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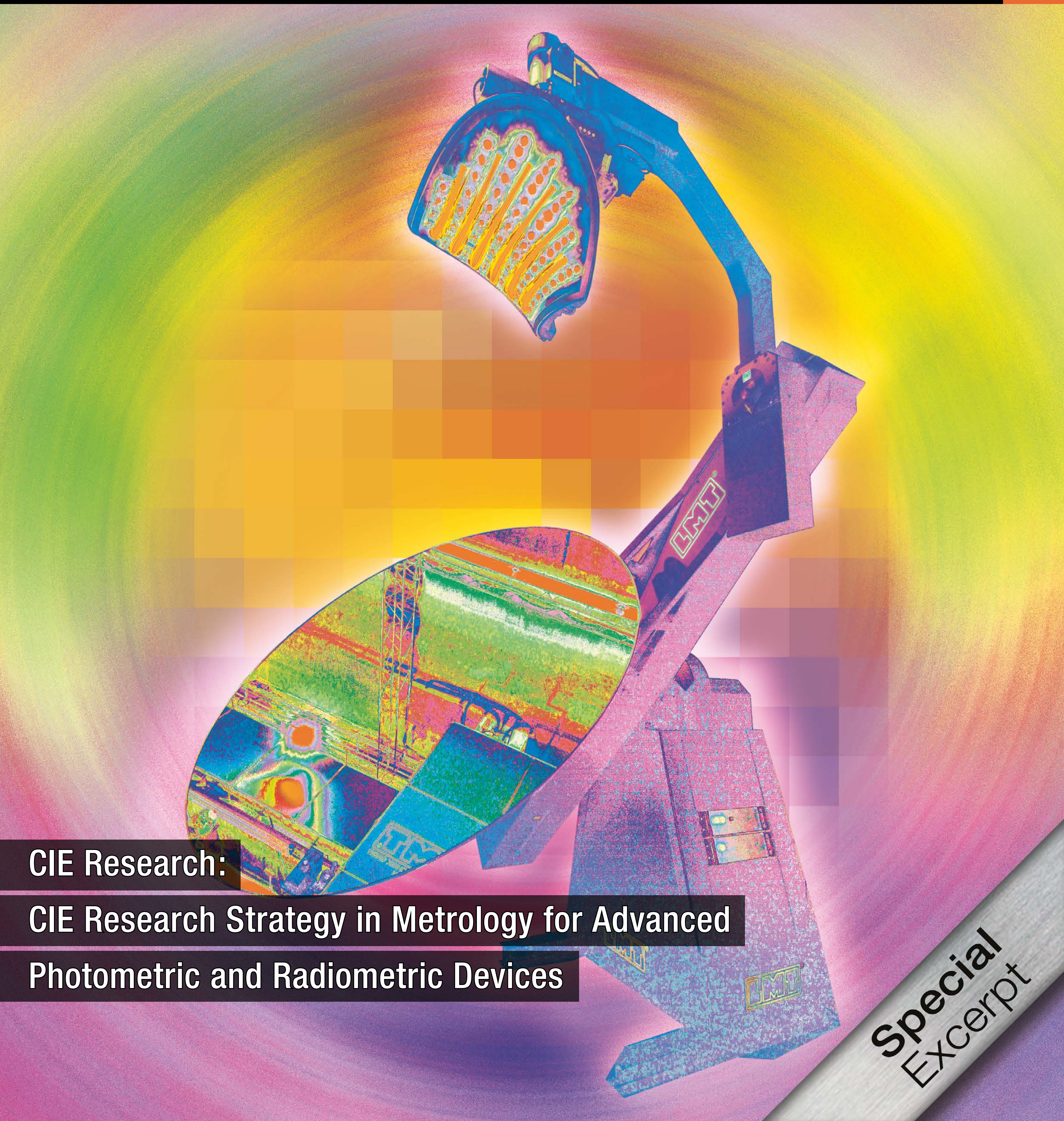



## CIE Research:
## CIE Research Strategy in Metrology for Advanced Photometric and Radiometric Devices

# CIE Research Strategy in Metrology for Advanced Photometric and Radiometric Devices

Photometric devices are devices that measure optical radiation and which are designed with a very specific spectral response. Most commonly, illuminance meters and luminance meters are used to measure the illuminance and luminance distributions in the field. These are relatively simple devices, characterized by a specific input optics according to the required task and a filter to make the spectral response of the instrument match the spectral luminous efficiency function of the human eye (typically V(λ) for photopic vision). In testing laboratories, integrating spheres are used to measure the total luminous flux of a light source and goniophotometers are used to measure luminous intensity distributions, total luminous flux and partial luminous flux. These devices are all well understood, and several CIE technical reports are available that give guidance on their characterization and calibration [1][2][3][4].

Due to technological progress new types of photometric and radiometric measurement devices have recently appeared on the market and are used in many applications. Additionally, new types of instrumentation are currently under development in response to new CIE publications and new lighting technologies emerge onto the market.

## Examples of New Types of Instrumentation and Applications

### Imaging luminance measurement devices (ILMDs)

Analogous to using a digital camera for photography, ILMDs combine an array detector (typically a CCD or CMOS sensor) and a specially designed filter to measure a luminance distribution in a “single shot”. They can be used to evaluate complex scenes much more rapidly and with greater resolution than traditional spot luminance meters. As a result, ILMDs are becoming very popular in many areas of applications, for example glare evaluations in indoor lighting, street and tunnel lighting measurements, and light emission measurements.

### Hyperspectral imaging devices.

These devices allow direct measurement of spectral and spatial distributions, i.e. each pixel of an image also contains spectral information. This can be used to identify materials (i.e. mineralogy), to measure the stages of development of vegetation, to identify skin anomalies and even for surveillance purposes.

### Imaging luminance-based near-field goniophotometers

Combining ILMDs with a goniophotometer allows the measurement of spatially- and angularly-resolved luminance distribution of light sources in the near-field. The collected data can be used to improve the performance of luminaires through optical raytracing methods and allow users to evaluate illuminance distributions in virtual measurement planes at any distance from the source. Additionally, far field data (i.e. luminous intensity distributions) can be determined using quite compact measurement devices.

### Measurement devices for quantifying photochemical and photobiological effects

It is well known that intrinsically photosensitive retinal ganglion cells (ipRGCs) in the human retina have an impact for various non-visual effects, including synchronizing circadian rhythms, pupillary control and conscious visual perception. CIE joint technical committee JTC 9 has recently defined a metric, and in particular several action spectra, to quantify such effects. New measurement devices will soon appear on the market that perform measurements according to the new metric and the defined action spectra. These instruments will need to be characterized and calibrated.

### High-speed measurement systems to quantify fast-varying (pulsing, modulating, flickering) optical signals

Temporal light modulations (TLM) are known to affect human visual perception and performance. The freely available CIE technical note TN 006 [5] gives new definitions for the perceptual effects modulated light can produce.
Measurements are usually performed using high-speed acquisition systems. Several types of measurement devices (including "flickermeter") can be found on the market but there is currently no harmonized way of characterizing these instruments, leading to an inability to compare measurement results between different instruments and different laboratories.

### Hybrid measurement devices using spectroradiometers and broadband measurement devices

One of the challenges for manufacturers and users of photometric devices is the match of the spectral responsivity of the instrument to the required spectral luminous efficiency function. This match can never be perfect, resulting in measurement errors. This is especially apparent for spectrally narrow sources, such as coloured LEDs. Some devices available on the market now are using a built-in spectroradiometer to correct spectral mismatch of a photometric device in real-time. In addition, colorimetric data (i.e. chromaticity coordinates, correlated colour temperature, colour rendering and colour fidelity indices) can also be obtained as a part of the measurement.

## CIE Activities

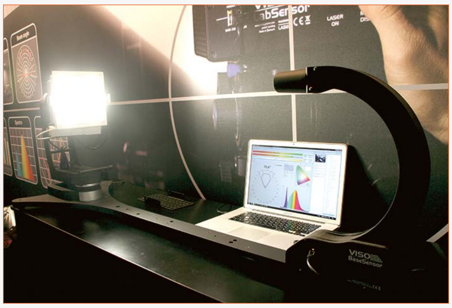
New CIE technical committees have been established and are currently writing technical reports to provide guidance on the characterisation and calibration of some of these devices. Further, it is anticipated that other new technical committees will follow in the near future. However, in most cases additional research is still necessary, and the period of time allowed to finalize a technical report or standard is often too short. In spite of this, there is an immediate need to define quality criteria and calibration procedures for devices such as near-field goniophotometers and high-speed measurement systems to quantify fast-varying (pulsing, modulating, flickering) optical signals, as such devices are becoming more widely used in practice. Hence, CIE is calling for new contributors not only to participate in the technical committees, but also to offer practical research on the open topics to feed into the technical committees. Having more research groups operating in parallel can enable a technical committee to perform its work more efficiently.

### The key research questions are:

- What are the relevant quality indices needed to characterize advanced photometric and radiometric devices? How do these indices relate to the measurement uncertainty encountered in typical lighting measurement situations?
- How to describe the mathematical models and equations describing the measurement procedure?
- What would a typical measurement uncertainty budget look like for measurements on particular types of equipment and for measurement of different types of light sources?
- How to calibrate these new types of devices? What are the best artefacts to transfer the photometric and radiometric quantities to the measurement devices?

On a wider scale, an additional motivation for this research topic is that new challenges like "smart lighting" (i.e. adaptive and sensor-based lighting) and the implementation of the other research topics within the CIE Research Strategy priority list imply on the one hand the need to completely characterize a given lighting situation, including daylight and artificial light from various sources, and on the other hand to thoroughly characterize the light sources with respect to spectral and spatial properties.

As with all physical metrology, traceability of measurement results to the International System of Units (SI) is often mandatory. New knowledge is required to combine source-based and detector-based



measurements under various environmental conditions. New devices and measurement systems such as those described above are needed to meet these challenges. The outcomes of this research topic will increase the quality of photometric and radiometric measurements in general and therefore increase confidence in lighting products. The availability of reliable and traceable measurements is also a prerequisite to develop and verify intelligent sensor systems used to enable smart and adaptive lighting.

The key questions and topics described above are defined in the CIE research strategy, available at the CIE website (http://www.cie.co.at/research-strategy). This particular aspect of the CIE research strategy is managed by CIE Division 2. Division 2 deals with the physical measurement of light and radiation, which includes studying procedures for the metrological evaluation of ultraviolet, visible and infrared radiation, and studying the optical properties and performance of physical detectors and other devices required for their evaluation. ■

**References:**

[1] CIE 070:1987 The Measurement of Absolute Luminous Intensity Distributions
[2] CIE 084:1989 Measurement of Luminous Flux
[3] CIE 121:1996 The Photometry and Goniophotometry of Luminaires
[4] CIE 210:2014 Photometry Using V(λ)-Corrected Detectors as Reference and Transfer Standards
[5] CIE TN 006:2016 Visual Aspects of Time-Modulated Lighting Systems – Definitions and Measurement Models