Consultative Committee for Photometry and Radiometry (CCPR)

24th Meeting (19 - 20 September 2019)

Questionnaire on activities in radiometry and photometry

Reply from: LNE

Delegate: Jimmy Dubard

---

1. Summarize the progress in your laboratory in realizing top-level standards of:

   (a) broad-band radiometric quantities :

No progress for broad-band activities

   (b) spectral radiometric quantities :

Development of primary standard for BRDF, BTDF and BSSRDF spectrophotometric quantities. BRDF is operational since 2016 but improvements are being implemented to reduce uncertainty (polarization effect, large uncertainty below 400 nm). BTDF and BSSRDF are under development as new quantities.
Reduction by a factor 2 of uncertainty in the visible range for spectral transmittance by implementing a better control of the temperature of the filters during the measurement has been done and validated by CCPR-K6.
Full modification of spectral radiance and irradiance measurement facility with simplification of the link with the cryogenic radiometer has been completed in 2018, with the hope of a validation by CCPR-K1a.
Extension of the spectral range of regular transmittance, irradiance and detector sensitivity from250 nm up to 200 nm is engaged since 2018 with the objective to be completed before spring 2020.

   (c) photometric quantities :

Nothing has been done over the period, but according to last results of CCPR-K3, the lab will engage a full project to consolidate the link between photometers and cryogenic radiometer

2. What other work has taken place in your laboratory in scientific or technological areas relevant to the CCPR?

Development of a goniospectrophotometer to access BRDF of surfaces with an ultra high angular resolution (below 0.2 µsr). Application are characterizations of gloss, of functional surfaces, and development of state of the art in the field of comprehension of optical reflection on rough surfaces.

Works in connection with the measurement of appearance of materials (exploring new routes for the measurement of gloss, of translucency)

LNE participates to several European projects in the framework of the EMRP program (European Metrology Research program):

BiRD project

LNE-CNAM coordinates the Euramet JRP BiRD (Birectionnal Reflectance Definitions). BiRD is a 36 months project that started in May 2017 and implicates 10 partners (9 NMIs). Objective of the project is to initiate normalization work with CIE to clarify how bidirectional reflectance measurements on standard artefacts and surfaces exhibiting goniochromatism, gloss and sparkle visual effects should be carried out. It aims also to will provide data file recommendation for BRDF measurement share.

Beyond coordinating the project, LNE-CNAM is implicated in WP1 (BRDF) by providing BRDF measurements on glossy samples, and accessing the specular peak with a 0.015° angular resolution provided by ConDOR, its goniospectrophotometer. CNAM is also in charge of exploring the effect of the illumination shape, divergence and uniformity on the BRDF measurement. All this work will be reported to CIE TC2-85, chaired by CNAM, to feed the section related to glossy samples in the "CIE recommendations for the measurement of the BRDF".

LNE-CNAM is also implicated in WP3 (gloss) to provide psychophysical scales collected on different gloss scales provided by NCS company, as well as optical measurements carried on the same samples.

LNE-CNAM is finally highly implicated in WP5 (impact) by organizing meetings with the 30 project stakeholders, facilitating the link with CIE TC2-85 and CIE JTC17, and promoting the project results to the scientific community (GDR APPAMAT, ITN ApPEARS),

PVENERATE project

The aim of the project is to provide the metrological infrastructure, techniques and guidance to accelerate time-to-market for emerging photovoltaics (PV) technologies, which have the potential to significantly reduce the cost of photovoltaic energy.

The project has two main objectives: Firstly, to improve the PV energy rating standards and secondly, to improve the measurement equipment and methodologies to enable precise measurements of the parameters required for the energy rating.

Pilot: PTB, 13 participants

LNE contributes to the following tasks

WP1 : Definition and realisation of standard test conditions for bifacial solar devices

Task 1.2: Improvement of hardware for measuring characteristics of bifacial solar devices

FhG-ISE and LNE will determine the uncertainty budget of the setup developed by FhG-ISE. The setup will be evaluated by measuring at least three large-area solar cells with single-sided illumination and comparing the measurement results with those obtained from well-established setups for monofacial solar cells. LNE will apply the Monte Carlo technique particularly for measurands involving spectral data.

Task 1.5: Improvement of the uncertainty evaluation of the spectral mismatch correction
LNE will apply the Monte Carlo technique for the uncertainty evaluation of the spectral mismatch correction.

WP2: *Extending energy rating to bifacial solar modules and modules in buildings*

Task 2.4: Enhancing energy rating through optimised use of continuous outdoor test data
NPL and LNE will model uncertainty propagation (in device performance and conditions) through outdoor measurements and interpolation / extrapolation to reference conditions to produce an uncertainty model for energy rating based on outdoor measurement data.

WP4: *Impact*

Task 4.1 Knowledge transfer
LNE will ensured that at least 3 articles will be published in broader-readership publications by partners.
LNE will organise a symposium on the topic of advanced energy rating, characterisation of bifacial PV, or similar at the EUPVSEC conference.

SURFACE project

This project will provide validated, optimised and reliable geometrical conditions for the measurement of road surface reflectance spatial distribution characteristics (the so called luminance coefficient *q* or reduced luminance coefficient *r*) and new data representative of current road pavements. The knowledge of *q* is an unavoidable requirement for designing road lighting installations for motorised traffic and is needed to be able to assure that road luminance is adequate for visual conditions and traffic safety. However, the current reference tables of *r* do not provide values for all directions acknowledged in the relevant

standards. For example data is missing or is often based on measurements performed more than 40 years ago.

Therefore, new validated data is needed for pavements, LED and smart lighting systems in order to support the enhancement of performance for visual optimisation, energy efficiency and safety as set out in current Road Lighting Standards.

Pilot INRIM, 9 participants

LNE contributes to the following tasks

WP1: Instruments

Task 1.3: Traceability and uncertainty evaluations

Using as input results of tasks 1.1, 1.2 and 1.4 LNE, INRIM METAS, SP, and METROSERT will define the measurement model for evaluating uncertainty of the instruments involved in an intercomparison .Based on the measurement model LNE will develop a software for the evaluation of the uncertainty taking into account of correlated values. Feedback from partners using the software will allow to refine the uncertainty evaluation algorithm. In this way a useful asset is provided to simplify the evaluation of intercomparison results and a real test of the proposed model/models of measurement uncertainty is carried out.

LNE will coordinate and harmonize the contributions of the other partners. LNE will also develop, under CC policy, software for the *q* measurement uncertainty evaluation. This software will be available to the community and will be a powerful tool for stakeholder.

Task 1.4: Influences of the light source spectral characteristics on measurement results

LNE and Cerema , will provide guidelines to statistically estimate the contribution to measurement uncertainty due to the instrument light source spectrum. LNE will take advantage of its experience in the use of the Monte Carlo technique for evaluating measurement uncertainty involving spectral data.

3. What work in PR has been/will be terminated in your laboratory, if any, in the past /future few years? Please provide the name of the institution if it has been/will be substituted by a DI or accredited laboratory.

LNE contributes to the IEA (International Energy Abency) annex 4E IC2017 comparison on LED luminaires with Dr Yosho Ohno as task leader and KILT (Korea Institute of Lighting Technology) as organizing laboratory. Two Nucleous Laboratories KILT and LNE performed the measurements during the bilateral comparisons between participants and the Nucleous laboratories.
The measurements are performed on a set of 4 luminaires including a narrow beam spot light, interior luminaires and a street luminaires.
The quantities to measure are those set in the CIE S025 publications: spatially resolved photometric quantities, colorimetric quantities, electrical quantities,…

40 testing and industrial laboratories all over the world participated to the comparison. The measurement started in December 2017. All the measurements are performed and data analysis is on-going. The comparison report is expected end of 2019.

4. What are present, new or emerging needs of users of your services that are not being supported sufficiently by current CCPR activities or initiatives? In the light of this information please suggest desirable changes in the future working program of the CCPR.

Spectral calibrations in the field 200 nm to 250 nm (sensitivity, transmittance, reflectance, irradiance) must be reinforced but I think that this activity is in good hands with the different pilot comparison engaged.
Bidirectionnal reflectance and transmittance are getting more and more common in industry and validity of the scales developed by NMIs must be consolidated.

5. What priorities do you suggest for new research and development programmes at NMIs in the area of Photometry and Radiometry?

Development of new quantities in the field of spectrophotometry (BTDF, BSSRDF) and exploring the link between sphere based quantity and open spaced quantities

6. Are there any research projects where you might be looking for collaborators from other NMIs or are there studies that might be suitable for collaboration or coordination between NMIs?

Collaboration between European NMIs is effective in the field mentioned (spectrophotometry) thanks to EURAMET joint research projects. We must now think about inter RMO comparison of BRDF/BTDF scales to ensure that uncertainties claimed are valid.

7. Have you got any other information to place before the CCPR in advance of its next meeting?

No

8. Bibliography of radiometry and photometry papers of your laboratory since the last CCPR (September 2014)?

DUBARD J., OBEIN G., SURYANI D., 2019, “Bilateral comparison of luminous flux using lamps as transfer standards (EURAMET.PR-K4.2)”, *Metrologia*, **56**, 02001.

I. Kröger, D. Friedrich, S. Winter, E. Salis, H. Müllejans, D. Pavanello, J. Hohl-Ebinger, K. Bothe, D. Hinken, S. Dittmann, G. Friesen, M. Bliss, T. Betts, R. Gottschalg, L. Rimmelspacher, J. Stang, W. Herrmann, and J. Dubard, « Results of the round robin calibration of reference solar cells within the PhotoClass project », *International Journal of Metrology and Quality Engineering*, **vol. 9**, August 2018

E. Salis,, D. Pavanello, I. Kroeger, S. Winter, K. Bothe, D. Hinken, T. Gandy, J. Hohl-Ebinger, G. Friesen, S. Dittmann, J. Dubard, H. Müllejans, “Results of four European round-robins on TCO measurements for PV devices of different size”, *Progress in photovoltaics*, 2018

A Sperling, M Meyer, S Pendsa, W Jordan, E Revtova, T Poikonen, D Renoux and P Blattner, “ Multiple transfer standard for calibration and characterization of test setups for LED lamps and luminaires in industry”, *Metrologia* **55**, 2018

CHANDOUL F., COUTIN J. M., ROUGIÉ B., 2017 "Improvement of the spectral responsivity measurements in the UV range at the French national metrology laboratory", *NEWRAD 2017 Proceedings*, Tokyo, Japan.

ROUGIÉ B., VALIN M. H., "Thermodynamic measurement and validation of a high temperature blackbody for spectral radiance and irradiance reference" *NEWRAD 2017 Proceedings*, Tokyo, Japan.

GED G., RABAL A. M., OBEIN G., 2017 "Absolute BRDF measurements with ultra-high angular resolution for the characterization of optical surfaces", 2017, *NEWRAD 2017 Proceedings*, Tokyo, Japan.

VALIN T., DUBARD J. "Monochromator based set-up for stray light characterization of industrial spectroradiometers" *NEWRAD 2017 Proceedings*, Tokyo, Japan.

OBEIN G., SIMIONESCU M., DUBARD J., SEUCAN A., BASTIE J., 2017, "Luminous intensity bilateral comparison using lamps as transfer standards between LNE (France) and INM-RO (Roumania)", *Metrologia*, **54**, Tech. Suppl., 02003.

PAGE, M., OBEIN, G., BOUST, C., & RAZET, A. , 2017, "Adapted Modulation Transfer Function Method for Characterization and Improvement of 3D printed surfaces", *Electronic Imaging*, *2017*(8), 92-100.

GED G., RABAL A. M., HIMBERT M. E., OBEIN G., 2017 "Does the visual system extract more information than gloss in the specular direction ?", October 2017, *CIE Midterm conference*, Jeju Island, Republic of Korea.

DÖNSBERG T., MANOOCHERI F., SILDOJA M., JUNTUNEN M., SAVIN H., TUOVINEN E., RONKAINEN H., PRUNNILA M., MERIMAA M., TANG C. K., GRAN J., MÜLLER I., WERNER L., ROUGIÉ B., PONS A., SMÎD M., GÁL P., LOLLI L., BRIDA G., RASTELLO M. L. IKONEN E., 2017 "Predictable quantum efficient detector based on n-type silicon photodiodes", *Metrologia* **54**, 821

Strothkämper C., Ferrero A., Koo A., Jannson P., Ged G., Obein G., Källberg S., Audenaert J., Leloup F., Verdu F., Perales E., Schirmacher A., Campos J., 2016, "Multilateral Spectral Radiance Factor Scale Comparison", *Applied Optics,* **56**(7), p1996-2006,

GED G., LELOUP F., DE WIT Y., OBEIN G., 2016, "Intercomparison of visual gloss psychometric scales", *Proceedings of 4th CIE Expert Symposium on Colour and Visual Appearance, CIE x043:2016,* Prague, CZ.

LELOUP F., AUDENAERT J., OBEIN G., GED G., HANSELAERE P., 2016, "Repeatability and reproducibility of specular gloss meters in theory and practice", J Coat Technol Res. **13**: 941