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Optics and photonics – Wavefront sensors for characterising optical systems and optical components

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National foreword

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Foreword

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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is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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Optics and photonics — Wavefront sensors for characterising optical systems and optical components

1 Scope

This Technical Report gives terms and definitions and describes techniques for the characterization of wavefronts influenced by optical systems and optical components. It describes basic configurations for a variety of wavefront sensing systems and discusses the usefulness of tests in different situations.

The aim is to cover practical instruments and techniques for measuring the wavefront produced by optical systems and optical components. This Technical Report includes various implementations of the Hartmann method, the curvature sensor and applications of the knife-edge method. The use of interferometers is discussed. This Technical Report also includes techniques such as phase diversity and pyramid sensors, currently used in astronomy and being developed for other areas.

NOTE More information on interferometry can be found in ISO/TR 14999-1, ISO/TR 14999–2 and ISO/TR 14999–3.

This Technical Report explains briefly how these techniques work and includes diagrams illustrating the use of this type of equipment for making the measurements required for ISO 10110-5, ISO 10110-8, ISO 10110-12 (slope requirements) and ISO 10110-14.

2 Introduction to wavefront sensing techniques

Interferometry is a well-established technique for comparing a test wavefront with a reference wavefront, usually spherical or planar, and requires a degree of coherence between the two wavefronts to produce an interference pattern. Some interferometers for wavefront characterization are self-referencing, such as shearing interferometers. These reveal the slope of the wavefront at various points with values deduced from the interferogram and integrated to calculate the phase profile.

More recently non-interferometric techniques have been developed, partly driven by the needs of adaptive optics, and it is possible to apply these to wavefronts with limited coherence. The majority of these techniques are based on measuring the wavefront slope values.

Many of the non-interferometric techniques can be categorized as screen tests. A screen test is a general term for the test of a beam with an opaque plate placed or moved in the focusing beam and the irradiance pattern transmitted by the opaque plate analysed. The screen may have one or more holes, slits or edges to transmit part of the beam while blocking with the opaque part.

Non-interferometric techniques include focused waist (image of source) measurements and wavefront sampling which gives slope measurements. The knife-edge is a simple test that isolates regions of the wavefront to reveal aberrations. The Hartmann test uses a perforated screen to isolate bundles of rays and the direction of these bundles is measured to calculate the wavefront slopes. The Shack-Hartmann test uses an array of small lenses to sample the wavefront. The wavefront slopes are deduced from the positions of the focal spots generated by the lens array and the slope values are integrated to calculate the phase profile.

Wavefront curvature sensing and phase diversity techniques are a class of wavefront retrieval mechanisms that infer the wavefront from measurements of the intensity of the light as the beam propagates. Typically this involves the measurement of two images along the beam path, from which the intensity gradient is derived. Two standard approaches are to measure the intensity either side of a focus or either side of a pupil plane in an optical system. Phase diversity techniques use calculation algorithms for the retrieval of wavefront phase. Once the intensity data are collected, a processing step is required to calculate the wavefront. This can be achieved using the intensity transport equation,

