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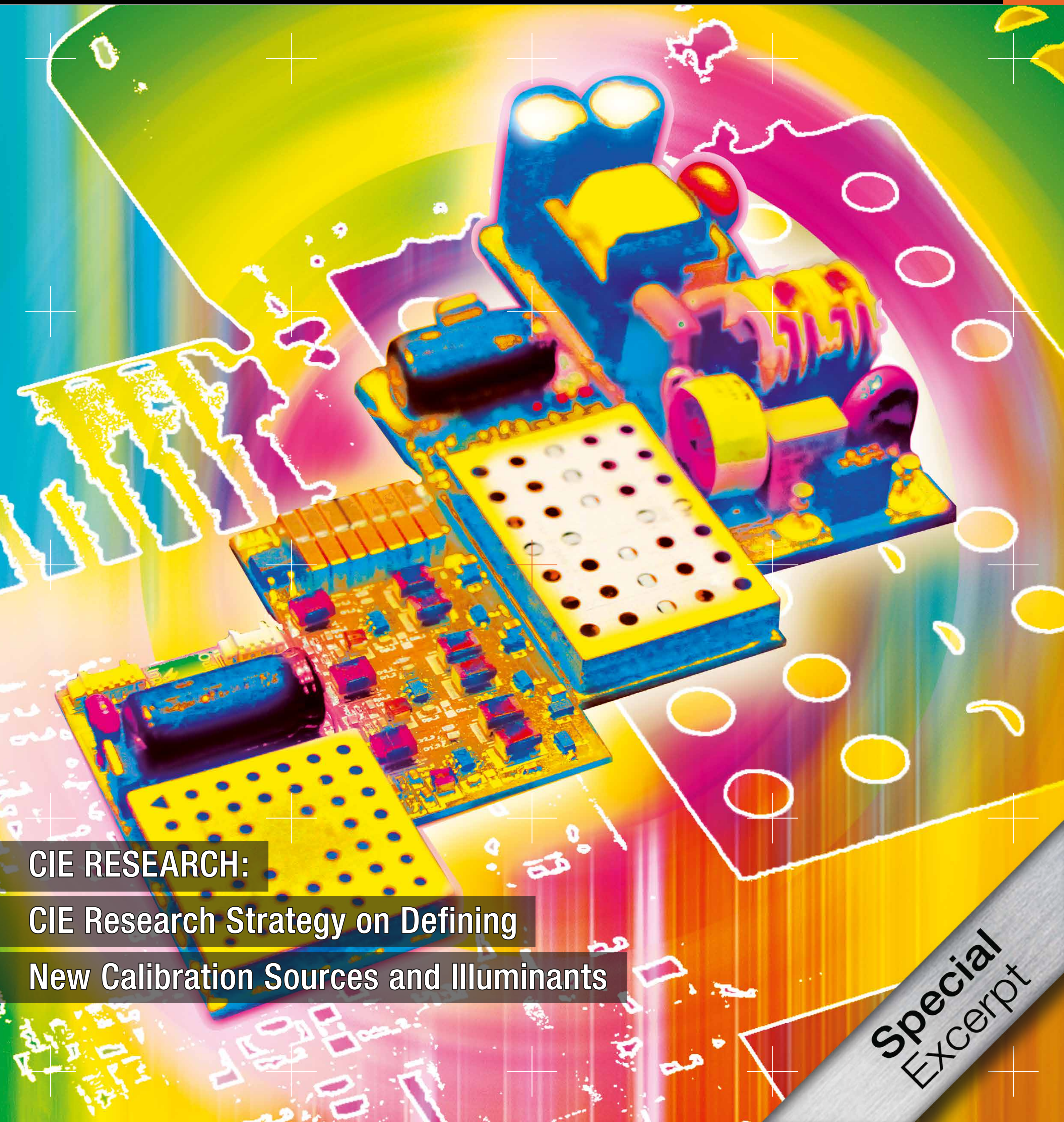

CIE RESEARCH:

CIE Research Strategy on Defining New Calibration Sources and Illuminants

Special Excerpt

CIE Research Strategy on Defining New Calibration Sources and Illuminants

In photometry and radiometry, traceability of measurements requires appropriate calibration sources and transfer 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 while the prices of such standard lamps are already increasing. In addition, calibration conditions should ideally be chosen to be as close as possible to the measurement conditions. Furthermore, the number of LED lighting measurements in laboratories and in the field has significantly increased, while the calibration of photometers is still done using incandescent-based standards. Therefore, it is important to investigate the pros and cons of replacement of conventional standard lamps with new solid-state technology. Peter Blattner and Tony Bergen, Division 2 Director and Secretary respectively, explain how CIE has defined the research topic "New Calibration Sources and Illuminants for Photometry, Colorimetry, and Radiometry" to address these concerns.

Many national and international standards require traceability of the measurements to an internationally-recognized realization of the International System of Units (SI). This is typically done by relating measurement results to a reference through an unbroken chain of calibrations. Calibration means that a device under test is compared to a reference device in well-defined calibration conditions (i.e. environmental conditions, calibration geometries, spectral distribution of the calibration source etc).

In the field of radiometry and photometry, tungsten or halogen based sources are typically used for the calibration of radiometric and photometric devices such as spectroradiometers and photometers. According to the international standard ISO/CIE [1] all photometers are calibrated using a CIE Standard Illuminant A, typically realized by adjusting a tungsten lamp to a distribution temperature of 2856 K. The lamp is aligned on the optical axis at "far-field" to simulate a point source and the ambient temperature of the laboratory is set to 25°C.

In practice, the measurement conditions might differ significantly from this calibration condition: for example, the calibrated photometer could be used to measure in an LED street lighting installation. In such a situation the spectral distribution, the measurement geometry and the ambient temperature might be significantly different from the calibration condition. These differences will lead to errors which should be quantified and corrected. However even after corrections some uncertainties remains due to the fact the test condition (and the calibration condition) are only known with some degree of uncertainties. In addition, such corrections might be very time-consuming or simply not possible due to the limited knowledge of the test condition and the behaviour of the measurement instrument.

There are different strategies to address this problem and thus reduce the measurement uncertainty. A high quality instrument will be less sensitive to the deviation between the calibration and test conditions. For this purpose, CIE has defined different quality indices for photometric devices [1]: for example, the general *V(λ)* mismatch index *f1'* describes how well the relative spectral responsivity of the photometer matches the standard relative spectral luminous efficiency function *V(λ)*. The smaller the value the better the spectral match. This is illustrated by Figure 1, which reports the spectral mismatch correction factors (SMCF) for phosphor-type white LEDs and different values of photometers. The SMCF enables correcting for spectral mismatch for a given specific spectral distribution. However, a correction of the measured photometric value in respect to the spectral mismatch of the photometer is only possible if the relative spectral responsivity of the photometer and the relative spectral distribution of the radiation of the device under test are known. If no correction is applied the uncertainty associated with the spectral mismatch can be estimated from the black lines in Figure 1 showing the upper and lower limit of the correction factor. As an example, a photometer with an *f1'* of 6% will

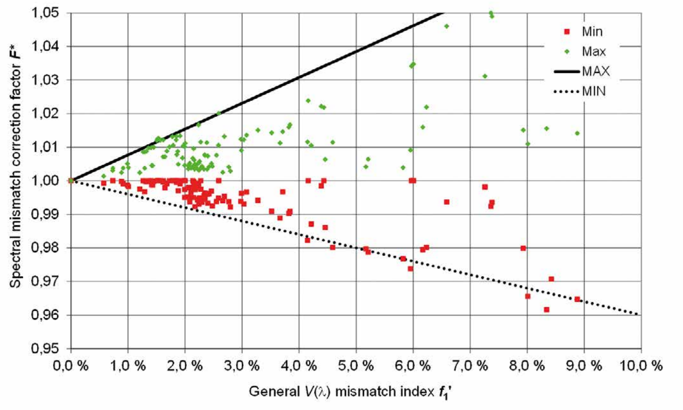

Figure 1: Spectral mismatch correction factors (SMCF) for phosphor-type white LEDs and different values of photometers [2]

contribute a maximum of about 4.8% to the uncertainty when measuring phosphor-type white LEDs. In most cases this is the dominant uncertainty parameter in the measurement of LED lamps and luminaires when the measurements are performed using photometers. According to the international LED measurements standard (CIE S 025, [2]) the measurement uncertainty shall be reported as part of the measurement results.

To further reduce the uncertainty, the calibration condition should be closer to the measurement condition. Hence if the photometer is used to measure mainly white LED sources it might be reasonable to consider a white LED as calibration source.

However, some challenges must be considered when defining an LED as a calibration source: in particular, the fact that there is not a single spectral power distribution that would be representative of all 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 CIE 015:2004, where selected spectral distributions of different fluorescent lamp designs are standardized as lamp spectra F1 to F12.

To address the issue, the CIE technical committee TC 1-85 is presently updating the fundamental CIE publication 15:2004 Colorimetry. It is intended to include a set of typical white light LED reference spectra referenced as Illuminant L1, L2, etc., of various types (phosphor based, hybrid, RGB, violet pumped). For this purpose, the reportership DR 1-62 has been established to select typical available LED spectra. This work is supported by the European research project EMPIR 15SIB07 PhotoLED [3] that collects and analyses a large number of spectra of SSL products on the market. The selection methodology and the selected spectra will be presented in a dedicated workshop at the next CIE midterm meeting [4]. Parallel to the Division 1 activities, CIE Division 2 has set up the reportership DR 2-71, which will select a subset of spectra that could be used to define new calibration reference spectra and consider possible implications of the new spectra. Presently CIE Standard Illuminant A is used in different contexts, such as calibrations of photometers and in the definition of the quality indices. Therefore, it is important to investigate the advantages and disadvantages of replacement of conventional standard lamps with new solid-state technology. There needs to be availability of sources that are able to reproduce the nominal spectra power distributions. It is therefore crucial to characterize possible LED standard lamps carefully.

The CIE research topic is not only limited to define new LED based calibration sources for general lighting application but it also outlines the need for calibration sources for spectral quantities in extended wavelength ranges (UV to NIR) as replacement of existing halogen-based sources. Alternative types of sources could be considered, including new broadband LED sources, laser-driven light sources, white-light laser sources, and tuneable laser sources for detector-based calibration.

In particular the research topic lists the following key questions to be addressed in near future:

- 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)?

CIE invites all interested partners including university research laboratories, lamp and measurement instrument manufacturers, private and national calibration and testing laboratories to conduct the necessary research to address these research questions. CIE calls on national and international research funders to create opportunities that will enable the research community to provide this necessary support to the CIE. The results of such research can best be published at CIE conferences and discussed at CIE workshops or Division meetings. The next opportunity is the CIE midterm meeting on October 22nd to 25th, 2017 in Jeju Island, Korea [4].

References:

[1] ISO/CIE 19476:2014(E): Joint ISO/CIE Standard: Characterization of the Performance of Illuminance Meters and Luminance Meters
[2] CIE S 025/E:2015: Test Method for LED Lamps, LED Luminaires and LED Modules
[3] Future Photometry Based on Solid State Lighting Products, http://photoled.aalto.fi/
[4] http://cie2017.org

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