

Consultative Committee for Photometry and Radiometry (CCPR)
25th Meeting (on-line 10-11 May 2022)

**CCPR member report on activities in radiometry and photometry since the last
CCPR meeting (2019)**

Reply from: Instituto de Óptica “Daza de Valdés” (IO-CSIC)

Delegate: Joaquín Campos Acosta

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1. Summarize the recent progress in your laboratory with respect to measurement standards, research projects, and metrology services to fulfil the demands of customers in:
 - (a) broad-band radiometric quantities: No progress in this area since the last report.
 - (b) spectral radiometric quantities: No progress in this area since the last report.
 - (c) photometric quantities: No progress in this area since the last report.
 - (d) other area(s) relevant to CCPR:
 - A new service has been established to measure insertion losses in optical fibers and fiber optic devices.
 - Funding has been obtained from the Spanish government's National R&D&I Plan to prepare facilities and equipment to respond to recent demands for characterization and calibration services for new very high precision optical sensing systems and sensing elements based on single photon sources that require detection systems at the level of a few tens of photons.
 2. What work in PR has been/will be terminated in your laboratory, if any, in the past /future few years? Please explain the reasons and provide the name of the institution if it has been/will be substituted by a DI or accredited laboratory.

No metrological activity has been terminated in the laboratory during this period. There are no plans to terminate any service.
 3. Summarize the Capacity Building and Knowledge Transfer activities undertaken by your institute in photometry and radiometry (courses, training, ...):
 - IO-CSIC together with 7 other NMI are taking part in the project “Supporting smart specialisation and stakeholder linkage in Photometry and Radiometry” (Program EMPIR 20SCP01, Smart PhoRa). led by PTB. The overall aim of the project is to enable emerging NMIs/DIs to develop their metrological knowledge and expertise concentrated in areas that are important to their specific needs of the stakeholders within their region with respect to smart specialisation in the field of photometry and radiometry. IO-CSIC participates

as a transmitter of knowledge in the areas of fiber optics and reflectometry, while it is a receiver of knowledge in gloss.

- IO-CSIC participates in a master on metrology of the Universidad Nacional de Educación a Distancia (UNED), where it is responsible for the part of Photometry and Radiometry.
- IO-CSIC participates in an interuniversity master on photonic technologies of four universities in Madrid (UC3M, UPM, UAH, URJC) where it is responsible for the metrology of optical fibers.

4. Summarize the research projects currently performed within a collaboration with one or more NMIs or Dis (name of the project, participants):

- New quantities for the measurement of appearance (BxDiff, EMPIR 18SIB03). Led by LNE-CNAM, with participation of Aalto, CMI, CSIC, DFM, METAS, PTB, RISE and other non NMI partners.
- Revision and extension of standards for test methods for LED lamps, luminaires and modules (RevStdLeds, EMPIR 19Nrm02). Led by PTB, with participation of Aalto, CSIC, IPQ, LNE TUBITAK and other non NMI partners.

5. Are there any other 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?

- Solid state lighting. Propagation model based on radiant intensity or radiance distributions rather than in ray tracing. It may be very useful for rendering in computer imaging.
- Appearance metrology, particularly on issues attempting to relate the BRDF of gonio-apparent objects with their perceptual properties: colour, translucency, gloss and texture. Issues on modelling sparkle and graininess.
- New fields of optical radiation measurements where IRMDs (imaging radiance meter devices) can play a role on improving existing devices. Examples could be found in meteorological measurements.
- If the CCPR considers the study of nonlinear effects in fibres, including the femtosecond regime, as an interesting research project, the coordination and the collaboration with others NMIs would be necessary.
- The developments of standards for high power pulsed laser in NIR (800 - 2 000 nm), and standards and methods for measuring femtosecond pulses from mode locked optical fibre lasers.
- Nonlinear effects in fibres and crystals and their application in optical radiometry.
- Use of photon sources to study the spectral yield of the eye and its relationship with $V(\lambda)$ or $V'(\lambda)$.
- Radiometric devices on a chip.

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

None

7. Bibliography of radiometry and photometry papers of your laboratory since the last CCPR (September 2019):

a. 2019.

- Alexander Kokka et al, Validation of the fisheye camera method for spatial non-uniformity corrections in luminous flux measurements with integrating spheres 2019 Metrologia 56 045002.

b. 2020

- A Calderón et al, Accounting for polarization–related effects in the measurement of the bidirectional reflectance distribution function, 2020 Metrologia 57 045003.
- Ferrero, A., & Campos, J. (2020). Angular and Spectral Bandwidth Considerations in BRDF Measurements of Interference-and Diffraction-Based Coatings. Coatings, 10(11), 1128.
- A Ferrero et al, An insight into the present capabilities of national metrology institutes for measuring sparkle. 2020 Metrologia 57 065029.
- Alejandro Ferrero, Berta Bernad, Joaquín Campos, Noël Richard, Christine Fernández-Maloigne, and Manuel Melgosa, "Goniochromatic assessment of gray scales for color change," J. Opt. Soc. Am. A 37, 1266-1275 (2020).
- GONIOSPECTRORADIOMETRY OF OPTICAL RADIATION SOURCES, CIE 239:2020. DOI: 10.25039/TR.239.2020.
- Magalhães, R.; Costa, L.; Martin-Lopez, S.; Gonzalez-Herraez, M.; Braña, A.F.; Martins, H.F. Long-Range Distributed Solar Irradiance Sensing Using Optical Fibers. Sensors 2020, 20, 908. <https://doi.org/10.3390/s20030908>.
- Magalhães, R., Pereira, J., Tarasenko, O., Martin-Lopez, S., González-Herráez, M., Margulis, W., & Fidalgo Martins, H. (2020). Towards Distributed Measurements of Electric Fields Using Optical Fibers: Proposal and Proof-Of-Concept Experiment. Sensors, 20(16), 4461.

c. 2021

- Huraibat, K., Perales, E., Kirchner, E., Van der Lans, I., Ferrero, A., & Campos, J. (2021). Accurate physics-based digital reproduction of effect coatings. Optics Express, 29(21), 34671-34683.
- Ferrero, A., Frisvad, J. R., Simonot, L., Santafé, P., Schirmacher, A., Campos, J., & Hebert, M. (2021). Fundamental scattering quantities for the determination of reflectance and transmittance. Optics Express, 29(1), 219-231.

- A. Ferrero, E. Perales, N. Basic, M. Pastuschek, G. Porrovecchio, A. Schirmacher, J. L. Velázquez, J. Campos, F. M. Martínez-Verdú, M. Šmid, P. Linduska, T. Dauser, and P. Blattner, "Preliminary measurement scales for sparkle and graininess," *Opt. Express* 29, 7589-7600 (2021)
- Santafé-Gabarda, P., Ferrero, A., Tejedor-Sierra, N., & Campos, J. (2021). Primary facility for traceable measurement of the BSSRDF. *Optics Express*, 29(21), 34175-34188.
- Khalil Huraibat, Esther Perales, Eric Kirchner, Ivo Van der Lans, Alejandro Ferrero, and Joaquín Campos, "Visual validation of the appearance of chromatic objects rendered from spectrophotometric measurements," *J. Opt. Soc. Am. A* 38, 328-336 (2021).
- David González-Andrade, Thi Thuy Duong Dinh, Sylvain Guerber, Nathalie Vulliet, Sébastien Cremer, Stephane Monfray, Eric Cassan, Delphine Marris-Morini, Frédéric Boeuf, Pavel Cheben, Laurent Vivien, Aitor V. Velasco, and Carlos Alonso-Ramos, "Broadband Fourier-transform silicon nitride spectrometer with wide-area multiaperture input," *Opt. Lett.* 46, 4021-4024 (2021).
- Miguel Soriano-Amat, Hugo F. Martins, Vicente Durán, Sonia Martin-Lopez, Miguel Gonzalez-Herraez, and María R. Fernández-Ruiz, "Quadratic phase coding for SNR improvement in time-expanded phase-sensitive OTDR," *Opt. Lett.* 46, 4406-4409 (2021).
- Thi Thuy Duong Dinh, David González-Andrade, Miguel Montesinos-Ballester, Lucas Deniel, Bertrand Szelag, Xavier Le Roux, Eric Cassan, Delphine Marris-Morini, Laurent Vivien, Pavel Cheben, Aitor V. Velasco, and Carlos Alonso-Ramos, "Silicon photonic on-chip spatial heterodyne Fourier transform spectrometer exploiting the Jacquinet's advantage," *Opt. Lett.* 46, 1341-1344 (2021).
- Soriano-Amat, M., Martins, H. F., Durán, V., Costa, L., Martin-Lopez, S., Gonzalez-Herraez, M., & Fernández-Ruiz, M. R. (2021). Time-expanded phase-sensitive optical time-domain reflectometry. *Light: Science & Applications*, 10(1), 1-12.