International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

中国照明学会
China Illuminating Engineering Society

CIE Online Tutorial

Understanding and application of CIE S 026:2018 "CIE System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light"

Pre-recorded presentations: accessible online from June 13, 2021

Online live Q&A sessions:
July 6, 2021, 09:00 – 11:00 CEST and July 13, 2021, 16:00 – 18:00 CEST

https://cie.co.at/news/cie-s-0262018-tutorial

This CIE Tutorial has been developed to support the understanding, adoption and proper application of CIE S 026/E:2018 CIE System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light.

After completion of the tutorial, participants will be able to:

- explain and apply the standardized light metrology of CIE S 026, which is based on five (α-opic) retinal photoreceptor types that influence human health and well-being via non-visual photoreception and circadian rhythms; and
- characterize, compare and rudimentarily design lighting environments and spectra that use non-visual photoreception to reinforce human health, sleep, well-being and performance in specific user groups.

Presenters and presentation titles:

Name	Presentation title
Luc Schlangen, NL	Rod-, cone- and melanopsin-based metrology (CIE S 026) to quantify light for its non-visual responses
Christian Cajochen, CH	Circadian and sleep effects of short wavelength light
Luke Price, GB	CIE S 026 Toolbox introduction, and demonstration of its application using familiar examples
Tim Brown, GB	Recommendations for Healthy Daytime, Evening, and Night-Time Indoor Light Exposure
Vineetha Kalavally, MY	Wearable spectral light sensors
Shigekazu Higuchi, JP	The influence of correlated colour temperature on non-visual effects of light at night
Raymond Najjar, SG	Light therapy for myopia-control?

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What to expect from the tutorial:

Besides enabling vision, light has important neurophysiological, neurobehavioral and circadian responses that are mediated by ocular photoreception. For instance, light is the main synchronizer of the central human biological clock: it can shift the phase of its circadian rhythm and thereby regulate the timing of our sleep. Light in the evening and at night can disrupt sleep and cause acute suppression of the sleep-consolidating hormone melatonin. There are also reports that light can increase heart rate, improve alertness, alleviate seasonal and non-seasonal depression, influence thermoregulation, and affect the electroencephalogram (EEG) spectrum. Exposure to light elicits fast responses (i.e. in the range of milliseconds and seconds) in the pupillary reflex and brain activity.

To reflect their functional distinction from perceptual vision, the effects listed above are often collectively referred to as non-visual or non-image-forming responses to light. The official term for lighting solutions that integrate both the visual and non-visual effects of light to produce beneficial physiological and psychological effects on humans is *integrative lighting*. However, terms with a similar meaning such as “human-centric lighting” (HCL), “circadian lighting”, and “biodynamic lighting”, are also being used.

Non-visual responses to light are largely driven by intrinsically-photosensitive retinal ganglion cells (ipRGCs). These cells have their own intrinsic sensitivity to light (which is based on melanopsin, a photopigment with a peak sensitivity at approximately 480 nm) and combine this intrinsic melanopic input with rod and cone inputs.

Traditionally, lighting designs, standards, regulations and practice have been based on considerations that relate to human vision and energy efficiency. However, awareness amongst lighting professionals is increasing that there is also a need to consider melanopsin-based, non-visual photoreception in lighting specifications, codes, recommendations and research.

The focus of the tutorial is the explanation and application of the α-opic metrology of CIE S 026:2018 in lighting applications, specifications, metrology and research. Invited experts will present lectures that explain the newly defined CIE metrics and quantities and their Toolbox. Moreover, various familiar examples like indoor lighting for the workplace and domestic settings, self-luminous displays and natural daylight will be discussed. The role and performance of wearable spectral light loggers will also be covered.

The tutorial team and their presentations:

	Presenter	Presentation title and contents
	**Dr Luc Schlangen** *Eindhoven University of Technology, The Netherlands* Luc is senior researcher at Eindhoven University of Technology, in the Intelligent Lighting Institute, department of Human Technology Interaction. His main interests are visual and non-visual responses to light and lighting in lab and field settings (workplaces, homes, education and healthcare). Luc is Director of CIE Division 6 “Photobiology and Photochemistry” and chaired the committee that prepared CIE S 026:2018 with new metrics to quantify light for its non-visual (and ipRGC-influenced) responses.	**Rod-, cone- and melanopsin-based metrology (CIE S 026) to quantify light for its non-visual responses** Photometric quantities with units like lux and lumen are insufficient to quantify light for its non-visual effects like regulating sleep, circadian rhythms, alertness, mood and hormone secretion. In 2018 the International Commission on Illumination (CIE) defined a new metrology to describe light for its ability to stimulate each of the five α-opic photoreceptor classes (rods, S/M/L-cones, ipRGCs) that can contribute to eye-mediated non-visual effects of light. In this presentation the fundamentals of the new metrology will be explained, and an open-access CIE toolbox that calculates the α-opic quantities as defined in CIE S 026:2018 will be briefly demonstrated.
	**Prof Christian Cajochen** *University of Basel, Switzerland* Christian is heading the Centre for Chronobiology at the University of Basel, Switzerland. He received his PhD in natural sciences from the ETH in Zürich, Switzerland, followed by a 3-y postdoctoral stay at the Harvard Medical School in Boston, USA. His major research interests include investigative work on the influence of light on human cognition, circadian rhythms and sleep, circadian-related disturbances in psychiatric disorders, and age-related changes in the circadian regulation of sleep and neurobehavioral performance. He has held a number of honours and has authored more than 200 original papers and reviews in his career.	**Circadian and sleep effects of short wavelength light** Starting from the fundamental findings, our current state of knowledge on how short-wavelength, or "blue" light, specifically can impact circadian rhythms and sleep will be discussed. The presentation will focus on empirical evidence and place it into the context of interventions in the home and office environment. Topics covered: • Fundamentals in the non-visual effects of light, such as melatonin suppression and circadian phase shifting as well as its impact on human alertness and cognition • Experimental methods and protocols to address non-visual effects of light • Optimizing the lighting environment to minimize circadian disruption

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	Presenter	Presentation title and contents
	**Dr Luke Price** *Public Health England, United Kingdom* Luke is a public health professional working in the field of light and its benefits and risks for health. He is Secretary of CIE Division 6 on Photobiology and Photochemistry and an Associate Editor of Lighting Research & Technology. Luke served as the secretary of the committee that prepared CIE S 026:2018 with a new equivalent-illuminance metrology to quantify light for its non-visual, ipRGC-influenced, responses. He is also the author of the CIE S 026 Toolbox, having introduced the concept of equivalent illuminances to express non-visual stimuli whilst acting as CIE Rapporteur to the first of the expert Manchester workshops, in 2013.	**CIE S 026 Toolbox introduction and demonstration of its application using familiar examples** The new α-opic metrology of CIE S 026 enables traceable measurements and a formal, quantitative specification of personal light exposures, photic interventions and lighting designs. This presentation will demonstrate the open access CIE S 026 Toolbox for the α-opic metrology and apply the Toolbox to some familiar examples, including a range of LED lighting products, a smartphone display screen and a natural daylight time series.
	**Prof Timothy Brown** *University of Manchester, United Kingdom* Tim is professor of Neuroscience based within the University of Manchester Centre for Biological Timing. His research interests centre on defining how visual signals influence physiology and behaviour, with a particular focus on circadian and related 'non-visual' responses. These activities build on insights gained from experiments in rodent models and modelling using data from human studies to define how defined photoreceptive signals contributed to the relevant responses, and have contributed to the scientific consensus workshops that formed the prelude to CIE S 026:2018 and subsequent lighting recommendations based around that standard.	**Recommendations for Healthy Daytime, Evening, and Night-Time Indoor Light Exposure** In addition to more conventional visual qualities, 'non-visual' effects such as those on the circadian system, sleep and alertness are important considerations in lighting design and a promising route for maximizing health and well-being. The CIE S 026 standard now, for the first time, provides an accepted measurement standard upon which to base such considerations. Here I discuss the expert scientific consensus recommendations of the 2nd international workshop on circadian and neurophysiological photometry (2019) for daytime, evening and night-time light exposure, expressed in the language of this new standard and intended to support appropriate non-visual functions.

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	Presenter	Presentation title and contents
	**Dr Vineetha Kalavally** *Monash University, Malaysia* Vineetha is an Associate Professor at the Electrical and Computer Systems Engineering Department, Monash University, Malaysia. She is the director of their Intelligent Lighting Laboratory and also the director of Division 6 of MyCIE. Her current research focusses on the development of lighting systems which are human-centric, with a focus on engineering solutions for improving productivity and well-being.	**Wearable spectral light sensors** This presentation has been developed to enhance the understanding of metrology of optical radiation for human photoreception using wearable light spectral sensing devices. An outcome for participants at this tutorial will be achieving clarity on how such devices can be characterized and calibrated for high accuracy by considering dark noise, stray light, non-linearity, directional response, sensor saturation and spectral response. The challenges and trade-offs associated with miniaturization will be presented.
	**Prof Shigekazu Higuchi** *Kyushu University, Japan* Shigekazu is a professor at Kyushu University, in the faculty of Design, department of Human Science. He worked at the department of public health of Akita University school of Medicine (1997–2006), the Japan national institute of occupational safety and health (2006–2007) and at the National Center of Neurology and Psychiatry (2007–2009). His research interests include the non-visual effects of light at night (LAN) on sleep and circadian rhythms and individual and age-dependent variations in circadian sensitivity to LAN.	**The influence of correlated colour temperature on non-visual effects of light at night** High correlated colour temperature (CCT) light contains a relatively large amount of shorter wavelengths (i.e. in the "blue" range of the visible spectrum) and therefore has the potential to strongly impact on circadian rhythms. In many Asian countries, high CCT light is often used at night at home even in living rooms and bedrooms. The presentation will focus on the effects of high CCT lighting on the delay of circadian rhythm and melatonin secretion in children, university students, and adults. Individual and age-dependent variations in circadian sensitivity to light exposure at night will also be discussed.

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	Presenter	Presentation title and contents
	**Dr Raymond Najjar** *Singapore Eye Research Institute / Duke-NUS Medical School, Singapore* Ray is a Junior Principal Investigator in the Department of Visual Neuroscience at the Singapore Eye Research Institute (SERI) and Assistant Professor at Duke-NUS Medical School. He received his PhD in Neuroscience from the University of Lyon, France, followed by a 2 years postdoctoral fellowship at Stanford University, USA. He is interested in mechanisms related to non-image forming responses to light and translational technical applications related to that matter. Some of his current research at the Singapore Eye Research Institute focuses on understanding light-driven processes of emmetropization and myopia control.	**Light therapy for myopia-control?** Myopia is the leading cause of visual impairment worldwide. Besides its direct socio-economic burden, myopia is associated with vision threatening ocular complications. Increased time spent outdoors is preventive against myopia. The protective effect of time spent outdoors could be due to the increased brightness and unique spectral characteristics of sunlight that are generally lacking indoors. In this presentation I will summarize some of the key and novel findings on the impact of light on ocular growth and highlight new findings on the impact of spectral tuning of artificial light on myopia development.

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