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

Questionnaire on activities in radiometry and photometry

Reply from: NIM China

Delegate: LIN Yandong

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

(a) broad-band radiometric quantities

a broad-band radiometer was developed. The power responsivity was traceable to He-Ne laser power responsivity, reflection was corrected. We took part in the first comparison of terahertz power. The results showed good agreement among of the participants.

Researches were conducted on the UVA irradiance and power measurement. For the LED or high mercury point lamp, large UVA irradiance can be realized when the detector is close to the lamp while the uniformity of the irradiance is usually problematic. Experiment has been doing so as to provide suggestion on the specified condition for the power and irradiance responsivity measurement.

(b) spectral radiometric quantities

A new spectral power measurement system based on the ACR (absolute cryogenic radiometer) and monochromator has been put into use. Absolute broad-band spectral responsivity from 350nm to 2300nm will be realized based on QTH lamp and super-continuum white light source, by using Si, InGaAs and Ex-InGaAs detectors. Results showed a good consistency between two existing ACR systems at 633nm.

We participated the APMP.PR k2.b, APMP key comparison on spectral responsivity 300 nm to 1000 nm, the measurement of comparison was finished and the results has been verified for pre-draft A check send by the pilot lab (KRISS).

(b) photometric quantities

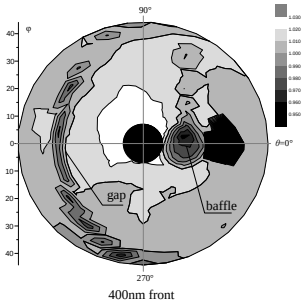
Developed LED filament lamp as luminous flux standard lamp

A kind of LED based standard calibration sources---LED filament lamp, for luminous flux has been developed at NIM. It has a 7 to 12 min warm-up time which is faster than other types of LED we have tested. It showed satisfactory stability during the measurement period, burning 2475h or just storage(8 month). The developed LED filament standard lamp has many advantages compared with the traditional incandescent standard lamp, which is insensitive to shock and vibration, easy to transport, while the filament of incandescent is fragile, the nominal lifetime of LED filament lamp is at least ten times longer than incandescent lamp, the drift rate is about 1/10 of incandescent lamp. The model of it now covering DC or AC driven; power: 4W, 6W, 8W(430lm-1000lm); CCT: 2700K,4000K,6500K; bulb: clear or frosted. It is a good candidate of the future LED based standard lamp, its model will be enriched, performance will be improved, and long term stability will be investigated.

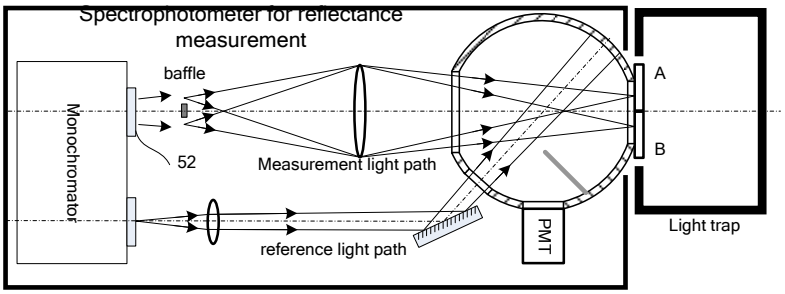
2. What other work has taken place in your laboratory in scientific or technological areas relevant to the CCPR?

(a) **Diffuse reflectance**

The reflectance nouniformity of the sphere is the biggest systematic error source of the absolute diffuse reflectance measurement in Sharp-Little method. A uniformity analysis method is developed basing on scanning technique with CCD array spectrometer for reducing the effect of uniformity to the primary color standard measurement. The effect of sphere nouniformity can be corrected basing on the scanning data of uniformity distribution.



Uniformaty map of sphere



Schematic diagram for nonlinearity measurement technique

an absolute nonlinearity measurement technique is proposed for the diffuse reflectance measurement spectrophotometer. By switching two sprayed $BaSO_4$ plates at the sample port, the average reflectance of the sample port is modulated, and the nonlinearity can be calculated by superposition theory. A baffle is inserted at the conjugate plane of sample and blocks the light onto the gap between the plates, so the multi-reflection error is eliminated, and the accurate nonlinearity of diffuse reflectance can be obtained.

(b)APMP TCPR S7 comparison "Spectral grey-scale diffuse reflectance"

Time Table:	Finish the artifact experiments in **2016**, and discuss the protocol details with participants
Comparison Style:	**Star-typed**, **12 sets** of the artifacts will be supplied by NIM.
Proposed Comparison Artifacts:	**10%~20% (dark), 40% to 60% (mid) and 99% (*high)** (* the 99% reflectance level is already covered by K5, hence, the 99% plate is optional measurement in S7, not used to calculate the RV and DOE. The data of 99% helps NMIs to identify the systematic error sources of grey scale reflectance: calibration system's nonlinearity, or the absolute value of the white standard.)
Wavelength Range:	360 nm to 820 nm at 20 nm step.
Measurement Condition:	0:d or d:0 If it's not true zero: 8:d or d:8 SCE

(c) Spectral light engine & color measurement for florescent samples

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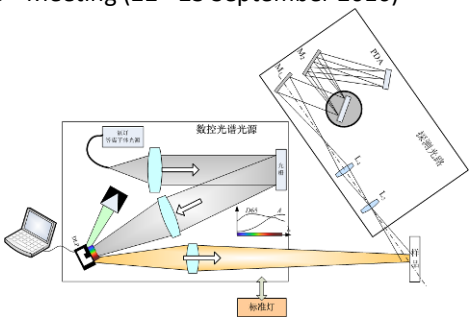

A digital controlled spectral light source has been initially established by DMD technique. In 2017-2019, we are trying to realize the D65 standard illumination, and cover the wavelength from 300-900nm; and then, couple the digital standard illuminator to the 0:45 reflectance reference apparatus, and establish a reflectance color measurement for florescent samples.

(d) PPFD calibration standard for PAR meter

Artificial lighting is widely used in the plant factory, PPFD Photosynthetic Photon Flux Density (μmol s^{-1} m^{-2}) is preferred to be used in plant science than radiant and photometric quantity for assessing the photosynthesis active radiation (PAR). A measurement system for PPFD which trace to spectral irradiance standard has been developed in NIM.

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.

   None.

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

(a) Photovoltaic metrology, for solar cells, PV modules and outdoor photovoltaic power generation systems.

(b) Spectral radiometry in photobiological safety.

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?

(a) Diffuse reflectance & color measurement for florescent samples

We would like to collaboration with other NMIs and having a comparison.

(b) Optical power measurement using cryogenic radiometer based on monochromator.

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 2014)?

(1) Yuqiang Deng, Heiko Füser, and Mark Bieler, "Absolute intensity measurements of cw GHz and THz radiation using electro-optic sampling," IEEE Transactions on Instrumentation and Measurement (TIM) 64(6), 1734-1740 (2015).
(2) Andreas Steiger, Ralf Müller, Alberto Remesal Oliva, Yuqiang Deng, Qing Sun, Malcolm White, and John Lehman, "Terahertz Laser Power Measurement Comparison", IEEE Transactions on Terahertz Science and Technology 6(5), (2016). DOI: 10.1109/TTHZ.2016.2590260.
(3) Yu Zhang, Lin Zhang, Ping Sun, Yingfeng He, Yun Zou, and Yuqiang Deng, "Extracting complex refractive index from polycrystalline glucose with self-referenced method for terahertz time-domain reflection spectroscopy," Applied Spectroscopy 70(7), 1102–1108 (2016).
(4) Y. He, L. Xiong, J. Zhang, et al. Primary calibration of solar cells based on DSR method at the National Institute of Metrology of China[C].Proc. SPIE,2015, (9623):China Instrument and Control Society (CIS); The Society of Photo-Optical Instrumentation Engineers (SPIE)
(5) Sun Ruoduan, and Ma Yu. "Sphere reflectance uniformity analysis and compensation for primary color standard." SPIE, 2014.
(6) Tao Xu, Haiyong Gan, Jing Yu, et al. Temporal response of laser power standards with natural convective cooling. Optics Express, 2016, 24(2): 935-944.