatial frequency filtering, holography, laser-induced fusion, light wave communications, and in science and industry. Although there are many more applications that are not included in the book, we feel that we have covered some of the most important applications.

We believe that the reader should have some sense of perspective of the history of the development of the laser. One obvious way to go about would be to introduce the reader to some of the original papers; unfortunately these papers are usually not easy to read and involve considerable mathematical complexity. We felt that the Nobel lectures of Charles H Townes, Nicolai G Basov, and A M Prokhorov would convey the development of the subject in a manner that could not possibly be matched and therefore in the third part of the book we reproduce these Nobel Lectures. We have also reproduced the Nobel lecture of Theodor W Hansch who in 2005 was jointly awarded the Nobel Prize for developing an optical "*frequency comb synthesizer*," which makes it possible, for the first time, to measure with extreme precision the number of light oscillations per second. The frequency comb techniques described in the lecture are also offering powerful new tools for ultrafast physics.

Numerical examples are scattered throughout the book for helping the student to have a better appreciation of the concepts and the problems at the end of each chapter should provide the student with gaining a better understanding of the basics and help in applying the concepts to practical situations. Some of the problems are expected to help the reader to get a feel for numbers, some of them will use the basic concepts developed in the chapter to enhance the understanding and a few of the problems should be challenging to the student to bring out new features or applications leading perhaps to further reading in case the reader is interested. This book could serve as a text in a course at a senior undergraduate or a first-year graduate course on lasers and their applications for students majoring in various disciplines such as Physics, Chemistry, and Electrical Engineering.

The first edition of this book (entitled LASERS: Theory & Applications) appeared in 1981. The basic structure of the present book remains the same except that we have added many more topics like Erbium Doped Fiber Lasers and Amplifier, Optical Parametric Oscillators, etc. In addition we now have a new chapter on Semiconductor Lasers. A number of problems have now been included in the book which should be very useful in further understanding the concepts of lasers. We have also added the Nobel Lecture of Theodor Hansch. Nevertheless, the reader may find some of the references dated because they have been taken from the first edition.

We hope that the book will be of use to scientists and engineers who plan to study or teach the basic physics behind the operation of lasers along with their important applications.

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