International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

1 New Calibration Sources and Illuminants for Photometry, Colorimetry, and Radiometry

1.1 Description of research

In photometry and radiometry appropriate calibration sources and transfer detectors are necessary to ensure traceability of measurements. In addition, calibration conditions should be chosen as close as possible to the measurement conditions. Incandescent lamps have been used for such calibrations for decades, but their availability is diminishing. LED-based standards would bring several benefits for calibration laboratories, photometer manufacturers, and for those using instruments for measurement of white LED lighting. However, different types of LED-based standards have to be considered in general:

- LED standards to realize the lamp based quantities to define and disseminate the units for luminous intensity, luminous flux and luminance. These are the highest precision devices which have to cover at least the whole visible spectral range from 360 nm to 830 nm defined by $V(\lambda)$, $V'(\lambda)$ and $V_{\mathrm{mes},m}(\lambda)$.
- LED standards for the dissemination of the photometric units with properties close to typical LED lamps, modules and luminaires used in applications. These standards are typically based on coloured or white LEDs, not necessarily covering the whole spectral range of the visible spectrum.
- LED standards can be used for the general characterization of measurement setups used in test laboratories. These standards are used to reduce the uncertainties encountered by test laboratories in measurements of general purpose luminaires.

In the case of LED standards for the dissemination of photometric units for white LEDs, some drawbacks must be considered, in particular the fact that there is not a single spectral power distribution that would be representative of white LED sources. Thus, it may be necessary to consider a family of standard LED illuminants to represent these different applications. This is a similar principle to what has been done in standardizing lamp spectra F1 to F12 of fluorescent lamps (CIE 015:2018), where selected spectral distributions of different lamp designs are specified.

Finally, research is needed for calibration sources for spectral quantities in extended wavelength ranges (UV to NIR) as replacement of existing halogen-based sources. Different possibilities could be considered, including new LED sources, laser-driven light sources, white-light laser sources, and tuneable laser sources (for detector-based calibration).

1.2 Key research questions

- What spectral range is necessary for LED standard sources and what composition of LEDs should be used to realize such a standard?
- What would be the best reference spectrum (spectra) based on LED products for general-purpose white lighting LEDs, considering that these products are still in evolution?
- What are the alternative sources to calibrate spectroradiometers over extended wavelength ranges, including NIR and UV?
- What are the impacts due to the changes to new calibration sources and in the definition of new (standard) illuminant(s)?

1.3 Justification of the need for the proposed research topic

A good metrological system relies on the availability of stable light sources and detectors. A major challenge is the technological revolution of lighting products towards LED lighting and the ban of incandescent lamps. This raises concern about the availability of incandescent photometric standard lamps in the future. The prices of such standard lamps are already increasing, and acquiring some lamp types has become increasingly difficult. Therefore, it is

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important to investigate the pros and cons of replacement of conventional standard lamps with new solid-state technology.

Metrology using LED-based devices is much more complex than it was using the former, incandescent-based, technology. Uncertainties originating from the operating parameters, spectral distribution and spatial properties are frequently underestimated. Appropriate standards together with improved measurement devices (Research Topic "Metrology for Advanced Photometric and Radiometric Devices") are a basic prerequisite and fundamental to facilitate future smart and adaptive lighting technologies and applications.

1.4 Related current activities in CIE

TC 2-87	Broadband UV LED radiometric measurements between 320 nm and 420 nm
TC 2-90	LED Reference Spectrum for Photometer Calibration

1.5 Existing CIE publications

CIE 015:2018	Colorimetry, 4th Edition
CIE 149:2002	The Use of Tungsten Filament Lamps as Secondary Standard Sources
CIE 198-SP2:2018	Determination of Measurement Uncertainties in Photometry – Supplement 2: Spectral Measurements and Derivative Quantities

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