Bureau International des Poids et Mesures

Consultative Committee for Photometry and Radiometry (CCPR)

Report of the 25th meeting
(10-11 May 2022)
to the International Committee for Weights and Measures

Comité international des poids et mesures

LIST OF MEMBERS OF THE
CONSULTATIVE COMMITTEE FOR PHOTOMETRY AND RADIOMETRY
as of 10 May 2022

President

Dr M. L. Rastello, member of the International Committee for Weights and Measures.

Executive Secretary

Dr J. Viallon, International Bureau of Weights and Measures [BIPM], Sèvres.

Members

All Russian Research Institute for Optical and Physical Measurements, Rosstandart [VNIIOFI], Moscow.

Centro Nacional de Metrología [CENAM], Querétaro.

Czech Metrology Institute [CMI], Brno

Federal Institute of Metrology [METAS], Bern-Wabern.

Instituto de Optica “Daza de Valdés” [IO-CSIC], Madrid.

Korea Research Institute of Standards and Science [KRISS], Daejeon.

Laboratoire National de Métrologie et d’Essais [LNE], Paris.

Measurement Standards Laboratory of New Zealand [MSL], Lower Hutt.

National Institute of Metrological Research/Istituto Nazionale di Ricerca Metrologica [INRIM], Turin.

National Institute of Metrology [NIM], Beijing.

National Institute of Standards and Technology [NIST], Gaithersburg.

National Measurement Institute of Australia [NMIA], Lindfield.

National Metrology Centre, Agency for Science, Technology and Research [NMC, A*STAR], Singapore.

National Metrology Institute of Japan, AIST [NMIJ/AIST], Tsukuba.

National Metrology Institute of South Africa [NMISA], Pretoria.

National Metrology Institute of Turkey /TÜBITAK Ulusal Metroloji Enstitüsü [UME], Gebze-Kocaeli.

National Physical Laboratory [NPL], Teddington.

National Research Council of Canada [NRC], Ottawa.

Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center [PMOD/WRC(CH)], Davos Dorf.

Physikalisch-Technische Bundesanstalt [PTB], Braunschweig.

Slovak Institute of Metrology/Slovenský Metrologický Ústav [SMU], Bratislava.

VSL B.V., [VSL], Delft.

VTT Technical Research Centre of Finland Ltd, Centre for Metrology / Mittatekniikan keskus [MIKES], Espoo.

The Director of the International Bureau of Weights and Measures [BIPM], Sèvres.

Observers

Industrial Technology Research Institute/Center for Measurement Standards [CMS/ITRI], Hsinchu.
Instituto Nacional de Metrologia, Qualidade e Tecnologia [INMETRO], Rio de Janeiro.
Standards and Calibration Laboratory [SCL], Wanchai.

Liaisons

International Commission on Illumination [CIE].
World Meteorological Organization [WMO].

1. OPENING OF THE MEETING, MEMBERS AND OBSERVERS PRESENT, INTRODUCTIONS

The Consultative Committee for Photometry and Radiometry (CCPR) held its 25th meeting as an online meeting hosted by the International Bureau of Weights of Measures (BIPM) on Tuesday 10 and Wednesday 11 May 2022.

The meeting was chaired by the CCPR President, Dr M.L. Rastello (CIPM member).

The following delegates from member institutes were present: E. Atkison (NMIA), I.H. Bae (KRISS), Ö. Bazkir (UME), P. Blattner (METAS), G. Brida (INRIM), L. Burger (NMISA), J. Campos Acosta (IO-CSIC), H.A. Castillo Matadamas (CENAM), P. Corredera Guillen (IO-CSIC), P. Dekker (VSL), J. Dubard (LNE), M. Dury (NPL), W. Finsterle (PMOD/WRC(CH), N. Fox (NPL), A. Gamouras (NRC), H. Gan (NIM), V. Gabrilov (VNIIOFI), J. Gröbner (PMOD/WRC), B. Hay (LNE), Y. He (NMIA), E. Ikonen (MIKES), Y. Iawasa (NMIJ/AIST), B. Khlevnoy (VNIIOFI), A. Koo (MSL), M. Krempasky (SMU), S. Kück (PTB), D.-H. Lee (KRISS), J. Lehman (NIST), S.-D. Lim (KRISS) Y. Lin (NIM), Y. Liu (NMC, A*STAR), C.H. Matamoros Garcia (CENAM), A. Meda (INRIM), M. Milton (Director of the BIPM), M. Nadal (NIST), G. Obein (LNE-LCM/Cnam), Y. Ohno (NIST), M. Richter (PTB), H. Shitomi (NMIJ/AIST), R. Sieberhagen (NMISA), M. Smid (CMI), A. Sperling (PTB), N. Swift (MSL), M. Tanabe (NMIJ/AIST), L.-L. Tay (NRC), E. Thorvaldson (NMIA), A. Todd (NRC), E. Woolliams (NPL), J. Zhang (NMC, A*STAR), P. Zu (NMC, A*STAR).

Observers: Y.C. Chuang (CMS/ITRI), B.G. de Almeida (INMETRO), T. Lai (SCL), B. Lam (SCL), T. Menegotto (INMETRO), K.-N. Wu (CMS/ITRI).

Liaisons: T. Bergen (CIE), I. Rüedi (WMO).

Representatives of Institutes from Member States invited to attend as Observers: J. Gran (JV), M. Huriev (NSC IM).

Invited: M. AlFohaid (SASO), A. Bescupschii, (NMI (MD)), T. Goodman (NPL).

Also attending the meeting: J. Viallon (Executive Secretary of the CCPR, BIPM), M.J.T. Milton (Director of the BIPM).

Dr Rastello opened the meeting by introducing herself and welcoming everyone to the 25th meeting of the CCPR. She noted that the last CCPR meeting had been in in September 2019. She remarked that despite the current difficulties around the world, work is progressing well in all CCPR Working Groups. She thanked the CCPR Executive Secretary, Dr Viallon and the CCPR officers, Dr Smid, Dr Lee and Dr Nadal, for their excellent work. She asked Dr Viallon to share the attendance list. She went through the list of attendees.

Dr Rastello enquired if any of the attendees were missing from the attendance list. Dr Wu and Dr Chuang from CMS-ITRI, Dr Lam and Dr Lai from SCL-Hong Kong, and Dr Menegotto from INMETRO noted that they were missing from the list. Dr Viallon apologized for page that was missing from the attendance list, which contained all of the observers and noted that it will be added to the final attendance list.

2. APPOINTMENT OF THE RAPPORTEUR

Dr Tay was appointed rapporteur for the meeting.

3. APPROVAL OF AGENDA

Dr Rastello presented the agenda for both days and asked for its approval. All members agreed.

4. ACTIONS FROM THE 24TH MEETING

Dr Rastello asked Dr Viallon to review the action points from the 24th CCPR meeting.

AP1: Dr Kuck to ask EURAMET NMIs for permission to share documents from the workshop in support of collaboration and coordination.

This has been completed. Dr Kuck provided a document, which was added to the list of online working documents as CCPR/22-07.

AP2: WG-SP to prepare proposals for workshop(s) in conjunction with the next CCPR meeting.

No specific CCPR workshops were organized over the last two years due to the Covid-19 pandemic. However, NEWRAD was held online and the BIPM-WMO "Metrology for Climate Action" workshop is scheduled for September 2022, with CCPR member involvement.

5. NEWS FROM THE CIPM

Dr Rastello presented a report on the news from the CIPM. There had been three CIPM meetings since the last CCPR meeting in 2019. She summarized a selection of recommendations and decisions from the 2019, 2020 and 2021 CIPM meetings.

108th CIPM meeting (2019)

The CIPM accepted SCL HK (Hong Kong, China) as an observer in the CCPR.

Dr Sené was appointed as the president of the CCRI and Dr Laiz as the president of the CCAUV.

109th CIPM meeting (2020)

The CIPM noted the decision taken by correspondence on 7 August 2020 that all CC working groups and workshop meetings were to be held online to ensure continuity during the Covid-19 pandemic.

The CIPM approved a joint task group between the BIPM and OIML (International Organization of Legal Metrology) with the aim to foster enhanced collaboration and to facilitate both organizations to better serve their Member States. The task group will

investigate ways to make both organizations more attractive to states that are not participants of either organization. Dr Louw, Dr Milton and Dr Richard were appointed as BIPM/CIPM representatives to the joint task group.

The CIPM welcomed the draft document "Evolving needs in Metrology" prepared by Strategy sub-committee (SC1). The CIPM has appointed CIPM contact persons for each of the themes proposed. The BIPM will publish details of the contacts on its website.

The CIPM recognized that the "Grand Vision" prepared by the CIPM Task Group on the Digital SI (CIPM-TG-DSI) and its Expert Group (EG) will continue to evolve and appointed Dr Laiz, Dr Duan and Dr Sené as new members of the TG and to approve an update to its terms of reference. The CIPM decided to support the proposed activities in "digital transformation" including in the BIPM work programme. The BIPM and NMIs were encouraged to work with the TG to realize the Grand Vision and noted the possible drafting of a resolution for the 27th meeting of the CGPM (2022).

110th CIPM Meeting (2021)

Following a Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB) recommendation, the CIPM admitted GULFMET as a full member of the JCRB with a voice and the right to vote.

The CIPM approved the joint statement of intent on the digital transformation in the international scientific and infrastructure and noted the intent for the joint statement to be signed by the OIML, CODATA and IMEKO. Other major stakeholders will be approached before the next quadripartite meeting. A significant impact on the metrology community is expected.

The CIPM decided to establish a Sectorial Task Group on Climate Change and Environment. Dr Del Campo, Dr Sené and Dr Duan were appointed as founding members of the group. They were encouraged to build momentum by seeking external expert collaborations and promote the benefits of the work of the international metrology community with the parties at future UN Climate Change Conferences (known as COP).

The CIPM received a report from the CCU Working Group on Core Metrological Terms (CCU-WG-CMT) and noted that consensus cannot be reached on the three definitions (quantity, quantity of value and unit). The CIPM-TG-DSI was asked to review "machine actionability" of the three definitions and to report back in March 2022. The meeting took place, but no decision was taken.

Other information

Dr Rastello presented "Key Scientific questions in the definition of the SI unit of luminous intensity, the candela" at the 25th CCU (2021). A copy of her presentation is in the working document CCPR repository.

The 27th meeting of the CGPM (2022) will be held on 15-18 November 2022 in Versailles. It will be organized as a hybrid meeting.

The CIPM has issued guidance on impacts of events in Europe (specifically, Eastern Europe); It recognized several governments are implementing foreign policy decisions that may place additional constraints on international collaborations. It noted that the Metre Convention is an international treaty with a scientific and technical focus and our objective

is to continue as far as is possible with joint research projects and measurement comparisons. It recognizes difficulties associated with transport of standards, equipment, and travel restrictions to and from some Member States. The CIPM encourages all CCs to continue with their scientific and technical business as far as it is practical. Everyone is encouraged to acquaint themselves with the views of their own individual institute/organization and what they are permitted to do. It also encouraged those encountering difficulties to contact their CC Executive Secretary and CC President to discuss the situation. It is proposed that if a comparison cannot proceed according to the agreed protocol, a number of actions may be considered. They include: re-arranging the comparison; continuing with the comparison without the concerned parties and planning support for CMC claims through other means for the impacted parties; request the CC Executive Secretary to assist with communication; temporarily remove results of certain NMIs/DIs so that an interim report can be published; consider an alternative reviewer for CMCs if the review is impacted.

Dr Rastello acknowledged that the CCPR Working Group on Key Comparisons (CCPR-WG-KC) is heavily impacted and noted this will be discussed during the meeting.

Dr Rastello invited questions and comments from the participants. There were no questions.

6. REPORT OF THE WORKING GROUP ON CALIBRATION AND MEASUREMENT CAPABILITIES (WG-CMC)

Dr Smid, Chair of the Working Group on Calibration and Measurement Capabilities presented his report on its activities. Dr Smid said that he would focus on the work of the three Task Groups established by WG-CMC since the previous CCPR meeting.

There have been three online meetings (9 December 2020; 14 September and 6 October 2021; and 28 April 2022) since the last CCPR meeting in September 2019. Dr Smid thanked all WG members for their input. Dr Smid described the work of the four task groups and TG chairs in the task group.

Dr Smid presented the report “Clarify and harmonise CMC review process” from WG-CMC-TG3 chaired by Ms Goodman. The objective of the task group was reviewed. TG3 has held many meetings since the last meeting of the CCPR. Since then, the guideline document CCPR-G9 “*Rules for review of CMC claims and requirements for supporting evidence*” was approved and published in June 2021. All CMC reviews will be conducted according to these guidelines.

An overview of CCPR-G9 was presented. The new guidelines introduce three basic categories of quantities: Key comparison quantities, core and secondary quantities. It adopts a risk-based approach for reviewing requirements. The high-risk quantities (KC and Core quantities) are subject to intra- and inter-regional review and low-risk quantities (secondary quantities) only require intra-regional review. Guidance is also given regarding the scope of Key Comparisons in terms of CMC support (“how far the light shines”). Flowcharts and checklists are included to ensure all requirements are clear and aid reviewers.

Dr Smid presented an update from WG-CMC Task Group 2 (Update Excel PR CMC Supporting evidence file (CCPR-WG-CMC-TG2)). The first TG2 objective is to maintain two documents: “Classification of services in PR” and “Supporting evidence for CMCs in PR3. Recently, a second objective was added: to maintain the consistency of CCPR KCDB

data entries for application of machine reading for digital certificates. The task group is chaired by Dr Cooksey of NIST. After publication of CCPR-G9 by TG3, TG2 revised the "Supporting evidence" document, published in September 2021.

Dr Smid presented an update on WG-CMC Task Group 4 (Recommending a CMC structure for fibre optics (CCPR-WG-CMC-TG4)). TG4 proposed a revision to the CMC structure for fibre optics, which was approved by WG-CMC in 2021. TG2 has implemented the TG4 proposed revision to both "Classification of services in PR" and "Supporting evidence of CMCs in PR". The WG-CMC approved the revision of both documents in April 2022, which replaced the previous online versions.

The harmonization of CMCs for photometry was presented. In testing the new KCDB API results, a number of inconsistencies (such as spelling errors, incorrect units, missing or incorrect quantities/parameters/instruments) for CMC entries were discovered. TG2 reported the inconsistencies to RMO TC chairs. As of April 2022, 21 revisions have been submitted by NMIs.

Dr Smid presented activities from WG-CMC Task Group 1 (Use of comparison results in assessment of CMC claims (CCPR-WG-CMC-TG1)). TG1 was dissolved in 2019 after the publication of the document CCPR-G8 "*Guidelines for the evaluation of CMC claims in light of comparison results*" but was subsequently revived to address a correction to G8 proposed by APMP. In addition, it is examining the impact of the use of Mandel Paule (and other dark uncertainty methods) on CMC claims. Consensus is that CMCs should be expanded to include dark uncertainty components if they have been used to achieve consistency in the analysis of comparison results. However, this will need further clarifications on the use of dark uncertainty, particularly its impact on linked comparisons. The possibilities to minimize the need for dark uncertainty will be discussed.

Dr Smid presented the activities of TG4 on "recommending a CMC structure for fibre optics". One solution proposed by TG4 for improved service categories was approved by CCPR-WC-CMC in December 2020. The updated Classification of Services and Supporting evidence for CMC documents are both available on the CCPR website.

Dr Koo commented that Mandel Paule has been used for a long time without considering its impact on CMCs. This has implications that the CCPR's KCDB entries may not necessarily imply equivalence. The CCPR needs to know how much uncertainty needs to be added before proposing a change of rules regarding CMC claims. Dr Koo will send an invitation to invite additional members.

Dr Ikonen asked about the removal of obvious outliers from intercomparisons. He noted that even few results, which are clearly outside of the uncertainty limit in a comparison, will add large uncertainty, and this is not right for other participants. Dr Ikonen suggested it is important to be able to remove the obvious outliers prior to including a dark uncertainty contribution to CMCs.

Ms Woolliams commented that dark uncertainty (Mandel Paule for CCPR) was introduced for good reason. WG-KC has learned how to apply it differently depending on circumstances to achieve consistency. Many discussions have already taken place within the CCPR on this subject, and it is coming up in other CCs. This issue will require collaboration between the working groups on KCs and CMCs.

Dr Smid commented that PR CMCs are often requested by end-stakeholders at a level very close to what NMIs can provide, therefore consistency is a concern.

Ms Goodman commented that it was decided that TG2 will not revisit the published CMC claims in the database. It may impact past CMCs, but it would not make sense to revisit them. She hopes the new guideline will help with the submission and review of new CMCs and improve consistency. She welcomed comments on the G9 guideline from those who review and submit CMCs.

Dr Smid added that the G9 guideline is very helpful, as evidenced by the noticeably increased CMC submissions from all RMOs. The lack of comments indicated that the G9 document is clear and well written. Ms Goodman concurred that she had heard it is the case. He also welcomed proactive approaches from the RMOs, for example, SIM submitted a useful guideline for a step-by-step approach to help the reviewers. He agreed to circulate this guideline to everyone. Dr Rastello thanked WG-CMC members for their hard work.

7. REPORT OF THE WORKING GROUP ON KEY COMPARISONS (WG-KC)

Dr Lee, Chair of the Working Group on Key Comparisons, presented his report on its activities. He started by summarizing the status of the Working Group members and introduced its four task groups. He went on to summarize the activities of the Working Group since the last CCPR meeting in 2019.

The WG-KC held two meeting via WebEx on 24 November 2020 and 30 November 2021 as well as 22 March 2022. Three decisions were made during the second meeting. They are:

1. The document summarizing planned comparisons will not be maintained anymore, because the KCDB 2.0 provides sufficient information.
2. Where necessary, CCPR members may take up the offer of assistance in communication with other states to continue progress of the CCPR comparisons.
3. A recommendation to the CCPR for approval to abandon APMP.PR K2.b.

WG-KC will hold its next meeting in November 2022; it is likely to be virtual, but members will be consulted.

Dr Lee announced the completion of the comparison CCPR-K3-2014, which was piloted by NRC (Canada). WG-KC approved the draft B-2 in April 2021 and the report was sent to CCPR members for review and approval on 12 April 2021. As no further comments were received, Dr Lee recommended NRC to submit the final report to the KCDB for publication.

Dr Lee presented the second round of key comparisons and noted that a few of the KCs were discussed during the WG meeting.

He summarized the issues in K2.b.2016 spectral responsivity 300 – 1000 nm (Pilot KRISS). In the review of relative data, it was found that the long-term reproducibility of the pilot lab was poor (up to 1 %). A meeting for the participants was held on 2 June 2021, which resulted in two actions:

1. To carry out a stability test between KRISS and NIST on a transfer detector. This test showed that the transfer detector was not the cause of the problem.
2. The pilot lab would calculate DoEs without showing the participants' names to evaluate the impact of the pilot lab reproducibility.

A second meeting was held on 16 March 2022 to review the results of the two actions. It was decided to continue with the data analysis without re-measurements. The pre-draft A

resumed in April 2022. Dr Lee noted that resolution of this issue caused a one-and-a-half year delay in the KC, but the comparison has now resumed.

Dr Lee summarized the issues in K1.a.2017 spectral irradiance 250 – 2500 nm (Pilot VNIIOFI). This comparison was in the pre-draft A stage when an issue of exclusion of two participants from the KCRV arose. This is due to their inability to report full sets of results. This issue was discussed among the participants and in the Working Group meeting on 30 November 2021. It was suggested that the pilot calculate the anonymized DoEs before further discussion. However, calculated DoEs had identified NMI names, which concluded the pre-draft A. The pilot lab was absent from the 23 March 2022 meeting and since then, communication between the participants and the pilot lab has been hindered due to the situation in Ukraine. This case requires more discussion, and input from the pilot lab is needed.

Dr Lee presented issues in the K2.d spectral responsivity 10 nm – 200 nm (PTB) comparison. In the first two calls for participants in June-October 2020, only three participants (PTB, NIST and VNIIOFI) applied to participate. This KC process has stopped due to the situation in Ukraine, but further discussion is needed to deal with the low number of participants.

RMO comparison activities were also discussed. Comparison activities of each RMO are shared on the BIPM website. NMIs can participate in KCs outside of their own RMO. This will help with managing the total number of comparisons.

Since October 2019, WG-KC has reviewed three technical protocols and approved two draft B reports in RMO KCs, as well as two technical protocols and five draft B reports in RMO SCs. For supplementary comparisons (SCs), only review comments were sent. There are two pending actions for the revision of the guidelines CCPR-G2 (on the authorship list in KC reports) and G7 (on experts involved during the review of RMO SCs).

One issue was raised from RMO KCs of APMP.PR-K2.b. The pilot lab (KRISS) proposes to abandon this comparison at the draft A report stage due to the unstable link to the first round of CCPR comparisons in 2000-2001. All participants agreed and this was brought forward to the CCPR for approval. An investigation into the cause of the instability can then start. It was agreed to draft a paper after the investigation is completed.

Dr Lee presented an update on the task group activities.

TG1 (Pilot comparison for spectral regular transmittance in the UV (CCPR-WG-KC-TG1)) is investigating the possibility of extending the K6 wavelength range to shorter wavelengths (200 – 400 nm). The test candidate filters are in progress but have been delayed due to the Covid-19 pandemic.

TG2 (RMO linkage (CCPR-WG-KC-TG2) is developing guidance on data analysis for RMO KCs. TG2 has developed and published appendices to guidelines G5 and G6. A matrix-based approach to link comparisons is under development, although the latest update is from November 2020.

TG3 (Comparison analysis (CCPR-WG-KC-TG3)) is aiming to develop guidance on data analysis for CCPR KCs. The JCRB proposal for the exclusive use of dark uncertainty models to achieve consistency for comparison analysis in the guidelines CIPM-MRA-G11 was reviewed, and the reply submitted in March 2022. Three issues were raised related to the “dark uncertainties” in the comparisons:

1. The use of Mandel Paule in a primary comparison impacts the analysis of linked RMO comparisons.
2. Guidance for use of Mandel Paule should be clarified. Is it applied to a fixed effects model or a consensus model?
3. How to amend the analysis process to minimize the need for Mandel Paule components?

These issues are important for both WG-KC TG3 and WG-CMC TG1 (both TGs chaired by Dr Koo). Dr Koo will send the call for membership soon.

TG4 (Pilot study for the use of alternative standards for photometric comparisons (CCPR-WG-KC-TG4)) is chaired by Dr Ikonen. The aim is to investigate the possibility of using LED-based sources for future K3 (Luminous intensity) and K4 (Luminous flux) comparisons. The candidate lamps have been selected and will be provided by NIM (flux and intensity) and PTB (intensity). A comparison protocol is in preparation with a provisional start date of 2022.

Dr Lee presented a summary of major tasks for 2023. This includes a revision of the comparison procedures to gain from the experience of the completion of the second round of CCPR KCs. Development of better data analysis methods for CCPR and RMO KCs is required, such as minimization and proper usage of the Mandel Paule components. TG2 and TG3 will lead this work and revise the guideline documents as required. Lastly, in planning for the third round of CCPR-KCs, a decision on extension of the wavelength range of K6 based on TG1 results as well as artefact lamps in K3 and K4 based on results of TG4 will be very helpful.

Questions and Comments

Ms Woolliams commented that although TG2 has several draft documents, it needs a good pilot example and regular discussions with the pilot lab to write the final recommendation. The pilot and TG2 can jointly develop software and write the document at the same time to avoid TG2 developing a theoretical document with no practical examples. Dr Blattner replied that the current intercomparison with ~80 lamps is a good candidate for collaboration. They can provide TG2 with real data and organize training (for example a tutorial on linkage) in order to understand the mathematics behind the theory. Dr Lee suggested that the abandoned APMP K2b may be used to test the various TG2 analysis methods.

Dr Khlevnoy commented on the K1a.2017 (spectral irradiance 250nm – 2500nm) issue. He apologized for not being able to take part in the last WG-KC meeting. He had followed the recommendation of the KC in November 2021 and prepared three different sets of analyses and circulated the anonymized results of DoEs to all participants. It was decided that all steps in the pre-draft A were completed following the third round of analyses. He communicated the DoEs with the NMIs identified to help finalize the decision on the inclusion of two participants that were not able to provide the full set of results. The final decision was to include all 12 participants' results in the KCRV. Dr Khlevnoy confirmed the K1a.2017 is in the draft-A stage. Dr Lee noted that three different DoE results, with the NMI identities revealed, could influence decisions on which set of DoE to include. However, he also noted that the differences were very small so there is no serious concern in this case.

Dr Lee requested CCPR approval to abandon APMP PR K2b. Dr Rastello asked if there were any comments from the CCPR. Dr Richter (PTB) asked what would happen to the KC after abandonment. Dr Lee explained that a new one will be organized to link to the second round of the KC. Dr Ohno asked if the results will be published elsewhere so that the data will be made available. Dr Lee confirmed that they will be. Ms Woolliams said she was in favour of abandoning the comparison. Dr Nadal enquired about the reason for abandonment. Dr Lee replied that the four participants' results all showed a large systematic error of up to 3 %. This indicated a potential link lab problem and suggested the linked results from the two link labs are not consistent. Dr Richter commented that the linking problem could be on both sides, either in the previous comparison or the current one. Dr Lee agreed but commented that it is impossible to determine and makes more sense to start an investigation to understand what caused the issue. Dr Richter suggested that the problem needs to be resolved before starting another new comparison. Dr Lee agreed.

Dr Viallon enquired if the CCPR agrees with the proposal to abandon APMP PR K2b. Dr Rastello requested that an email be sent to members to obtain their agreement for the abandonment; Dr Viallon will send the email.

Dr Ikonen enquired about the letter from the CIPM regarding the continuity of KCs interrupted by the current situation in Eastern Europe. Dr Rastello invited Dr Milton to comment. Dr Milton suggested that if a lab is not able to receive or send artefacts, its participation might be delayed and eventually may be dropped. It was recommended to re-organize the sequencing of the comparison and complete the comparison as far as possible, whilst recognizing that a comparison may need to continue without a particular lab.

8. REPORT OF THE WORKING GROUP ON STRATEGIC PLANNING (WG-SP)

Dr Nadal, Chair of the Working Group on Strategic Planning, presented her report on its activities. Dr Nadal introduced the members of the WG-SP and task groups and their chairs. She noted the presentation will cover a subset of the TGs due to the time constraint. Additional information from other TGs can be obtained directly from the TG Chair. She invited anyone who wished to join a TG to contact the chairperson directly.

She highlighted the decision points of both TG4 on SI (DP-2019-01) and JTC-2 (DP-2019-02). TG4 was formed in 2009 to monitor and revise the definition of the candela. This work has been completed and the task group was dissolved. Similarly, work of the JTC-2 has been completed and was published in CIE018:2019 Principles Governing Photometry (3rd edition) and BIPM report 2019/05 Principles Governing Photometry (2nd edition). Both were published on 20 May 2019. These documents form a bridge between the CCPR and CIE. The task group was dissolved in September 2019. Additionally, there is a third decision point (DP-2019-03) on the name change of TG14 from "Discussion forum on improved 1W laser power responsivity" to "Discussion forum on radiometry to support gravitational wave detection" with new Terms of Reference. TG14 is chaired by Dr Leman. Dr Nadal invited those interested in joining the TG to contact Dr Leman.

The WG-SP had held two virtual meetings since 2019. One held on 3 December 2021 with 39 participants and all member NMIs represented. A second meeting was held on 9 December 2021 with 35 participants, with all member NMIs represented. The meeting was joined by several observer NMIs and the CIE. Dr Nadal expressed appreciation for the great support provided by Dr Viallon and she presented the meeting highlights.

WG-SP 2020 meeting: Participants shared the impact of the Covid-19 pandemic on their NMI's activities. Most reported that lockdowns have severely impacted research and delayed calibration services. Most NMIs have seen an increased demand for the calibration of UVC lamps. International collaborations have also been severely impacted by the pandemic due to travel restrictions.

Dr Nadal presented highlights from selected working groups.

TG9 is concerned with OTDR (Length) comparison with the aim to address all relevant topics related to OTDR calibration including discussion of CMC entries and realization of intercomparisons supporting the entries. The TG has put forward a proposal to WG-CMC on improving the service categories for fibre optics. The updated file of CCPR service categories will be published soon. A series of intercomparisons from APMP and AFRIMETS to support the new entries are in progress.

TG11 on Single photon radiometry is currently carrying out a pilot study on the detection efficiency of single photon detectors. The measurements of the pilot study for single-photon detectors are in progress but experienced delay due to the difficulty of shipping internationally. Additional interested participants were encouraged to contact the chair (Dr Kuck). Measurement results obtained so far suggest good stability of the Si SPAD detector used in the comparison.

TG10, on the CCPR Strategy Document, has been very active since the last CCPR meeting. It held five meetings between 8 January 2021 to April 2022 and published a new CCPR one-page summary strategy document on the BIPM website. It has prepared the new CCPR Vision and Mission statements which state "The CCPR vision is a world in which all photometric and radiometric measurements are made at the required level of accuracy to meet the needs of society." "The CCPR mission is to advance global compatibility of photometric and radiometric measurements through promoting traceability to the SI photometric unit, the candela, and associated derived units, enabling Member States and Associates to make measurements with confidence."

TG10 prepared and launched a survey to gain a better understanding of the metrological needs and priorities of the CCPR stakeholders, including its members and observers. The data collected will help TG10 to formulate a roadmap for the future work of the CCPR. This survey has 33 questions covering radiometry, photometry, optical properties of materials, workshops, comparisons/pilots, CMCs. The survey allowed participants to make additional comments. The TG has received 24 responses from all (but two) members and all observers. TG10 is reviewing the results.

Dr Nadal highlighted a few examples of responses from the survey. On question 8 of the survey (Detector based-spectroradiometry to replace source-based photometry), 80 % of the respondents noted that this is important for both the CCPR and the participants' institutes. The TG categorized it as high priority (#1). On question 9 of the survey (Replacement of source-based photometry by detector based spectroradiometry), it was identified that there is a need for workshops and methodologies for calibration of detector based spectroradiometry for luminous intensity and total luminous flux measurements was ranked highest. On question 33 of the survey (EUV lithography), most respondents showed little or no clear interest. The TG categorized it as having a lower priority (#3). Dr Nadal noted the results of the survey will be used to formulate a plan and be included in the strategic document.

The recent focus of TG10 has been on drafting the new CCPR strategy document, which contains significant revisions from the previous strategy document. The revision reflects the work and advances in the field since 2017. The first draft had been circulated to all CCPR members as a working document before this meeting.

With regard to new business, the WG-SP proposed a new TG on "discussion on the impact on digitalization on matters related to the CCPR". The task group will be chaired by Dr Blattner. The proposed Terms of Reference are to monitor activities related to digitalization in the field of photometry and radiometry and to support and coordinate the implementation of the SI digital framework in the field of photometry and radiometry. Interested participants should contact Dr Blattner.

Questions and comments

Dr Hiroshi Shitomi asked about the survey's integration into the updated CCPR strategy. Dr Nadal replied that most of the results from the survey will be integrated into sections 5.2 of the strategy document on stakeholder engagement as well as 5.4 capacity building and knowledge transfer. The survey will facilitate the development of a roadmap. Dr Shitomi further enquired if the result of the Survey can be shared. Dr Nadal and Dr Viallon confirmed that the results will be shared after an initial period of analysis by TG10.

Dr Richter enquired about the difference between the few photon (TG7) and single photon metrology (TG11) task groups in WG-SP. Dr Nadal replied that TG7 is a discussion forum (few photon metrology), which is focused on collection and exchange of information to define future direction. TG7 has a membership that is not strictly limited to CCPR. TG11 is on single photon radiometry and is focused on carrying out a pilot study. Both TGs are in close collaboration and exchange information.

Dr Rastello thanked the working group chairs and Dr Viallon. She closed the first day of the meeting.

9. OPENING OF DAY 2 OF THE CCPR MEETING

Dr Rastello opened second day of the meeting. Dr Viallon presented the updated list of attendees including the list of observers, liaisons and RMO chairs as well as guests to the CCPR, which was missing from the Day 1 presentation. The updated attendee list will be the final version uploaded on the BIPM website. An updated agenda for Day 2 was presented with a few changes, specifically the CORM presentation was removed from the agenda following a proposal by Dr Nadal; the presentation remains available as CCPR working document #21 for anyone who wishes to review it. This will allow time for a presentation from Thiago Menegotto of INMETRO as part of their application for CCPR membership as well as time for discussions on the observership and membership applications. Dr Nadal asked anyone with questions about the CORM presentation to contact her by email.

10. REPORT BY RMO CHAIRS

AFRIMETS

Mr Sieberhagen presented his report on the activities of AFRIMETS. An AFRIMETS TCPR meeting is planned for July 2023 with participants from NMISA, NIS and KEBS. Invitations to the meeting will be sent to other NMIs to encourage participation and help

establish PR activities in the rest of AFRIMETS. He provided an update on the CMC submission in fibre optics from NIS (Egypt) on wavelength scale, wavelength and spectral characteristics.

A K3 key comparison is planned for 2023/2024 with invitations sent to NIS and KEBS; however a link lab is yet to be determined. There is interest in developing a proficiency testing scheme for illuminance meters. Lastly, an UV-A trilateral comparison is planned for NMISA, NIS and possibly other labs.

Dr Rastello noted her full support for the idea of inviting new labs to the TC meeting and asked if Egypt and Kenya would be interested in attending the next CCPR meeting as observers. Mr Sieberhagen noted both have expressed interest in the past and he will extend the invitation to them for the next CCPR meeting.

APMP

Dr Koo presented her report on the activities of APMP. Since the last CCPR Meeting in 2019, the APMP TCPR has met three times (December 2019, November 2020 and November 2021). It hosted a workshop in 2022 on “Evidence for CMCs”. It is currently planning to organize two more workshops. A workshop on the “Realization of the Candela” will be organized by the APMP developing economies committees. It will involve experts form the regions to help develop PR activities in developing economies. A second planned workshop will be on UVC measurements.

There has been considerable CMC activity within APMP, with over 200 new and revised CMCs published since 2019. Dr Koo noted that APMP did not reply to a review request for a large number of CMCs partly due to introduction of the KCDB 2.0 and the change of guidelines. Dr Koo thanked the other RMOs for the comments received by APMP members and noted there are still over 30 CMCs needing a response to comments by APMP members. She expressed the hope that the workshop on CMCs will help guide APMP members in addressing the outstanding comments, clarify the process and develop the risk-based approach.

She provided an update on the ongoing comparison activities in the regions. There were many comparisons, and updates were presented in the list by the lead laboratories. She provided updates on planned comparisons for APMP.PR-K1.a, -K2.b, -K6 and UVC. There was a high demand for K1.a on spectral irradiance and it will hopefully start in late 2022. APMP.PR-K2.b was discussed in the WG-KC presentation and has been abandoned. She thanked those who participated in the SIM and EURAMET comparison of K6. There are a few labs who are still looking to participate in K6 and another comparison will be organized soon. For UVC, many of the APMP labs are interested in a pilot comparison and have started this activity and related services. It is hoped that the planned workshop on UVC measurement will lead to an agreement on a format for this pilot study.

Dr Smid expressed WG-CMC’s appreciation for the workshop organized by APMP. Dr Koo thanked WG-CMC for the clear guidelines in helping APMP to improve its processes.

COOMET

Dr Anatolii Bescupschi presented his report on the activities of COOMET. Since the start of the Covid-19 pandemic, COOMET meetings have moved online. This resulted in increased participation opportunities for other members.

He presented the status of comparisons. Ten comparisons have been completed, there are three ongoing supplemental comparisons and three new comparisons are planned. COOMET-PR-K3.a luminous intensity was published in June 2020 and the bilateral comparison, COOMET.PR-K1.b.1 spectral irradiance 200 – 350 nm, between VNIIOFI and PTB was published in May 2019. Measurements are in progress on COOMET.PR-K1.a spectral irradiance 250 – 2500 nm. For supplementary comparisons, the COOMET.PR-S1 on whiteness and brightness was published in January 2022. COOMET.PR-S2 on "Angle of rotation of plane of polarization" was also published in January 2019. COOMET.PR-S5 on "Spectral regular transmittance (250 nm – 635 nm)" has been approved by WG-KC and is awaiting publication. COOMET.PR-S7, Laser power responsivity was published in November 2021. COOMET.PR-S8 on Wavelength (fibre optics) in June 2021; and COOMET.PR-S9 on Polarization mode dispersion in fibre optics in September 2021. COOMET.PR-S10 for transmitted colour was in the draft-A stage, as well as COOMET.PR-S11 on surface colour. Two pilot studies were completed, on spectral regular transmittance (200 nm – 380 nm) and on diffuse absorbance of transmitted samples (340 nm − 770 nm). Planned comparisons include: Refractive index; polarization mode dispersion in optical fibre; wavelength for fibre optics and spectrally-selective transmitting material. These are all scheduled to start in 2023. The number of published CMCs was presented. It was noted that some CMCs from other RMOs were not reviewed on time due to a lack of knowledge of the KCDB 2.0. The process will be monitored more carefully in the future in order to avoid this situation.

He concluded his report by describing two knowledge transfer activities covering the introduction to and practical exercises for the KCDB 2.0.

Dr Khlevnoy noted a correction that the Ukrainian participant for the comparison on whiteness and brightness was NSC-IM (Institute of Metrology). Dr Bescupschi will make the correction as suggested.

EURAMET

Dr Campos presented his report on EURAMET activities. He started by introducing the membership and summarized the meetings that have occurred and the workshop held by TCPR. The workshops were organized prior to the annual meeting to discuss the EMPIR call for proposals. In 2020, a BIPM-EURAMET workshop on the KCDB 2.0 was held. A workshop will be organized to share progress and results of the EMPIR projects.

EURAMET.TCPR activities are organized in projects which are summarized according to collaboration types: traceability (seven projects), consultation (one project), research (one non-EU funded) and comparisons (six projects in progress). A breakdown for the joint research projects funded by the EU and EURAMET was presented. He discussed the European Metrology Networks, which were created to help engagement between external communities and metrologists and to coordinate European metrological services and research in support of stakeholder needs. There are two new activities (on Climate and Ocean observation and Quantum Technologies) that are relevant to the CCPR.

Since the last report, ten new CMCs have been published and 41 modified (most through the harmonization process). He updated the CCPR on CMC activities and the status of ongoing key, supplemental and pilot comparisons.

Dr Viallon enquired if any output is available from the workshop on digitalization that was held in April 2022. Dr Campos replied not yet. Another meeting will be scheduled in

October 2022 to look for information on what has been done in the CCPR and other RMOs before finalizing actions at the TC level.

SIM

Dr Menegotto presented his report on SIM activities. He introduced the new SIM-PR vice chair Juan Pablo Babaro from INTI and the five new NMIs who had joined since 2019. They are IBMETRO (Bolivia), INACAL (Peru), CENAMEP (Panama), SLBS (Saint Lucia) and LANAMET (Nicaragua). The SIM-PR has held two online meetings in 2020 and 2021. INMETRO has published 18 claims. The quality systems of both INMETRO and INTI were re-approved in 2020.

He updated the CCPR on the status of CMCs. SIM currently has five new claims for Lametro/ICE (Costa Rica) which is the DI for fibre optics. The CMCs were approved and the DI is currently waiting for the quality system certificate for JCRB review. There were three modified claims from NIST (Boulder, USA), which were all approved and submitted to JCRB review. SIM has also participated in CMC reviews submitted by other RMOs.

In terms of comparisons, SIM.PR-K6 on regular spectral transmittance (380 – 1000 nm) has been completed and the final report published in *Metrologia* in 2021. For supplementary comparisons, two COOMET comparisons with participants from SIM (INMETRO and CENAM) were completed and published. A survey was carried out to determine the need for future comparisons and to guide planned future comparisons. A list of planned comparisons was presented. All the planned comparisons will start following the completion of the CCPR comparisons. For K3, a preliminary list of participants was drafted in 2018 by the pilot (CENAM), but the comparison was halted in 2019 by the pilot due to internal issues. It is time to resume SIM.PR-K3 following the completion of CCPR.K3. A list of supplementary comparisons was presented.

A new project from SIM on the evaluation of UVC technologies for UV Radiation disinfection was presented. SIM members participated in a workshop organized by NIST. Other projects include strengthening the quality infrastructure; improvement of traceability for spectral irradiance from UVC to NIR; and Differential spectral responsivity for calibration of solar cells.

Dr Smid thanked SIM for implementing new CMC review activities. He asked SIM to invite members of WG-CMC-TG3 for a Q&A session.

GULFMET

Dr Alfhaid presented his report on the activities of GULFMET. He opened with a brief introduction of the GULFMET TC-PR and the meetings which had taken place since its creation. The TC was set up to cover the needs of its members in PR through the organization of KCs and SCs, CMC reviews, capacity building and knowledge transfer as well as scientific research. Although no formal training has been organized yet, the TC hopes to start organizing training as soon as possible.

For comparisons, GULFMET.PR-K4.2021 on luminous flux was registered in the KCDB in December 2021 with UME as pilot. It started in February 2022 and the hope is that it will be completed at the end of 2023.

GULFMET's members participated in RMO-TCs such as EURAMET-TCPR and APMP TCPR meetings.

Dr Menegotto commented that the hybrid meeting format will allow more NMIs to participate in both RMO and CCPR meetings as observers. This is in response to Dr Rastello's earlier comments on the invitation to NMIs from AFRIMETS to participate in the CCPR meeting as observers. Dr Rastello noted that she will find a way to make this possible. Together with Dr Viallon, she will contact RMO TC chairs to gain a full understanding of the NMIs in each region that may be interested in joining the CCPR.

11. LIAISON WITH OTHER ORGANIZATIONS

WMO

Dr Ruedi reported on a major reform of the WMO structure that took place in 2019. The reform established two technical commissions (TC), including the Commission for Observation, Infrastructure and Information Systems, which is relevant to CCPR. This infrastructure commission met in 2020 to establish its working structure. Specifically, the Standing Committee on Measurements, Instrumentation and Traceability (SC-MINT) will manage solar and terrestrial reference matters. The SC-MINT has a number of Expert Teams, of which the Radiation Reference (ET-RR) is most relevant to the CCPR. This team is aimed at assessing the current status of the solar and terrestrial radiation references and addressing implications of proposed changes to those references.

PMOD/WRC resumed its intercomparison programme in 2021, after a pause due to the pandemic. Two comparisons, one on pyrheliometer (IPC-XIII) and one on pyrgeometer (IPgC-III) were organized at PMOD in 2021. Final reports are yet to be published.

Dr Ruedi recalled that the WMO supports the ensuring of traceability of irradiance measurements to the SI. This was already the case when the World Radiometric Reference was established 40 years ago and the WMO welcomes the work done in developing instruments that could become new references. She emphasized the importance of the homogeneous time series in climate and modelling applications. She noted a balanced approach is needed to mitigate risks associated with a reference based on a single instrument/technology and to ensure there is effective means to disseminate the scale to field instruments as well as ensuring a clear process to reprocess old data in order to have a homogeneous irradiance time series.

For solar irradiation, the expert team ET-RR recognized that the World Radiometric Reference is shifted by 0.3 % higher than the SI. The cryogenic radiometer, CSAR/MITRA is a mature technology providing traceability to the SI with a much lower uncertainty than the World Radiometric Reference. However, there is only one realization of CSAR/MITRA and it is still being improved. It cannot be used for routine operation so there is a need for a radiometer to be used as a transfer standard. In addition, commercial stakeholders are calling for introduction of a new solar radiation reference. As a draft recommendation, ET-RR plans to submit a set of three mandatory conditions to the Infrastructure Commission that need to be met to introduce a new solar radiation reference:

1. The new primary solar radiation reference must have been compared with a cryogenic radiometer from an NMI with CMCs for spectral sensitivity and the results to be published in a metrology peer-reviewed journal.
2. A standard group of cavity radiometers continues to be operated as main transfer standard with procedures for linking the new reference and transfer group and maintaining a transfer group in case of failure of the new reference.

3. A procedure must be available for correcting measurements, traceable to World Radiometric Reference (WRR), to the new reference scale (to harmonize the time series) and this needs to be straightforward and based on the results of comparisons between the new reference and the WRR.

Other additional recommendations by the ET-RR (though not mandatory) are intended to urge NMIs to develop independent realizations; to realize a second realization of CSAR/MITRA and to continue research to further improve the instruments as well as development of newer instruments in the transfer group. ET-RR will submit its above recommendations to the infrastructure commission INFCOM-2 in October 2022. The recommendation will first have to be discussed in a session of INFCOM and later approved by the WMO congress.

For terrestrial radiation, the situation is slightly different. There are two traceability paths for long wavelength radiation: The Infrared Integrating Sphere (IRIS) linked to the SI through a blackbody is a mature technology, and the Active Cavity Radiometer (ACR) is supposedly directly traceable to the SI. Both technologies require careful monitoring during operation, which requires a group of radiometers as transfer standards. The new reference would introduce a scale shift of ~ 5 W/m^2 for clear-sky conditions, decreasing to 0 W/m^2 for overcast conditions. Therefore, the scale shift will be dependent on climatology of the local measurements. Hence, it is much more difficult to implement the new reference than for the solar radiation case. Therefore, the ET-RR drafted another set of recommendations for mandatory conditions that need to be met to introduce a new terrestrial radiation reference:

1. A standard group of reference pyrgeometers continues to be operated as the main transfer standard with a procedure for linking the new reference and transfer group.
2. To have a procedure available for correcting measurements, traceable to the World Infrared Standard Group (WISG), to the new reference scale to harmonize the time series. This is not straightforward since the raw data are not kept in main data repositories.
3. It is mandatory for the Baseline surface radiation network (BSRN) to record the pyrgeometer raw data to ensure traceability.

Other recommendations are similar and will be submitted to INFCOM-2 in October 2022.

Finally, Dr Ruedi mentioned that the WMO is working with the BIPM on the workshop on *Metrology for climate action* in September 2022. The aim is to develop a set of recommendations on key technical challenges for metrology and climatology over the next decade. The workshop has two main themes:

1. Metrology in support of the physical science basis of climate change and climate observation
2. Metrology as an integral component of operational systems to estimate greenhouse gas emissions based on accurate measurements and analysis.

Questions and comments

Dr Ikonen enquired about the uncertainty of the present group with regard to the difference of 0.3 % in the solar reference. Dr Ruedi replied that the expanded uncertainty of the present group is also about 0.3 %. Dr Ruedi noted that the WMO would be willing to take any recommendations from the CCPR community on managing the reference change.

Dr Viallon enquired about the impact on time series measurements and the recommended procedure on treatment of historical data. Dr Ruedi confirmed that there is a need to correct historical data, which forms the basis for climate trend analysis in climate models. For solar radiation, it is not an issue. For terrestrial radiation, it is a problem because historical raw data may not be accessible.

Dr Blattner observed the similarities in the approach employed by the WMO with the road map decided by the CIPM before adoption of the new SI definitions. He asked if the WMO had considered uncertainty and consistency requirements for the instruments as a requirement for scale change. Dr Ruedi confirmed that previous recommendations had considered this and it could be included in the final version.

Dr Smid asked about the effort in re-processing all data and if an example can be provided where this is a significant problem. Dr Ruedi replied that this is a problem for terrestrial radiation where not all of the historical raw data are available. She invited Dr Gröbner to comment on this. Dr Gröbner clarified that a scale change introduced to a long time series will introduce discontinuity in the time series. Reprocessing all data is necessary. For solar radiation, a simple correction factor can be applied to obtain continuity, but for terrestrial radiation, it is a more complex calculation and the old raw data needs to be reprocessed based on new models.

CIE

Dr Bergen, Director of CIE Division 2, presented the report on the activities of the CIE. There have been 15 new publications since the last CIE report to the CCPR. Of interest is the technical note on CIE TN013:2022 *Terms related to Planckian radiation temperature for light sources*, which provides technical terms and definitions relevant to the CCPR. The ISO/CIE DIS 23539:2021 "*Photometry – The CIE system of physical photometry*" is a fundamental document prepared by CIE-TC 2-93 to bring the standard up to date with recent developments such as physical measurements, spectral luminous efficiency functions and cone-fundamental-based spectral luminous efficiency function. The CIE244:2021 *Characterization of imaging luminance measurement devices* contain details on how to calibrate and adjust these devices. The CIE TN 012:2021 *Guidance on the measurement of temporal light modulation of light sources and lighting systems* is a technical note. It is intended to provide guidance while a more detailed technical report is being prepared. A few other TCs are also near publication, specifically, the 2-90 "*LED reference spectrum for photometer calibration*" is a reference spectrum to supplement source A for calibration of photometers, which may be published in 2022.

The CIE has three new TCs, two of which are of interest to the CCPR. TC 2-96 on the revision of ISO/CIE 19476:2014 *Characterization of the performance of illuminance meters and luminance meters* and TC 2-97 on the revision of CIE S 025/E:2015 *Test method for LED lamps, LED luminaries and LED modules and its supplement*. The CIE is establishing additional new TCs. A new TC on the revision of CIE 130-1998 *Practical methods for the measurement of reflectance and transmittance* is to be chaired by Dr Cooksey of NIST. Another new TC will be set up on reference spectra and metrics for software validation as well as new reportership on a recommendation for standardization of maximum luminous efficacy for a given photometric condition.

Dr Bergen presented details of upcoming events. A CIE symposium on the measurement of temporal light modulation and the CIE division 2 annual meeting will be held in Athens

(Greece), in October 2022. The next CIE quadrennial meeting will be held in September 2023 in Ljubljana (Slovenia). There will be future tutorial activities and a survey to solicit those who are interested in providing tutorial subjects.

Dr Blattner gave a presentation on the Cone Fundamental Based Photometry, which he had been invited to prepare by Dr Rastello. He reminded the CCPR that the $V(\lambda)$ has been in use for 100 years. Colorimetry started at about the same time by Wright 1928/1929 and Guild 1931 with the introduction of the RGB systems, transformed to the colour matching function that is the CIE 1931 2° colour matching functions. A decision was made at the time to use the y-channel as $V(\lambda)$ function. However, there are some problems with the $V(\lambda)$ function. For example, the 2° field of view may not be the most relevant condition for normal viewing; the colour matching function are not the best representation of the colour vision and some of the chromaticity diagrams are obsolete. There has been notable progress in steps towards correcting some of these problems. A physiological modelling of the eye to allow parametrization of the transmittance of the eyes, which depends on the age of a person was developed. There are a number of CIE works on Cone Fundamentals. The Cone Fundamentals-based colorimetry (photometry) allows the parameterization of the colour matching functions and the spectral luminous efficiency function. The CIE 1-97 technical committee has developed a cone fundamental tool on Github to calculate the colour matching function that is a better match to the observer, based on an observer's age and field of view. The CIE has implemented the cone fundamentals in the documents ISO/CIE DIS23539L2021 and CIE S 026/E: 2018. The CIE TC1-98 will establish a roadmap for the development of a new, complete, self-consistent system of CIE colorimetry measures based directly on cone fundamentals, with explicit consideration on the impact of normal variations of the cone fundamentals due to age, field of view and individual diversity.

This will have implications for photometry. Through linear transformation, the $V_F(\lambda)$ function can be obtained similarly to how the $V(\lambda)$ function was obtained. Changing from $V(\lambda)$ to $V_F(\lambda)$ would mean that the lumens of lamps or lux will change. Potentially, it will increase by 5 % for an average lamp and ~35 % for blue LED and an average observer (32 years old at 2^0 viewing condition). It is possible to introduce a $K_{cd,F}$ to maintain the value of the luminary products. There are lots of questions with regards to such a change. For example, is the action worth the effort. The change will only impact coloured light sources, which is not a major application area and will result in the need for new photometers. A more difficult question would be how to standardize diversity.

Questions/Comments

Dr Ohno commented that CIE D1 is active in the transition in colorimetry. The current system dating from 1931 demonstrates many problems and there have been significant advances since. TC198 has had a discussion on how to approach the transition, which will be difficult. Draft documents are under preparation and may be of interest to the CCPR. He suggested that the issue be examined in-depth in the WG-SP.

Dr Rastello thanked Dr Blattner for his presentation. She commented that visual and physical photometry drifted apart in the 1970s with the new definition of the candela. The CCPR needs to be involved in a discussion of the impact on the end user and on the fundamental constant for photometry.

Ms Woolliams enquired about diversity of individuals specifically pertaining to common colour blindness. Dr Blattner replied modelling exists for colour deficiency such as colour blindness. The model can be applied for colour deficiency but will have a huge impact.

Dr Sperling expressed his concern for this important work. He said it is important that we need to change, but the problem is how to convince industry and the public to accept this major change, particularly for colorimetry. Dr Blattner replied that the change is not significant for photometry but agreed that the impact on colorimetry will be significant, adding that industry needs to be involved. Dr Ohno interjected that the introduction of cone fundamental will require a re-definition of CCT in the UV region, which will lead to significant changes to lighting products and will impact the lighting industry. CIE TC is looking into this and examining if it is necessary to transition to the new $V_F(\lambda)$ function. Dr Obein commented that lighting producers do not rely on colour temperature anymore but rather have control of the full spectrum. They are more interested in adaptive lighting and less reliant on the old indices (for example colour temperature or CRI). He is convinced the CIE index may become obsolete with the adoption of tunable lighting. He recommended the community be ready to adopt these new types of LED sources.

Dr Burger enquired about the gender-based visual difference (women can see further into the red) and if this will be part of the investigation by CIE. Dr Ohno replied that he is not aware of the gender-based difference in IR.

Dr Rastello suggested to Dr Nadal that WG-SP starts a discussion forum on the new $V_F(\lambda)$ as soon as possible and to plan for a workshop involving stakeholders so that it can obtain a complete view of the position and anticipated issues. It is a very sensitive point for the industry but will be an improvement for our capability in light measurement. It is likely that the next CCPR meeting in June 2024 will be in person and Dr Rastello suggested organizing a workshop around the same time. Dr Nadal confirmed that she will begin by looking for a chair for the discussion forum followed by development of Terms of Reference. This will be followed by a call for membership. Dr Blattner suggested this could be a joint BIPM-CCPR-CIE workshop. Dr Rastello agreed this is a good idea. Dr Milton noted that the BIPM welcomes the proposal for a joint workshop in this area and it is the kind of scientific challenge that CCs should propose to the BIPM.

12. MEMBERSHIP AND OBSERVERSHIP OF CCPR

Justervesenet

Dr Gran presented Justervesenet's (JV) application for CCPR membership. Dr Gran presented JV's participation in comparisons, contribution to the metrology community, overview of research activity and highlighted the chipS.CALe project. JV has been participating in CIPM MRA comparisons as well as EURAMET.PR comparisons since 1999. JV has been a EURAMET TC-PR member since late 1990 with Dr Gran serving as TCPR chair and convener for strategic planning. He is also coordinating the joint EU project on chipS.CALe. JV has participated in many European joint research projects (such as Quantum standards) as well as national funded projects. He presented a list of relevant publications related to self-calibration of detectors and PQEDs, modelling and uncertainty propagations of digital filters.

For the chipS.CALe project, he showed that the PQED IV measurements at one wavelength are sufficient for extraction of the loss parameters and responsivity over the wide spectral

range calculated. A paper on the work was accepted in *Metrologia* in March 2022. He discussed a different passivation method for the improved PQED devices. The results were published in December 2021 in *Sensors*. He highlighted dual mode detectors, where an Si photodiode acts as an electrical substitution radiometer operating at room temperature. This work has been accepted for publication in *Metrologia*.

National Scientific Centre "Institute of Metrology" (NSC-IM)

Dr Huriev presented NSC-IM's application for CCPR observership. He provided a brief overview of the institute. At present, the institute of metrology offers seven types of measurements with 53 national standards, ten of which are in PR. The main standard in PR is luminous flux, luminous intensity, spectral transmittance, and reflectance and spectroradiometry. There are also standards for laser radiations. He presented prototypes of reference luminous flux based on an incandesce lamp, which showed long-term stability and an insignificant difference between the experimental and theoretical model. NSC-IM has participated in the CIPM MRA through publication of 180 CMCs, of which eight were in the area of PR. In PR, it has participated in K1.a 2018, K3.a, K4.1 and COOMET supplemental comparison S1 and S10. MSC-IM piloted COOMET.PR-S10, which is currently at the draft A stage. It has also participated in EMPIR projects with results published.

Dr Ohno asked about the slide that showed an integrating sphere a with standard reference lamp and filter for the LED spectrum and asked why the LED sources were not used directly. Dr Huriev replied this was done because of the high stability of the incandescent lamp. Dr Ohno acknowledged that some standard LED lamps are quite stable. However, he noted that the incandescent lamp may have higher stability.

INMETRO

Dr Menegotto gave a presentation outlining the capabilities of INMETRO. INMETRO fulfils the roles of NMI, the regulatory agency for conformity assessment and legal metrology, as well as being the accreditation body in Brazil. Dr Menegotto introduced the organizational structure of INMETRO. The PR activities are within the Optical Metrology Division. There are eleven staff involved in INMETRO's PR activities. He presented the detailed Infrastructure that supports a range of PR activities and showed a list of PR calibration services. A new service for the calibration of lamps in spectral irradiance from 250 – 1110 nm will be offered soon.

Currently, INMETRO has 18 CMCs in the KCDB. INMETRO's last peer review was in 2019 and its quality system was re-approved in 2020. He discussed results of some comparisons, including SIM.PR-S3 and SIM.PR-K6.2010 as well as COOMET.PR-S9. It has participated in a number of collaborative research and development activities, including comparison of RT-PQED (2016), the SSL Annex 2013 IEC- measurement of electrical, photometric and colorimetric quantities and two cooperation projects with PTB and other NMIs.

INMETRO has been chairing SIM-MWG for PR since 2017 and has actively participated in review of CMC and comparison activities. It hosts the national committee of CIE (CIE-BR) and NC-CIE-BR has 37 members representing several sectors of industry. A list of publications was presented.

Dr Rastello commented that she is delighted to see the applications for membership and observership and to learn of the high quality of work in the applicants' labs. She thanked all

three presenters for their presentations. She reminded the CCPR that approval rests with the CIPM and it is based on the recommendation provided by the CCPR. Dr Rastello asked the members of CCPR if anyone opposed the applications of JV, NSC-IM and INMETRO. None were raised. Dr Rastello concluded that the CCPR approves the applications of JV as a member, NSC-IM as an observer, and INMETRO as a member after previously being an observer. She noted that the CIPM will meet in June 2022 and hopefully the CCPR will hear the CIPM decision very soon.

13. CLOSING

Dr Rastello closed the meeting, thanking all participants for the discussions. She expressed thanks to the working groups and to the BIPM. Dr Viallon took the final participant group photo.

Appendix 1 Working Documents

WORKING DOCUMENTS SUBMITTED TO THE CCPR AT ITS 25TH MEETING

File	Title
CCPR/2022-01	Agenda of the CCPR 2022 online meeting
CCPR/2022-02	CCPR Strategy Document 2022-2032
CCPR/2022-03	Questionnaire on activities of CCPR members since 2019
CCPR/2022-03-01	Report on activities since 2019 - PMOD
CCPR/2022-03-02	Report on activities since 2019 - SCL
CCPR/2022-03-03	Report on activities since 2019 - INRIM
CCPR/2022-03-04	Report on activities since 2019 - NMIJ
CCPR/2022-03-05	Report on activities since 2019 - NMIA
CCPR/2022-03-06	Report on activities since 2019 - MSL
CCPR/2022-03-07	Report on activities since 2019 - NIM
CCPR/2022-03-08	Report on activities since 2019 - VSL
CCPR/2022-03-09	Report on activities since 2019 - KRISS
CCPR/2022-03-10	Report on activities since 2019 - UME
CCPR/2022-03-11	Report on activities since 2019 - CMI
CCPR/2022-03-12	Report on activities since 2019 - LNE
CCPR/2022-03-13	Report on activities since 2019 - NRC
CCPR/2022-03-14	Report on activities since 2019 - MIKES
CCPR/2022-03-15	Report on activities since 2019 - IO-CSIS
CCPR/2022-03-16	Report on activities since 2019 - VNIIOFI
CCPR/2022-03-17	Report on activities since 2019 - INMETRO
CCPR/2022-03-18	Report on activities since 2019 - NIST
CCPR/2022-03-19	Report on activities since 2019 - METAS
CCPR/2022-03-20	Report on activities since 2019 - PTB
CCPR/2022-03-21	Report on activities since 2019 - NMC-ASTAR
CCPR/2022-03-22	Report on activities since 2019 - NPL
CCPR/2022-03-23	Report on activities since 2019 - CMS
CCPR/2022-03-24	Report on activities since 2019 - NMISA
CCPR/2022-04	Overview of INMETRO's Activities in Photometry and

	Radiometry
CCPR/2022-04-02	Presentation of INMETRO activities in PR
CCPR/2022-05	Summary application for CCPR membership by Justervesenet (JV)
CCPR/2022-06-01	Presentation of NSC-IM Activities in Photometry and Radiometry
CCPR/2022-06-02	Publications of NSC-IM in Photometry and Radiometry
CCPR/2022-07	CCPR-AP-2019-01 Smart PhoRa Summary
CCPR/2022-08	Presentation of ML Rastello to CCU 2021
CCPR/2022-09	News from the CIPM to CCPR
CCPR/2022-10	WG-CMC report to CCPR
CCPR/2022-11	WG-KC report to CCPR
CCPR/2022-12	WG-SP report to CCPR
CCPR/2022-13	AFRIMETS report to CCPR
CCPR/2022-14	APMP report to CCPR
CCPR/2022-15	COOMET report to CCPR
CCPR/2022-16	EURAMET report to CCPR
CCPR/2022-17	SIM report to CCPR
CCPR/2022-18	GULFMET report to CCPR
CCPR/2022-19	WMO presentation
CCPR/2022-20	CIE presentation (part 1)
CCPR/2022-20-02	CIE presentation (part 2)
CCPR/2022-21	CORM presentation
CCPR/2022-22	WebEx captions

APPENDIX 2
SUMMARY OF ACTION POINTS

AP1. Dr Koo to send out a fresh invitation to refresh membership of the CCPR WG-KC TG3 on the use of the Mandel Paule process in comparison analysis.

AP2. Dr Smid to share the SIM document on the “CMC step-by-step guideline for reviewers” with all participants.

AP3. Mr Sieberhagen to reach out to Egyptian and Kenyan NMIs and convey the invitations for both institutions to participate in the next CCPR meeting as observers.

AP4. WG-SP to start a discussion forum on the cone fundamental based photometry and radiometry and plans for a workshop on the cone fundamentals and its impact.