SLOVENSKI STANDARD
oSIST prEN ISO 11146-1:2020

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Laserji in laserska oprema - Preskusne metode za širine laserskega žarka, kota divergence in faktorja širjenja žarkov - 1. del: Stigmatični in enostavni astigmatični žarki (ISO/DIS 11146-1:2020)

Lasers and laser-related equipment - Test methods for laser beam widths, divergence angles and beam propagation ratios - Part 1: Stigmatic and simple astigmatic beams (ISO/DIS 11146-1:2020)

Laser und Laseranlagen - Prüfverfahren für Laserstrahlabmessungen, Divergenzwinkel und Beugungsmaßzahlen - Teil 1: Stigmatische und einfach astigmatische Strahlen (ISO/DIS 11146-1:2020)

Lasers et équipements associés aux lasers - Méthodes d'essai des largeurs du faisceau, angles de divergence et facteurs de limite de diffraction - Partie 1: Faisceaux stigmatiques et astigmatiques simples (ISO/DIS 11146-1:2020)

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

Part 1: Stigmatic and simple astigmatic beams

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Partie 1: Faisceaux stigmatiques et astigmatiques simples

ICS: 31.260

IMPORTANT — Please use this updated version dated 2020-02-27, and discard any previous versions of this DIS. Formulae have been corrected and the ballot dates have been changed.

This document is circulated as received from the committee secretariat.

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Contents

Page

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 172, *Optics and Photonics*, Subcommittee SC 9, *Laser and electro-optical systems*.

This second edition cancels and replaces the first edition (ISO 11146-1:2005), which has been technically revised.

The main changes compared to the previous edition are as follows:

— The terms and definitions were harmonized with the new ISO 11145.

A list of all parts in the ISO 11146 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The propagation properties of every laser beam can be characterized within the method of second order moments by ten independent parameters (see ISO/TR 11146-3). However, due to their higher symmetry most laser beams of practical interest need fewer parameters for a complete description. Most lasers of practical use emit beams which are stigmatic or simple astigmatic because of their resonator design.

This document describes the measurement methods for stigmatic and simple astigmatic beams while Part 2 deals with the measurement procedures for general astigmatic beams. For beams of unknown type the methods of Part 2 shall be applied. Beam characterization based on the method of second order moments as described in both parts is only valid within the paraxial approximation.

The theoretical description of beam characterization and propagation as well as the classification of laser beams is given in ISO/TR 11146-3, which is an informative Technical Report and describes the procedures for background subtraction and offset correction.

In this document, the second order moments of the power (energy) density distribution are used for the determination of beam widths. However, there may be problems experienced in the direct measurement of these quantities in the beams from some laser sources. In this case, other indirect methods of the measurement of the second order moments may be used as long as comparable results are achievable.

In ISO/TR 11146-3, three alternative methods for beam width measurement and their correlation with the method used in this document are described. These methods are:

— variable aperture method;

— moving knife-edge method;

— moving slit method.

The problem of the dependence of the measuring result on the truncation limits of the integration area has been investigated and evaluated by an international round robin experiment carried out in 1997. The results of this round robin testing were taken into consideration during the preparation of this document.

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

Part 1: Stigmatic and simple astigmatic beams

1 Scope

This document specifies methods for measuring beam widths (diameter), divergence angles and beam propagation ratios of laser beams. This document is only applicable for stigmatic and simple astigmatic beams. If the type of the beam is unknown, and for general astigmatic beams, ISO 11146-2 is applicable.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies

ISO 11145, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols*

ISO 11146-2, *Lasers and laser-related equipment — Test methods for laser beam widths, divergence angles and beam propagation ratios — Part 2: General astigmatic beams*

ISO 13694, *Optics and photonics — Lasers and laser-related equipment — Test methods for laser beam power (energy) density distribution*

EN 61040:1992, *Power and energy measuring detectors, instruments and equipment for laser radiation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145, ISO 13694, EN 61040:1992 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

NOTE The *x*-, *y*- and *z*-axes in these definitions refer to the laboratory system as described in Clause 4. 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 case of pulsed sources.

3.1
first order moments of a power density distribution
$\bar{x}, \bar{y}$
centroid coordinates of the power density distribution of a cross section of a beam given as

$$\bar{x}(z)=\frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)\,x\,\mathrm{d}x\,\mathrm{d}y}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)\,\mathrm{d}x\,\mathrm{d}y} \tag{1}$$

and

$$\bar{y}(z)=\frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)\,y\,\mathrm{d}x\,\mathrm{d}y}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)\,\mathrm{d}x\,\mathrm{d}y} \tag{2}$$

Note 1 to entry: The first order moments are used for the definition of beam centroid in ISO 11145.

Note 2 to entry: For practical application, the infinite integration limits are reduced in a specific manner as given in Clause 7. The limitation of the integration area here differs from the integration area given in ISO 11145

3.2
second order moments of a power density distribution
$\sigma_x^2, \sigma_y^2, \sigma_{xy}^2$
normalized weighted integrals over the power density distribution, given as

$$\sigma_x^2(z)=\langle x^2\rangle=\frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)(x-\bar{x})^2\,\mathrm{d}x\mathrm{d}y}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)\,\mathrm{d}x\mathrm{d}y} \tag{3}$$

and

$$\sigma_y^2(z)=\langle y^2\rangle=\frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)(y-\bar{y})^2\,\mathrm{d}x\mathrm{d}y}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)\,\mathrm{d}x\mathrm{d}y} \tag{4}$$

and

$$\sigma_{xy}^2(z)=\langle xy\rangle=\frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)(x-\bar{x})(y-\bar{y})\,\mathrm{d}x\mathrm{d}y}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}E(x,y,z)\,\mathrm{d}x\mathrm{d}y} \tag{5}$$

Note 1 to entry: For practical application, the infinite integration limits are reduced in a specific manner as given in Clause 7.

Note 2 to entry: $\sigma_{xy}^2(z)$ is a symbolic notation, and not a true square. This quantity can take positive, negative or zero value.

Note 3 to entry: The angular brackets are the operator notations as used in ISO 11146-2 and ISO/TR 11146-3.

3.3
principal axes
<power density distribution> axes of the maximum and minimum beam extent based on the centered second order moments of the power density distribution in a cross section of the beam

Note 1 to entry: The axes of maximum and minimum extent are always perpendicular to each other.

3.4
azimuthal orientation
φ
<power density distribution> azimuthal angle between the *x*-axis of the laboratory system and that of the principal axis of the power density distribution which is closer to the *x*-axis

Note 1 to entry: From this definition it follows that $-\pi/4<\varphi<\pi/4$ for $|\varphi| \neq \pi/4$; if $\varphi=\pm\pi/4$, φ is defined as the angle between the *x*-axis and the major principal axis (axis of maximum extent) of the power density distribution.

3.5
beam widths
$d_{\sigma x}$, $d_{\sigma y}$
extent of a power density distribution in a cross section of the beam at an axial location *z* along that principal axis which is closer to the *x*- or *y*-axis of the laboratory coordinate system, respectively, based on the three centered second order moments of the power density distribution

Note 1 to entry: If the principal axes make the angle π/4 with the *x*- and *y*-axes of the laboratory coordinate system, then $d_{\sigma x}$ is by convention the larger beam width.

Note 2 to entry: This definition differs from that given in ISO 11145:2018, 3.5.2, where the beam widths are defined only in the laboratory system, whereas for the purposes of this document the beam widths are defined in the principal axes system of the beam.

Note 3 to entry: Equations for calculation of the beam widths from the three centered second order moments are given in Clause 7.2.

3.6
beam ellipticity
$\varepsilon(z)$
parameter for quantifying the circularity or squareness of a power (energy) density distribution at z

$$\varepsilon(z)=\frac{d_{\sigma y}(z)}{d_{\sigma x}(z)}$$

where the direction of x is chosen to be along the major axis of the distribution, such that $d_{\sigma x} \geq d_{\sigma y}$

Note 1 to entry: If $\varepsilon \geq 0{,}87$, elliptical distributions can be regarded as circular.

Note 2 to entry: In case of a rectangular distribution, ellipticity is often referred to as “aspect ratio”.

Note 3 to entry: In contrast to the definition given here, in literature the term “ellipticity” is sometimes related to $1-\frac{d_{\sigma y}(z)}{d_{\sigma x}(z)}$. The definition given here has been chosen to be in concordance with the same definition of ellipticity in ISO 11145 and ISO 13694.

3.7
circular power density distribution
power density distribution having an ellipticity greater than or equal to 0,87

[SOURCE: ISO 11145:2018, 3.6.4]

3.8
beam diameter
d_{σ}
extent of a circular power density distribution, based on the second order moments

Note 1 to entry: Equations for calculation of the beam diameter from the centered second order moments are given in Clause 7.2.