Consultative Committee for Photometry and Radiometry (CCPR)

24th Meeting (19 - 20 September 2019)

Questionnaire on activities in radiometry and photometry

Reply from: VSL

Delegate: Steven van den Berg

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

   (a) broad-band radiometric quantities :

   (b) spectral radiometric quantities :

   - VSL is extending its range for spectral responsivity measurements up to 2500 nm. The design of an enhanced InGaAs based integrating sphere detector has been updated and new detectors have been built and calibrated against the cryogenic radiometer. Further characterization is in progress.

   (c) photometric quantities :

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

   - Within the EMRP project METEOC2 (2014-2017) VSL has developed a filter radiometer for measuring radiance at low signal levels at 1550 nm. The filter radiometer forms the transfer standard between a primary black body source and a plate radiator. After several design optimizations the filter radiometer has been used as transfer standard between a PTB black body and a plate radiator. The latter has been used in field experiments to calibrate grazing incidence p-branch spectrometers (GRIPS), which are used for measuring the temperature of the mesopause via a spectroscopic method. The traceability chain from black body to the GRIPS instrument via het filter-radiometer and plate radiator has proven to deliver the requested measurement uncertainty <1 %.
   - VSL participated in the EMRP project 'ATMOZ' (2014-2017), on traceable measurement of atmospheric total column ozone, by developing a portable instrument for wavelength calibration of spectroradiometers under field conditions. A 'wavelength ruler', showing a wavelength-dependent transmission, serves as the reference for wavelength. The instrument is based on a Lyot filter and has been developed and optimized for spectrometers that are typically used for field measurements on atmospheric ozone. A final field campaign has been held in September 2016. VSL contributed to model-development and uncertainty calculation for deriving the total column of

ozone for different types of spectroradiometers that are typically used for field measurements. The work on the uncertainty budget also comprised the effects of cross-correlation among influence parameters entering the measurement equation of total column ozone.

- VSL has started with a project to develop metrology for Photobiological Safety, driven by requests on quantifying potentially harmful emission of radiation from various instruments or devices. VSL is developing a transportable setup based on a spectroradiometer for on-site (ir)radiance measurement, initially for UV irradiance (200 nm – 400 nm), with the aim to extend this to radiance measurement (300 nm – 1400 nm).
- VSL has developed AC-driven LED-based photometric standards (EMPIR PhotoLED project, 2016-2019) for luminous flux measurement at NMI level as well as for dissemination to testing laboratories. Stable electrical power consumption and luminous flux, and well-defined spectral power distribution (SPD) were key design criteria for the lamps. The lamps show a luminous flux stability of 0.1% and a power factor > 0.97 after a warm up time of 30 minutes. The standards have been used for a comparison among test laboratories and NMIs on luminous flux measurement coordinated by VSL.
- Within the EMPIR METEOC 3 project (2017-2020), VSL is developing a widely tunable (210 nm – 2400 nm) laser-based radiance source for the calibration of (Earth Observation) spectroradiometers. Currently the setup has been built and calibration is about to take place. As a case study a cube-sat based spectroradiometer will be calibrated against the radiance source. Furthermore, and experiment has been designed to calibrate spectrometers for mesopause measurement like the GRIPS instrument (see above) with a transportable radiance source, that is driven by a tunable IR laser (1500 nm - 1600 nm).

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.

   none

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.

   We observe increasing attention for human centric lighting and health and safety aspects of lighting and other radiation sources.

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

The priorities are sufficiently covered by the CCPR strategy document and the EURAMET Strategic Research agenda, to highlight a few:

- Development of LED-based standard lamps to replace incandescent standard lamps.
- Metrology for calibration of imaging systems, both photometry (e.g. near field goniometer calibration) and radiometry (e.g. camera calibration of Earth observation imagers).

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?
   - Comparison on spectral responsivity measurement 1600-2500 nm
7. Have you got any other information to place before the CCPR in advance of its next meeting?

   none
8. Bibliography of radiometry and photometry papers of your laboratory since the last CCPR (September 2016)?

- Steven van den Berg; Omar El Gawhary; Paul Dekker; Marijn van Veghel; Ramon Vink; Steven Sablerolle;Gianluca Casarosa, End to end calibration of a radiometer at high irradiance levels, Proceedings Volume 11180, International Conference on Space Optics — ICSO 2018; 111807Y, (2019) https://doi.org/10.1117/12.2536205

- Steven van den Berg; Paul Dekker; Tessel van der Laan; Gerard Otter; Niels Dijkhuizen; Bilgehan Gür; Sanneke Brinkers, Traceable radiance source for spectroradiometer calibration Proceedings Volume 11180, International Conference on Space Optics — ICSO 2018; 1118068 (2019) https://doi.org/10.1117/12.2536143

- Steven van den Berg, Paul Dekker, Max Reiniger, Berndt Gutschwager, Christian Monte and Jörg Hollandt, *Traceability of the Network for Detection of the Mesospheric Change (NDMC) to radiometric standards via a Near Infrared Filter radiometer,* J. Phys.: Conf. Ser. 972 012006 (2018)

- Tomi Pulli, Saulius Nevas, Omar El Gawhary, Steven van den Berg, Janne Askola, Petri Kärhä, Farshid Manoocheri, and Erkki Ikonen, "Nonlinearity characterization of array spectroradiometers for the solar UV measurements," Appl. Opt. **56**, 3077-3086 (2017)

- Dekker, P. et al. Mains-operated led-based transfer source for luminous flux scale realisation and dissemination. in PROCEEDINGS OF the 29th Quadrennial Session

of the CIE 1134–1142 (International Commission on Illumination, CIE, 2019). doi:10.25039/x46.2019.PO067

- Schneider, T., Dekker, P., Young, R., Blattner, P. & Poikonen, T. Extrapolation of phosphor converted white led spectra beyond the visible wavelength range. in PROCEEDINGS OF the 29th Quadrennial Session of the CIE 1229–1237 (International Commission on Illumination, CIE, 2019). doi:10.25039/x46.2019.PO105

- Poikonen, T., Dekker, P et al. Future photometry based on solid-state lighting products. in PROCEEDINGS OF the 29th Quadrennial Session of the CIE 719–724 (International Commission on Illumination, CIE, 2019). doi:10.25039/x46.2019.PP13

- Kokka, A., Dekker, P et al. Development of white LED illuminants for colorimetry and recommendation of white LED reference spectrum for photometry. Metrologia 55, 526–534 (2018).

- Zhao, D. et al. Traceable measurements of the electrical parameters of solid-state lighting products. Metrologia 53, 1384–1394 (2016).

- H. Ahmadpanahi, O. El Gawhary, R. Vismara, O. Isabella, and M. Zeman, “Assessing light absorption contributions in thin periodically-textured silicon absorbers under oblique illumination”, AIP Advances **9**, 045001, 2019.

- Berjn, A. Redondas, M. Sildoja, S. Nevas, K. Wilson, S. F. Len-Luis, O. El Gawhary, and I. Fountoulakis, “Sensitivity study of the instrumental temperature corrections on Brewer total ozone column measurements”, Atmos. Meas. Tech., **11**, 3323-3337, 2018