EMPIR Call 2018 – Health, SI Broader Scope, Normative and Research Potential

Selected Research Topic number: **SRT-s11**
Version: 1.0

Title: Future photometry based on LED technology

Abstract

As incandescent light bulbs are banned from the market, there is a global need to establish novel photometric measurement methods that take into account the characteristics of LED lighting products. Furthermore, new scientific grade standard lamps based on LED technology are needed for the next key comparisons of luminous intensity and luminous flux, and for proficiency testing of laboratories. New validated LED-based source standards for luminance and radiance should be developed to ensure continuity of future photometric/radiometric calibrations. In addition, reliable electrical power measurements of AC/DC-converters of LED products need to be developed.

Keywords

Light-emitting diode (LED), luminous intensity, luminous flux, luminance, spectral radiance, electrical power, impedance

Background to the Metrological Challenges

The International Commission on Illumination (CIE) has published a research strategy with top priority topics, including development of new LED calibration sources and illuminants for photometry, colorimetry and radiometry. EMPIR JRP 15SIB07 PhotoLED is studying the viability of LED-based photometry as a potential alternative to the classical photometry based on incandescent standard lamps. That project defines new LED illuminants, which may be used for colorimetric analysis of materials and as LED reference spectra for calibration of photometers. That project is also developing new LED standard lamps for luminous intensity and luminous flux based on the defined reference spectra. CIE Division 1 is currently considering the publication of new LED illuminants as part of a revision of Technical Report CIE15: Colorimetry; and a new technical committee (TC) is being considered by CIE Division 2 to publish a new LED Reference spectrum. The new LED Reference spectrum, once available, will allow scientific quality LED standard lamps to enter the market.

In photometry and radiometry, calibrations are often linked together. For example, illuminance can be calculated from the radiometric quantity spectral irradiance by spectral integration. In the case of incandescent lamps, spectra of the sources are often modelled to allow extrapolation and interpolation of the data based on limited amount of measurement points. Planck’s radiation law with emissivity correction is often used for this purpose. Similar models for electroluminescent spectra of LEDs are needed for the development of new scientific LED sources with extended wavelength range to enable calibration of photometric and radiometric instruments.

A pilot study is currently being organised by Task Group 4 of CCPR Working Group on Key Comparisons which requires input on the use LED standard lamps in future key comparisons of luminous intensity and luminous flux. The key characteristics of potential LED standard lamps need to be studied and suitable lamp artefacts need to be selected for these comparisons and for supporting the work of accredited laboratories.

To ensure continuity in luminance and radiance calibrations in the future, a traceability chain for these calibrations based on LED technology needs to be developed and validated. As in the case of illuminance meters, calibrating luminance meters, imaging luminance-measuring devices (ILMDs) or near-field goniophotometers equipped with luminance measuring heads, using a LED luminance source standard would significantly reduce the uncertainty associated with spectral mismatch in cases where the instrument is used for measuring LED products and lighting.

AC-operated LED-products of different types are characterised and calibrated by NMIs for proficiency testing at test laboratories. The lamps used for the purpose need to have different electrical and optical properties to comprehensively study the capabilities of the measurement facilities used for testing of new lighting products coming to market. In 2013, the International Energy Agency (IEA) 4E SSL Annex arranged an interlaboratory comparison (IC 2013) with over hundred laboratories participating in measuring photometric, colorimetric and electrical quantities of a group of AC-operated LED products. The comparison revealed issues in measurements of the lamp artefacts. In the case of electrical power, deviations up to 35 % were observed, possibly due to differences in the AC voltage sources and bandwidths of electrical power meters used by the laboratories. It is crucial to solve these issues linked to electrical power measurement, as they lead to erroneous judging of LED product performance during testing and the energy-classifications of products.

Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the protocol.

The JRP shall focus on the development of new photometric standards and measurement methods based on LED technology.

The specific objectives are

1. To develop and test theoretical models for the electroluminescence spectra of LEDs, which can be used for interpolating and extrapolating spectral data of light sources, and evaluating uncertainties in a similar manner to the Planck's radiation law with emissivity correction for incandescent lamps.
2. To investigate and propose a selection of the most suitable LED standard lamps to be used as artefacts in the next round of CCPR Key Comparisons of luminous intensity and luminous flux, as well as in proficiency testing of laboratories. The artefacts should be fully characterised for electrical, photometric and radiometric properties, including information of short- and long-term stability.
3. To develop and validate new scientific LED source standards for calibration of luminance meters, imaging luminance-measuring devices (ILMDs) and hyperspectral cameras with an uncertainty of 0.3 % to 0.6 % (k = 2). The source standards should provide possibility to test the quality of $V(\lambda)$-filtered instruments for leakage at ultraviolet (UV) and near-infrared (NIR) wavelength regions.
4. To define and validate new reference electrical conditions for characterisation of AC-operated LED products at NMIs and at test laboratories, including compatibility with dimmers, high-end digitizers and electrical power meters with reduced bandwidth. The target uncertainty of electrical power measurements for well-behaving LED products is 0.1 % (k = 2).
5. To facilitate the take up of the technology and measurement infrastructure developed in the project by engaging the measurement supply chain (e.g. test laboratories), standards developing organisations (e.g. CIE TC2-59, CIE TC2-62, CIE TC2-67, CIE TC2-69 and CIE TC2-76, as well as CCPR WG-KC, CEN TC169 WG7 and IEC TC34) and end users (e.g. instrument and lighting product manufacturers).

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research work, the involvement of the larger community of metrology R&D resources outside Europe is recommended. A strong industry involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. In particular, proposers should outline the achievements of the EMPIR project 15SIB07 PhotoLED and EMRP ENG62 MESaIL, and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.8 M€, and has defined an upper limit of 2.1 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 20 % of the total EU Contribution across all selected projects in this TP.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the "end user" community, describing how the project partners will engage with relevant communities during the project to facilitate knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the "end user" community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the solid state lighting sector.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of EMPIR to develop a coherent approach at the European level in the field of metrology and include the best available contributions from across the metrology community. Specifically, the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.