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Lasers and laser-related equipment — Test methods for determination of the shape of a laser beam wavefront —

Part 2: **Shack-Hartmann sensors**

Lasers et équipements associés aux lasers — Méthodes d'essai pour la détermination de la forme du front d'onde du faisceau laser —

Partie 2: Senseurs Shack-Hartmann

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15367-2 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Electro-optical systems*.

ISO 15367 consists of the following parts, under the general title *Lasers and laser-related equipment — Test methods for determination of the shape of a laser beam wavefront*:

— *Part 1: Terminology and fundamental aspects*

— *Part 2: Shack-Hartmann sensors*

Introduction

Characterization of the beam propagation behaviour is necessary in many areas of both laser system development and industrial laser applications. For example, the design of resonator or beam delivery optics strongly relies on detailed and quantitative information over the directional distribution of the emitted radiation. On-line recording of the laser beam wavefront can also accomplish an optimization of the beam focusability in combination with adaptive optics. Other relevant areas are the monitoring and possible reduction of thermal lensing effects, on-line resonator adjustment, laser safety considerations, or “at wavelength” testing of optics including Zernike analysis.

There are four sets of parameters that are relevant for the laser beam propagation:

— power (energy) density distribution (ISO 13694);

— beam widths, divergence angles and beam propagation ratios (ISO 11146-1 and ISO 11146-2);

— wavefront (phase) distribution (ISO 15367-1 and this part of ISO 15367);

— spatial beam coherence (no current standard available).

In general, a complete characterization requires the knowledge of the mutual coherence function or spectral density function, at least in one transverse plane. Although the determination of those distributions is possible, the experimental effort is large and commercial instruments capable of measuring these quantities are still not available. Hence, the scope of this standard does not extend to such a universal beam description but is limited to the measurement of the wavefront, which is equivalent to the phase distribution in case of spatially coherent beams. As a consequence, an exact prediction of beam propagation is achievable only in the limiting case of high lateral coherence.

A number of phase or wavefront gradient measuring instruments are capable of determining the wavefront or phase distribution. These include, but are not limited to, the lateral shearing interferometer, the Hartmann and Shack-Hartmann wavefront sensor, and the Moiré deflectometer. In these instruments, the gradients of either wavefront or phase are measured, from which the two-dimensional phase distribution can be reconstructed.

In this document, only Hartmann and Shack-Hartmann wavefront sensors are considered in detail, as they are able to measure the wavefront of both fully coherent and partially coherent beams. A considerable number of such instruments are commercially available.

The main advantages of the Hartmann technique are

— wide dynamic range,

— high optical efficiency,

— suitability for partially coherent beams,

— no requirement of spectral purity,

— no ambiguity with respect to 2π increment in phase angle,

— wavefronts can be acquired/analysed in a single measurement.

Instruments which are capable of direct phase or wavefront measurement, as, e.g. self-referencing interferometers, are outside the scope of this part of ISO 15367.

