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 95 SPRING, 2011

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CONTENTS, Continued.

CORM 2011 Annual Technical Conference and Business Meeting

May 4 - 6, 2011

The CORM 2010 conference will be held in Gaithersburg, MD. All technical sessions including a NIST workshop on Uncertainty in Optical Radiation Measurements, and a tour of NIST Optical Technology division facilities.

The conference Hotel is the Holiday Inn, Gaithersburg, Two Montgomery Village Ave., Gaithersburg MD. Phone: 301-948-8900.

The Conference Themes are:

- **Solid State Lighting (SSL): Novel Ideas/Applications & Standardization Updates**
- **Practical Ideas and Tips for Laboratory Measurement of / with Light**
- **Optical Properties of Materials including but not limited to Solar, Display, SSL Technologies**
- **Laboratory versus Production SSL Metrology**

The NIST workshop themes will include:

- **Fundamentals of Uncertainty analysis for optical measurements: Where do I start?** Cameron Miller
- **Case study: Uncertainty analysis for NIST spectral irradiance measurements** Howard Yoon
- **Case study: Uncertainty analysis for NIST reflectance colorimetry measurements** Maria Nadal
- **Case study: Uncertainty analysis for integrating goniometric measurements** Cameron Miller

The 2011 Annual CORM Technical Conference is structured to provide interaction between the optical radiation industry and National Metrology Institutes. CORM provides pdf copies of Annual Conference presentations to attendees on USB drives at the CORM Annual Conference.

Schedule & Locations

Wednesday, May 4

AM NIST Tour NIST
PM NIST Workshop NIST
PM CORM Technical Committee Meetings NIST

Thursday, May 5
8:00 AM Session I: TBA NIST
10:00 AM Session II: TBA NIST
1:00 PM Session III: TBA NIST
6:00 PM Reception Holiday Inn
7:00 PM Grum Memorial Lecture and Banquet Holiday Inn
Friday, May 6
8:00 AM Session IV: NIST
12:00 PM CORM Business Meeting NIST
12:30 PM CORM Board of Directors Meeting NIST

Registration link:
Visit the CORM Website www.cormusa.org and click on **CORM 2011 Registration**

Conference fees:
- Regular attendees: $495 through April 1, $595 thereafter
- Students: free with valid ID
-

Franc Grum Memorial Lecture:

A view from the other side of technology: SSL, market forces, politics, and communication
– Dr. Dale Work, Philips Lighting (Retired)

The presentation will address:
1. Will SSL "take over" as the global lighting source?
2. Should the government be involved in determining the commercially available lighting choices?
3. How do existing lighting metrics stifle the adoption of new lighting developments?
4. When is the technologist's job over?

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.

For more information contact: **Conference Coordinators**

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CORM NEWS

NREL Handbook Enables Concentrating Solar Power Development

Large concentrating solar power (CSP) systems require a substantial investment—construction costs can exceed $1 billion. Developers who conduct financial analyses for such projects must have the best possible information about the quality and reliability of the fuel source. To help with this important task, the National Renewable Energy Laboratory (NREL) has published a handbook that tells how to collect, interpret, and use solar resource data during all stages of development, from selecting the site to operating the system.

"Concentrating Solar Power, Best Practices Handbook for the Collection and Use of Solar Resource Data" includes guidance on how to collect reliable data about the solar resource at specific locations, including seasonal, daily, hourly, and even sub hourly variability. Such data can be used to predict the daily and annual performance of a proposed CSP plant. The handbook also provides an introduction to important concepts, an inventory of historical data, an overview of methods for modeling solar resources, and how to apply the data to CSP projects.

Project developers, engineering procurement construction firms, utility companies, energy suppliers, financial investors, and others involved in CSP plant planning and development will likely find this handbook a valuable resource.

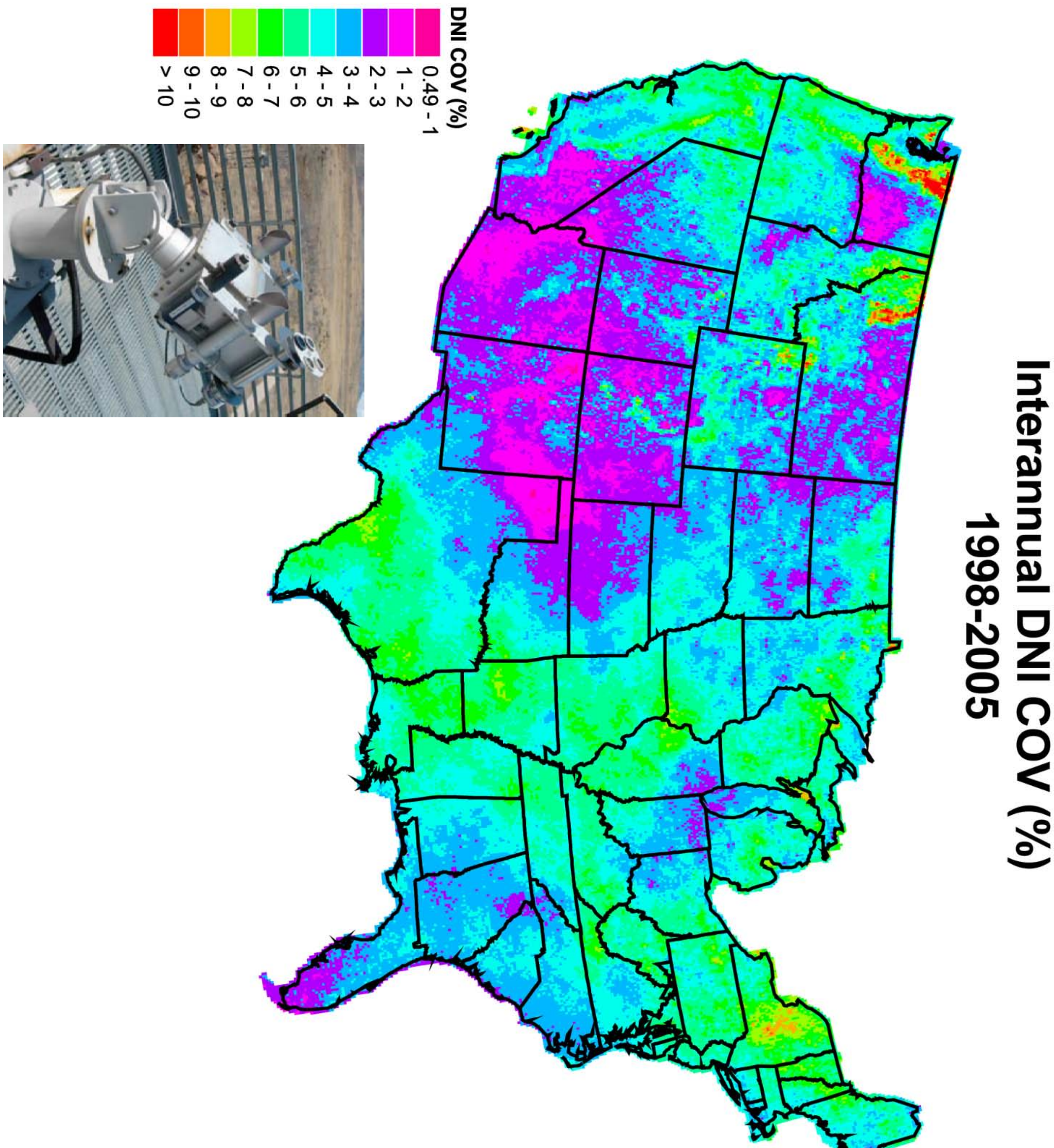
The publication was assembled by scientists and engineers with many decades of combined experience in atmospheric science, radiometry, meteorological data processing, and renewable energy technology development. The work culminates more than 30 years of research and development investment by the U.S. Department of Energy (DOE) and NREL to advance understanding of the nation's renewable energy reserves.

The effort was led by NREL's Tom Stoffel, manager of the Resource Information and Forecasting Group in the laboratory's Electricity, Resources, and Building Systems Integration Center. "There was a high level of interest from the start—many external reviewers volunteered their time to give us valuable critiques of our first draft. And within 48 hours of publication we had enthusiastic user feedback. I'm glad to see our combined expertise in solar resource characterization will be put to use by our stakeholders."

Stoffel and the handbook team are not resting on their laurels, however. They consider the publication a work in progress. Users are encouraged to provide feedback to the authors for future revisions and expansion of the scope and content.

The figure below, from the handbook, shows the relative interannual temporal variability of Direct Normal Irradiance (DNI) utilized by concentrating solar conversion systems, in percent. The variability is derived from the coefficient of variation (standard deviation divided by mean value) at a resolution of 10 km for the US. The 10 km hourly solar radiation data was developed from NOAA GOES meteorological satellite image data and a conversion model developed by Dr. Richard Perez of the State University of New York, Albany.

For more information, view the handbook, and related data on the NREL Website at http://www.nrel.gov/docs/fy10osti/47465.pdf and http://rredc.nrel.gov/solar/new_data/variability.



Above: Relative year to year variability in magnitude of direct normal irradiance utilized by concentrating solar power systems. Inset: Pyrheliometers, instruments for measuring the direct normal irradiance, mounted on solar tracking platform.

NIST Physics Laboratory Optical Technology Division

NIST NEWS from the Optical Technology Division

NIST Telescope Calibration May Help Explain Mystery of Universe's Expansion

Is the expansion of the universe accelerating for some unknown reason? This is one of the mysteries plaguing astrophysics, and somewhere in distant galaxies are yet-unseen supernovae that may hold the key. Now, thanks to a telescope calibrated by scientists from the National Institute of Standards and Technology (NIST), Harvard University and the University of Hawaii, astrophysicists can be more certain of one day obtaining an accurate answer.

NIST expertise helped calibrate the 1.4 billion pixels in the camera of the Pan-STARRS telescope in Hawaii, whose observations may reveal details about the expansion of the universe. For more images of the Pan-STARRS telescope, visit http://ps1sc.org/Photo_Gallery.shtml.

Credit: Rob Ratkowski, Copyright PS1SC.

The NIST scientists travelled to the summit of Haleakala volcano in Hawaii to fine-tune the operation of billions of light-collecting pixels in the Pan-STARRS telescope, which scans the heavens for Type IA supernovae. These dying stars always shine with the same luminosity as other Type IA supernovae, making them useful to observers as “standard candles” for judging distance in the universe. Any apparent shift in the supernova’s spectrum gives a measure of how the universe has expanded (or contracted) as the light travelled from the supernova to Earth.

Because Type IA’s are valuable as signposts, astrophysicists want to be sure that when they observe one of these faraway stellar cataclysms, they are getting a clear and accurate picture—particularly important given the current mystery over why the rate of expansion of the universe appears to be increasing. For that, they need a telescope that will return consistent information about supernovae regardless of which of the roughly 1,400,000,000 pixels of its collector spots it.

“That’s where we came in,” says NIST's John Woodward. “We specialize in measurement, and they needed to calibrate the telescope in a way that has never been done before.” Ordinary calibrations involve a telescope’s performance at many light wavelengths simultaneously, but Pan-STARRS needed to be calibrated at many individual wavelengths between 400 and 1,000 nanometers. For the job, Woodward and his colleagues used a special laser whose wavelength can be tuned to any value in that range, and spent three days testing the telescope’s huge 1.4 gigapixel camera–the largest in the world, Woodward says.

“Pan-STARRS will scan the same areas of the sky repeatedly over many months,” Woodward says. “It was designed to look for near-Earth objects like asteroids, and it also pulls double duty as a supernova hunter. But for both jobs, observers need to be sure they can usefully compare what they see from one image to the next."

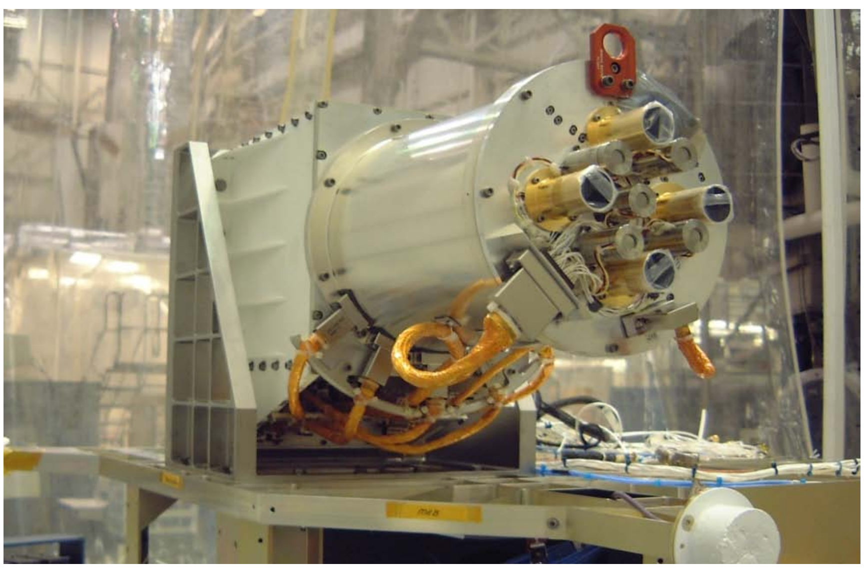
Woodward says that because this is one of the first-ever such calibrations of a telescope, it is unclear just how much effect the team's work will have, and part of their future work will be determining how much they have reduced the uncertainties in Pan-STARRS's performance. They will use this information to calibrate a much larger telescope–the Large Synoptic Survey Telescope, planned for construction in Chile.

* C.W. Stubbs, P. Doherty, C. Cramer, G. Narayan, Y.J. Brown, K.R. Lykke, J.T. Woodward and J.L. Tonry. Precise throughput determination of the Pan-STARRS telescope and the gigapixel imager using a calibrated silicon photodiode and a tunable laser: Initial results. *Astrophysical Journal Supplement*, Dec. 2010, Pages 376-388.

Contact: John Woodward (john.woodward@nist.gov)

Calibration of the NIST Advanced Radiometer

In preparation for possible launch in 2013, NIST recently completed calibration of the NIST Advanced Radiometer (NISTAR). This instrument is designed to measure the absolute, spectrally integrated irradiance that is reflected and emitted from the sunlit face of Earth, as viewed from an orbit around the Earth-Sun L-1 point. From this vantage point, NISTAR, along with its companion imaging spectrometer, the Enhanced Polychromatic Imaging Camera (EPIC), will have a continuous "big picture" view of the illuminated Earth. Earth-orbiting satellites, in contrast, alternate between "daytime" and "nighttime" views.



NIST Advanced Radiometer (NISTAR)

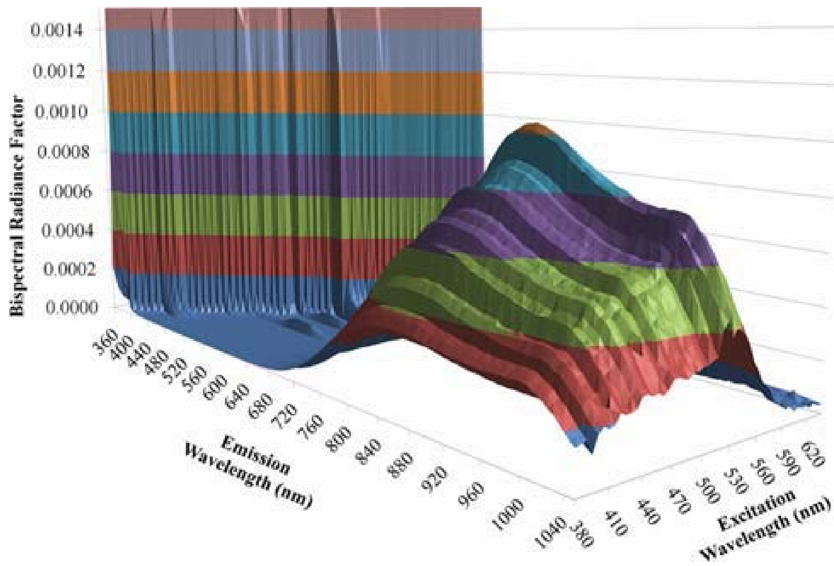
NISTAR was designed and built between 1999 and 2001 by Ball Aerospace and Technology Corporation and the NIST Optical Technology Division, in conjunction with the Scripps Institute of Oceanography and NASA, as part of the Deep Space Climate Observatory (DSCOVR) mission. The instrument consists of four detectors: three electrical-substitution active cavity radiometers and a photodiode, plus several band-defining optical filters that can be used with any of the detectors.

NISTAR was calibrated in a thermal vacuum chamber in a clean-room environment at NIST, using a portable version of the NIST Spectral Irradiance and Radiance Responsivity Calibrations using Uniform Sources (SIRCUS) facility. This calibration included system-level measurements of the relative spectral response of the NISTAR bands, using a wavelength-tunable laser and absolute responsivity measurements of each of the four NISTAR detectors at a wavelength of 532 nm. The

standard uncertainty of the absolute responsivity calibration obtained using this technique was below 0.2 % ($k = 1$), limited by the signal-to-noise ratio of the NISTAR absolute detectors.
Contact: Joseph Rice (joseph.rice@nist.gov)

Reflectance Factor Measurement Systematic Errors Due to Near Infrared Fluorescence

Researchers at the National Institute of Standards and Technology (NIST) have found that the orange and red ceramic tiles widely used as the industry color standards unexpectedly exhibit fluorescence in the near infrared spectral region when illuminated by light with wavelengths less than 630 nm. In general, two types of measurement systems are employed to determine the reflectance factor of a test sample. The first involves illuminating the test sample with broadband light and spectrally resolving the light coming from the sample. The second illuminates the test sample with monochromatic light and uses a broadband detector to measure the light coming from the sample.



The bispectral radiance factor, $b_\lambda(\mu)$, matrix for the orange tile on an expanded scale.

Theoretically, the two measurement systems should determine the identical quantity for reflectance factor when instrumental factors such as illumination bandwidth or detector bandwidth are removed from the measurement results. The presence of this near infrared fluorescence causes an error on the order of 50 % for reflectance factor measurements for wavelengths less than 500 nm when using a silicon broadband detector. More information can be found in the recent publication: Nadal, M.E., Miller, C.C., and Zarobila, C., "Reflectance Factor Measurement Systematic Errors Due to Near Infrared Fluorescence," *Color Research & Application*, 36, April 2011, 96–100.

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

NVLAP Supports EPA Energy Star Program

The National Voluntary Laboratory Accreditation Program (NVLAP) has received recognition from the U.S. Environmental Protection Agency's (EPA's) Energy Star Program as an accrediting body.

The Energy Star program is used by millions of Americans to identify products that reduce energy costs and protect the environment, and has grown to encompass more than 60 product categories. To ensure that Energy Star remains a trusted symbol for environmental protection and superior energy efficiency, all Energy Star product partners will be required to follow a new set of Third-Party Certification procedures starting December 31, 2010.

Testing at an EPA-recognized laboratory will be required once the EPA transition to the new conformity assessment requirements is fully implemented. The enhanced program will require not only laboratory accreditation, but also accredited certification of the Energy Star products. Details of the program can be found at http://www.energystar.gov/index.cfm?c=partners.enhanced_test_verification.

NVLAP anticipates that a majority of its accredited energy efficient lighting, some of its electromagnetic compatibility and telecommunications, and some of its thermal insulation product testing laboratories will be able to become recognized under the new EPA requirements. The NVLAP recognition will be a necessary step for test data to be accepted under the enhanced Energy Star program.

Contact: Sally Bruce (sally.bruce@nist.gov)

NIST Quality System for Measurement Services Gains Recognition within SIM

The Sistema Interamericano de Metrología (SIM, in English, the Interamerican Metrology System) Quality System Task Force (QSTF) met November 3–4, 2010, in Miami, Florida. Members of the task force reviewed and approved the quality systems of the four NIST Divisions: Ionizing Radiation, Time and Frequency, Thermophysical Properties, and Building Environment Division. QSTF review was a necessary step for final approval of NIST's competence in the measurement areas under the CIPM MRA.

SIM is the regional metrology organization for the Americas of the Committee of International Weights and Measures (CIPM). The SIM QSTF, which is comprised of representatives from the SIM countries that also are signatories to the CIPM Mutual Recognition Arrangement (MRA), has the responsibility for reviewing and determining that quality systems from National Metrology Institutes (NMIs) such as NIST comply with the terms of the CIPM MRA. The process of implementing the CIPM MRA calls for demonstrations of competence by NMIs through international comparisons of measurement capabilities accompanied by the use of acceptable quality systems and practices.

The NIST Quality System for Measurement Services covers the provision of both calibrations and standard reference materials. It is based on the ISO/IEC 17025 standard, General Requirements for the Competence of Testing and Calibration Laboratories, and meets the relevant requirements of ISO Guide 34, General Requirements for the Competence of Reference Material Producers.

NIST's Quality System has been developed by and for the technical divisions within NIST that provide measurement services. For additional information, please visit http://www.nist.gov/nistqs.

Contact: Sally Bruce (sally.bruce@nist.gov)

System-Level Calibration of VIIRS

In collaboration with NOAA, PML scientists have achieved the first-of-the-kind system-level calibration of a satellite sensor. The sensor, known as the Visible Infrared Imager Radiometer Suite (VIIRS), is scheduled to be flown on the next generation of weather and climate satellites, the Joint Polar Satellite System (formerly known as the National Polar-orbiting Operational Environmental Satellite System).

VIIRS operates from the infrared to the visible and is the primary sensor responsible for producing environmental data products. Of particular interest is ocean color, which provides an assessment of ocean health and ocean organic carbon storage. The measurement requirements for ocean color are stringent, and testing of the sensor at the component level in 2008 raised concerns about the ability of VIIRS to meet the accuracy requirements required for continuing the 20-year remote sensing ocean-color climate data record.

As a result, NOAA scientists requested system-level testing of VIIRS using Optical Technology Division's portable calibration system, "Travelling SIRCUS." It is a portable version of the Division's facility for the Spectral Irradiance and Radiance Responsivity Calibrations using Uniform Sources (SIRCUS). The system generates tunable monochromatic radiation of known spectral radiance, and it was used to determine the spectral responsivity of the VIIRS system in the visible and near-infrared bands.

Testing confirmed that VIIRS had small leaks of radiometric flux between its sensor bands, a phenomenon known as crosstalk. However, the amount of crosstalk was low enough that VIIRS scientists will be able to extract the necessary spectral information from the data set.

In a separate test, Traveling SIRCUS was employed to study the internal, on-orbit calibration system used by VIIRS. While the data analysis is still in progress, the comparison between measured and predicted signals will provide critical information about its performance.
This testing demonstrates a fruitful collaboration between different government agencies, satellite sensor companies, and data product analysts. Additionally, it demonstrates the potential for tunable laser systems, like NIST's Travelling SIRCUS, to improve the calibration and characterization of satellite sensors, and with reduced testing time and cost.

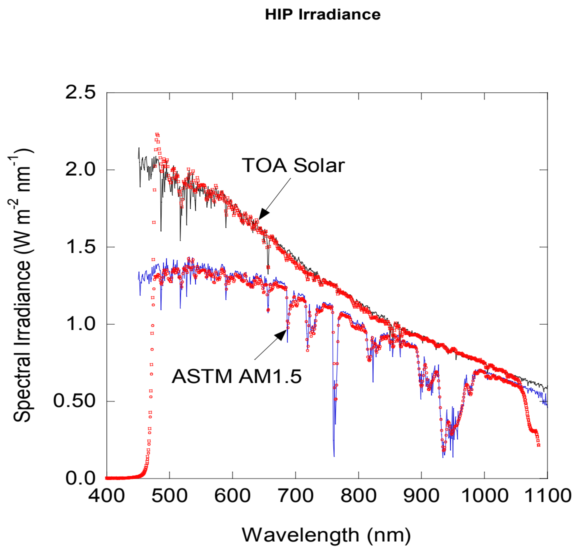
Contact: Keith Lykke (keith.lykke@nist.gov) and Steven Brown (steven.brown@nist.gov)

Hyperspectral Image Projector Simulates Solar Spectra Shape to Unprecedented Fidelity

A spectrally programmable source, that is part of the Hyperspectral Image Projector (HIP) being developed by NIST and Resonon for the past few years, has been successfully shown to be able to simulate the spectra of several natural scenes typical of those that occur in Earth observation research for climate monitoring. It has reached the milestone of having 2 nm to 5 nm spectral resolution across the spectral range 450 nm to 1700 nm while maintaining the radiance of bright sunny day outside (in technical jargon, the "radiance of a bright sunny day outside" is equivalent to the solar reflected spectral radiance from a white lambertian target at the top of the Earth's atmosphere or anywhere below, ignoring specular reflections) over a 0.5 cm^2 area.

Recently NIST researchers looked into the idea of using the HIP, originally developed as an Earth radiance similar, as a solar irradiance simulator. The attached plot shows how well the newly-developed spectrally programmable source of the NIST HIP can match solar irradiance. The black data points represent the top-of-the atmosphere (TOA) solar irradiance spectrum. The blue data represent the terrestrial ASTM standard spectrum for an atmospheric mass (AM) of 1.5. The red data points plot, for each of the two respective spectra, the measured irradiance at the output of a HIP spectrally programmable source in a NIST laboratory, over an 8 mm diameter at the output of a liquid light guide, but integrated over an angular divergence in an approximately 90 degree cone angle(rather than the 0.5 degree cone angle of the direct sun). As one can see, the HIP is capable of matching the shape of solar spectra to unprecedented fidelity at the solar irradiance level, albeit with the spatial mismatch mentioned above, and only over the spectral range shown (extension of this work from 1000 nm to beyond 1700 nm using existing hardware is in progress, and will be reported at a future date). This may be useful as a solar simulator that can test small cells with low spectral mismatch, as well as enabling the ability to test small solar cells under a much wider of atmospheric conditions than using conventional solar simulator technology.

Contact: Joseph Rice (joseph.rice@nist.gov)



NIST Hyperspectral Image Projector (HIP) match to solar irradiance. Black points – TOA solar irradiance spectrum; Blue points – Terrestrial ASTM standard spectrum for an atmospheric mass of 1.5; Red points – Irradiance at the output of the NIST HIP.

NIST 'Vision Science Facility' Aims for Lighting Revolution

Light-emitting diodes, or LEDs, have become popular with backpackers and cyclists who mount them on headbands for a reliable, hands-free source of illumination. Now, a new lab at the National Institute of Standards and Technology (NIST) is helping to bring these tiny but brilliant devices into your home, to help save both energy costs and the environment. It's a vision of illumination's future. And to realize it, Davis, along with Yoshi Ohno and a team of physicists, created the NIST Spectrally Tunable Lighting Facility (STLF). Their main goal is to improve the quality of the light that LEDs produce, so that when you turn them on, home feels homey.

"Everyone wants light that appears natural and is pleasing to the eye, but with LEDs we're not consistently there yet," Davis says. "LEDs offer a lot of advantages over incandescent and fluorescent lighting, but they don't always emit light that looks 'right.'"

About 12 percent of electricity consumed in the United States powers lights. Using LEDs wherever practical would halve that, but a few problems must be overcome. When a newfangled device goes up against a product as historically omnipresent as the light bulb, the newcomer has to prove it can work better than the incumbent, and that's where Davis and her colleagues are focusing their effort. The new STLF distinguishes itself from most optical technology labs in that it concentrates on the relationship between physical measurements of light and human perception of light and color. Here, scientists experiment with combining LEDs of different hues to produce an overall light color that pleases the eye.

The lab space makes sense even to a nonscientist. One section is decorated with couches, tables, and food-filled plates, just like a living room—but above, hundreds of LEDs cover the ceiling like stars in the sky. Davis can activate varied groups of them like color-coordinated constellations. Adjusting the level of different colors demonstrates the effect lighting has on the appearance of the food and furniture below.

Learning from efforts like this is helping the team develop a way to quantify how LEDs affect the colors of objects in ways meaningful to the lighting industry. They are currently developing a measurement tool called the Color Quality Scale to help manufacturers develop LEDs for general lighting.A video of the operating facility is available at the following internet address: http://www.nist.gov/pml/div685/lighting_092810.cfm

Contact: Wendy Davis (wendy.davis@nist.gov)

2011 Photometry Short Course – September 27-30, 2011

The 9th NIST Photometry Short Course is planned for three and half days at the NIST Gaithersburg, Maryland campus The course will consist of ten lectures (first two days) given by NIST scientists and Dr. Sauter from PTB, Germany, 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.

Course participants are divided into three groups and will participate in actual measurements of luminous flux, luminous intensity and illuminance, and color temperature to gain experiences in the calibration of lamps, photometers, and colorimeters.

This course is intended for photometry engineers and technicians in industries such as lighting, photography, and avionics; calibration and testing laboratories; instrument manufacturers; and others. Participants should have some basic knowledge and experience in photometric or radiometric measurements as well as calculus. The course is suited for those who want to learn photometry systematically in depth, in theory, and in experimental practice. The course is limited to 18 participants, with 10 additional spots available for lecture-only participants. http://www.nist.gov/pml/div685/sc/photometry_course.cfm

Contact: Cameron Miller (c.miller@nist.gov)

Optical Technology Division Staff Members Honored

Steve Brown, George Eppeldauer, and **Keith Lykke** received the Department of Commerce Gold Medal Award for developing and deploying SIRCUS, the most advanced laser-based facility in the world for the calibration of optical sensors used for satellite and many other critical applications.

Thom Germer received the Department of Commerce Silver Medal Award for developing innovative light-scattering measurement instruments, standards, and mathematical models to enhance the capability of the micro and nanoelectronics industry to inspect wafers for particle contamination and defects.

Angela Hight Walker received the NIST Bronze Medal Award for advancing the understanding of the synthesis, functionalization, magnetic and thermal properties, and stability of magnetic and gold nanoparticles. David Plusquellic also received NIST Bronze Medal Award for advancing the experimental and theoretical applications of terahertz spectroscopy.

Steve Brown was honored with Arthur S. Flemming Award for advances in light measurements and application to the remote sensing of the Earth and space, including development of SIRCUS. See http://flemming.gwu.edu for more information about this prestigious award.

Yoshi Ohno was appointed as a NIST Fellow and joins the highly select group of 40 scientists and engineers at NIST. This honor recognizes his outstanding contributions in photometry and solid-state lighting and his exceptional technical leadership in the development of international standards.

National Research Council of Canada

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

Liaison Report from the Photometry and Radiometry Group

Progress in NRC High Temperature Fixed Points

With the aim of measuring the absolute melting temperatures of the high temperature eutectic fixed points Co-C, Pt-C and Re-C (whose melting temperatures are nominally 1597 K, 2011 K and 2747 K, respectively) the NRC linear pyrometer (LP3) has been calibrated near the fixed point melting temperatures using a filter radiometer (FR1) that has been calibrated against the cryogenic radiometer. The LP3 can then be used to measure the small aperture (3 mm dia.) eutectic fixed point melting temperatures. Measurements have now been performed on Co-C and Re-C and we are currently measuring a Pt-C fixed point.

We have also begun measurements of the melting temperature of two TiC-C eutectic fixed points: one large aperture (10 mm dia.) cell suitable for measuring with a FR and one small aperture cell (4 mm dia.) that must be measured by the LP3. The TiC-C eutectic fixed points have a nominally melting temperature of 3033 K and were supplied with the BB3500M furnace purchased from the All-Russian Research Institute for Optical and Physical Measurements (VNIIOFI). Preliminary measurements of the small aperture fixed point has allowed us to determine the best location for the fixed point within the furnace

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 of ORN, a series of measurements of the transverse wavefunctions of single photons has now been completed and the results will soon be submitted for publication. The result of a typical measurement is indicated in Figure 1, where real and imaginary measurements of the transverse wavefunction of a photon are indicated. In this measurement the phasefront of the photon was flat with a slight amount of tilt. This measurement was made with a stream of photons from a classical laser source. Similar measurements have been made with a single photon source. The single photons were produced by spontaneous parametric downconversion and were heralded by the twin of the measured photon. A follow-on experiment is planned where a measurement of the wavefunction of a photon ensemble from a classical source will be made using a CCD camera instead of a single element detector. In this configuration a complete mapping of the wavefunction should be possible with the camera only requiring four frames of data.

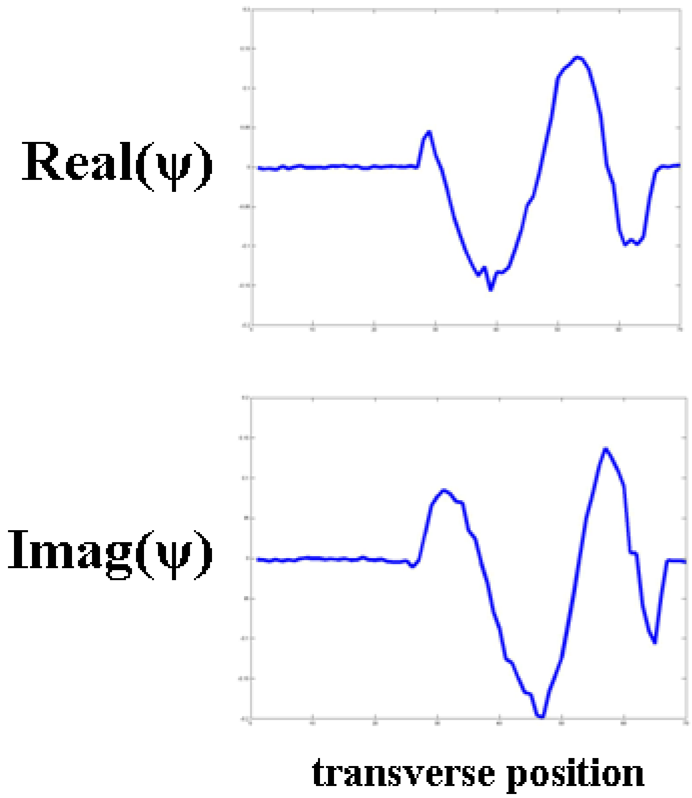


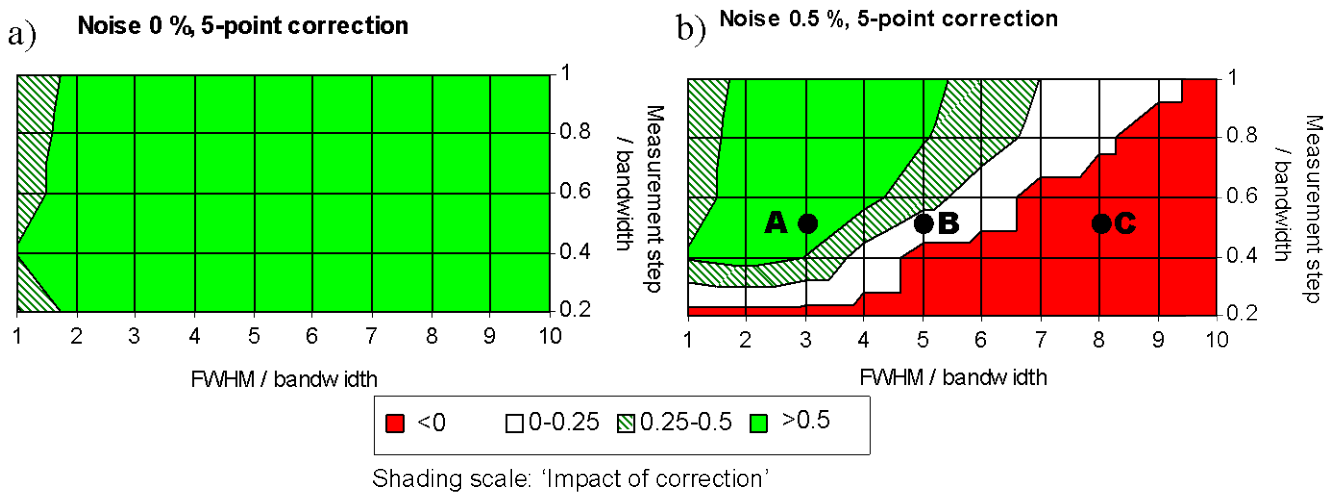
Figure 1 Real and imaginary measurements of the transverse wavefunction of a single photon.

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

Spectroradiometer bandpass correction

A practical method has been developed for correcting spectroradiometer data for generalized bandpass functions. This method allows for correction of a set of equi-spaced measured values provided by a spectrometer with a finite bandwidth, an arbitrary bandpass function, and at an arbitrary wavelength step. A correction formula is derived using a formal mathematical inversion approach. A metric is proposed for measuring the impact of the correction and is applied for real spectra in the presence of measurement noise.

The figure below shows the impact of correction for 'LED model' spectra of different widths (horizontal axis represents the full width half maximum of the LED spectrum) and for different wavelength steps (vertical axis represents wavelength step as a fraction of bandwidth). The figure on the left (a) is for no noise, the figure on the right (b) is for 0.5 % noise. The shading and hatching represent different 'impacts of correction'. An impact of 1 means perfect spectral recovery, an impact of 0 means no improvement, and a negative impact means that the correction actually degrades the spectrum.



This work was carried out in collaboration with Emma R. Woolliams, Agnieszka Bialek and Maurice G. Cox, of National Physical Laboratory, U.K. and in connection with CIE TC2-60 (Effect of instrument bandpass and measurement interval in spectral quantities).

For further information, contact Réjean Baribeau, 613-993-9351

CIE Whiteness Assessment of Papers: Impact of LED illumination

The attribute of whiteness is a commercially important specification of paper products, such as fine white papers, coated board and recycled newsprint. Papermakers typically enhance the whiteness of these products by the use of fluorescent whitening agents (FWAs) which are excited in the near-UV and emit in the visible blue, to give a preferred bluish-white appearance. The objective whiteness assessment of these paper products is carried out using ISO standardized procedures based upon CIE colorimetry, notably the CIE Whiteness equation.

With the use of new and improved FWAs, papermakers have recently produced commercial white papers that are above the CIE whiteness limits. This fact, and other limitations of the CIE Whiteness and Tint equations has motivated the creation of a new CIE technical committee within Division 1 (TC 1-77) to recommend improvements to these equations . One of the most serious limitations of these equations is that they have only been developed and tested for CIE standard illuminant D65 conditions. However, in practice, whiteness assessment methods have been developed by various Standardizing Organizations (ISO, AATCC, ASTM) that assume the use of these CIE Whiteness equations for other illumination conditions , for example C and D50, and are considering their use for the new indoor daylights recently defined by the CIE (CIE 184:2009). In the development of these Standards using other illuminants, it was rationalized that they have a correlated color temperature close to that of D65, so their whiteness assessments should also be well correlated.

Recent energy savings initiatives, as well as significant technological progress in the production of white LED s, have promoted their use as possible replacements for several general lighting applications. It appears that in the near future, these LEDs will replace the incandescent light bulb for home and office use. The question then, is what impact this LED illumination will have on various color and appearance assessment applications that are based on traditional indoor illumination conditions.

NRC Radiometry and Photometry Group has recently addressed this issue of whiteness assessment of fluorescently-whitened papers under this LED illumination. For this evaluation, we considered several white LED sources on the market that are being used for various general illumination conditions to replace incandescent, fluorescent and display lighting. These LED sources have correlated color temperatures that agree well with their respective replacement lamps. The question is whether this condition is sufficient to also provide good agreement with whiteness assessment under these different sources.

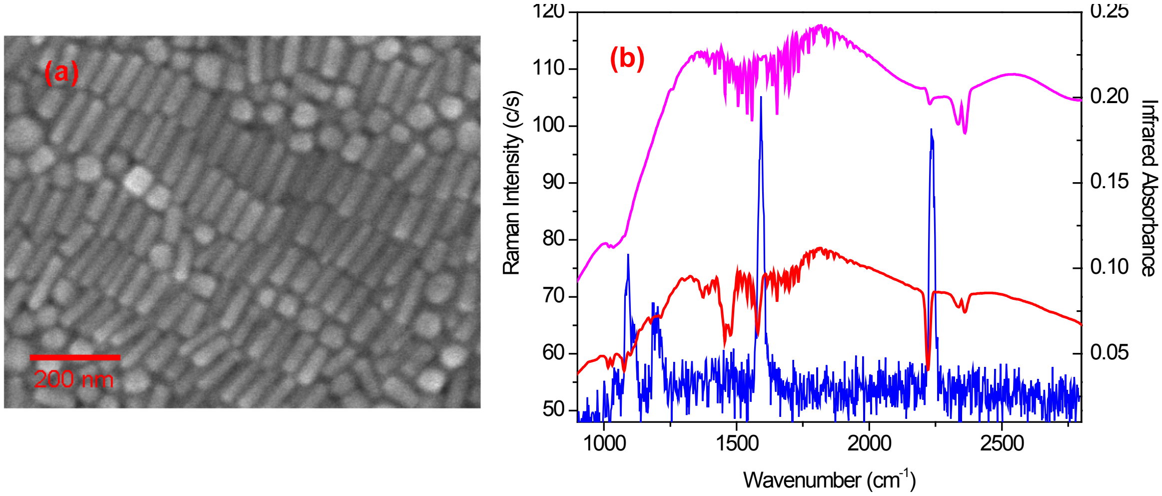
The illumination of a fine white fluorescent paper by these various LED sources and the resultant whiteness appearance has been simulated by considering the spectral power distribution (SPD) of the sources interacting with the spectral characteristics of a representative fluorescent paper sample, measured on the NRC Reference Spectrofluorimeter. Both linear and constant extrapolation procedures as recommended by CIE have been used to estimate the impact of missing source data below 380 nm. This measured and assumed data is used to calculate the corresponding total spectral radiance factor data and CIE whiteness values for this paper sample. Comparison of these results with their assessment using CIE standard illuminant conditions shows significant differences. It has been generally believed that the major impact of LED illumination on whiteness assessment of papers would be due to their relative deficiency in UV output. However, it is shown that the major impact comes from the spectral quality of these LED sources over a wide spectral range in the UV and visible which is quite different from the assumed CIE illuminant conditions. This causes a significant change in the assessed hue of the fluorescent paper with a peak wavelength shift to either longer or shorter wavelengths, depending on the details of the LED illumination. This simulation analysis of whiteness assessment of papers using white LEDs for general illumination purposes has a significant impact on both the papermaker and the LED lighting industry.

For further information, contact Joanne Zwinkels, 613-993-9363 or Mario Noël, 613-991-1637

Surface-Enhanced Infrared Absorption and Raman Scattering From Absorbate Saturated Au Nanorods

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. Surface enhanced Raman scattering (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 is within the mid-infrared region. In collaboration with the NRC Institute for Microstructural Sciences and the Department of Chemistry and Biochemistry, National Chung Cheng University (Chia-Yi, Taiwant), we have demonstrated the use of gold nanorods (Au NRs) as a suitable substrate capable of sustaining strong SEIRA spectroscopy. Adsorbate saturated Au NRs typically exhibit Fano resonances in their SEIRA spectra obtained using FTIR reflectivity. Representative results for Au NRs having an aspect ratio of about 2.5 are shown below in the Figure below. A 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.



(a) SEM image of Au NRs with an aspect ratio of ~2.5. The Au NRs were conjugated to *p*-MBN and cast dried on a Si wafer. (b) Overlay of SERS (blue trace) and SEIRAS spectra of *p*-MBN. The red trace was measured in IR transmission and the magenta trace in IR reflection.

For further information, contact Nelson Rowell, 613-993-2377

CENAM
CENTRO NACIONAL DE METROLOGÍA

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

NIST-CENAM MOU signed at the *Simposio de Metrología 2010*

The *Simposio de Metrología 2010*, SM2010, was attended by 415 participants from 15 countries. This included 8 plenary talks, 91 contributions presented in oral and posters sessions, one round table on how metrology helps to increase the productivity and promotes economical development, 19 pre-congress workshops and 14 sponsor's presentations. As for the previous editions, the SM2010 proceedings are now available for reference in electronic format at: http://www.cenam.mx/simposio2010/.

Also during the SM2010, a technological and scientific cooperation agreement was signed by representatives of NIST, CENAM, the National Council for Science and Technology of Mexico, CONACyT, and the Secretary of Economy of Mexico, SE. The photo below is of the signing ceremony, involving M. Sc. Juan C. Romero, CONACyT Director; Dr. Patrick Gallagher, NIST Director; Dr. Héctor Nava, CENAM Director; and Christian Turégano, SE representative.

From left to right: M. Sc. Juan C. Romero, CONACyT Director; Dr. Patrick Gallagher, NIST Director; Dr. Héctor Nava, CENAM Director; and Christian Turégano, SE representative.

Peer-review to photometric CMCs declared by Mexico

Prof. Erkki Ikonen, from the Metrology Research Institute of Finland, visited the *Laboratorio de Fotometría* of CENAM in order to complete a peer review to the Mexico's CMCs declared in this area and published by the BIPM.

Thus Prof. Ikonen assessed the quality management system documents related to the measurement and calibration services in five photometric quantities: total luminous flux, luminous intensity, luminance, illuminance and photometric responsivity; as well as the corresponding national standards and measurement systems; concluding that all CENAM's CMCs declared by Mexico are well supported and developed by qualified personnel.

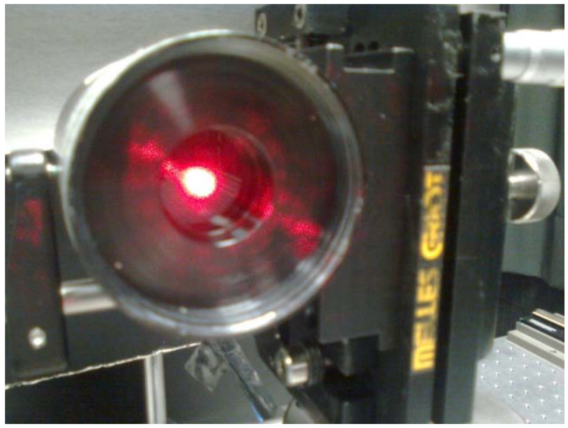
Chromatic dispersion standard under development

The *Laboratorio de Fibras Ópticas* of CENAM (Optical Fibers Laboratory) has began with the development of a chromatic dispersion standard to operate in the range from 1500 nm to 1610 nm, and which will be used in the calibration of optical fiber chromatic dispersion tests sets.

The standard will be based in the differential phase shift method, and the stage under progress consists of equipment testing and automation. A second stage of the development will include the establishment of a fiber spool characterization array.

Instrument contributions to uncertainty for luxmeter calibrations

As a common practice in the *Grupo de Fuentes Ópticas* (Optical Sources Group), directed towards the continuous improvement of the measurement and calibration capabilities; a more detailed analysis of the contributions to uncertainty estimation for luxmeters calibration has been conducted. This analysis will provide better and more detailed information about the several uncertainty components arising from the instrument under calibration; such as that due to the exact location of the detection plane, its V-lambda function matching degree, the sideways misalignment of the detection head, and its responsivity linearity, among others. The photo below shows laser illuminated optical axis alignment fixture for establishing the detection plane of a meter under test.



Optical axis setup alignment fixture , carried out in the accurate determination of luxmeters detection plane.

New Mexican regulation for energy consumption efficiency in lamps

Last December, the Mexican Federal Government published a new mandatory regulation for energy consumption efficiency in lamps.

The standard NOM-028-ENER-2010 is now valid and will gradually force the manufacturers and distributors to commercialize more efficient lamps in Mexico; and its application will be technically supported by the total luminous flux Mexican national standard maintained at CENAM.

Incandescent lamps will no longer be allowed for use in Mexico.

Better performance specifications for smoke meters to be used in Mexico

The *Laboratorio de Caracterización Óptica de Materiales* (Optical Properties Laboratory) concluded with the proficiency testing (PT) for the smoke meters calibration, in which the six participating laboratories had the opportunity to identify the required improvements they need to implement in order to reach an optimum compliance with the Mexican regulations established for environmental protection promotion.

This PT was coordinated by the Mexican accreditation body and technically conducted by CENAM and provided an extraordinary possibility to refine the technical specifications the smoke meters must fulfill when used in Mexico.

CIE NEWS

COMMISSION INTERNATIONALE DE L'ECLAIRAGE

Dr. Peter Blattner New CIE Division 2 Director

Dr. Peter Blattner (METAS, Switzerland) has been officially approved as the next Division 2 Director for the 2011 to 2015 term by CIE Board of Administration. Peter was also best supported by the preference voting done earlier within D2. He is really the best person to take over the leadership of Division 2. He will be appointed as D2D in South Africa. Please join me to congratulate Peter for his coming new position.

After the changeover,previos Division 2 Director Dr. Yoshi Ohno, of NIST, will keep active in D2, and hope to support especially on the SSL related TC activities and liaison with other organizations as next CIE VP-Technical.

LED Related Technical Committees and Strategy Proposed at CIE Bern Meeting

Discussions in Bern on the LED related Technical Committees (TC) were carried out on strategies for SSL standards. Two new TC proposals werer pending because of questions on these issues.

There were substantial discussions among some D2 officers and with CIE BA members and CB late last fall. The result has been proposed new strategies on SSL standards. This is basically a proposal for a new TC and will need to be formalized with Division/BA ballot soon, Outgoing Director of D2, Dr. Yoshi Ohno, solicited comments or suggestions on the proposals.

The proposal is to start a new TC to develop a series of CIE standards (not technical reports) on test methods for SSL products and components (LED lamps, LED luminaires, light engines, LED modules, LED packages). The TC will produce a first standard quickly on the essence of test methods for LED lamps, LED luminaires, and LED modules in one document, to address the imminent needs from the IEC standards for these products, as their recent drafts started including test methods (including photometric and colorimetric measurements), which is really the work to be done by CIE. IEC started doing this because CIE does not have standards or even technical reports on such test methods. There is liaison with IEC TC34 but this is beyond the liaison issue. The new CIE standards work should be done with good cooperation with IEC (and other organizations) D2 is in communication with IEC TC34 and also at higher level of IEC by CIE Central Bureau (CB). Standards (not technical reports) are needed for test methods because laboratory accreditation requires standards to support regulatory programs. The needs for lab accreditation for SSL will grow rapidly and CIE should provide standards for those before many different regional standards are created. CIE work will save time for duplicated efforts and also avoid problems of inconsistent regional standards that can become trade barrier.

Dr. Ohno proposed radical changes for the new work proposed above. Special steps are needed to develop the first standard in a required short time frame. We have many members in D2 who are active in other standards committees, which work fast. Examples include the work to develop IES LM-79 and ANSI C78.377, both of which were completed (published) in two year efforts.

Regarding the pending two proposals on the new TCs, Jiangen Pan updated his proposal with initial members confirmed. It is clear that this TC is for a technical report. Tongsheng Mou clarified that TC2-58 (Kohmoto) deals with LED components (packages) while Mou's TC will cover lamp and lamp systems including traditional lamps and LED lamps (and LED light engines and LED modules), but not LED components, so these TCs will not overlap.

The new TC proposals for Division C/M ballot are below.

New TC proposal 1
Title: CIE Standards on test methods for LED lighting products and components
Technical Rationale: To prepare a series of CIE standards on test methods for photometric and colorimetric performance of LED lighting products and components including LED luminaires, LED lamps, LED light engines, LED modules, and LED packages.
Chair: Y. Ohno (at least for the start of the TC.)
Initial members: TBD (there will be at least from five countries.)

New TC proposal 2 (from R2-42, pending from Bern)
Title: Test Methods for LED Luminaires
Technical Rationale: To prepare a technical report on test methods for LED lumiaires in a form of fixtures incorporating light sources, which describes the conditions, procedures and precaution for the reproducible measurements of total luminous flux, electrical power, luminous intensity distribution, luminance and chromaticity.
Chair: Jiangen Pan(CN)
Initial members: Hans Peter Grieneisen(BR), Japanese member(TBD), Pei-ting Chou(TW), Teresa Goodman(GB), Tony Bergen(AU), Yandong Lin(CN), Yandan Lin(CN) ... confirmed.
(Remark: Prof. Dr. Yandan Lin is China CM for CIE D4 and expert from Fudan University)

New TC proposal 3 (from R2-46, pending from Bern)
Title: Photobiological Safety Measurements of Lighting Products
Technical Rationale: To prepare a technical report for the measurement of optical radiation related to photobiological safety of lighting products, more focusing LED products.
Chair: Tongsheng Mou (China)
Initial members: Rolf Bergman(USA), Kohtaro Kohmoto (Japan),David sliney(USA), Werner Horak*(Germany), Yuqin Zong(USA), Yandong Lin(China), Richard Distl(Germany), Chou Pei-Ting(Taiwan), Yu Hsueh-Ling(Taiwan).... confirmed.

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.

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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.

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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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