INTERNATIONAL STANDARD

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Lasers and laser-related equipment — Test methods for laser beam parameters — Polarization

Lasers et équipements associés aux lasers — Méthodes d'essai des paramètres du faisceau laser — Polarisation

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Foreword

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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.

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ISO 12005 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 9, *Electro-optical systems*.

This second edition cancels and replaces the first edition (ISO 12005:1999), which has been technically revised.

Introduction

This International Standard specifies a relatively quick and simple method, requiring minimum equipment, for determining the state of polarization of a laser beam.

This method is for well-polarized laser beams, including those emitted by lasers with a high divergence angle. However, if more completeness in the determination of the polarization status is required, the use of a more sophisticated analysing device is necessary. Although not within the scope of this International Standard, the principle of operation of such devices is given in Annex A, together with a description of the Stokes parameters which are needed in that case.

Lasers and laser-related equipment — Test methods for laser beam parameters — Polarization

1 Scope

This International Standard specifies a method for determining the polarization status and, whenever possible, the degree of polarization of the beam from a continuous wave (cw) laser. It can also be applied to repetitively pulsed lasers, if their electric field vector orientation does not change from pulse to pulse.

This International Standard also specifies the method for determining the direction of the plane of oscillation in the case of linearly polarized (totally or partially) laser beams. It is assumed that the laser radiation is quasi-monochromatic and sufficiently stable for the purpose of the measurement.

The knowledge of the polarization status can be very important for some applications of lasers with a high divergence angle, for instance when the beam of such a laser shall be coupled with polarization dependent devices (e.g. polarization maintaining fibres). This International Standard also specifies a method for the determination of the state of polarization of highly divergent laser beams, as well as for the measurement of beams with large apertures.

2 Normative references

The following referenced documents are indispensable for the application 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 11145:2001, *Optics and optical instruments — Lasers and laser-related equipment — Vocabulary and symbols*

IEC 61040:1990, *Power and energy measuring detectors, instruments and equipment for laser radiation*

CIE 59-1984, *Definitions and Nomenclature, Instrument Polarization*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145:2001, IEC 61040:1990, CIE 59-1984 and the following apply.

3.1
polarization
restriction of oscillations of the electric field vector to certain directions

NOTE This is a fundamental phenomenon which can be explained by the concept that electromagnetic radiation is a transverse wave motion, i. e. the vibrations are at right angles to the direction of propagation. It is customary to consider these vibrations as being those of the electric field vector.

3.2
state of polarization
classification of polarization as linear, random, circular, elliptical or unpolarized

3.3
direction of polarization
direction of the electric field vector of an electromagnetic wave

3.4
plane of polarization
plane containing the electric field vector and the direction of propagation of the electromagnetic radiation

3.5
ellipticity
b/a
⟨elliptically polarized radiation⟩ ratio of the minor semiaxis b of the ellipse to the major semiaxis a of the ellipse

NOTE The ellipse is described by the motion of the terminal point of the electric field vector in a transverse plane to the direction of radiation propagation (see Annex A).

3.6
ellipticity angle
ϵ
angle whose tangent is the ellipticity

NOTE The ellipticity angle is constrained to $-45^\circ \leqslant \epsilon \leqslant +45^\circ$. When $\epsilon = \pm 45^\circ$ the polarization is circular and when $\epsilon = 0^\circ$ the polarization is linear (see Annex A).

3.7
azimuth
Φ
angle between the major axis of the instantaneous ellipse and a reference axis perpendicular to the direction of propagation

NOTE See Annex A.

3.8
linear polarizer
optical device whose output is linearly polarized, without regard to the status and degree of polarization of the incident radiation

3.9
extinction ratio
⟨linear polarizer⟩ measure of the quality of the linear polarizer

NOTE If perfectly linearly polarized radiation is incident on a polarizer, then the extinction ratio of the polarizer is given by

$$\text{extinction ratio} = \frac{\tau_{\text{min}}}{\tau_{\text{max}}} \text{ or } \frac{\rho_{\text{min}}}{\rho_{\text{max}}}$$

where

$\tau_{\text{max}}\ (\rho_{\text{max}})$ is the maximum transmittance (reflectance)

$\tau_{\text{min}}\ (\rho_{\text{min}})$ is the minimum transmittance (reflectance)

of power (energy) through (of) the linear polarizer.

3.10
quarter wave plate
optical device which resolves an incident totally polarized beam of radiation into two orthogonally polarized components and introduces a 90° phase shift between them

3.11
stokes parameters
set of four real quantities, which completely describe the polarization state of monochromatic or quasi-monochromatic radiation

NOTE The parameters are, collectively, known as the Stokes vector, a 4×1 vector (see Annex A for a complete description and formulae for Stokes parameters).

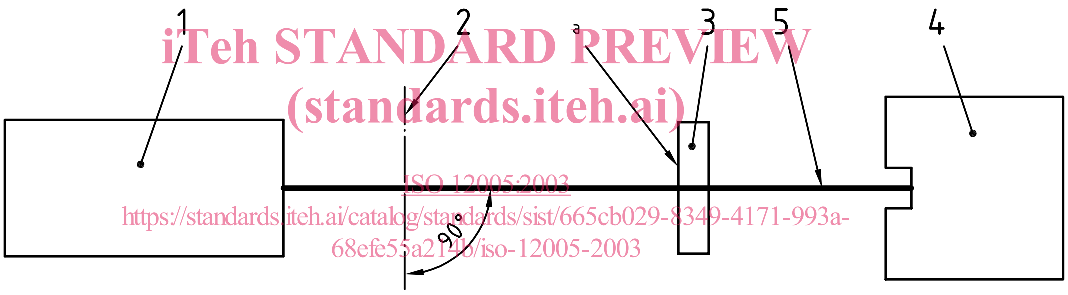
4 Test method for state of polarization

4.1 Principle of measurement

The first test for laser beam polarization determines whether the beam is linearly polarized. This involves recording the maximum and minimum levels of the transmitted radiation while the angular orientation of the linear polarizer is varied, as shown in Figure 1.

If the beam is not linearly polarized (according to the criteria given in 4.5), it is tested for elliptical or circular polarization. For this test the beam is measured after transmission by both a quarter-wave plate and a linear polarizer, as shown in Figure 2.

If not in either of these states, it is only partially polarized or unpolarized.



Key
1 laser
2 reference axis
3 polarizer
4 detector
5 laser beam
[a] Rotation 180°

Figure 1 — Schematic arrangement for the test for linear polarization

4.2 Equipment arrangement

4.2.1 General

The experimental set-up is shown in Figures 1 and 2.

