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Third edition
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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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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).

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This document was prepared by Technical Committee ISO/TC 172, *Optics and Photonics,* Subcommittee SC 9, *Laser and electro-optical systems,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 123, *Lasers and photonics*, in accordance with the agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 12005:2003), which has been technically revised.

The main changes are as follows:

— Description errors in 4.5 (Analysis of the results) were corrected.

— Definitions of the “degree of polarization” and the “degree of linear polarization” were made clear.

— Definition of extinction ratio was changed.

— Previous 3.3 (direction of polarization), 3.4 (plane of polarization), and 3.5 (ellipticity) were deleted, because these terms are confusing due to the different definitions, and they are not necessarily required for this document. Previous 3.11 (Stokes parameters) was deleted and moved to Annex A, because they are not used in the measurement and analysis.

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

This document deals with a method for determining the polarization state of a laser beam.

This document is applicable 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 document, 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 document specifies a method, which is a relatively quick and simple method with minimum equipment, 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 document also specifies the method for determining the direction of the electric-field vector oscillation in the case of (completely or partially) linearly polarized laser beams. It is assumed that the laser radiation is quasimonochromatic and sufficiently stable for the purpose of the measurement. This document is applicable to radiation that has uniform polarization over its cross-sectional area.

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 document is applicable not only for a narrow and almost collimated laser beam but also for highly divergent beams as well as for beams with large apertures.

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 11554, *Optics and photonics — Lasers and laser-related equipment — Test methods for laser beam power, energy and temporal characteristics*

CIE 059-1984, *Definitions and Nomenclature, Instrument Polarization*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145, CIE 059-1984 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 https://www.electropedia.org/

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

Note 1 to entry: This is a fundamental phenomenon which can be explained by the concept that electromagnetic radiation is a transverse wave motion, i.e. the oscillations are at right angles to the direction of propagation. It is customary to consider these oscillations as being those of the electric field vector.

3.2
state of polarization
classification of *polarization* (3.1) as linear, circular, elliptical or unpolarized

3.3
ellipticity angle
ε
<elliptically polarized radiation> angle whose tangent is the signed ratio of the minor semiaxis b to the major semiaxis a of the *polarization* (3.1) ellipse where its positive or negative sign designating the right-handed or left-handed elliptical *polarization* (3.1), respectively; i.e. $\tan \varepsilon = \pm b/a$

Note 1 to entry: The polarization 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).

Note 2 to entry: The ellipticity angle is constrained to $-45° \le \varepsilon \le +45°$. When $\varepsilon = \pm 45°$ the polarization is circular and when $\varepsilon = 0°$ the polarization is linear (see Annex A).

3.4
azimuth
Φ
angle between the major semiaxis of the *polarization* (3.1) ellipse and a reference axis perpendicular to the direction of propagation

Note 1 to entry: The azimuth is constrained to $-90° \le \Phi \le +90°$ (see Annex A).

3.5
linear polarizer
optical device whose output is linearly polarized, without regard to the status and *degree of polarization* (3.9) of the incident radiation

3.6
extinction ratio
r_e
<linear polarizer> measure of the quality of the *linear polarizer* (3.5)

Note 1 to entry: If perfectly linearly polarized radiation is incident on a polarizer, then the extinction ratio of the polarizer is given by

$$r_e = \frac{\tau_{max}}{\tau_{min}} \text{ or } \frac{\rho_{max}}{\rho_{min}} \tag{1}$$

where

τ_{max} (ρ_{max}) is the maximum transmittance (reflectance)

τ_{min} (ρ_{min}) is the minimum transmittance (reflectance)

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

Note 2 to entry: The extinction ratio is often described in the following form:

$$r_e = \frac{\tau_{max}}{\tau_{min}}:1 \text{ or } \frac{\rho_{max}}{\rho_{min}}:1 \tag{2}$$

3.7
r_p
polarization ratio
<laser beam> measure of the *degree of linear polarization* (3.10) for completely or partially polarized laser beams

$$r_p = \frac{P_{max}}{P_{min}} \text{ or } \frac{Q_{max}}{Q_{min}} \tag{3}$$

where, P_{max} (Q_{max}) and P_{min} (Q_{min}) are the maximum radiant power (energy) and minimum radiant power (energy) passing a *linear polarizer* (3.5), when varying the angle of the rotatable polarizer

Note 1 to entry: The measured beam powers P_{max} and P_{min} and measured beam energies Q_{max} and Q_{min} are specified in 4.4.2.

3.8
quarter-wave plate
optical device which resolves a completely polarized incident beam of radiation into two orthogonally polarized components and introduces a 90° phase shift between them

3.9
degree of polarization
p
ratio of the beam power (or energy) of the completely polarized component to the total beam power (or energy)

3.10
degree of linear polarization
p_L
ratio of the difference to the sum of beam powers P (energies Q) in the direction ξ of maximum transmission and the direction η of minimum transmission through the *linear polarizer* (3.5)

$$p_L = \frac{P_{max} - P_{min}}{P_{max} + P_{min}} \text{ or } \frac{Q_{max} - Q_{min}}{Q_{max} + Q_{min}} \tag{4}$$

Note 1 to entry: The measured beam powers P_{max} and P_{min} and measured beam energies Q_{max} and Q_{min} are specified in 4.4.2.

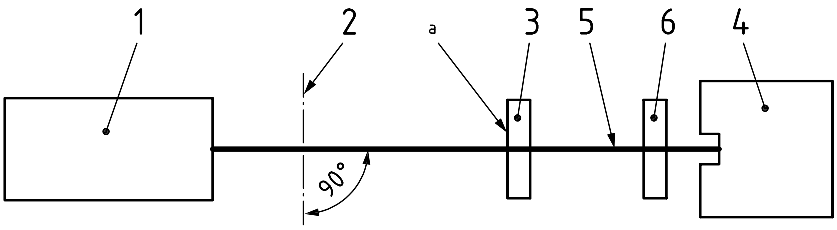
4 Test method for state of polarization

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.

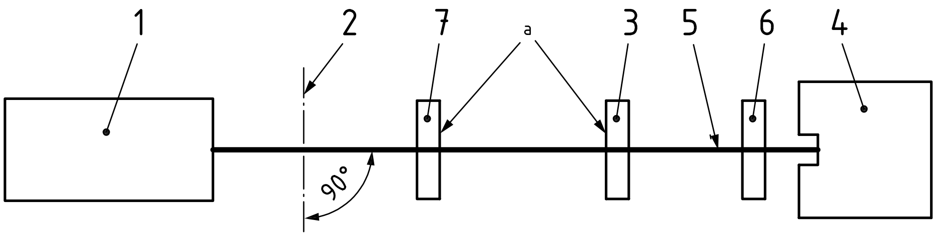
If the beam is not in either of these states, it is only partially polarized or unpolarized.



Key

1 laser
2 reference axis
3 linear polarizer (rotatable)
4 detector
5 laser beam
6 attenuator (optional)
[a] Rotation 180°.

Figure 1 — Schematic arrangement for the test for linear polarization



Key

1 laser
2 reference axis
3 linear polarizer (rotatable)
4 detector
5 laser beam
6 attenuator (optional)
7 quarter-wave plate (rotatable)
[a] Rotation 180°.

Figure 2 — Schematic arrangement for the test for elliptical or circular polarization

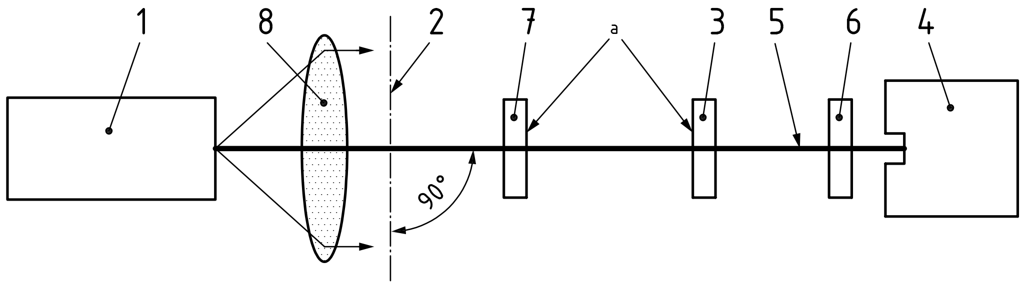
4.2 Equipment arrangement

4.2.1 General

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

4.2.2 Special arrangement for the testing of beams with large divergence angles

A highly divergent beam will not be transmitted through all the components of the test arrangements given above. In this case, a collimating assembly shall be inserted between the laser and the first component (reference axis) (see Figure 3). This assembly is made of collecting optics (such as a lens or a group of lenses), optionally followed by a telescope, achieving a reduction of the beam diameter to a value compatible with the rest of the arrangement.



Key

1 laser
2 reference axis
3 linear polarizer (rotatable)
4 detector
5 laser beam
6 attenuator (optional)
7 quarter-wave plate (rotatable)
8 collimating optics
a Rotation 180°.

Figure 3 — Schematic arrangement for the testing of lasers with highly divergent beams

4.2.3 Special arrangement for the testing of beams with large apertures

Care shall be taken that the detecting system captures the whole beam. If this is not possible, for example for beams with large apertures, the measurement shall be performed using smaller non-overlapping sub-apertures. The uniformity of the polarization can be confirmed by the measurement at plural sub-apertures.

NOTE Measurement of spatially non-uniform polarization is out of the scope of this document. However, spatially non-uniform but locally uniform polarization can be measured using the above-mentioned smaller non-overlapping sub-apertures. Also, a CCD or CMOS camera will help to detect spatially non-uniform polarization states.

4.3 Components

4.3.1 Radiation detector

The provisions of ISO 11554 shall apply to the measurement configuration including the radiation detector, and the measurement of laser beam power (energy). Note that only relative measurements are necessary for the polarization analysis. Furthermore, the following points shall be noted.

a) It shall be confirmed, from manufacturer's data or by measurement, that the output quantity of the detector (e.g. the voltage) is linearly dependent on the input quantity (laser power). Any wavelength dependency, nonlinearity or non-uniformity of the detector and the accompanying electronic circuit shall be minimized or corrected by use of a calibration procedure.

b) Care shall be taken to ascertain the damage thresholds (for irradiance, radiant exposure, power and energy) of the detector surface and of all the optical elements located between the laser and the detector (e.g. polarizer, attenuator) so that it is not exceeded by the incident laser beam.

4.3.2 Linear polarizer

The linear polarizer with the extinction ratio $r_e \geq 50$ shall be used. This is because the polarization leakage of the linear polarizer can introduce a measurement error in the degree of polarization p as large as the order of r_e^{-1} .

The direction of maximum transmission shall be indicated on the mount.

4.3.3 Quarter-wave plate

The quarter-wave plate is selected for the wavelength to be tested, such as to introduce a ($\lambda/4 \pm \lambda/200$) optical path difference between the two resolved orthogonal polarized components. The direction of oscillation of the fast component (lowest refractive index) shall be indicated on the mount.

4.3.4 Optical attenuator

An attenuator is used to reduce the laser power density.

Optical attenuators shall be used when the output laser power or power density exceeds the detector's working (linear) range or the damage threshold. Any wavelength dependence, nonlinearity or non-uniformity of the optical attenuator shall be minimized or corrected using a calibration procedure.

4.4 Test procedure

4.4.1 General

Set up the experimental apparatus as specified in 4.2.

Ensure that there is no reflective feedback into the laser by adjusting the angle of the components and their position along the optical path.

If attenuating optics are used, test independently to ensure that they have no effect on the polarization. For this purpose, the optical attenuator for use is set between the polarizer 3 and the detector 4. Set a standard laser with linearly polarized beam at the position 1. The angle of the polarizer is set to obtain maximum detected power. Rotate the attenuator around the axis and measure the power. Confirm that the detected power is independent of the rotating angle (e.g. 0°, 45°, and 90°).

After the initial preparation is completed, an evaluation to determine if the entire laser beam reaches the detector surface shall be made. Apertures of different diameters can be introduced into the beam path in front of each optical component. Aperture size is reduced until the output signal has been reduced by 5 %. This aperture should have a diameter at least 20 % smaller than the aperture of the optical component.

4.4.2 Measurement 1

See Figure 1.

Specify and record the orientation of a reference axis perpendicular to the beam axis.

a) Rotate the polarizer to obtain the maximum and minimum readings at the detector.

b) Record these readings and the angular orientation ($\gamma^{(p)}$)of the polarizer during the maximum and minimum readings of the detector.

c) Calculate the contrast C from the beam powers P_{max} and P_{min} (or beam energies Q_{max} and Q_{min}) in two orthogonal directions ξ and η, as shown in Formula (5)

$$C = \frac{P_{max} - P_{min}}{P_{max} + P_{min}} \text{ or } \frac{Q_{max} - Q_{min}}{Q_{max} + Q_{min}} \qquad (5)$$

Beam powers P_{max} and P_{min} or beam energies Q_{max} and Q_{min} are related to polarization ratio r_p by the Formula (3).

The directions ξ and η are chosen so that the beam power (energy) is transmitted maximally in the ξ direction and minimally in the η direction, respectively, through the linear polarizer (see Figure A.1).

From the Formulae (3) and (5), the contrast C is represented as a function of r_p as given by Formula (6):

$$C = \frac{r_p - 1}{r_p + 1} \tag{6}$$

d) Repeat the measurement at least 10 times and calculate the average contrast C_{a1}.

   If C_{a1}<0,9, proceed with measurement 2.

4.4.3 Measurement 2

See Figure 2.

a) Rotate both the quarter-wave plate and the polarizer independently to obtain maximum and minimum readings at the detector. Repeat the procedure to ensure that the absolute maximum and minimum measurements are taken as a function of the angular orientation for both the quarter-wave plate and the polarizer.

b) Record these maximum (P_{max}) and minimum (P_{min}) readings, the angles $\gamma_{max}^{(p)}$ and $\gamma_{min}^{(p)}$ of the polarizer, and the angles $\gamma_{max}^{(q)}$ and $\gamma_{min}^{(q)}$ of the quarter-wave plate.

c) Calculate the contrast as specified above for measurement 1 from the measurements obtained.

d) Repeat the measurement at least 10 times and calculate the average contrast C_{a2}.

4.5 Analysis of the results

The contrast C_{a1} from the data in measurement 1 directly gives the degree of linear polarization p_L of the laser beam under test. The contrast C_{a2} from the data in measurement 2 equals to the degree of polarization p of the laser beam. Since $p \geq p_L$ in theory (see Annex A), the inequality $C_{a2} \geq C_{a1}$ should hold. Care shall be taken that, however, when C_{a2} and C_{a1} are very close, specifically when $|C_{a2} - C_{a1}|$≤0,1, the inequality $C_{a2} \geq C_{a1}$ can be broken for the experimentally measured contrasts due to the measurement error. Accordingly, the state of polarization of the laser beam can be categorized from the contrasts, as follows:

If C_{a1}≥0,9, then the laser beam is considered as completely linearly polarized. The azimuth is given by the angular orientation of the polarizer during the maximum reading.

If 0,1<C_{a1}<0,9, 0,1<C_{a2}<0,9, and $|C_{a2} - C_{a1}|$≤0,1, then the laser beam is partially linearly polarized.

If C_{a1}≤0,1 and C_{a2}≥0,9, then the laser beam is considered as completely circularly polarized.

If C_{a1}≤0,1 and 0,1<C_{a2}<0,9, then the laser beam is partially circularly polarized.

If 0,1<C_{a1}<0,9 and C_{a2}≥0,9, then the laser beam is completely elliptically polarized. Determination of the azimuth and of the ellipticity angle of the polarization ellipse can be made with the use of a polarization analysing device which gives access to the four Stokes parameters (see Annex A).

If 0,1<C_{a1}<0,9, 0,1<C_{a2}<0,9, and C_{a2}-C_{a1}>0,1, then the laser beam is partially elliptically polarized. Determination of the azimuth and of the ellipticity angle of the polarization ellipse can be made with the use of a polarization analysing device which gives access to the four Stokes parameters (see Annex A).

If C_{a1}≤0,1 and C_{a2}≤0,1, then the laser beam is measured as unpolarized.

It is assumed that the radiation has uniform polarization properties over its cross-sectional area. Radiation that exhibits random and spatially unresolvable variations in the state of polarization (and over its aperture or direction behaves as unpolarized to the detector) should be retested, using smaller apertures (as required) to determine the spatially distributed state of polarization (see 4.2.3).

The above-mentioned categorization of the polarization state is summarized in Table 1. Figure 4 shows a flow chart for the analysis of the results.

Table 1 — Categorization of the polarization state

Measurement 1	Measurement 2	C_{a2} - C_{a1}	Polarization state
$C_{a1} \geq 0,9$	-	-	completely linearly polarized
$0,1 < C_{a1} < 0,9$	$0,1 < C_{a2} < 0,9$	$\lvert C_{a2} - C_{a1} \rvert \leq 0,1$	partially linearly polarized
$C_{a1} \leq 0,1$	$C_{a2} \geq 0,9$	-	completely circularly polarized
$C_{a1} \leq 0,1$	$0,1 < C_{a2} < 0,9$	-	partially circularly polarized
$0,1 < C_{a1} < 0,9$	$C_{a2} \geq 0,9$	-	completely elliptically polarized
$0,1 < C_{a1} < 0,9$	$0,1 < C_{a2} < 0,9$	$C_{a2} - C_{a1} > 0,1$	partially elliptically polarized
$C_{a1} \leq 0,1$	$C_{a2} \leq 0,1$	-	unpolarized

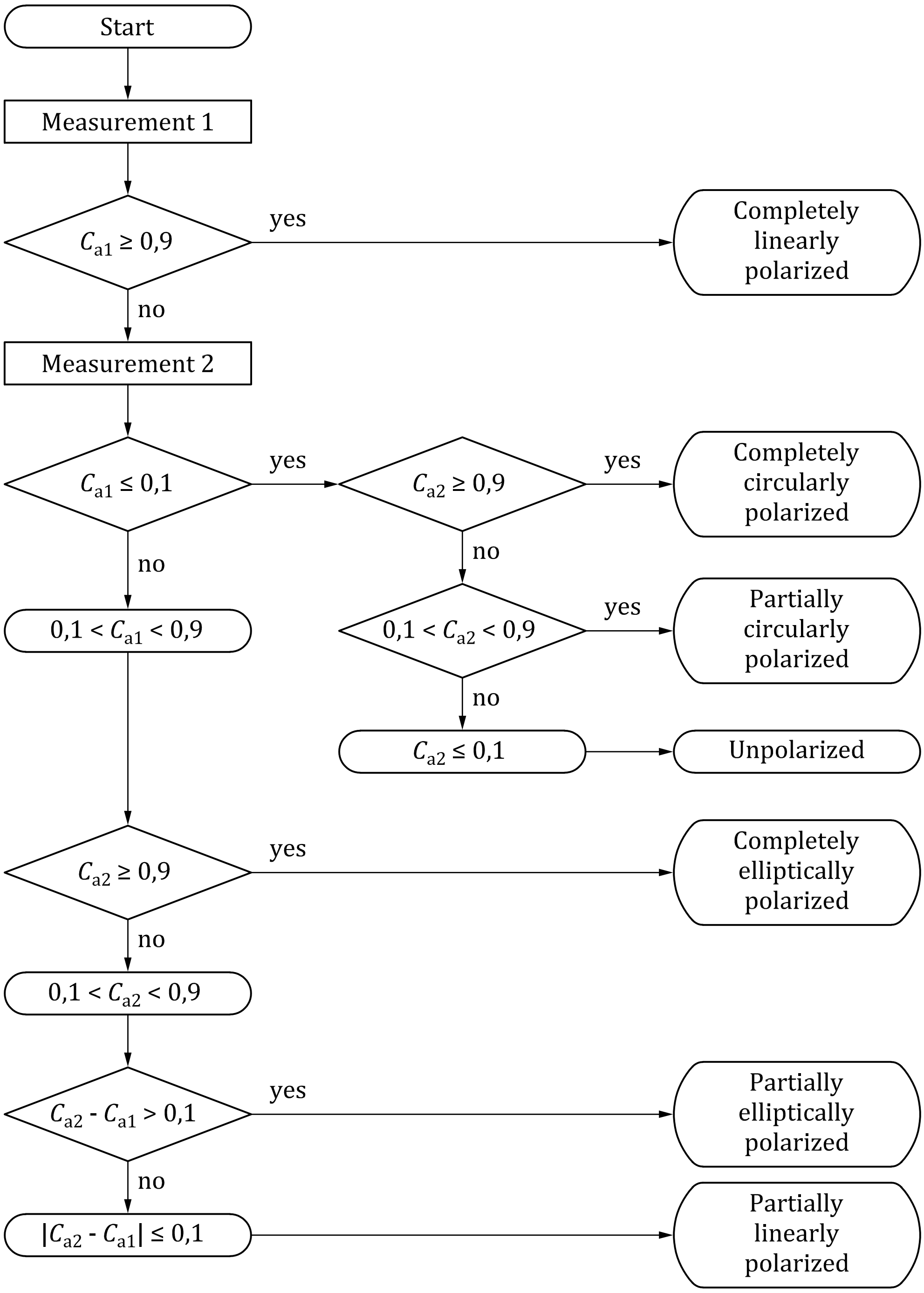


Figure 4 — Flow chart for the analysis of the results

5 Test report

The following information shall be included in the test report.

a) General information:

1) a reference to this document, i.e. ISO 12005:2022;

2) date of test;

3) name and address of test organization;

4) name of individual performing the test.

b) Information concerning the tested laser:

1) laser type;

2) manufacturer;

3) manufacturer's model designation;

4) serial number.

c) Test conditions:

1) laser wavelength(s) (or wavelength range)

2) measurement temperature in K (diode laser cooling fluid) (only applicable for diode lasers);

3) operating mode (cw or pulsed);

4) laser parameter settings:

— output power or energy;

— current or energy input;

— pulse energy;

— pulse duration;

— pulse repetition rate;

5) mode structure (if known);

6) environmental conditions.

d) Information concerning testing and evaluation:

1) detector and sampling system:

— response time of the detector system;

— trigger delay of sampling (for pulsed lasers only);

— measuring time interval (for pulsed lasers only);

2) beam forming optics and attenuating method (if applicable):

— type of attenuator;

— type of beam splitter;

— type of focusing element;

3) polarizers used for the test;

4) orientation of the reference axis;

5) width of the sub-aperture and resulting measuring angle (if applicable).

e) Test results

1) Measurement results or readings, in accordance with Table 2;

2) state of polarization;

3) degree of polarization and degree of linear polarization;

4) azimuth of the polarized component (if linear);

5) results of the measurements as a function of the angular position of the sub-aperture in respect to the laser beam (if applicable).

f) any deviations from the procedure;

g) any unusual features observed.

Table 2 — Measurement results

	Average contrast		**Angle polarizer**				**Angle quarter-wave plate**			
			$\gamma_{max}^{(p)}$		$\gamma_{min}^{(p)}$		$\gamma_{max}^{(q)}$		$\gamma_{min}^{(q)}$	
	mean	σ[a]	mean	σ[a]	mean	σ[a]	mean	σ[a]	mean	σ[a]
Measurement 1							X	X	X	X
Measurement 2										

[a] σ is the standard deviation.

Annex A
(informative)

Complete description of the polarization status of a monochromatic laser beam

A.1 Stokes vector

The Stokes vector of a laser beam is specified as a set of four real-number quantities, named Stokes parameters: S_0 to S_3, each having units of power, and giving a complete description of the state of polarization and power of the beam.

The first parameter S_0 measures the total power of the beam. Therefore $S_0 > 0$.

The most general state of the completely polarized component, the power of which is S_p, is elliptical. The ratio $p = S_p/S_0$ is the degree of polarization of the beam.

The complete characterization of this component requires the knowledge of the azimuth Φ and the ellipticity angle ε, as shown in Figure A.1 in association with the polarization ellipse; 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. The laser beam is assumed to be propagating in $+z$ direction (indicated by ⊙ in Figure A.1), which is perpendicular to the xy plane. Note that the ellipticity angle ε is usually used as a signed number and its sign designates the rotation direction of the electric field vector. Specifically, the positive and negative numbers of ε denote the right-handed and left-handed elliptical polarization, respectively. When $\varepsilon = \pm 45°$ the polarization is circular and when $\varepsilon = 0°$ the polarization is linear.

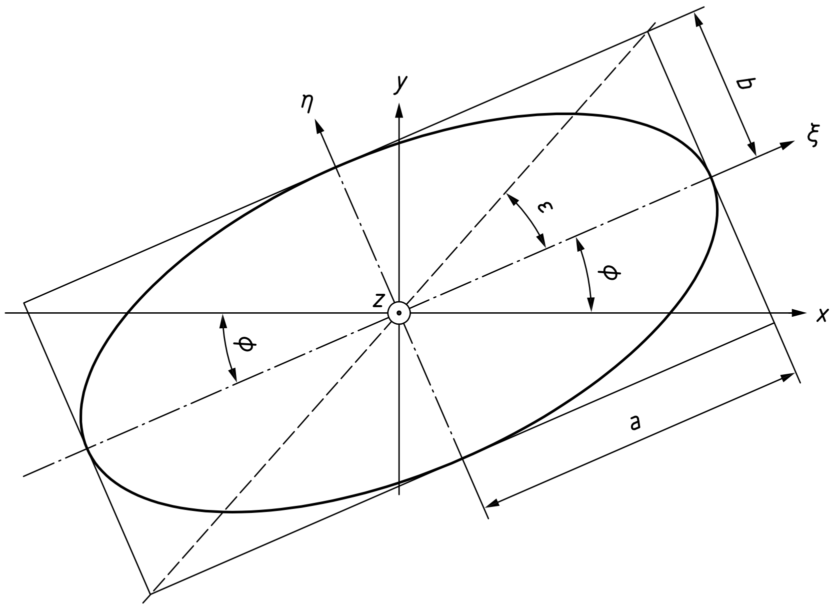


Figure A.1 — Geometrical representation illustrating the significance of the azimuth Φ and ellipticity angle ε for an elliptically polarized radiation

The second (S_1), third (S_2) and fourth (S_3) Stokes parameters give an alternative description of the polarized component through Formulae (A.1) to (A.3):

$$S_1 = S_P \cos(2\Phi)\cos(2\varepsilon) \tag{A.1}$$

$$S_2 = S_P \sin(2\Phi)\cos(2\varepsilon) \tag{A.2}$$

$$S_3 = S_P \sin(2\varepsilon) \tag{A.3}$$

Finally, the Stokes vector can be written as a function of the total beam power, P, the degree of polarization, p, the azimuth, Φ, and the ellipticity angle, ε, namely, as given by Formula (A.4)

$$\boldsymbol{S} = \begin{pmatrix} S_0 \\ S_1 \\ S_2 \\ S_3 \end{pmatrix} = P \begin{pmatrix} 1 \\ p\cos(2\Phi)\cos(2\varepsilon) \\ p\sin(2\Phi)\cos(2\varepsilon) \\ p\sin(2\varepsilon) \end{pmatrix} \tag{A.4}$$

Conversely P, p, Φ and ε can be determined from the Stokes vector, using the following Formulae (A.5) to (A.8):

$$P = S_0 \tag{A.5}$$

$$p = \left(S_1^2 + S_2^2 + S_3^2\right)^{\frac{1}{2}} / S_0 \tag{A.6}$$

$$\Phi = \frac{1}{2}\tan^{-1}\left(\frac{S_1}{S_2}\right) \tag{A.7}$$

$$\varepsilon = \frac{1}{2}\tan^{-1}\left[S_3 / \left(S_1^2 + S_2^2\right)^{1/2}\right] \tag{A.8}$$

A.2 Basic characteristics of two contrasts obtained in measurements 1 and 2

The principle of measurement 2 is based on the fact that any “partially polarized” radiation can be decomposed into “completely polarized” and “unpolarized” components. Among them, the “completely polarized” component can be converted to a (completely polarized) “linearly polarized” radiation by use of a quarter-wave plate, because the orthogonal electric fields along the major and minor semiaxes of the polarization ellipse (Figure A.1) are shifted in phase by 90° with each other; the phase shift can be cancelled or added to 180° by the quarter-wave plate whose principal axes are set to coincide with the two semiaxes of the polarization ellipse. In contrast, the quarter-wave plate has no influence on the “unpolarized” component. Accordingly, the maximum and minimum readings in measurement 2 give $S_p + S_u/2$ and $S_u/2$, respectively, where S_p and S_u respectively denote the powers of “completely polarized” and “unpolarized” components. Therefore, the contrast from the data in measurement 2 gives $S_p/(S_p + S_u)$, namely the degree of polarization defined in 3.9.

From some polarization calculus, it can be shown that the degree of polarization p obtained from the contrast of measurement 2 is related to Stokes parameters as given by Formula (A.9):

$$p = \left(S_1^2 + S_2^2 + S_3^2\right)^{\frac{1}{2}} / S_0 \tag{A.9}$$

This is the relationship between the degree of polarization p and Stokes parameters, as was denoted in A.1. Similarly, the degree of linear polarization p_L obtained from the data in measurement 1 is related to Stokes parameters as given by Formula (A.10):

$$p_L = \left(S_1^2 + S_2^2\right)^{\frac{1}{2}} / S_0 \tag{A.10}$$

It should be noted that the degree of circular polarization p_C is also specified by Stokes parameters as:

$$p_C = |S_3| / S_0 \tag{A.11}$$

From comparison among Formulae (A.9) to (A.11), the following Formulae (A.12) and (A.13) are obtained.

$$p \geq p_L \tag{A.12}$$

$$p \geq p_C \tag{A.13}$$

Namely, the degree of polarization is always larger than or equal to the degree of linear polarization and the degree of circular polarization.

A.3 Polarization analysis

As apparent from A.1, the complete description of the polarization status of a laser beam implies the determination of the four Stokes parameters.

This requires at least four independent measurements, in each of which the beam is analysed for a different “polarization content”. Such a requirement is fulfilled for instance by the 4-detector polarimeter[1][2]. Any device whose principle of measurement is based on this principle is suitable for extracting the four Stokes parameters, and consequently the degree of polarization, the azimuth and the ellipticity angle of any laser beam, including the most general situation.

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