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

Selected Research Topic number: **SRT-n12**
Version: 1.0

Title: Metrology for wearable light loggers and optical radiation dosimeters

Abstract

Lighting is known to have an impact on humans, and clinical research is being carried out on the biological and physiological effects of light on sleep, health and wellbeing. Wearable light loggers, or radiation dosimeters, are light-weight wireless devices comprising one or multiple light sensors, filters and associated electronics logging time series data or summary metrics deduced from those data. Wearable light dosimeters have been used to assess the light exposure of humans. Though standardised methods and metrics have been introduced (CIE S 026:2018), calibration and characterisation of such dosimeters remains challenging. Guidance on providing traceability for wearable light dosimeters is therefore needed. Proposals addressing this SRT should therefore aim to standardise measurement methods and conditions to characterise, calibrate and use such dosimeters. This framework should support ongoing research on the impact of light on human health and wellbeing.

Keywords

Optical radiation dosimeters, wearable light logger, photobiological effect of light, physiological effect of light, psychological effect of light, spectral irradiance

Background to the Metrological Challenges

Spectral measurement and characterisation of light sources in testing laboratories are usually well understood and the measurement uncertainties are at an acceptable level for current uses. For the assessment of spectrally weighted irradiances, radiances and doses in field experiments and research, the situation is more difficult due to various environmental and design constraints, not present in laboratory settings.

Wearable light loggers and optical radiation dosimeters are powerful tools to measure light exposure for the study of photobiological or physiological effects of light. However, their compact and light-weight, black-box design introduces a variety of limitations that leads to inaccuracies, inappropriate metrics or non-representative data. How the data is processed depends on a number of parameters for each device, such as the number and type of sensor used, sampling rate, data format and model. While the specificity of each device may be necessary due to different end users and goals, CIE identified the need to harmonise photobiological and photometric quantities, in CIE TN 002:2014, which in part led to work on standard CIE S 026:2018. Reliable and well-calibrated wearable light loggers are essential to properly measure the human exposure to light (across days and seasons) and its relationship to human health and wellbeing [1].

A good understanding of the field of application is necessary to determine relevant quality indices and appropriate ranges for particular metrics. Based on standards for illuminance and luminance meters (ISO/CIE 19476:2014), some relevant quality indices have already been identified, and simple methods to evaluate those indices have been designed. However, those methods should be revised and improved to standardised characterisation methods to ensure reliability and reproducibility, as well as to facilitate the identification of external influencing parameters. As with measurements of visual imaging effects, measurements of non-image-forming effects of light are impacted by spectral mismatch, non-linearity and directional responsivity. Temperature and aging effects are also of major concern for wearable devices, which are subjected to environmental changes e.g. indoor or outdoor, day or night, seasonality and weather conditions.

Following this, it is of crucial importance to ensure consistency of data evaluation, conversion and restitution across devices with well-defined summary metrics. These metrics should also be relatable to more well-established spectral measurement and characterisation methods from laboratories. This would enable comparison between environmental data from monitoring networks and behavioural data from portable

dosimeters. Similarly, data models and formats should be harmonised to facilitate comparison and transfer across the scientific community. In addition to measuring light, other parameters must be recorded so that significant findings can be generated by combining different data (behavioural, environmental, etc.).

Wearable light loggers and optical radiation dosimeters are meant to be carried by test subjects, patients, or even the retail users at times. As such, it is essential to have guidelines on the practical use of the devices in order to balance ease of use for the wearer and reliability of the data generated.

Another point of concern linked to the technology is the lack of spatially resolved measurements in the field of view. The devices measure spatially averaged illuminance or irradiance that do not account for contrast or glare and may also be unable to capture lighting fluctuations detected by the eye due to compromises between sampling rate and battery or data storage. Investigations of new portable devices that can overcome those limitations are thus needed.

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 metrology research necessary to support standardisation in wearable and mobile devices used for the evaluation of optical radiation exposure over time and study the photobiological effects and/or physiological effects on humans.

The specific objectives are

1. To develop novel characterisation methods, and propose a set of quality indices for light loggers and optical radiation dosimeters. The quality indices may be similar as those defined by ISO and CIE for illuminance meters and luminance meters and their measurement should be validated through an interlaboratory comparison.
2. To develop data analysis methods to verify and increase the quality of data, and to establish the correlation between different data sets.
3. To produce recommendations on i) (meta-)data model and data formats, as well as summary metrics and on ii) the practical use of light loggers, including device placement, compliance and quality control.
4. To investigate the performance of new portable devices able to measure spatially resolved photobiological quantities and to compare them with spatially averaging devices, to determine relevancy depending on use case.
5. To collaborate with CIE Division 2 and Division 6, and the users of the standards they develop to ensure that the outputs of the project are aligned with their needs, including the provision of recommendations in a form that can be incorporated into future standards at the earliest opportunity.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art and explain how their proposed research goes beyond this.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€ and has defined an upper limit of 1.2 M€ for this project.

EURAMET also expects the EU Contribution to the external funded beneficiaries to not exceed 30 % 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,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the users and manufacturers of wearable light loggers.

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

1 *006 CIE Div 6 wearable light loggers sensors and dosimeters performance*

http://www.metpart.eu/normative-call-2022