Consultative Committee for Photometry and Radiometry (CCPR)
23rd Meeting (22 - 23 September 2016)

Questionnaire on activities in radiometry and photometry

Reply from: Czech Metrology Institute

Delegate: Dr. Marek Šmíd

1. Summarize the progress in your laboratory in realizing top-level standards of:
   (a) broad-band radiometric quantities
   (b) spectral radiometric quantities
   (c) photometric quantities

The progress in CMI laboratory is strongly linked with the successful CMI research achieved in the framework of joint research projects of EMRP program completed in last 2 years since last CCPR meeting. In these results many other project partners were contributed. Results were published in peer-reviewed journals; key publications are listed in par. 8.

Below see please the list of completed rch
SOLAR ULTRAVIOLET RADIATION (2011-2014):
This project significantly enhanced the reliability of spectral solar UV radiation measured at the Earth surface by developing new methods of observation (techniques and instruments) to provide traceable solar UV irradiance measurements with an uncertainty of less than 2%. **CMI** research within the project was focused in improvements of reference spectro-radiometers and developments of DLP based array spectro-radiometers with stray-light rejection: Results were published in peer reviewed journals and are listed below

MIQC-Metrology for Industrial Quantum Communications (2011-2014):.
The project was focused on Quantum Key Distribution technologies which is the most advanced towards practical application.
CMI teams' activities were focussed in the works towards better metrological characterisation of quantum receivers (in close collaboration with NPL and INRIM)

NEWSTAR (2013-2016):
The main goal of project is to develop a primary standard for radiometry which has approximately the same cost and functionality as transfer standard detectors thus enabling NMIs to actually build the primary standard into different applications taking full advantage of its properties.
CMI is the leading team of activities dealing with implementing the room-temperature Predictable Quantum Efficiency detectors (RT-PQED) or applications at 100 ppm uncertainty as spectral responsivity standards.

SIQUTE -Single Photon Sources for Quantum Technologies (2013-2016):
The aim of this JRP was to develop deterministic, compact and efficient single-photon sources (SPS) for needs of cutting edge quantum optical technologies such as quantum communication, quantum computation and quantum metrology.

CMI team was responsible for developing low noise low photon flux transfer standard detectors for validation the single-photon sources

xDReflect - Multidimensional reflectometry for industry (2013-2016):
this project was the collaboration between National Metrology Institutes, partners from Industry and the research Community in Europe aiming to validate reliable optical measurements with traceability to the SI-system to describe the overall macroscopic appearances of modern surfaces.
CMI team took mostly a part in activities aiming to measure gonio-chromatic samples using a new CMI robot based gonio-photometer (see figure 1 below) and was responsible for networking of NMIs with the EU and global industries, having hosted the 4th CIE Expert symposium on Visual Appearance in Sept 2016 in Prague.

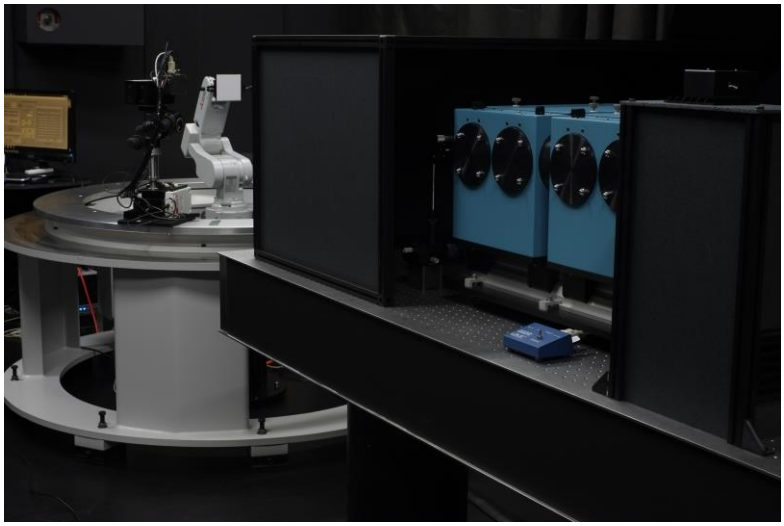

Fig.1.: CMI Robot-based gonio-photometer for BRDF/BTDF measurement

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

CMI team participates in the further EMRP and EMPIR ongoing projects in the technological areas relevant to the CCPR :

ATMOZ- Traceability for atmospheric total column ozon (2014-2017)
METEOC2 – European Metrology for Earth Observation and Climate (2014-2017)
MIQC2 – Metrology for quantum communication 2 (2015-2018)
PhotIND – Metrology for photonic industry (2015-2018)
PhotoLED - Future photometry based on solid state lighting products (2016-2019)

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.
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.

5. What priorities do you suggest for new research and development programmes at NMIs in the area of Photometry and Radiometry?
   - Absolute cryogenic radiometers for infrared spectral range
   - Development of metrology supporting visual appearance assessment
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?
7. Have you got any other information to place before the CCPR in advance of its next meeting?
8. Bibliography of radiometry and photometry papers of your laboratory since the last CCPR (September 2014)?

G. Porrovecchio, M. Šmid, M. López, H. Hofer, B. Rodiek, S. Kück, "Comparison down to sub-100-fW optical power level between a high sensitive, low noise Silicon photodiode and a low optical flux measurement facility based on a double attenuator technique", Metrologia 53 1115–1122, (2016), doi:10.1088/0026-1394/53/4/1115.

Gregor Hülsen, Julian Gröbner, Saulius Nevas, Peter Sperfeld, Luca Egli, Geiland Porrovecchio, and Marek Smid Traceability of solar UV measurements using the Qasume reference spectroradiometer ", Applied Optics, Vol. 55, Issue 26, pp. 7265-7275, 2016 doi: 10.1364/AO.55.007265

Feldmann A., Burnitt T., Porrovecchio G., Smid M., Egli L., Gröbner J., Nield K., Diode-Array UV solar spectroradiometer implementing a digital micromirror Device, Metrologia, 51, 6, 2014. doi:10.1088/0026-1394/51/6/S289, 2014.

M L Rastello, I P Degiovanni, A G Sinclair, S Kück, C J Chunnilall, G Porrovecchio, M Smid, F Manoocheri, E Ikonen, T Kubarsepp, A Tosi, G Brida, A Meda, F Piacentini, P Traina, A Al Natsheh, J Y Cheung, I Müller, R Klein, A Vaigu, Metrology for industrial quantum communications: the MIQC project, Metrologia 11/2014; 51(6):S267. DOI:10.1088/0026-1394/51/6/S267

M. Shpak, P. Kärhä, G. Porrovecchio, M. Smid, and E. Ikonen, Luminance Meter for Photopic and Scotopic Measurements in the Mesopic Range, Meas. Sci. Technol. 25, 095001, 7 pages (2014).