Optical Radiation News

Published by the COUNCIL for OPTICAL RADIATION MEASUREMENTS (WWW.CORMUSA.ORG) to report items of interest in optical radiation measurements. Inquiries may be directed to the Editor, Daryl R. Myers, National Renewable Energy Laboratory 1617 Cole Boulevard, Golden CO 80401 Tel: 303-384-6768 Fax: 303-384-6391 e-mail: daryl.myers@nrel.gov

NUMBER 96 FALL, 2011

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CORM 2012 Annual Technical Conference and Business Meeting

The CORM 2012 conference is currently in the planning stages. Conference topics and sessions will be announced shortly on the CORM website, www.cormusa.org. Preliminary submissions for abstract and session topics may be sent to the conference coordinators, listed below.

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CORM NEWS

The CORM 2011 Annual Technical Conference was held May 4-6, 2011 in Gaithersburg Maryland, and featured topics in solid state lighting, optical properties of materials, uncertainty analysis, and laboratory measurements of light. It also included a workshop dedicated to uncertainty analysis of photometric and radiometric measurements. Conference presentations in included the following:

Workshop

Fundamentals of uncertainty analysis for optical measurements: Where do I start? (Cameron Miller)

Case Study: Uncertainty analysis for luminance ratio measurements (Cameron Miller)

Case study: Uncertainty analysis for NIST spectral irradiance measurements (Howard Yoon)

Case study: Uncertainty analysis for NIST reflectance colorimetry measurements (Maria Nadal)

Uncertainty budgets for integrated photometric measurements (Rolf Bergman)

Case study: Uncertainty analysis for integrating goniometric measurements (Cameron Miller)

SSL Novel Ideas/Applications, Standardization Updates

A Practical Photometer for CIE Performance Based Mesopic Photometry System (Tatsukiyo Uchida)

Proficiency Test Group 12 results (Rolf Bergman)

Calculation of CCT and Duv and Practical Conversion Formulae (Yoshi Ohno)

Development of a 365 nm LED Source as a UV Transfer Standard (Dr. Shen Zhu)

Fluorescence errors in integrating sphere measurements of remote phosphor type LED light sources (Arno Keppens – Presented by Yuqin Zong)

Practical Ideas and Tips for Laboratory Measurements

TM-21 Update: Method for Projecting Lumen Maintenance of LEDs (Eric Richman)

Real-time Passive Fluorescence Spectra of Induced Stress in Vegetation (Arnold Theisen)

Review of Commercial Light Meter Calibration (K Frank Lin)

Practical Lumen Maintenance Testing Using LM - 80 - A discussion of Best Practices and Recent Standards Activity (Jeff Hulett)

A closer look at photobiological safety measurements (Egbert Lenderink)

Simple silicon photodiode based femto-watt measurement system and its implication – (Yuqin Zong)

Frank Grum Memorial Lecture

"A view from the other side of technology: SSL, market forces, politics, and communication" – Dale Work

Dr. Dale Work holds degrees in math, chemistry and business. His PhD in chemistry is from Michigan State. His career has been in the lighting industry, primarily with Philips Lighting. He served as VP R&D North America for ten years, and then managed the Central Lamps Laboratory in the Netherlands for three years. From 2002-2007 he was a technical lobbyist for Philips in Washington, DC. Before retiring in 2010, he was the General Manager of the Philips Lighting Innovation Campus in Shanghai, China.

Optical Properties of Materials

Characterization of Fluorescent Materials (Sven Leyre)

Results of a Nationwide Intercomparison of Infrared Spectral Reflectance Capabilities – (Boris Wilthan/Leonard Hanssen)

A high-power, tunable, supercontinuum-based VIS-SWIR light source for the STARR II gonioreflectometer (Heather Patrick/and Clarence J. Zarobila)

Integrating sphere superposition technique for quantifying the linearity of InGaAs detectors (Angelo Arecchi)

Laboratory Versus Production SSL Metrology

Laboratory versus Production SSL Metrology: Lessons and Questions from CALiPER (Mia Paget – Presented by Eric Richman)

Thermal issues in relation to metrics reported on LED data sheets (Andras Poppe)

Calibrating Optical Sensors for Semiconductor Process Control (John Corless)

CALiPER Deep Dive Long-Term Testing—Correlation from SSL Device Performance to End Product (Mia Paget – Presented by Eric Richman)

Rensselaer Lighting Research Center Recent Activities

Studies Published on Minimizing Flicker from SSL Systems; ASSIST to Release Related Recommendation

Flicker and stroboscopic effects have been a concern with solid-state lighting (SSL), and industry and the ENERGY STAR program have debated recently the effects of frequency and other driving modes on the perception and acceptability of flicker. To provide further data and guidance in this area, the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute has conducted human factors studies of flicker that were recently published in the journal Lighting Research and Technology (Volume 43, Issue 3). The studies, funded by the Alliance for Solid-State Illumination Systems and Technologies (ASSIST), will become the basis for future ASSIST recommends guidelines on flicker from SSL systems. The study results indicated that although flicker was not directly visible at frequencies of 100 Hz or higher, indirect stroboscopic effects of flicker were perceptible even at 300 Hz. Lower modulation depths substantially reduced the perception of stroboscopic effects, and a higher duty cycle resulted in somewhat higher rated comfort than a lower duty cycle. Neither the shape of the flicker waveform nor the correlated color temperature of the light affected responses to flicker under the conditions studied. A project summary for the LRC studies can be accessed at: http://www.lrc.rpi.edu/programs/solidstate/assist/flicker.asp.

Recommendations for Evaluating Street and Roadway Luminaires

In 2009, ASSIST published an alternative method for evaluating outdoor luminaires designed for parking lot lighting. The ASSIST metric, called luminaire system application efficacy (LSAE), is based on the concept of application efficacy in which efficacy is measured by the amount of luminous flux reaching the task plane that meets the application's photometric requirements rather than all the lumens exiting the luminaire. For a parking lot luminaire, this meant counting the lumens reaching the parking lot ground that conformed to recommended illuminance and uniformity guidelines, and discounting everything falling outside the application area or not conforming to photometric requirements. This new volume of ASSIST recommends extends the parking lot LSAE metric to street and roadway luminaires. A detailed description of ASSIST's street and roadway luminaire evaluation method can be found online:
http://www.lrc.rpi.edu/programs/solidstate/assist/recommends/roadway.asp.

Recommendations for Estimating Discomfort Glare

Because outdoor lighting is utilized at relatively low light levels and because outdoor lighting equipment (e.g., lamps and luminaires) tends to be relatively bright, there is a substantial potential for discomfort glare in outdoor lighting applications. This volume of ASSIST recommends describes a calculation method for predicting discomfort glare from outdoor lighting systems, based on an existing rating scale and a published discomfort glare model. The ASSIST calculation method is an extension of this model that incorporates the source luminance, resulting in improved predictions of the De Boer rating for a given lighting system. A detailed description of ASSIST's discomfort glare calculation method can be found online:
http://www.lrc.rpi.edu/programs/solidstate/assist/recommends/discomfortglare.asp.

NIST Physics Laboratory Optical Technology Division

NIST NEWS from the Optical Technology Division

Bridging Data Gaps in Climate Change Monitoring

NIST has published a report based on discussions at a one-day workshop entitled "Bridging Satellite Climate Data Gaps," in the current issue of the NIST *Journal of Research*. The report addresses the issue of data gaps in time series of satellite measurements, which can be either intentional or unplanned. Such gaps can occur due to launch delay, launch failure, measurement inconsistencies, or data jumps in radiometric scales between satellites. Data records of interest include sea-surface temperature, ocean color, vegetation level, soil moisture, and atmospheric temperature. These gaps create added uncertainties in the small signatures of climate change.

The overarching recommendation, voiced by leading experts in the Earth Observation community, is that all calibrations and measurement procedures for space borne and aircraft sensors should be rigorously traceable to the SI. Long-term monitoring of climate change will inevitably involve piecing together data from multiple sources. This process is made particularly robust when all measurements relevant to climate change are SI traceable to accepted absolute scales.

The report summarizes the strategies required to attain SI traceability. They include continuing improvements in prelaunch, onboard, and vicarious calibrations and transfer standards; establishing celestial standards and procedures for intercomparisons; establishing SI traceability for alternative measurement strategies, such as *in situ* networks and airborne sensor campaigns; and leveraging international satellite assets.

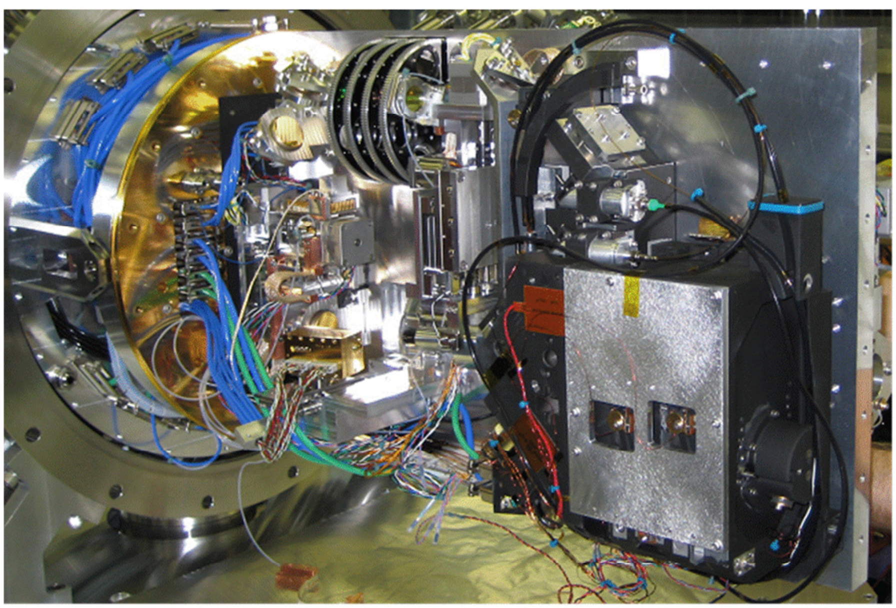
Physics Laboratory sponsored the workshop on December 10, 2009 at NIST. Approximately 50 people attended, including experts from NASA, NOAA, the U.S. Geological Survey, the University of Wisconsin, Harvard University, and Utah State University. NIST also presented the results from the workshop at the SPIE Optics and Photonics Conference in San Diego in August 2010.

For further information, see "*Workshop on bridging satellite climate data gaps*," J. Res. Natl. Inst. Stand. Technol. **116**, 505–516 (2011).
CONTACT: Raju Datla (PML), ext. 2131

Missile Defense Transfer Radiometer enhanced with a Cryo-FTS

Since 2001, the Low-Background Infared (LBIR) facility at the NIST has provided radiometric calibrations of the collimated output beam irradiance from ground test chambers used in the development and testing of infrared (IR) sensors for missile defense applications. These calibrations have been performed using the Ballistic Missile Defense Transfer Radiometer (BXR), a cryogenic radiometer with a 7 cm entrance pupil. The BXR is calibrated against an absolute cryogenic radiometer (ACR) at NIST and uses a Si:As blocked-impurity band (BIB) detector and a set of 10 bandpass filters from 2 µm to 14 µm wavelength to provide coarse spectral coverage over the wavelength range of interest to the missile-defense community. The uncertainty (k=1) in these calibrations is typically ± 3 % over a range of approximately 10^{-14} W/cm^2 to 10^{-9} W/cm^2.

However, spectrally complex or tunable sources cannot be adequately characterized or calibrated with a discrete filter radiometer such as the BXR. NIST has thus developed a new portable cryogenic radiometer, the Missile Defense Transfer Radiometer (MDXR), which includes several enhancements relative to the BXR. Specifically, a cryogenic Fourier-transform spectrometer (Cryo-FTS) designed to provide continuous spectral coverage from 3 · m to 20 · m with < 1 cm^{-1} resolution was constructed to NIST specifications under contract by Telops, Inc. The Cryo-FTS/BIB detector combination is capable of measuring spectral fluxes in the long-wave infrared on the order of ≈ 14 fW in a 4 cm^{-1} spectral interval with 1 minute of averaging. The MDXR with its Cryo-FTS was successfully deployed to measure the spectral irradiance of several sources within The Cryo-FTS (lower right) as mounted in the MDXR chamber. The output beam from the Cryo-FTS passes through the filter wheel assembly in the top center of the picture before striking a fold mirror and being focused down to the detector stage by the off-axis paraboloidal mirror in the upper left.



The Cryo-FTS (lower right) as mounted in the MDXR chamber. The output beam from the Cryo-FTS passes through the filter wheel assembly in the top center of the picture before striking a fold mirror and being focused down to the detector stage by the off-axis paraboloidal mirror in the upper left.

Measurement Validation for Ocean Color

On August 4–5, 2010, members of the satellite remote sensing community, including PL's Optical Technology Division, participated in a workshop off the coast of Long Island, New York. Their objectives were to interpret and implement recently published protocols for measuring normalized, water-leaving spectral radiances by above-water *in situ* radiometry, and to compare the results.

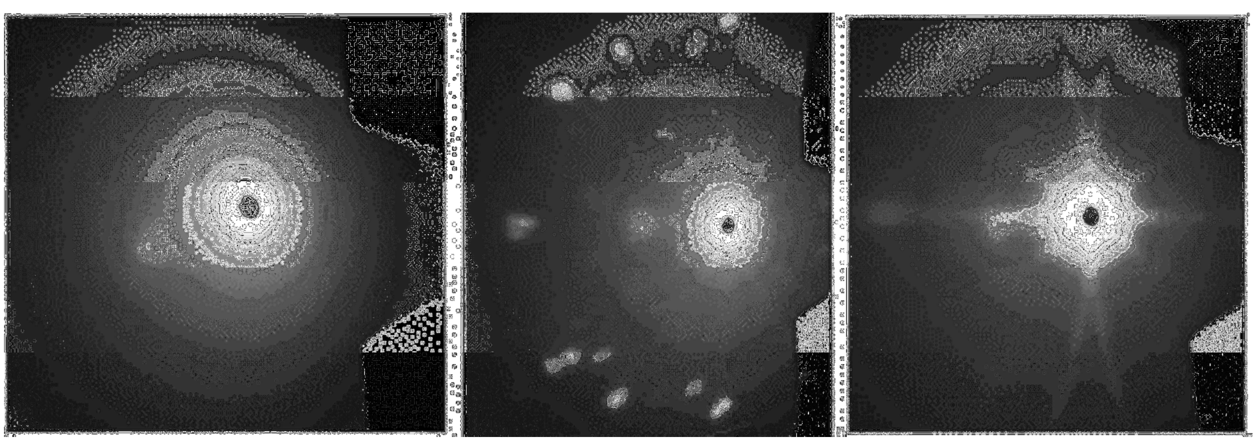
Each research team applied the measurement protocols to the water's surface and three reflectance standard targets supplied by NIST—a white and a gray diffuse reflectance target and a blue ground-glass target. The reflectance values of the water's surface and the test targets were determined and analyzed by each team.

The workshop participants included researchers from NIST, Naval Research Laboratory (team lead), City University of New York, Mississippi State University at Stennis Space Center, NOAA's National Ocean Service and the National Environmental Satellite, Data, and Information Service, and the Center for Hydro-Optics and Remote Sensing at San Diego State University. A report on the workshop will be prepared detailing the methods for comparison of the participant's results, methods of analysis, and data reduction.

This workshop served as preparation for the validation activities that will follow the launch of Visible Infrared Imager Radiometer Suite (VIIRS). Above water, *in situ* radiometric measurements will be one method to validate the data products, such as chlorophyll concentration, that are derived from ocean color sensors on VIIRS.

NIST's role in the upcoming validation activities of VIIRS includes addressing the uncertainty budget, completing characterization of selected sun photometers, and observing the implementation of the measurement protocols. NIST's first characterizations of the sun photometers, planned for September 2010, will involve their spectral characterization using the Spectral Irradiance and Radiance Responsivity using Uniform Sources (SIRCUS) facility in Optical Technology Division.
CONTACT: Carol Johnson (PL), ext. 2322

Reflectance Factor Measurement Systematic Errors Due to Near Infrared Fluorescence



Images of the goniodistribution of the reflected light for different retroreflective materials.

The current 2011 code of federal regulations in Appendix to Subpart F of Part 655 states "Although the FHWA Color Tolerance Charts depreciate the use of spectrophotometers or accurate tristimulus colorimeters for measuring the daytime color of retroreflective materials, recent testing has determined that 0:45 or 45:0 spectroradiometers and tristimulus colorimeters have proved that the measurements can be considered reliable and may be used." This language was added in the 1980s and reapproved in 2002.

Informal inter-laboratory or inter-instrument comparisons such as the one presented by David Burns at the 2004 Annual Conference of the Council on Optical Radiation Measurements suggests that the current code is not appropriate leading to measurement discrepancies too large for the industry to overlook. Dr. Burns concluded that the variance in these measurements were due to an optical property of prismatic retroreflective materials called "sparkle". For daytime measurements, the annular or circumferential 45:0 (or 0:45) geometries are recommended by standards committees. In this setup, the luminance factor is the measurand, which is the sample luminance, normalized to the luminance of an ideal diffusing material under the same illumination conditions. Current guidelines for daytime measurements have been surpassed by the technologies that make up these materials. For certain types of retroreflective material, anomalous bright spots appear in symmetric increments along the entire annular ring when observing a retroreflective surface at 45 degrees from the illumination angle.

NIST researchers have examined this problem by collecting Bi-directional Reflectance Distribution Functions (BRDF) on the NIST 5-axis Reflectance Goniometer for several types of retroreflective materials around a 0:45 and 45:0 geometry in order to characterize these sparkles or bright spots and to determine if these anomalies are significant enough to skew the results. Using these sets of data, we can integrate the function to simulate the signal for the various types of instruments based on their optical geometries and aperture sizes. The dependence for each aspect including entrance angle, entrance angle aperture, viewing angle, viewing angle aperture, and sampling size aperture can be determined in order to tighten the ASTM test method E1347 and E1349 and eventually the code of federal regulations.

Contact: Maria Nadal (maria.nadal@nist.gov)

2011 Photometry Short Course – September 27-30, 2011

The 10th NIST Photometry Short Course was held for three and half days at the NIST Gaithersburg, Maryland campus. The course consisted of ten lectures (first two days) given by NIST scientists, and three laboratory sessions (last day and a half) in the NIST photometry laboratory using the 4 m photometry bench, the 2.5 m integrating sphere, and the color temperature measurement facility. The course participants included 28 people from a wide range of lamp and luminaire manufacturers, instrument companies and calibration laboratories.

The course is intended for photometry engineers and technicians in industries such as lighting, photography, and avionics; calibration and testing laboratories; instrument manufacturers; and others. The course is suited for those who want to learn photometry systematically in depth, in theory, and in experimental practice. The course is offered every two years.
http://www.nist.gov/pml/div685/sc/photometry_course.cfm
Contact: Cameron Miller (c.miller@nist.gov)

2011 Spectrophotometry Short Course – April 25-29, 2011

The 4th NIST Spectrophotometry Short Course was held for 4 days at the NIST Gaithersburg, Maryland campus. The course consisted of twelve lectures given by NIST scientists, and three afternoon laboratory sessions, which made use of Optical Technology Division resources including the Fourier transform spectrophotometry lab, the goniometric optical scatterometry lab, and the

STARR facility. The course participants included 11 people from a range of optical manufacturing and testing laboratories in both industry and government.
This course is intended for engineers, scientists, technicians, managers, or others involved in the design or use of optical instrumentation, optical testing, or physical sciences in which optical properties of materials measurements are important. The course is offered every two years.
http://www.nist.gov/pml/div685/sc/spectrophotometry_course.cfm
Contact: Simon Kaplan (simon.kaplan@nist.gov)

11th International Conference on New Developments and Applications in Optical Radiometry

This year, The 11th International Conference on New Developments and Applications in Optical Radiometry (NEWRAD 2011) was convened at The Grand Wailea Resort on the island of Maui, Hawaii. The NEWRAD Conference covers all aspects of optical radiation measurements and a wide range of topics that was presented during the five day program. The specific themes of NEWRAD 2011 are Earth Observation and Few Photon metrology. Half-day sessions were devoted to both of these specific themes.

NIST had 6 papers accepted to this conference including an invited talk given by Alan Migdall titled, "Bridging the Gap: Radiometry from Watts to Single-Photons." The additional six talks are listed below and will be expanded upon in the next issue of ORN.

Leonard Hanssen: NIST – PTB Joint Study of Far Infrared Selected Black Coatings
Heather Patrick: BRDF measurements of graphite used in high temperature fixed point blackbody radiators: a multi-angle study at 405 nm and 658 nm
Joe Rice, Radiometric Characterization of a Hyperspectral Image Projector
Yugin Zong: New Method for Spectral Irradiance and Radiance Responsivity Calibration using Pulsed Tuneable Lasers from 210 nm to 2500 nm
George Eppeldauer: Development of new-generation transfer standard pyroelectric radiometers for monochromator use
Steve Brown, NIST: Stray light correction algorithm for multichannel spectrographs.

National Research Council of Canada

NRC · CNRC National Research Council Canada Conseil national de recherches Canada

Liaison Report from the Photometry and Radiometry Group

Comparison of the bidirectional diffuse reflection scales of PTB and NRC in the V(λ)-range

The scales of goniometric determined spectral diffuse reflection, referred as radiance factor or bidirectional reflectance distribution function (BRDF), of the Physikalisch-Technische Bundes-anstalt (PTB) and the National Research Council (NRC) have been compared in the V(λ)-range. The comparison includes measurements in five distinct geometries. These are the bidirectional geometries of 45:-30, 45:-20, 45:0, 45:30 and 45:65 as recommended in DIN 6175-2 and ASTM E2539-08. Both institutes operate similar layouts of robot-based gonioreflectometer facilities, but with different types of detection of the reflected radiation. Four different types of samples have been investigated: A matt white ceramic tile, a primed barium sulfate standard, an opal glass and a standard made of vapor-blasted aluminum.

The agreement between the NRC and the PTB measurements depends on the sample considered, and was best for the aluminum and the opal samples, where observed differences were mostly consistent with the stated uncertainties. The figure below shows a typical result. For the $BaSO_4$ and the CERAM samples, the differences were just slightly inconsistent with the stated uncertainties, indicating that some small systematic errors may still have been left uncorrected.

These results were presented at the NEWRAD 11th International Conference on New Developments and Applications in Optical Radiometry.

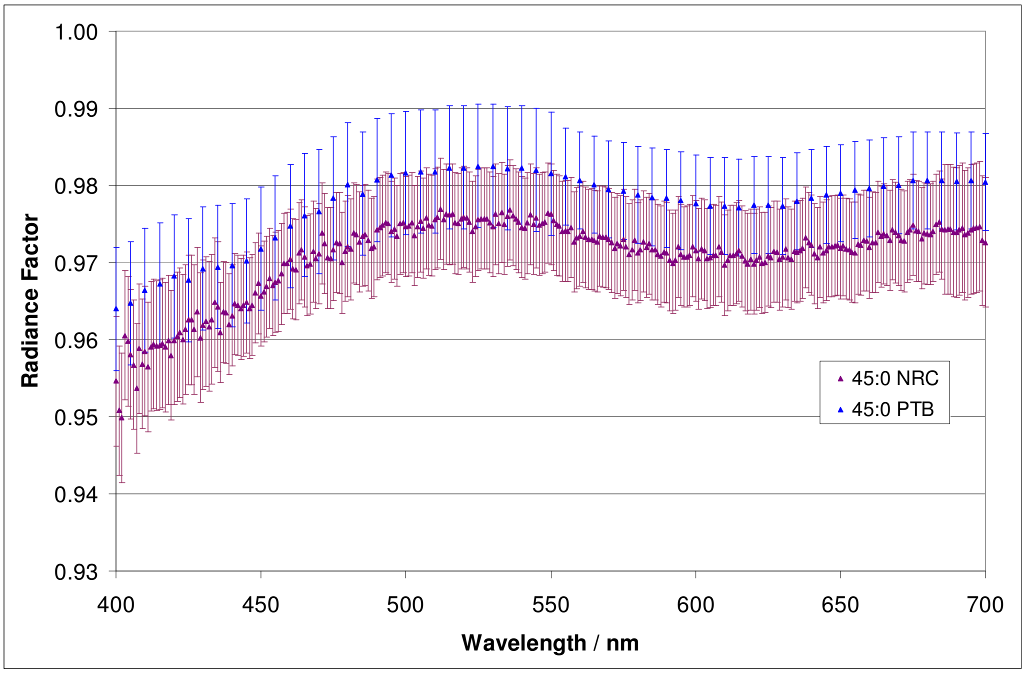
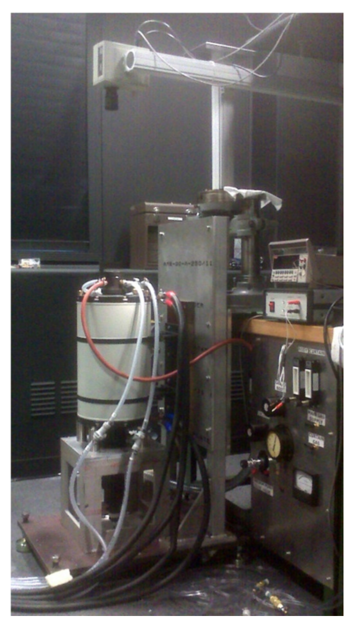


Figure: Comparison of the spectral radiance factors measured by NRC and PTB for an opal glass sample (NIST SRM-2017), for 45° incidence angle and 0° ref

For more information, contact Réjean Baribeau, 613-993-8351, Rejean.baribeau@nrc-cnrc.gc.ca

Progress in NRC High Temperature Fixed Points



Measurements of thermodynamic melting temperatures of Co-C, Pt-C and Re-C fixed points as part of preliminary work of Working Group 5 of the Consultative Committee for Thermometry (CCT-WG5) to assign melting temperatures to these fixed points has been completed at NRC. A report detailing our results has been submitted to the work package coordinator and the results will be published at the *9th International Temperature Symposium* (ITS9) in March 2012. Work is now underway to improve our method of measuring these fixed points and to lower the associated uncertainty in temperature assignment for the final round of measurements, which is expected to begin in 2012/2013.

Figure 1. The new high temperature fixed-point casting furnace

A new vertically-oriented high temperature furnace has been installed and is now in use within the NRC-PRT group. This furnace is of the BB3500M type (All-Russian Research Institute for

Optical and Physical Measurements (VNIIOFI)) and enables filling of fixed points with melting temperatures up to nearly 3500 K. Since its installation in the spring of 2011, two Co-C (melting near 1597 K) and one Re-C (melting near 2747 K) fixed points have been produced with this facility.

For further information contact: Andrew Todd, 613 993-7714, andrew.todd@nrc-cnrc.gc.ca

Update on NRC Quantum Candela Research Project

As outlined in the previous issue, a technique to directly measure the wavefunction of a quantum system was developed. We applied this technique by performing a series of measurements of the transverse wavefunctions of single photons. The technique and this example application were published in the June 9th, 2011 issue of Nature (Nature, pp 188-190, vol. 474 (2011)), where it was the most viewed paper that month. The work has since received coverage in Science, Physics World, Science News, Science et Vie, and a variety of newspapers.

The single photons were produced by first generating pairs of photons by spontaneous parametric downconversion. The presence a single photon in one beam was heralded by the detection of its twin in the other beam. This photon was sent in to an optical fiber to give it a Gaussian optical mode. We alter this mode (with glass plates and graded filters (RB)) to create a series of wavefunctions to test our technique with. The technique works by weakly measuring the transverse position of the photon. This corresponds to a small polarization rotation at position x (implemented by a sliver of waveplate). A Fourier transform lens allows us to select only those photons with zero transverse momenta with a slit in the focal plane. The rotation of the linear polarization of these photons is proportional to the real part of the initial wavefunction at x. Similarly, the rotation of the polarization ellipticity is proportional to the imaginary part. We measure these rotations with waveplates, a polarizing beamsplitter and two detectors.

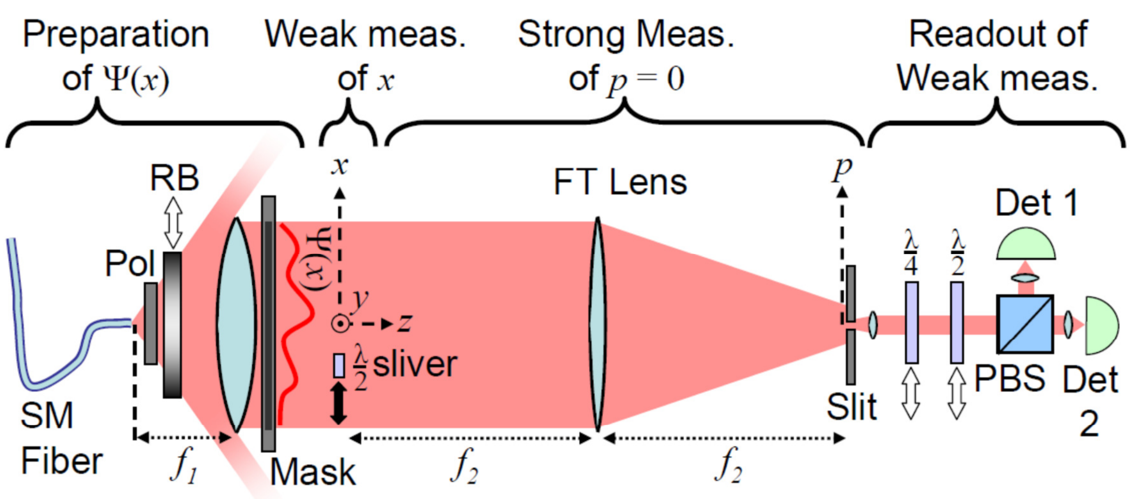


Figure 2. Apparatus for the direct measurement of the transverse wavefunction of a single photon.

For further information contact: Charlie Bamber, 613-990-8990 or Jeff Lundeen, 613-993-8913

Surface-Enhanced Infrared and Raman Spectroscopies of Absorbate Saturated Au Nanorod Array

In collaboration with researchers at the NRC Institute for Microstructural Sciences (John Hulse, Jeff Fraser and Li-Lin Tay), we have been investigating the optical properties of Au nanorod arrays using complementary surface-enhanced infrared and Raman spectroscopies. The renaissance of surface enhanced Raman scattering (SERS) is one of the most exciting developments in analytical vibrational spectroscopy in the last decade. Owing to the advances of nanotechnology, SERS has demonstrated versatile applications in the analytical quantification of chemical and biological species. The localized surface plasmon resonance (LSPR) is a collective oscillation of conduction electrons confined in metal nanostructures and is largely responsible for surface enhanced spectroscopies. SERS is the best known and most widely applied example of such a surface enhanced spectroscopy. Although closely related and complementary to SERS, surface enhanced infrared absorption (SEIRA) spectroscopy requires more careful engineering of the LSPR of metal nanostructures so that the resonance spans the mid-infrared region. In this work, we demonstrated the use of gold nanorods (Au NRs) arrays as a suitable substrate capable of sustaining strong SEIRA spectroscopy. As shown below, the adsorbate saturated Au NRs typically exhibit Fano-type resonances in their SEIRA spectra obtained using reflectance FTIR. Such line asymmetry occurs due to the coupling of the relatively sharp molecular vibrations to the broad continuum of the LSPR resonance of the aggregated Au NRs. We also carried out discrete dipole approximation (DDA) calculation of coupled nanostructures to quantify the electromagnetic field distribution over the coupled Au NRs in order to understand the observed enhancements over conventional Infrared absorption spectroscopy. Quantum cascade laser (QCL) mapping at several wavelengths around the protein amide bands near 1600 cm^{-1} was also employed to obtain information regarding the distribution of the adsorbate (immunoglobin G IgG) saturated nanorods as shown in figure 3.

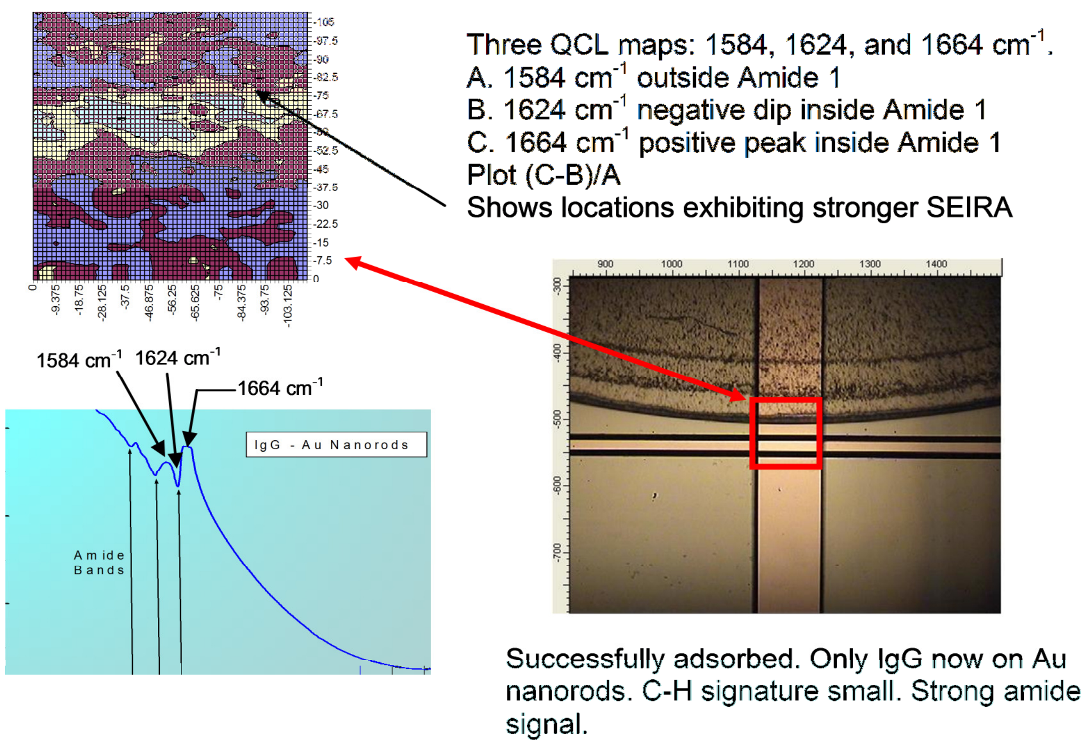


Figure 3. Quantum cascade laser (QCL) mapping at several wavelengths around the protein amide bands near 1600 cm^{-1} in immunoglobin G IgG) saturated nanorods.

For further information, contact Nelson Rowelll, nelson.rowell@nrc-cnrc.gc.a

CIE/USA and CIE/Canada Cooperation

The 8th biannual joint meeting of the Canadian National Committee of the CIE (CNC/CIE) and CIE USA will be held in Ottawa, Canada, on 2-4 October 2011. The two days of technical presentations, lab tours and business meetings will take place at the NRC The NRC tour will include the photometry and radiometry laboratories of the Institute for National Measurement Standards and the lighting research laboratories at the Institute for Research in Construction.

The speakers, affiliation and title of the technical presentations are:

- Rolf Berman, Independent Lighting Consultant, "EPA Energy Star Certification for Lighting Products"
- Alan Robertson, retired from NRC, "The CIE Colorimetry Standards"
- Lorne A. Whitehead, University of British Columbia, "Consideration of Meta-Standards for Colour Rendering Metrics"
- Benjamin J. Birt, Guy R. Newsham, Jennifer A. Veitch and Chantal D. Arsenault, NRC Institute for Research in Construction, "The real lit environment: Measurements from NRC's POE of Green Buildings Project
- Réjean Baribeau, NRC Institute for National Measurement Standards, " Gonioreflectometry of diffusely reflecting and regularly reflecting surfaces"
- K. Frank Lin, Lighting Sciences Canada Ltd., "Cross-referencing Calibration Standards in a Photometric Laboratory"
- André Laperrière, Energy Technology Laboratory, Hydro Quebec, "Advanced Lighting Technologies: LED Street Lighting in Rouyn-Noranda"

For further information, contact Joanne Zwinkels, 613-993-9363, joanne.zwinkels@nrc-cnrc.gc.a

Photometry, Radiometry and Thermometry (PRT) Group Staff Members Honored

Dr. Alan Robertson, retired from NRC, was the recipient of the CIE Wyszecki Gold Pin for Excellence in Fundamental Research, at the 27th Session of the CIE in Sun City, South Africa, 11-15 July 2011.

Dr. Joanne Zwinkels, Principal Research Officer in the NRC PRT Group, is a new Associate Director of CIE Division 2 (Physical Measurement of Light and Radiation) since March 2011 when former CIE Division 2 Associate Director, Norbert Johnson (USA) retired from this position.

At the NRC-INMS Peer Recognition Awards ceremony in December 2010, NRC-PRT group members, **Dr. Jeff Lundeen** and **Dr. Andrew Todd**, both Research Officers, and **Mr. Eric Côté**, Technologist, received Excellence Awards.

CENAM news from the *División de Óptica y Radiometría* (DOR), Mexico.

Uncertainty component of the effective detection plane location for commercial luxmeters calibration

The *Laboratorio de Fotometría* carried out a study in order to obtain an estimation of the uncertainty component due to the location of the effective plane for commercial luxmeters calibration. The study was done with a twelve luxmeters sample, comprising three of the most common detection heads shapes, Fig. 1, which dimensions are listed in Table 1.

Table 1. Evaluated luxmeters detection heads dimensions.

Detection head type	Detector head dimensions, (mm)			
	a, Dome diameter	b, Full width	c, Body width	d, Dome width
I	23.90	22.90	14.55	7.28
II	43.70	17.70	12.50	5.20
III	21.86	18.70	12.50	6.20

The analysis was based in the determination of the offset distance the luxmeters have between the most external diffuser dome plane, and the detection sensitive surface; and as a result, we found 0.17 % as the highest uncertainty component value, Fig. 2.

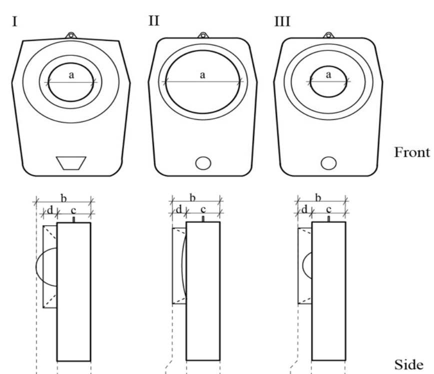


Fig.1. Front and side views of the three types of detection heads found in the studied luxmeters.

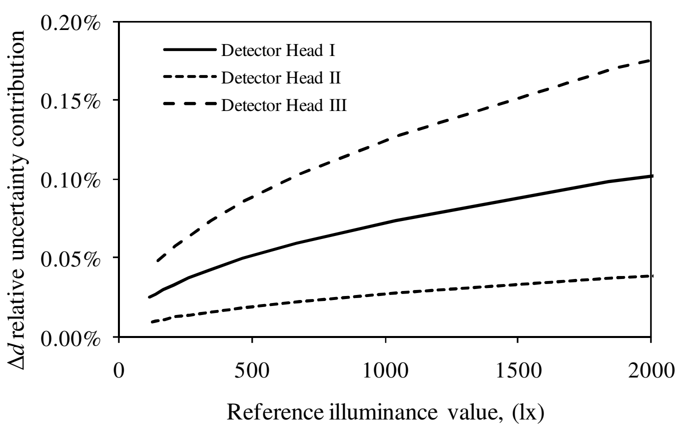


Fig. 2. Effective detection plane location uncertainty component for the studied detection heads.

The obtained uncertainty, once combined to the typical luxmeters calibrations uncertainty budget, agree with the 1 %, coverage factor k=2, illuminance Calibration and Measurement Capability declared by Mexico to the *Bureau International des Poids et Mesures*.

Fiber optics chromatic dispersion measurements at 1550 nm

A realization of the phase-shift method for chromatic dispersion measurements in mono-mode dispersion-shifted optical fibers used for the telecommunications C-band (1530 nm to 1565 nm) was carried out at the *Laboratorio de Fibras Ópticas*. Four realization replicas were done at a 40 MHz modulation frequency, a 2.5 nm wavelength step and the 1535 nm to 1570 nm wavelength scanning range; and the experimental obtained data were fitted with Sellmeier polynomials in order to produce representative determinations for the group delay and the chromatic dispersion, Fig. 3.

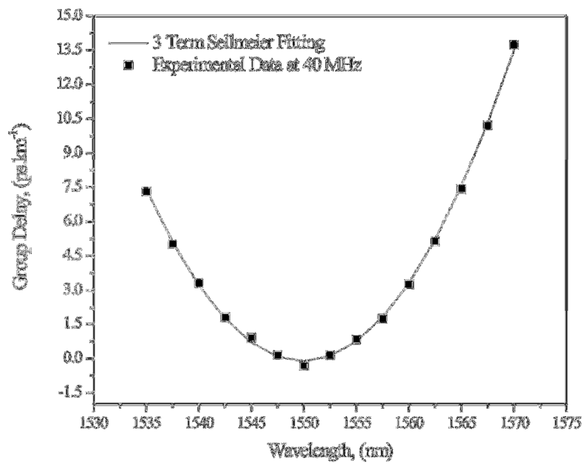


Fig. 3. Typical group delay per unit length, obtained for f_m=40 MHz, 1 535 nm to 1 570 nm range, and $\Delta\lambda$=2.5 nm.

We obtained 1549.388 nm ± 0.098 nm (k=1), and 0.7197 ps·nm^{-2} ± 0.0055 ps·nm^{-2} (k=1), for the zero dispersion wavelength and slope, respectively, Fig. 4; showing a good agreement with the certified values by the National Physical Laboratory for the tested fiber.

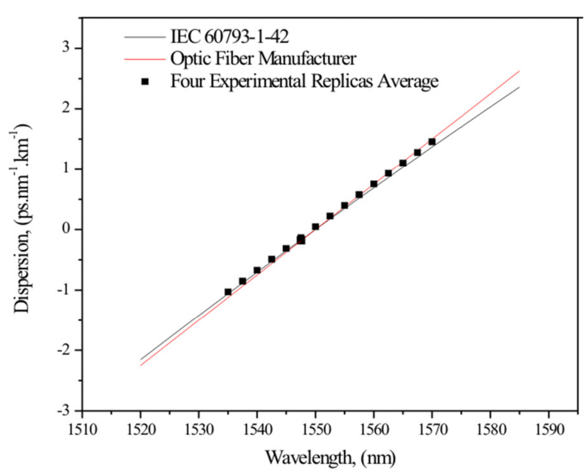


Fig. 4. Chromatic dispersion average obtained from the experimental data of four replicas; here compared to the international standard and the manufacturer's recommendation calculations.

This chromatic dispersion measurement and calibration capability development at CENAM will provide the Mexican telecommunications industry with a formally established SI unit's traceability source, thus enhancing this rapidly growing and high impact economic sector competitiveness in Mexico.

Total luminous flux determination for high-intensity white LEDs

The well known photo-goniometric method, based on illuminance spatial distribution direct measurements was used to determine the spatial distribution of total luminous flux for high-intensity white LED sources or integrated LED arrays (Fig. 5). This tested the CENAM primary metrology capabilities recently developed capability to face the increasing needs of the solid-state lighting industry in Mexico.

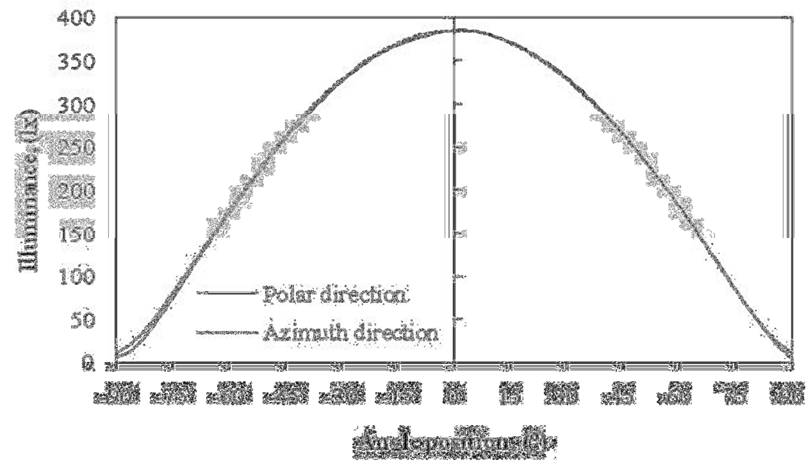


Fig. 5. Normalized illuminance spatial distributions for polar and azimuth directions.

The spectral mismatch corrected results obtained at CENAM after the gonio-photometric method implementation, allowed us to determine in good accuracy the total luminous flux for a high intensity white LED sources operated at different electrical currents, Fig. 6. The estimated uncertainty of the results is 2.86 % (k=1). It was determined that a better LED junction temperature control will need to be achieved in order to improve the measurement system accuracy.

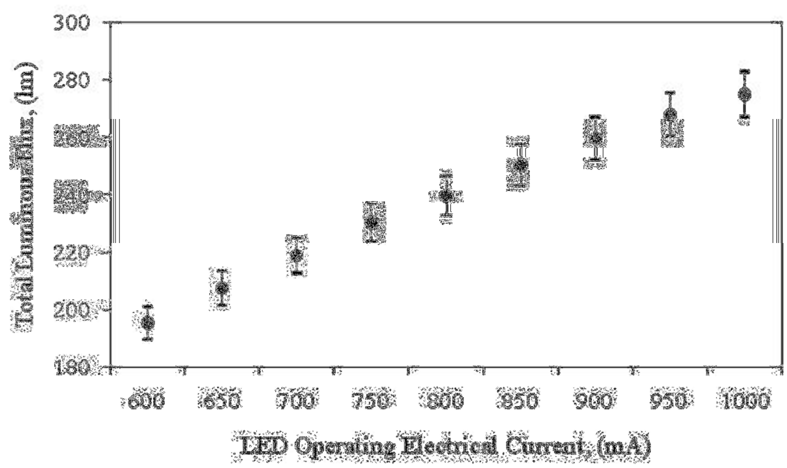


Fig. 6. White LED total luminous flux for different operating electrical currents.

New LED sources and LED based luminaries regulations to be established in Mexico

The Mexican authority has recently issued a first call to establish new regulations for measuring the energy efficiency of LED sources and LED based luminaries to be produced, commercialized and used in Mexico.

Those two new regulations will start being developed under the coordination of the Mexican agency for the efficient energy use promotion, the *Comisión Nacional para el Uso Eficiente de la Energía* early in the next month.

Luxmeters calibration training for Colombian laboratory

As part of the regular knowledge transfer, the *Laboratorio de Fotometría* trained a group of Colombian laboratory members in luxmeters calibrations based on luminous intensity standard lamps.

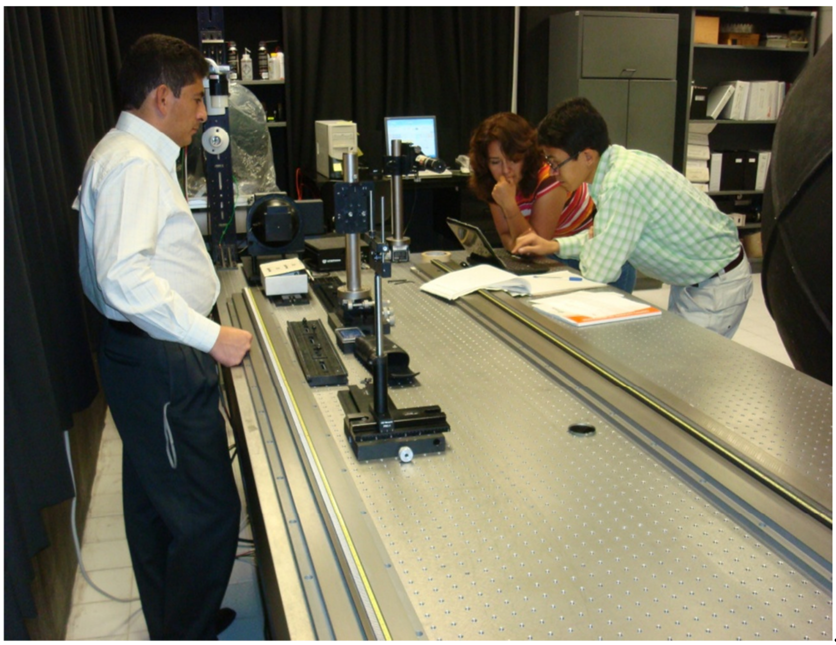


Fig. 7. Luxmeters calibration training for Colombian laboratory.

The provided training will help the Colombian laboratory to establish a luxmeters calibration capability. Columbia will continue development of the capability in order to meet the growing demand for the service in Colombia and to obtain accreditation for the service in the future.

CIE NEWS

COMMISSION INTERNATIONALE DE L'ECLAIRAGE

Call for Experts for new Technical Committees

TC 2-70 Title: Standards for Measurement of Reflectance and Transmittance Properties of Materials
ToR: To draft three new CIE standards that describe the minimum requirements for any instrument intended to measure the optical properties of planar, uniform, homogeneous (or nearly so) materials, The standards will define the geometric and spectral requirements, the processes for calibration or standardization of the scales and the required level of uncertainty for the measurement of spectral diffuse reflectance and reflectance factor, spectral regular transmittance and spectral diffuse transmittance, and spectral regular reflectance
Chair: Danny Rich

TC 2-71 Title: CIE Standard on test methods for LED Lamps, luminaires and modules
ToR: To prepare a CIE standard on test methods for photometric and colorimetric performance of LED lamps, LED luminaires, and LED modules in cooperation with CEN TC169 WG7 and IEC TC34.
Chair: Yoshi Ohno

TC 3-52 Title: Energy Performance of Buildings – Energy Requirements for Lighting
ToR: To develop a CIE standard based on the coming revision of the existing EN 15193 ""Energy performance of buildings – Energy requirements for lighting"" in line with the activities of ISO and CEN on the revision of all ISO/EN standards for the energy performance of buildings. EN 15193 was developed to establish conventions and procedures for the estimation of energy requirements of lighting in buildings, and gives a methodology for a numeric indicator of energy performance of buildings.
Chair: Dieter Schornick

Kicking-Off the CIE Training Programme

On November 23rd, 2011, the first in a series of training units will take place in the CIE Central Bureau in Vienna. The Training Programme shall transfer and implement the knowledge contained in CIE Publications/Standards to the stakeholders of the Commission and other interested parties.

CIE will provide trainings, workshops and seminars on lighting fundamentals as well as will complement each newly published Standard and Technical Report with a training unit. You can participate in these trainings either in "real life", in the Central Bureau in Vienna, or wherever you are during the seminar by using our life streaming facility and our online training tool. If you do not find the time to participate via one of these facilities you can later download the recorded and edited contents from our online platform.

The first seminar will take place on November 23rd, 2011 between 09:00am and 05:00pm in Vienna and will be chaired by Prof. Dr. Janos Schanda.

Goal: Summarizing fundamental differences in the measurement of traditional light sources and LEDs as well as LED modules.

Target group: anybody interested in solid state lighting, the photometry and colorimetry of solid state devices, especially LEDs and LED modules.

Subjects to be covered are the following:

1. Fundamental differences between LEDs, LED modules, LED lamps, and traditional light sources
2. The basic terms used with LEDs and LED modules
3. Photometry of LED devices (differences compared to traditional light sources):
a. Gonio-photometry
b. Integrating sphere photometry
c. Spectroradiometry
4. Colorimetry of LEDs and LED modules
a. Problems with the CIE 1931 Colorimetric System
b. CIE TC 1-36 based colorimetry and practical experience
5. Colour rendering
a. CIE Publ 13.3 Colour Rendering Index
b. Possible updates: colour fidelity, colour preference.
6. LEDs and non-visual effects

Price: EUR 800,-- + 20% VAT. (On discounts for students and corporate packages for companies please contact the CIE Central Bureau at ciecb@cie.co.at).

If you would like to participate either in real life or online simply send an email to ciecb@cie.co.at to pre-register (note: places are limited and will be assigned on a first come, first serve basis). CB staff will be delighted to provide you with any further details, particularly on upcoming further workshops, trainings and tutorials. Our recommendation: By subscribing to this newsletter, you ensure that you will not miss any topic of interest to you (e.g. the upcoming Mesopic Photometry Tutorial).

Recently Published:

Colorimetry - Part 3: CIE Tristimulus Values
Standard CIE S 014-3/E:2011

Colour stimuli with different spectral distributions can look alike. An important function of colorimetry is to determine which stimuli look alike to a given observer with a given set of colour-matching functions. This is done by calculating a set of three tristimulus values for each stimulus. Equality of tristimulus values indicates equality of colour appearance under equal irradiation and viewing conditions. This Standard is based on long-standing CIE recommendations (CIE15:2004 Colorimetry, 3rd edition) for the calculation of tristimulus values. It specifies methods of calculating the tristimulus values of colour stimuli for which the spectral distributions are provided. These colour stimuli may be produced by self-luminous light sources or by reflecting or transmitting objects. The standard method is defined as summation at 1 nm intervals over the wavelength range from 360 nm to 830 nm. Alternative abridged methods are defined for larger intervals (up to 5 nm) and shorter ranges (down to 380 nm to 780 nm). The alternative methods are to be used only when appropriate and when the user has reviewed the impact on the final results. The Standard may be used in conjunction with the CIE 1931 standard colorimetric observer or the CIE 1964 standard colorimetric observer. The Standard has been approved by the CIE National Committees.

Determination of Measurement Uncertainties in Photometry
CIE 198:2011
ISBN 978 3 902842 00 8

This report is a recommendation for the determination of measurement uncertainties associated with the values of selected quantities in photometry. The report explains the steps from the initial procedures for a measurement of input quantities to a final statement of the output values with associated expanded uncertainties. The main part summarises the fundamental definitions for the evaluation of standard, combined and expanded uncertainties following the rules in the internationally agreed "Guide to the Expression of Uncertainty in Measurements" (GUM) and its supplement 1. In conjunction with this report supplements, with a wide selection of examples, provide guidance on how to model measurement procedures in a measurement equation, combine uncertainties in a budget and convert to the presentation of expanded uncertainty. The publication is written in English, with a short summary in French and German. It consists of 30 pages with 3 figures and 2 tables.

Determination of Measurement Uncertainties in Photometry - Supplement 1: Modules and Examples for the Determination of Measurement Uncertainties

Part 1: Modules for the Construction of Measurement Equations
CIE 198-SP1.1:2011
ISBN 978 3 902842 01 5
Part 2: Examples for Models with Individual Inputs
CIE 198-SP1.2:2011
ISBN 978 3 902842 02 2
Part 3: Examples for the Solving of Systems of Equations
CIE 198-SP1.3:2011
ISBN 978 3 902842 03 9
Part 4: Examples for Models with Distributions
CIE 198-SP1.4:2011
ISBN 978 3 902842 04 6

This report supplements Technical Report CIE 198:2011 Determination of Measurement Uncertainties in Photometry for the determination of measurement uncertainties associated with the values of selected quantities in photometry. It is organized in a 1st part (CIE 198-SP1.1:2011), which shows modules for the construction of measurement equations and three more parts with examples grouped with increasing complexity. The 2nd part (CIE 198-SP1.2:2011) deals with single output quantities determined from several different input quantities. The used Excel workbook and the Mathematica program for the detailed examples explained in this part are downloadable from the CIE webpage (address to be found in the document). In the 3rd part (CIE 198-SP1.3:2011) examples* for two and more output quantities are presented which are determined from the same set of input quantities. Examples* of quantities defined as integrals of distributions (spectral, angular, spatial) are presented in the 4th part (CIE 198-SP1.4:2011).

* Till to date just one example in part 3 and 4 respectively is available, further ones are to follow. Thus, a subscription to the CIE Newsletter is highly recommended to stay updated.

The publication can only be purchased in combination with the main document CIE 198:2011. The documents are written in English, with short summaries in French and German. Part 1 consists of 20 pages with 7 figures, Part 2 consists of 94 pages with 25 figures and 28 tables, Part 3 consists of 15 pages, and Part 4 consists of 17 pages with 2 figures and 1 table.

Publications are readily available at the National Committees of the CIE or at the CIE Webshop http://www.techstreet.com/ciegate.tmpl

Future Events

November 23, 2011: Training "CIE Metrology of LEDs and LED Modules" (Vienna/AT)
January 2012 (tbc): Tutorial and Expert Symposium "CIE System of Mesopic Photometry" (Vienna/AT)
September 15-18, 2012: CIE Lecture on Photometry, Colorimetry, Metrology and Standards for SSL and LED Lighting (Hangzhou/CN)
September 19-21, 2012: CIE 2012 "Lighting Quality & Energy Efficiency" (Hangzhou/CN)
April 12-19, 2013: CIE Celebrating its 100th Birthday/CIE Midterm Meeting (Paris/FR)

Visit the website of the Central Bureau of the CIE (www.cie.co.at).

Purpose of the Council for Optical Radiation Measurements (CORM)

The Council for Optical Radiation Measurements is a non-profit organization with the following aims:

1. To establish and publish consensus among interested parties on national, industrial and academic requirements for physical standards, calibration services, and inter-laboratory collaboration programs in the fields of optical radiation measurement, including measurement of the transmittance and reflectance properties of materials, measurement of radiant sources, and characterization of optical detectors used for the measurement of these properties.
2. To establish national consensus on the priorities for these requirements.
3. To maintain liaison with the National Institute of Standards and Technology (NIST) and The National Research Council Canada (NRC) and to advise the Institute(s) of requirements and priorities.
4. To cooperate with other organizations, both public and private, to accomplish these objectives for the direct and indirect benefit of the public at large.
5. To assure that information on existing or proposed standards, calibration services, collaboration programs, and its own activities is widely disseminated to interested parties.
6. To answer inquiries about such standards activities or to forward such inquiries to the appropriate agencies.

Optical Radiation News Editorial Policy

Optical Radiation News (ORN) is published semi-annually in the April and October of each year. ORN reports upcoming technical meetings and news from NIST and other national metrology laboratories. News relating to the status and progress in optical radiation metrology from affiliated organizations, including, but not limited to, the *Commission International De Éclairage* (International Commission on Illumination, CIE), Inter-Society Color Council (ISCC), Lamp Testing Engineers Conference (LTEC), etc., is welcome. No commercial advertising, endorsements, or contributions with commercial content are included in ORN. Unsolicited contributions are subject to review and approval by the editor, CORM publications committee, and /or executive board prior to publication. Anonymous contributions will not be accepted. Contact information for a submission is required and will be published. ORN is included free with CORM membership.

Instructions for Contributing Authors

ORN is published in English. Deadlines for submission of News items and announcements concerning optical radiation metrology are 1 March and 1 September. Items may be submitted to the editor in via fax or e-mail attachments in plain ASCII text or common electronic word processing file formats, preferably Microsoft Word® or Corel WordPerfect®. Contributions should be in 12 point Times New Roman font with simple formatting, e.g., the "Normal" style and template in Word. *Use of complex style templates and formatting is strongly discouraged.* Submissions with high quality pertinent electronic graphics are welcome, however digital photographs and graphics will be reproduced in black-and-white or grayscale. Graphics included in hardcopy submissions via fax will not be reproduced. Submissions are credited to organizations, rather than individuals.

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