TECHNICAL REPORT

ISO/TR 11146-3

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Lasers and laser-related equipment — Test methods for laser beam widths, divergence angles and beam propagation ratios —

Part 3:
Intrinsic and geometrical laser beam classification, propagation and details of test methods

Lasers et équipements associés aux lasers — Méthodes d'essai des largeurs du faisceau, des angles de divergence et des facteurs de propagation du faisceau —

Partie 3: Classification intrinsèque et géométrique du faisceau laser, propagation et détails des méthodes d'essai

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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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 11146-3 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Electro-optical systems*.

This first edition of ISO/TR 11146-3, together with ISO 11146-1, cancels and replaces ISO 11146:1999, which has been technically revised.

ISO 11146 consists of the following parts, under the general title *Lasers and laser-related equipment — Test methods for laser beam widths, divergence angles and beam propagation ratios*:

— *Part 1: Stigmatic and simple astigmatic beams*

— *Part 2: General astigmatic beams*

— *Part 3: Intrinsic and geometrical laser beam classification, propagation and details of test methods* (Technical Report)

Introduction

The propagation properties of every laser beam can be characterized within the method of second-order moments by ten independent parameters. However, most laser beams of practical interest need less parameters for a complete description due to their higher symmetry. These beams are stigmatic or simple astigmatic, e.g. due to the used resonator design.

The theoretical description of beam characterization and propagation as well as the classification of laser beams based on the second-order moments of the Wigner distribution is given in this part of ISO 11146.

The measurement procedures introduced in ISO 11146-1 and ISO 11146-2 are essentially based on (but not restricted to) the acquisition of power (energy) density distributions by means of matrix detectors, as for example CCD cameras. The accuracy of results based on these data depends strongly on proper data pre-processing, namely background subtraction and offset correction. The details of these procedures are given here.

In some situations accuracy obtainable with matrix detectors might not be satisfying or matrix detectors might simply be unavailable. In such cases, other, indirect methods for the determination of beam diameters or beam width are viable alternatives, as long as comparable results are achieved. Some alternative measurement methods are presented here.

Lasers and laser-related equipment — Test methods for laser beam widths, divergence angles and beam propagation ratios —

Part 3: **Intrinsic and geometrical laser beam classification, propagation and details of test methods**

1 Scope

This part of ISO 11146 specifies methods for measuring beam widths (diameter), divergence angles and beam propagation ratios of laser beams in support of ISO 11146-1. It provides the theoretical description of laser beam characterization based on the second-order moments of the Wigner distribution, including geometrical and intrinsic beam characterization, and offers important details for proper background subtraction methods recommendable for matrix detectors such as CCD cameras. It also presents alternative methods for the characterization of stigmatic or simple astigmatic beams that are applicable where matrix detectors are unavailable or deliver unsatisfying results.

2 Second-order laser beam characterization

2.1 General

Almost any coherent or partially coherent laser beam can be characterized by a maximum of ten independent parameters, the so-called second-order moments of the Wigner distribution. Laser beams showing some kind of symmetry, stigmatism or simple astigmatism, need even fewer parameters. The knowledge of these parameters allows the prediction of beam properties behind arbitrary aberration-free optical systems.

Here and throughout this document the term “power density distribution $E(x,y,z)$” refers to continuous wave sources. It might be replaced by “energy density distribution $H(x,y,z)$” in the case of pulsed sources. Furthermore, a coordinate system is assumed where the z axis is almost parallel to the direction of beam propagation and the x and y axes are horizontal and vertical, respectively.

2.2 Wigner distribution

The Wigner distribution $h(x,y,\Theta_x,\Theta_y;z)$ is a general and complete description of narrow-band coherent and partially coherent laser beams in a measurement plane. Generally speaking, it gives the amount of beam power of a beam passing the measurement plane at the lateral position (x,y) with a horizontal paraxial angle of Θ_x and a vertical paraxial angle of Θ_y to the z axis, as shown in Figure 1.

NOTE The Wigner distribution is a function of the axial location z, i.e. the Wigner distribution of the same beam is different at different z locations. Hence, quantities derived from the Wigner distribution are in general also functions of z. Throughout this document this z dependence will be dropped. The Wigner distribution then refers to an arbitrarily chosen location z, the measurement plane.

