CIE WORKSHOP ON
CALCULATION AND MEASUREMENT OF OBTRUSIVE LIGHT

Online on ZOOM
November 12-13, 2020

PROGRAMME AT A GLANCE

<table>
<thead>
<tr>
<th></th>
<th>WORKSHOP ON CALCULATION AND MEASUREMENT OF OBTRUSIVE LIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thursday November 12, 2020</td>
</tr>
<tr>
<td>Morning</td>
<td>General aspects and considerations</td>
</tr>
<tr>
<td></td>
<td>Measurement instrumentation and methods</td>
</tr>
<tr>
<td>Afternoon</td>
<td>Calculation models and tools</td>
</tr>
<tr>
<td></td>
<td>Practical calculation</td>
</tr>
<tr>
<td></td>
<td>Effects of obtrusive light to humans, fauna and flora</td>
</tr>
<tr>
<td>Evening</td>
<td>Practical measurement</td>
</tr>
<tr>
<td></td>
<td>Summary and outcomes</td>
</tr>
</tbody>
</table>

WORKSHOP PROGRAMME (TENTATIVE)

**November 12, 2020**

10:00 – 12:00 Introduction (T. Novák, D. Gašparovský)

**General aspects and considerations**
- Obtrusive light and light pollution work in the CIE: overview (D. Gašparovský)
- CIE Guidelines on the problems of obtrusive light (C. Bouroussis)
- CIE 150:2017 – Application and implementation (M. Donners)
- Obstrusive Light from dynamic and colourful lighting and its limitation – The challenges and latest update (S. Lau)

12:00 – 14:00 LUNCH break

14:00 – 16:30 **Calculation models and tools**
- Software tools for calculation of obtrusive light parameters (T. Novák)
- Calculation methods and models (M. Kocifaj)
- ILLUMINA, a powerful tool for understanding and simulating the obtrusive light in real environments (M. Aubé)
- Calculation of glare and obtrusive light parameters from outdoor lighting installations using ReluxDesktop software (C. Bouroussis)
- Dynamic lighting in urban environments (K. Zielinska-Dabkowska)

**PRACTICAL CALCULATION:** Luminous intensity distribution of the upward flux from urban and road lighting (T. Novák)

16:30 – 17:00 **PRACTICAL MEASUREMENT:** Road lighting and outdoor workplace – introductory word to pre-recorded measurements (T. Novák)
November 13, 2020

09:00 – 12:30 Instrumentation and methods for measurement of obtrusive light
- Using digital cameras in measuring night sky brightness (Z. Kolláth)
- Quantify impacts of artificial light at night with one-dimensional photometric measurement devices (S. Wallner)
- Luminance/illuminance meters in relation to CIE 150:2017 (R. Dubnička)
- Spatial and temporal patterns in light emissions (Ch. Kyba)
- Measurement of obtrusive light using unmanned aerial systems (C. Bouroussis)
- The use of high-resolution aerial lighting maps to improve light pollution analysis (R. Chasseigne)
- The evaluation of obtrusive light from LED screens (B.J. Pong)

12:30 – 14:00 LUNCH break

14:00 – 15:00 Discussion to the results of practical measurements
PRACTICAL MEASUREMENT: Road lighting
PRACTICAL MEASUREMENT: Outdoor workplace

15:00 – 16:30 Effects of obtrusive light to humans, fauna and flora
- Impact of artificial light on the environment and recommendations to minimize the impact (A. Jägerbrand)
- The effects of light on circadian rhythms, melatonin and sleep (L. Schlangen)
- Quantify Night Light Pollution and Build a Light Environment for Human Living (M. Zhang)
- Impact of artificial light at night on aquatic ecosystems (A. Jechow)

16:30 – 17:30 Round table discussion
- Recommendations on revision of CIE publications and new work item proposals (C. Bouroussis)
- Summary and outcomes

17:30 Closure of the workshop
# Presentations

**Obtrusive light and light pollution in CIE: overview** (D. Gašparovský, SK)

This introductory presentation of the workshop aims to drag the participants into problems of obtrusive light and to give insight on how these problems are tackled in the International Commission on Illumination (CIE). Overview of the CIE Technical Reports relevant to obtrusive light and current activities of CIE in the field will be given. Terminology according to the International Lighting Vocabulary will be explained. Open questions that need urgent attention of researchers will be outlined.

**CIE Guidelines on the problems of obtrusive light** (C. Bouroussis, GR)

This talk will deal with CIE guidelines that are related to the limitation of the obtrusive light and the problems that are associated with it, like for example the skyglow, the intrusive light, etc. The related technical reports (e.g. CIE 001-1980, CIE 126-1997, CIE 150:2017, etc.) will be analysed while certain recommendations from them will be presented and discussed.

**CIE 150:2017 – Application and implementation** (M. Donners, NL)

CIE report 150 describes metrics and limits for obtrusive light. These are very much needed by all involved in outdoor lighting, from the owner of the lighting installation, to lighting designers, users and residents, up to those who have to enforce adherence to lighting standards. All these parties are confronted with practical issues when trying to apply CIE 150, making clear that additional guidance is urgently needed. This presentation will show where more work is needed and give suggestions for possible solutions.

**Obstrusive Light from dynamic and colorful lighting and its limitation- The challenges and latest update** (S. Lau, CN)

As you may already known, CIE already set up a technical committee to work on to provide guidelines for the implementation and usage of colourful and dynamic lighting in outdoor applications aiming at limitation of obtrusive light with respect to astronomical observations, humans and night-time environment and to develop metrics for obtrusive light from colourful and dynamic lighting systems and to propose suitable methods for limitation or prevention of obtrusive light from such systems. This presentation will give you a summary on the latest progress on the work and also the technical challenges and difficulties faced.

**Software tools for calculation of obtrusive light parameters** (T. Novák, CZ)

This article describes one possible way how to evaluate large outdoor lighting sources from the obtrusive light point of view. It is focused on modelling, evaluation and comparison of UFR generated from different outdoor lighting systems. The contribution describes how the model works and shows some examples of behavior of modeled large lighting systems like road lighting, billboards, windows, etc.
<table>
<thead>
<tr>
<th>Calculation methods and models (M. Kocifaj, SK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The huge diversity in many atmospheric properties makes the skyglow produced from artificial light sources highly variable. It is therefore highly unlikely that simple empirical models can predict accurately the wide range of skyglow patterns under distinct atmospheric conditions. Hence, there is a definite need for physical night-sky radiance models that can account for the optical properties of both the atmospheric environment and a variety of light sources. This presentation aims to succinctly introduce the fundamentals of the radiative transfer problem in the Earth's atmosphere and to provide a successful solution scheme for arbitrarily polluted environment. A new powerful numerical solver is presented that allows for the modeling of both the upward and downward spectral radiance and luminance distributions at a configurable grid of discrete elevations and distances from the light source. This physical approach allows to simulate how the properties of the radiative field are modified when transitioning from ground sites near sea level to elevated stations (like high-altitude astronomical observatories), and even up to satellite level. The most striking features of the model are discussed briefly, such as high accuracy, high resolution, full reproducibility of the computed radiance fields, and, especially high-speed computation. The latter feature is essential for real-time modeling even on personal computers. This is achieved thanks to an algorithm that does not impose progressively higher computational demands whenever one wants to obtain each higher-order radiance. CPU requirements are independent of the scattering order because of the novel iterative solution scheme in which the higher-order radiance is fully determined by that of its lower-order counterpart. The model is demonstrated using a number of examples with numerical results.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ILLUMINA, a powerful tool for understanding and simulating the obtrusive light in real environments (M. Aubé, CA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILLUMINA is a monte carlo based radiative transfer model aimed to simulate the artificial light at night propagation into the environment. The model typically uses satellite data and locally acquired data as inputs. It comprises the calculation of the first two orders of scattering into the atmosphere and reflections on the ground based surfaces. Illumina can simulate both the sky radiance (clear and overcast conditions) and the radiance coming from a direct sight to lighting devices and lit surfaces. ILLUMINA calculations are made over a multiscale resolution grid which is maximal near the virtual observer. ILLUMINA accounts for various aerosol optical properties, relative humidity, ground level atmospheric pressure, ground reflectances spectrum, topography, lamps spectra, lamps angular emission functions, cloud base height, type of cloud, and subgrid obstacles. The radiance can be calculated toward any viewing angle, including downward. So that in addition to being able to simulate the night sky radiance it can simulate a satellite view of the earth surface. In this presentation, we will explain the model capabilities and show some typical results it can deliver.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculation of glare and obtrusive light parameters from outdoor lighting installations using ReluxDesktop software (C. Bouroussis, GR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This talk with present practical calculation methods and examples, using the ReluxDesktop software, for the calculation of obtrusive light aspects from the perspective of lighting engineering, such as luminance, illuminance, luminous intensity calculations, directionality of glare, k-factor and other. The presented methods are related to technical documents and norms such as CIE 150:2017, ÖNORM O 1052:2012 and other.</td>
</tr>
</tbody>
</table>
## Dynamic lighting in urban environments (K. Zielinska-Dabkowska, PL)

Since the beginning of the 20th century, the image of our towns and cities at night has slowly but surely been shaped by luminous advertising. While the use of this new medium has been widespread, there are no clear rules or regulations to date, to ensure colourful and dynamic LED technology for advertising is applied in a creative and acceptable way. This lack of guidance makes it extremely difficult for local authorities to make educated decisions when dealing with applications for building permits of this kind. The current challenges exist because of a combination of factors including a lack of specifications to adequately define content, the fact that the products applied are indeed suitable, and that the choice of location for displays is appropriate. The need for the integration of control technology to programme and change displays luminance is also frequently overlooked or simply forgotten. As this topic is new and complex, it needs practical evaluation guidelines for professional specialist lighting planners. This lecture addresses key issues relating to the use of LED advertising systems on buildings in an urban context, and it includes the analysis of available measuring devices.

## Using digital cameras in measuring night sky brightness (Z. Kolláth, HU)

Multi-wavelength imaging radiometry of skyglow provides essential information on light pollution and sky quality. In my talk, I demonstrate that digital cameras capable of saving raw images can be used to provide precise measurements of night sky radiance. Our processing method includes a conversion to a metric which is connected to the real spectral sensitivity of the cameras. The results are given in band-averaged spectral radiance in all the colour channels (RGB). We provide the steps of calibration and the possible conversions to different units and the errors of the procedures. We also demonstrate that some conversions used in the literature are not grounded well. The primary source of errors in these cases is the spectral mismatch of the camera sensitivity curves respect to the calibration devices. Our metric eliminates this problem, and we also improve the calibration further by spectral measurements of the sky in real conditions. We demonstrate the measurement methods with real-life examples. In this talk, we also present recommendations for sky quality surveys. Acknowledgements: The project is supported by the European Union and co-financed by the European Social Fund (Grant no. EFOP-3.6.2-16-2017-00014; Development of international research environment for light pollution studies).

## Sky quality meter (S. Wallner, AT)

The Unihedron ‘Sky Quality Meter’ (SQM) is a hand-sized measurement device, providing an easy opportunity of one-dimensional photometric observations by detecting the brightness of, e.g., the sky’s zenith luminosity. Its production was undergone with the background of creating a low cost but still accurate instrument, being used by the wider public. Especially due to being low-priced and still providing data in a satisfactorily accurate precision - they are most used devices for characterising light pollution. Because they can work remotely, SQMs are worldwide used to create light monitoring networks and create long-term studies. The presentation will include details about the instrument, strengths and weaknesses of the devices, the successful installation of a light monitoring network in Austria and future prospects.
### Luminance/illuminance meters in relation to CIE 150 (R. Dubnička, SK)

Outdoor lighting systems excluding road lighting and public lighting e.g. LED screens, sports lighting systems, lighting systems of parking zones and outdoor lighting of industrial zones, illumination of buildings, decorative lighting of buildings etc. are a potential sources of obtrusive lighting. Light emerging from luminous areas of these installations have sometimes significant impact to the surrounding environment. The maximum permissible limits of photometric parameters from the outdoor lighting systems depend on the environmental zones defined by standards and CIE recommendation where lighting systems are installed. The values of limits luminance, illuminance levels or TI values are defined in the national standards and CIE documents treating obtrusive lighting. In some countries are these limits implemented in the law to minimize obtrusive lighting in outdoor environment. Practically operation of outdoor lighting installations often does not meet the standards or recommendation requirements. Too high luminance from these sources can cause visual discomfort mainly to the car drivers, to pedestrians or even more habitants in ambient residential buildings by intrusive lighting. Therefore, in practice it is needed to control of measure obtrusive lighting by means of on-site or laboratory photometric measurements in respect of particular outdoor lighting installation and environment where lighting installation is situated. The presentation deals with recommendation of on-site or laboratory photometric measurement methods to control measure of obtrusive lighting of real installed outdoor lighting systems by means of photometric devices i.e. luminance meters, illuminance meters and image luminance meters according to limits in relation to the publication CIE 150:2017.

### Spatial and temporal patterns in light emissions (Ch. Kyba, DE)

Using satellite data, I will present three important results: First, most light emissions come from sources other than streetlights (including colorful and dynamic lighting). Second, light emissions continue to grow worldwide, despite the existence of CIE 150:2017 and other norms and guidelines. Third, there are extraordinary differences in per capita light emissions among wealthy countries worldwide. Germany demonstrates that a country can be wealthy and have robust consumer activity while still being conservatively illuminated.

### Measurement of obtrusive light using unmanned aerial systems (C. Bouroussis, GR)

This talk will present new measurement methods and geometries for the measurement and assessment of obtrusive light using unmanned aerial systems. Since the light is distributed in the three-dimensional space, the assessment of outdoor installations should be also considered beyond the ground level measurements. New measurement geometries on the 3D space using unmanned aerial systems and new metric concepts will be presented and discussed along with some preliminary measurements results. The proposed measurement concepts are also intended to cover the relevant CIE Technical Reports like CIE 150:2017.

### The use of high-resolution aerial lighting maps to improve light pollution analysis (R. Chasseigne, FR)

Light pollution visualisation is mostly known from the public thanks to the large scale satellite images illustrating the impact of human activity on the environment. Today, the cities lighting optimisation is an important line of work. Combined with the in-house knowledge and existing data, the use of high resolution night aerial lighting maps give precise technical information on light pollution sources identification and lighting points localisation. The end-users maps are particularly powerful to build awareness for both the public and private actors.
### The evaluation of obtrusive light from LED screens (B.J. Pong, TW)

Since lots of citizen complaint about the commercial light sources in Taiwan, the major complaint are LED screens. The people live in/near urban area complained about too bright/too flashing of LED screens. However, the petition cases increased dramatically since 2014, more than 90 % cases are from metropolitan cities (6 capital cities). Hence, we conductive the study of obtrusive light(light pollution) caused by LED screens since 2011. In this talk, I will present our research results about the evaluation of dynamic glare and flicker of LED screens (LED billboards). It is suggested to use maximum luminance to evaluate the perceived glare discomfort for LED screen where maximum luminance can be obtained in terms of luminance meter aim at the center of LED billboard. Where the suggested maximum value of luminance is under 650 cd/m² for outdoor/indoor LED billboards. It is suggested to use 90th percentile flicker magnitude to evaluate the perceived flicker discomfort for LED billboard, where 90th percentile flicker magnitude can be obtained in terms of fast Fourier transformation (FFT) from the two-dimensional (2D) luminance distribution of LED billboard. Where the suggested maximum value of 90th percentile flicker frequency magnitude is under 31~33 for LED billboard with maximum luminance between 1 100 and 4 299 cd/m².

### Impact of artificial light on night-time environment (A. Jägerbrand, SE)

Outdoor lighting may cause an unwanted ecological impact in species and ecosystems. The unwanted ecological impact of outdoor lighting is especially worrying when it involves species and natural areas that need special protection from anthropogenic disturbances. The presentation will give an overview of well-known ecological impacts of outdoor lighting and present principles that can be implemented for minimizing such impacts. Examples of lighting design principles for protected species and/or ecosystems will be presented as well as thumb rules for identifying cases when the lighting must be extra carefully planned to avoid causing negative ecological impact.

### The effects of light on circadian rhythms, melatonin and sleep (L. Schlangen, NL)

The widespread use of electrical light and electronic devices results in extended exposures to light during late-evening hours and at night. This compromise our sleep, circadian rhythm, performance, wellbeing and health. We generally need most light in the morning and during the day, less in the evening, and the least possible at night. Nocturnal light acutely suppresses melatonin, a hormone that is implicated in sleep consolidation and sleep-wake-cycle regulation. Morning light is essential to entrain our circadian rhythm to the 24-hour light-dark cycle, thus regulating the timing and quality of our sleep. Bright light during daytime reinforces the circadian rhythm and reduces sensitivity to light in the evening/night, making such late light exposures less sleep-disruptive. In this presentation the CIE recommendations for proper light at the proper time will be explained and discussed. These recommendations adopt the new photoreceptor-based light metrology for non-visual (ipRGC-influenced) responses to light, as recently standardized in CIE S 026:2018.

### Quantify Night Light Pollution and Build a Light Environment for Human Living (M. Zhang, CN)

The background brightness of China’s urban residential areas has become brighter. The vertical illuminance on the outer surface of the window of a residential building basically meets the requirements, but a large proportion of residents still believe that it is affected by light trespass. The limit of the vertical illuminance on the outside surface of the window cannot reflect the impact of light trespass on residents. LED displays have become the main source of color and dynamic light trespass. Both its high brightness and instantaneous changes in brightness cause trespass.
**Impact of artificial light at night on aquatic ecosystems** (A. Jechow, DE)

Artificial light at night (ALAN) has an impact on ecosystems. Although aquatic ecosystems are biodiversity hotspots and overproportionally affected by ALAN, they are not as comprehensively studied as terrestrial ones. I will give an overview of existing knowledge on effects of ALAN on aquatic ecosystems from microbes to fish behavior. I will further present recent results from a large scale skyglow on lakes experiment and discuss specific challenges of light measurements for aquatic ecosystems.

---

**PRACTICAL CALCULATION**

**Luminous intensity distribution of the upward flux from urban and road lighting** (T. Novak)

As a part of the workshop, the organizers prepared an example of modelling the UFR. We hope that this example (educational video, complimentary software for 10 days free of charge, source file) will help us (users, software developers) to increase possibility to evaluate not only UFR, but photometric distribution curves of large outdoor lighting systems radiation, too. We prepared for you example of billboard which is illuminated from bottom and from the top. On this example it is possible to show demonstration of big UFR and photometric distribution curve differences caused by the same lighting system placed on the bottom and on the top of the billboard. It is possible to present and discuss modelling and behaviour of other lighting systems like road lighting (NAV, LED), windows, low beam car lights, facades, etc.

---

**PRACTICAL MEASUREMENTS**

**Road lighting of an area** (T. Novak)

Contribution of road lighting to skyglow depends on local conditions and other large light sources in an area or nearby. Aim of this measurement is to compare the sky luminance with road lighting on and road lighting off and using these values to deduce the real contribution of road lighting to the skyglow. Due to online arrangement of the workshop the measurements will be pre-processed and pre-recorded. Workshop participants will be provided by information important to assess the actual conditions (other large light sources in the wider radius, moon phase, weather etc.), luminaire types, description of the measured area etc. At a certain time the lighting of a larger area (village, city) will be switched off. For safety reasons this measurement is coordinated with road lighting operators, municipalities, police departments and other relevant parties. Measured illuminances and luminance maps will be given to the participants for final evaluation.

**Outdoor lighting of power substation in Nošovice** (T. Novak)

For this measurement we prepared switching on/off of two 420 kV power substations. There are large light sources operated on relatively small area. It is possible to control them. It is possible to model them and thus better separate them from other outdoor light sources such as road lighting. You will get information about switched lighting systems inside substations, working area, description of near other large light sources with possible influence on sky glow, measured illuminance and measured luminance maps for evaluation and discussion.
**ROUND TABLE introductory presentation**

**Recommendations on revision of CIE publications and new work item proposals (C. Bouroussis)**

The intermediate report of the DR 4-53 “Environmental Aspects of Obtrusive Light from Outdoor Lighting Installations” will be briefly presented and a discussion around proposed updates of current CIE documents or establishment of new Technical Committees will take place. Workshop’s attendees will be welcome to express their opinions on the discussion topics.
Prof Martin Aubé (CA)  
(École de Sherbrooke)

Martin is a world leading researcher in the field of remote sensing and modeling of light pollution. He got his PhD in remote sensing from U. Sherbrooke and a MSc in astrophysics from U. Laval. He is a physics professor at École de Sherbrooke and adjunct professor at U. Sherbrooke and at Bishops University. Martin received the 2014 excellence in research award from the Québec’s research agency, the 2013 "Raymond Gervais award" for excellence in science teaching, the International DarkSky Association 2018 Galileo award for outstanding achievements in research on light pollution over a multiple year period, and the 2019 Denise-Barbeau award for college based research from ACFAS association.

Dr Constantinos Bouroussis (GR)  
(National Technical University of Athens)

Constantinos is an Electrical and Computer Engineer. He got his PhD in Engineering in the field of road and tunnel lighting measurements from the National Technical University of Athens (NTUA). He is currently a research associate at the Lighting Laboratory of NTUA, with participation in more than thirty internationally and nationally funded projects. He also works as an independent technical consultant. His main areas of interest include lighting technology, photometry, imaging sensors, machine vision, and unmanned aerial systems. He has extensive experience in lighting measurements and evaluation of lighting infrastructures, lighting master planning, lighting education, instrument prototyping and other. He has given numerous lectures in lighting related aspects at universities and training institutes. He participates in the CIE, as the country member for Greece in Division 2, as a reporter in Division 4 (DR 4-53 “Environmental Aspects of Obtrusive Light from Outdoor Lighting Installations”) and as a member of several TCs. In addition, he was a member of the committees and lead author for the preparation of a Greek Technical Guide on Road Lighting and the Greek National Regulation for Road and Tunnel Lighting.
| **Romain Chasseigne (FR)**  
**Laboratoire national de métrologie et d’essais** |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Romain is an engineer in remote sensing and GIS (Geographic Information System) working in the photometry department of LNE (Laboratoire national de métrologie et d’essais, Paris, France). He is involved, as a project manager, in energy efficiency technical studies (solar energy mapping, infrared thermography of buildings, outdoor lights mapping) on behalf of various clients, mostly territorial authorities.</td>
</tr>
</tbody>
</table>

| **Dr Maurice Donners (NL)**  
**Signify** |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maurice is a lighting application scientist at Signify (former Philips Lighting) Research, focusing on outdoor lighting. His work covers the full range from developing perceptual models, specifying and developing new products and addressing emerging user needs. Recently he has been working on subjects like discomfort glare from LED sources, lighting needs of elderly, adaptive lighting and the influence of outdoor lighting on the natural environment. He is a member of the Outdoor Committee of the dutch national CIE, committee chair of CIE TC 4-54 and Division Secretary of CIE Division 4.</td>
</tr>
</tbody>
</table>

| **Dr Roman Dubnička (SK)**  
**Slovak University of Technology in Bratislava** |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Roman is 40 years old. After university graduation from Physics in 2006 he has been working at Slovak Metrological Institute SMU for four years. From position of PhD student to position of research worker he has started career as metrologist in the field of metrology of optical quantities. He was responsible person for national standard of luminous intensity in Slovakia and also has been national contact person at EURAMET organisation. From 2010 till now he worked as head of calibration laboratory and quality manager of calibration laboratory. In September 2012 till now he works at Slovak University of Technology in Bratislava as researcher with lectures in the field of photometry and also as quality manager and head of photometric laboratory at university. He finished his PhD study about mesopic photometry in 2018. In 2013 he was elected for president of Slovak National Committee of CIE and he is official national member in Division 1 and Division 2 at CIE.</td>
</tr>
</tbody>
</table>
| **Prof Dionýz Gašparovský (SK)**  
(Slovak University of Technology in Bratislava) |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dionýz is professor at the Institute of the Power and Applied Electrical Engineering, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava, responsible for the study programme Lighting Technology. He is deeply interested and involved in application problems of indoor and outdoor lighting with strong focus on road lighting. Besides conducting research he is experienced in practical lighting design and measurements. Road lighting calculations, energy performance of lighting, maintenance factor and adaptive road lighting belong to his long-term favourite topics in lighting. Dionýz is currently Director of CIE Division 4 – Transportation and exterior applications.</td>
</tr>
</tbody>
</table>

| **Dr Annika Jägerbrand (SE)**  
(Halmstad University) |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annika has a PhD in ecology and currently holds a position as assistant professor in environmental science at Halmstad University in Sweden. Before that Annika held a position as assistant professor in lighting science at Jönköping University. Annika has been leading research projects on road lighting for over ten years and is a highly experienced multi-disciplinary researcher. Research areas include the ecological impact of LED and measures against unwanted ecological impacts, light pollution, lighting design, sustainability and traffic safety. Annika has also worked several years as a consultant on environmental questions, for example, the impact of artificial lighting on protected species and habitats. She was elected as chairman of TC 4-61 &quot;Artificial Lighting and its Impact on the Natural Environment&quot;, a CIE TC that was activated in 2020.</td>
</tr>
</tbody>
</table>

| **Dr Andreas Jechow (DE)**  
(Environmental research institute (IGB Berlin)) |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Andreas is a physicist working at an environmental research institute (IGB Berlin). Andreas has a broad expertise in photonics, the science of light, which he applies in an interdisciplinary context. He received a PhD in photonics and laser physics from the University of Potsdam, Germany. He did a PostDoc in quantum optics in Australia where he imaged the &quot;first shadow of a single atom&quot; and subsequently worked in biophotonics and quantum microscopy. Andreas started to work on the topic of artificial light at night and light pollution in 2015. At IGB, he developed and built a skyglow light source for a large-scale ecological experiment at the LakeLab (ILES). His current research interests are measuring and assessing the impact of ecological light pollution, mainly skyglow, for all weather conditions (i.e. snow, clouds) and all terrain (i.e. deserts, sub-arctics, freshwater, marine) as well as daytime remote sensing of freshwater ecosystems.</td>
</tr>
</tbody>
</table>
Dr Miroslav Kocifaj (SK)
(Slovak Academy of Sciences / Comenius University)

Miroslav is senior researcher working in the Physics group of the ICA of the Slovak Academy of Sciences and Faculty of Mathematics, Physics, and Informatics of the Comenius University. His research includes interaction of light with atmospheric environment and aerosols, electromagnetic scattering theories, radiative transfer in disperse media, and solution of inverse problems. His research over the past decade has focused on sky-glow theory, modelling and measurement of night-sky radiance along with theoretical, and computational aspects of light scattering.

Prof Zoltán Kolláth (HU)
(Eszterházy Károly University)

Zoltán is a professor of Physics at the Eszterházy Károly University, Department of Physics (Eger, Hungary). He is a founding member of the TC 4-58 Technical Committee (Obtrusive Light from colourful and dynamic lightings and its limitation). He is a member of the IDA’s Dark Sky Places Committee, the Lighting Society of Hungary and the International Astronomical Union. He received his PhD (1990) in astrophysics and the Doctor of the Hungarian Academy of Sciences (Dsc) in 2003. Zoltán Kolláth has been working in stellar astrophysics and nonlinear data processing. He has been involved in light pollution-related studies for more than 20 years and now leads an EU funded project in Hungary focusing on measurements and modelling of light pollution.

Dr Christopher Kyba (DE)
(GFZ German Research Centre for Geosciences)

Christopher is a physicist who studies artificial light in the outdoor environment at the GFZ German Research Centre for Geosciences.
<table>
<thead>
<tr>
<th>Steve Lau (CN) (YD Illumination)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Steve</strong> is currently the TC chair for TC 4-58 Technical Committee (Obtrusive Light from colorful and dynamic lightings and its limitation) of CIE. He is also a member of TC 2-79 <em>Integrating sphere for photography and spectroradiometry</em>. He has more than 20 years of experience in LED lighting, lighting testing, laboratory accreditation (ISO17025, CNAS, nvlap), led quality management. He worked in OSRAM, Malaysia, Lumileds, Shanghai Philips and currently work as a deputy director in the Institute of Intelligent Lighting in YD Illumination. He is a regular speaker in both international and domestic forums and seminars in CIE, ALC, IFAL, CIES and other China Lighting Forum. In 2015 he was awarded the foreign expert certificate issued by the State Administration of foreign experts of the People’s Republic of China as a recognition to his outstanding contribution in the field of lighting and CIE.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dr Tomáš Novák (CZ) (VSB Technical University of Ostrava)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tomáš</strong> works at VSB–Technical University of Ostrava, Faculty of Electrical Engineering and Computer Science, Department of Electrical Engineering as associate professor and he is chair of Czech Lighting Society. He is a member of TC 4-58 and TC 4-62, too. His current research interests include road lighting, obtrusive light and smart city technologies. He has experience with technical designing and measurement of lighting systems.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dr Bao-Jen Pong (TW) (Center for Measurement Standards of ITRI Taiwan)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bao-Jen</strong> is the Deputy Director of Division 1 (Vision and Colour) of CIE Taiwan. As Principal Engineer at Center for Measurement Standards of ITRI Taiwan, he focus on the metrology of light pollution and image quality of display. In CIE, Bao-Jen contributed to CIE 150:2017 (Guide on the limitation of the effects of obtrusive light from outdoor lighting installations) as one of the authors. Currently he contributes to TC 4-58 <em>Obtrusive Light from Colourful and Dynamic Lighting and its Limitation</em> about the topic related to the glare and flicker evaluation of LED screen.</td>
</tr>
</tbody>
</table>
Dr Luc Schlangen (NL)  
(*Eindhoven University of Technology*)

Luc is senior researcher at Eindhoven University of Technology, in the Intelligent Lighting Institute, department of Human Technology Interaction. He holds a PhD degree from Wageningen University. His main interests are the circadian (timing) system, human photoreception and the visual and non-visual responses to light and lighting in laboratory and field settings (workplaces, homes, education and healthcare). Luc is board member of the International Commission on Illumination (CIE) and serves as Director of CIE Division 6 “Photobiology and Photochemistry”. He has chaired the CIE committee that prepared international standard CIE S 026:2018 with new metrics to quantify light for its non-visual (ipRGC-influenced) responses.

Stefan Wallner (AT)  
(*University of Vienna*)

Stefan is an astrophysicist, currently working at the Department of Astrophysics, University of Vienna (Austria) and the Slovak Academy of Sciences, Bratislava (Slovak Republic). My research field is the topic of measuring, modelling and quantifying light pollution, skyglow and atmospherical effects. Since 2019 I am project manager for light pollution research at the University of Vienna and currently working on the creation of Austria’s first official certified IDA Dark Sky Place.

Prof Zhang Mingyu (CN)  
(*Tianjin University*)

Mingyu is an associate professor of School of Architecture, Tianjin University, the member of the China Illuminating Engineering Society (CIES), and the associate director of the Tianjin Key Laboratory of Architectural Physics and Environment Technology. He is also a member of TC 4-58 Obtrusive Light from Colorful and Dynamic Lighting and its Limitation of CIE.

He was engaged in research work in the field of architectural technology science. Relevant research on the light trespass (including the part of the interference of light and the part of the reflective glare of the glass curtain wall). He has specific and clear research ideas on the interference mechanism of colored and dynamic light.
Dr Karolina M. Zielinska-Dabkowska (PL)  
(Gdansk University of Technology)

Karolina (CIE, IALD, IES, MSLL, RIBA) is a chartered RIBA architect and award winning practicing lighting designer. She is also an Assistant Professor at the Faculty of Architecture, Gdansk University of Technology, Poland, and co-founder of GUT LightLab, where she conducts research on various aspects of light and lighting. She is actively engaged in the work of international organisations such as the International Association of Lighting Designers (IALD), the Illuminating Engineering Society (IES), and the International Commission on Illumination (CIE).

Well known for her critical voice on urban lighting and light pollution, she is providing guidelines and sharing best practice for nighttime illumination in the built and natural environment.

In CIE Karolina is a member of TC 4-58 *Obtrusive Light from Colourful and Dynamic Lighting and its Limitation* and TC 4-61 *Artificial Lighting and its Impact on the Natural Environment.*