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Laser Physics and Applications

Subvolume A: Laser Fundamentals

Part 2

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Preface

The three volumes VIII/1A, B, C document the state of the art of "Laser Physics and Applications". Scientific trends and related technological aspects are considered by compiling results and conclusions from phenomenology, observation and experiments. Reliable data, physical fundamentals and detailed references are presented.

In the recent decades the laser source matured to an universal tool common to scientific research as well as to industrial use. Today the main technical goal is the generation of optical power towards shorter wavelengths, shorter pulses, higher efficiency and higher power for applications in science and industry. Tailoring the optical energy in wavelength, space and time is a requirement for the investigation of laser-induced processes, i.e. excitation, non-linear amplification, storage of optical energy, etc. According to the actual trends in laser research and development, Vol. VIII/1 is split into three parts: Vol. VIII/1A with its two subvolumes 1A1 and 1A2 covers laser fundamentals, Vol. VIII/1B deals with laser systems and Vol. VIII/1C gives an overview on laser applications.

In Vol. VIII/1A2 the following topics are treated in detail:

Part 5: Quantum optics

The quantum aspects of the electromagnetic field, represented by the photon, become of increasing importance, not only in scientific research, but also in applications. Examples are the stabilization of lasers and the lower limit of bandwidth, but also the entangled photons, quantum cryptography and their use in information technology.

This part compiles the basic elements of quantum aspects, starting with the quantization of the electromagnetic field, discussing the crucial experiments to prove the Bell inequality and Bose-Einstein condensation. The basic process of the laser, the mechanism of atom-field interaction, is presented in detail.

Part 6: Coherence and superradiance

In Part 6.1 the basic concepts of coherence including photon statistics are presented for classical and non-classical light. The parameters of interest to characterize the degree of temporal and spatial coherence are defined and experimental setups for their measurement are discussed. Part 6.2 deals with superradiance, also known as superfluorescence, amplified spontaneous emissions (ASE), or cooperative spontaneous emission, predicted already 1954 by Dicke. Although long time a phenomenon of more academic interest, it becomes now of importance for X-ray lasers, which operate mainly in the ASE-regime.

Part 7: Optical components

In three parts, the engineering aspects of modulators, thin-film technology, and beam shaping are compiled. For additional optical components see "Linear optics" (Part 3 of Vol. VIII/1A1).

The modulation of light is essential for most applications in data transmission as well as in material processing. The two relevant modulators, the electro-optical and the acousto-optical systems, are discussed in detail in Part 7.1 with many useful parameters in several tables.

Mirrors, polarizers and beam splitters are elements of major importance for the generation and handling of laser radiation. The quality of optical elements is in many cases the limiting factor for laser efficiency and output intensity. Therefore, thin-film technology plays a key role in laser engineering. In Part 7.2 the basis elements of thin-film systems are presented and the principles of production are compiled. The crucial quality parameters and their measurement are discussed in detail. The extensive references give access to detailed information.

In many cases, especially in material processing, the intensity structure of the laser output field has to be adapted to the special application. This requires beam shaping. Part 7.3 summarizes various elements of low-loss beam transforming with experimental examples.

Part 8: Optical resonators

Laser parameters as beam quality, output power, efficiency, misalignment sensitivity, intensity structure are determined by the optical resonator. In this part all types of optical resonators (stable, unstable, linear devices, ring resonators, wave-guide systems) are compiled together with experimental results and data relevant for a reliable construction. Special emphasis is laid on the real amplifying medium, which strongly influences the resonator by thermal effects and gain saturation.

Part 9: Interferometry

Although a classical field of metrology, it has become of increasing importance with the availability of coherent light sources and is on the way to become a powerful tool in many fields of optics. Part 9 starts with the basic facts of interference and coherence. All relevant interferometer types are described in detail. An extensive survey on the special procedures of measurement techniques including new methods as speckle interferometry, adaptive optics or digital holography is given. Many experimental results complete this part. A comprehensive list of references allows to gather detailed information.

August 2006 The Editors

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