European Partnership on Metrology
Call 2022 – Digital Transformation, Health, Integrated European Metrology, Normative and Research Potential

Selected Research Topic number: **SRT-s05**
Version: 1.0

Title: New calibration standards and methods for radiometry and photometry after phaseout of incandescent lamps

Abstract

Lights sources are ubiquitous in modern times, and the accurate knowledge of their optical radiation is crucial. Spectral irradiance, in particular, is used as a parameter to monitor industrial processes, essential climate variables, lighting, healthcare applications, biological safety, etc. For decades, the calibrations of measurement instruments have been done using incandescent lamps, which are the transfer standards for spectral irradiance. However, their availability is diminishing due to a production phaseout of incandescent lighting products and new replacement lamps based on solid-state-lighting (SSL) technology are restricted to visible wavelengths. Thus, alternative transfer standards are required. Proposals addressing the SRT should develop adequate and affordable replacement sources and methods for a detector-based transfer of the unit, to support stakeholders and end-users.

Keywords

Spectral irradiance, calibrations, transfer standard, spectroradiometer, radiometry, photometry

Background to the Metrological Challenges

Accurate knowledge of spectral irradiance of optical radiation emitted by artificial and natural light sources is essential in different sectors, such as industry (for UV-curing, disinfection, photovoltaic equipment, general and horticultural lighting, etc.), environment (solar radiation, essential climate variables, etc.), medical (sun beds, photobiological treatment, etc.), or scientific (analytical spectroscopy, plasma, etc.). The field of applications for spectral irradiance measurements has grown immensely during the last couple of decades due to the introduction in the market of affordable new-technology spectroradiometers based on array detectors and digital capabilities for in-situ processing of the spectral data.

Incandescent lamp-based transfer standards have been used for decades in the calibration of spectroradiometers. The availability of such lamps on the market used to fit the metrological purpose. However, the phaseout of the incandescent lighting threatens this availability. Incandescent lamps were followed by a technology change to solid-state-lighting (SSL) products. The spectra of the new replacement lamps based on the SSL technology, however, are restricted to visible wavelengths. Thus, alternative transfer standards built on new-technology sources with smooth spectra throughout the ultraviolet-visible-near infrared (UV-VIS-NIR) spectral range and/or detector-based calibration methods for the spectroradiometers are urgently needed. EURAMET TC-PR and CIE Division 2 [1] have acknowledged the need for further work on this area in their orientation papers.

To address the major needs of photometry, adequate transfer standards based on white-light LEDs were developed in EMPIR project 15SIB07. However, the useable spectral range of these standards is limited to a part of the visible wavelength range, and their quality and applicability for the spectral irradiance calibrations has not been evaluated. Within EMRP projects ENV03 and ENV59, and EMPIR project 19ENV04 stable sources for monitoring the stability of spectroradiometers have been developed based on LEDs to cover certain wavelength ranges of interest. They were, though, not meant to be used as transfer standards for spectral irradiance. Also, a new-technology laser-driven light source has been investigated within EMRP ENV03 project in terms of applicability as transfer standard for spectral irradiance in the solar UV spectral range.

Spectroradiometers can be calibrated directly at NMI or DI facilities provided that their key technical characteristics qualify them for such a task. The calibration can be accomplished either against a high-temperature blackbody as the primary standard for spectral irradiance, or a working standard source. Alternately, a spectroradiometer can be calibrated against a calibrated reference detector using a spectrally

tuneable laser, or a tuneable source of any other type adequate for the task. Within EMRP ENV03 and EMPIR 19ENV04 projects, a reference spectroradiometer for the quality assurance of solar UV radiation measurements in Europe was calibrated this way. However, the result of the calibration was stored in a portable source calibrator. Calibration of array spectroradiometers using tuneable laser sources has been shown also to be able to deliver promising results. However, further work on the analysis of achievable uncertainties along the traceability chain from the calibration to the end-user application is needed, and methods are required to secure the calibration results considering properties of the instrument and boundary conditions for the measurements. Additionally, to promote uptake by the end-users, guidelines should be developed and extensively disseminated.

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 traceable measurement of spectral irradiance and develop the metrological infrastructure required for these measurements after the technology change-driven phaseout of the incandescent lamps currently used as transfer standards.

The specific objectives are

1. To develop new standard sources for spectral irradiance in the ultraviolet-visible-near infrared (UV-VIS-NIR) spectral ranges, built on new-technology products, to replace current transfer standards that are based on incandescent lamps. The specific requirements for the spectral irradiance of the new standard sources are: i) well-defined and fit-for-purpose spectral and geometric properties, ii) long-term stability, iii) reproducibility, iv) robustness, and v) compatibility with existing calibration facilities. The new standard sources should allow dissemination of the spectral irradiance unit with transfer uncertainties as low as 0.5 % (k = 2).
2. To develop novel methods for enabling detector-based traceability of spectral irradiance measurements as an alternative to the incandescent lamps-based dissemination of the unit. This should involve i) the definition of the minimum requirements for relevant properties of (array) spectroradiometers to be suitable as transfer standards, ii) the development of procedures for their calibration that enable traceable measurements at end-user sites, and iii) the determination of uncertainties associated with the new traceability methods for spectral irradiance.
3. To demonstrate the metrological applicability of the new standard sources and methods, developed in objectives 1 and 2, in spectroradiometric applications involving spectral irradiance measurements in at least 3 end-user sites with total uncertainties as low as 1 % (k = 2).
4. To develop good practice guidelines for using the new standard sources and calibration procedures, as well as to implement the measurement methods and devices developed by the project.
5. To demonstrate the establishment of an integrated European metrology infrastructure and to facilitate the take up of the technology and measurement infrastructure developed in the project by the measurement supply chain (calibration and testing laboratories), standards developing organisations (CIE Division 2), technical committees (EURAMET TC-PR, CCPR) and end users (manufacturers and users of spectroradiometers).

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 both within and outside Europe, plus engagement with existing European research infrastructures and European Partnerships 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 and end users.

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 EMRP projects ENV03 and ENV59, and EMPIR projects 15SIB07 and 19ENV04 and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 1.9 M€ and has defined an upper limit of 2.6 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 25 % of the total EU Contribution across all selected projects in this TP.

Any industrial beneficiaries that will receive significant benefit from the results of the proposed project are expected to be beneficiaries without receiving funding or associated partners.

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,
- Develop an integrated self-sustaining European metrology infrastructure,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the users of spectroradiometers.

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 the Partnership 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.

Additional information

The references were provided by PRT submitters; proposers should therefore establish the relevance of any references.

[1] *014 CIE Div 2 detector-based calibration of spectroradiometers*

https://www.metpart.eu/go/need14