

Preface

The laser belongs to one of the most fascinating fields in modern physics since its first experimental demonstration in 1960 by T. H. Maiman. The laser itself and its applications have fundamentally influenced many fields in modern physics as well as in many other sciences—some of which only become possible through the existence of the laser. The outstanding quantum-mechanical properties of laser radiation, for example its coherence and interaction with atoms or molecules, opened new fields of research, from spectroscopy in physics, chemistry and biology to information processing, materials science and general metrology, and to some of the probably most fascinating fields of physics: the laser allows us to create and study extreme states of matter such as Bose-Einstein condensates or degenerate Fermi gases. It opens a way to important investigations in quantum mechanics, has a big impact on solid-state physics and electronics by creating a need for more and more efficient light sources such as laser diodes and it made the demonstration and exploitation of the interesting field of non-linear optics possible. The laser will provide an enormous contribution also in the future, to discover gravitational waves, to create extremely hot and dense matter, for example for inertial fusion, and it opens the way to understand the fundamentals of physics at ultra-short time scales, which has become possible only owing to the existence of femto- and atto-second laser pulses.

This text book originates from a lecture in laser physics at the Karlsruhe School of Optics and Photonics at the Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, which has been given there since 2008. A main item in the conception of this text book was, to describe the fundamentals of lasers in a uniform and especially lab-oriented notation and formulation, as well as many currently well-known laser types, becoming more and more important in the future. It closes a gap between, for example, the measurable spectroscopic quantities and the whole theoretical description and modelling.

This text book contains not only the fundamentals and the context of laser physics in a mathematical and methodical approach important for university-level studies. It allows simultaneously, owing to its conception and its modern notation, to directly implement and use the learned matter in the practical lab work. It is presented in a format suitable for everybody, who wants to not only understand the fundamentals

of lasers, but also use modern lasers or even develop and make laser setups. This text book tries to limit prerequisite knowledge and fundamental understanding to a minimum and is intended for students in physics, chemistry and mathematics after a bachelor degree, with the intention to create as much joy and interest as seen among the participants of the corresponding lecture.

This university text book describes in its first three chapters the fundamentals of lasers: light-matter interaction, the amplifying laser medium and the laser resonator. In the fourth chapter, pulse generation and related techniques are presented and investigated. The fifth chapter gives a closing overview on to different laser types gaining importance currently and in the future. It also serves as a set of examples, on which the theory learned in the first four chapters is applied and extended.

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Laser Physics

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